Township of Langley
Est. 1873

REPORT TO MAYOR AND COUNCIL

PRESENTED:	OCTOBER 5, 2020 - REGULAR MEETING	**REPORT:**	20-125
FROM:	ENGINEERING DIVISION	**FILE:**	5330-27-82
SUBJECT:	MURRAYVILLE AND BROOKSWOOD WATER QUALITY IMPROVEMENTS		

RECOMMENDATIONS:

That Council direct staff to include funding in the amount of $6,000,000 in the 2021 Water Utility budget for Council's consideration of approval to enable construction of the three (3) localized water treatment plants for the Murrayville and Brookswood areas, and authorize staff to proceed with the necessary detailed design work, utilizing funding currently available in the Water Utility account.

EXECUTIVE SUMMARY:

At its meeting of November 18, 2019, Council directed staff to implement the conversion of the municipal water supply in the Murrayville and Brookswood areas to Metro Vancouver sources as soon as practical, as a short-term measure, to address aesthetic issues due to iron and manganese in the groundwater. Subsequently, all five Township wells in Murrayville and Brookswood were disconnected from the municipal water supply system.

Staff retained the services of independent qualified professionals to study options for removing iron and manganese from the affected wells, as a long-term solution. After a comprehensive review of the available options, the consultant made a recommendation involving three localized treatment plants utilizing oxidization and filtration.

The proposed approach is similar to the treatment that has been successfully applied in the Township with the Aldergrove Water Treatment Plant since 1999, but on a much smaller scale. The consultant also provided high-level capital and operational costs to determine the estimated payback period in comparison to purchasing Metro Vancouver water. The capital cost to design and construct the three treatment plants is estimated at $6,400,000, with a projected payback period of approximately five years, based on current regional bulk water purchase costs.

Staff recommend proceeding with detailed design of the treatment plants as soon as possible, utilizing available water utility funding, and for construction to commence in 2021, subject to budget approval process. Alternatively, the following options are available for Council's consideration:

1. Phase construction over three years to distribute the required capital funding: this would be subject to additional potential risks, cost implications, and longer payback period;
2. Abandon existing local sources of water supply on a permanent basis and purchase Metro Vancouver water: this would reduce system resiliency and increase costs in the Water Utility, estimated at approximately $1.5M annually based on current regional bulk purchase rates; or
3. Utilize existing ground water resources without any treatment: this is not recommended as the water exceeds established water quality parameters, and is likely not accepted by the residents.

PURPOSE:

To provide Council with information on the water treatment options for the Murrayville and Brookswood areas and request authorization to proceed with the recommended option.

BACKGROUND/HISTORY:

At its Regular Afternoon Meeting on November 18, 2019, Council passed the following resolution:

> *"That Council direct staff to implement a conversion of the municipal water supply in the Murrayville and Brookswood areas to Metro Vancouver sources as soon as practical, as a short-term measure to address aesthetic issues, while maintaining the existing ground water supply facilities as reserve for emergencies and potential peak demand periods, until such time as other potential measures, such as centralized or localized treatment options and related cost implications have been fully explored; with costs related to the purchase of additional water from Metro Vancouver and connecting the Brawn pump station included in the 2020 budget."*

Subsequently, based on Council direction, staff implemented a temporarily shut-off of the five Township of Langley groundwater wells supplying the Murrayville and Brookswood neighborhoods, thereby providing for the water supply needs of the affected areas being met utilizing regional sources only. There are five wells affected; namely: Murrayville Wells #1 and #2, and Brookswood Wells #7, #9, and #10. Please refer to Attachment A for a context map of the affected wells.

Also, as directed by Council, following a Request for Proposals (RFP) process, retained the services of a qualified professional engineering firm, Kerr Wood Leidal Associates Ltd (KWL), to study the feasibility of implementing water treatment for the five wells in the Murrayville and Brookswood systems and to recommend treatment options as well as budgetary estimates.

DISCUSSION/ANALYSIS:

Water treatment is required for the five groundwater wells to meet the most current requirements of the Guidelines for Canadian Drinking Water Quality (GCDWQ). Water quality results from the Brookswood and Murrayville wells have typically reported iron and manganese levels exceeding the Aesthetic Objectives stated in the GCDWQ. In May 2019, Health Canada established a health-based Maximum Acceptable Concentration (MAC) value for manganese in drinking water and Brookswood Well #10 exceeds this new MAC.

KWL compared three common treatment options used for smaller facilities, required for the Brookswood and Murrayville wells. These options include:

1. Oxidation and Filtration using Catalytic Media:

   Most iron and manganese removal processes require oxidation as the first step of treatment to precipitate the iron and manganese dissolved in the water. Once oxidized, the precipitates can be settled or filtered out. Filtration with catalytic media is an effective and proven means for reducing both precipitated iron and dissolved or precipitated manganese in well water. The media acts as a catalyst for the manganese oxidation process and as water passes through the filter bed, the media retains the oxidized iron and manganese and their concentration reduces as the water progresses through the treatment system. The media requires periodic backwashing to remove the accumulated iron and manganese.

2. Oxidation and Media Filtration:

   Similar to the first option, this system incorporates oxidation to precipitate the iron and manganese dissolved in the water. Following oxidization, the water passes through sand media filter beds to reduce the iron and manganese. The sand media requires periodic backwashing to remove the accumulated iron and manganese. However this option requires an additional chemical to be added to fully oxidize the dissolved manganese.

3. Sequestration:

   This process is a form of treatment in which a sequestering agent, such as blended phosphates, is added to the well water. The agent forms a bond with the iron and manganese ions and prevents precipitation. The treatment process requires close monitoring of the well water source and continuous changes to the dosing amounts.

The catalytic filtration process is similar to the oxidation and filtration using sand media. Although both processes require oxidation as a pre-treatment prior to filtration, this is achieved with different chemicals, and both require backwashing to remove accumulated iron and manganese precipitate. The catalytic media filtration has proven more effective in the removal of iron and manganese and is more operationally simple.

The installation of sequestration equipment has a lower capital cost than the other options, but comes with increased operation and maintenance requirements. The sequestration agent can breakdown in the outer reaches of the water distribution system resulting in the iron and manganese precipitating out which could lead to dirty water complaints from residents.

Of the three available treatment options, oxidation and filtration using catalytic media, is the preferred process, due to its effective removal of iron and manganese and relatively simple operation and maintenance requirements.

This type of treatment is similar to the treatment applied at the Aldergrove Water Treatment Plant. The Aldergrove plant uses chlorine to oxidize the raw well water and large tanks of media to filter out the iron and manganese. This process has been successfully removing iron and manganese from the Aldergrove groundwater sources since 1999. The proposed treatment plants for the Brookswood and Murrayville wells would accomplish this, albeit at a smaller scale.

Based on the geographic locations of the five wells, it has been determined that the construction of three (3) localized treatment plants would be the most feasible option. The treatment plants would be strategically located to address the treatment needs of the Murrayville Wells #1 and #2, Brookswood Wells #7 and #9, and Brookswood Well #10 respectively.

It is recommended that the treatment plants be contained within prefabricated shipping containers, based on the following identified advantages/benefits:

- lower capital cost for the project;
- less disruption to the site;
- shorter construction period;
- less generated waste during construction; and
- the ability to relocate the building should a new groundwater source become available or a well relocation is needed in the future.

The treatment plant structures should be located within the parcels of the existing wells. The exact configuration and locations will be finalized during detailed design.

The Murrayville Water Quality Improvement Feasibility Study has been included as Attachment B.

Financial Implications:

The average volume of water produced between 2015 and 2019 by the Brookswood and Murrayville wells is estimated at approximately 1,867,000 m^3/year. Metro Vancouver conveys water to the Township at a cost of \$0.7836/m^3 (2020), projected to increase to 1.0953/m^3 in 2024.

With the temporary closure of the Brookswood and Murrayville wells, an additional annual water purchase from Metro Vancouver in the amount of approximately \$1,425,000 was anticipated for 2020 in the November 18, 2019 Report to Council. As of September 1, 2020, water consumption is within 5% of what was estimated year to date. The cost of this additional purchase of Metro Vancouver water is expected to increase yearly due regular projected increases in water rates.

The consultant has estimated the cost for all three proposed water treatment plants at approximately \$6,362,000. Note that these are high-level costs as no survey or design work has been completed. The total operational and maintenance costs for all three proposed treatment plants is estimated at \$333,500 per year. When considering the cost to purchase Metro Vancouver supplied water, it would take approximately five years to payback the initial capital investment of all three proposed treatment plants as shown in the table below.

Simple Payback Analysis – combined for all three proposed localized water treatment plants

Year	GVRD Water Rate ($/$m^3$)	Average Volume per Year (m^3)	Savings per Year ($)	O&M Cost per Year ($)	Cumulative Savings ($)	Cumulative Cash Flow [1] ($)	Return on Investment Met
2020	0.7836	-	-	-	-	-6,362,000 [2]	-
2021	0.8315	933,694 [3]	776,000	167,000	609,000	-5,753,000	No
2022	0.9049	1,867,387	1,690,000	340,000	1,959,000	-4,403,000	No
2023	0.9949	1,867,387	1,858,000	347,000	3,470,000	-2,892,000	No
2024	1.0953	1,867,387	2,045,000	354,000	5,161,000	-1,201,000	No
2025	1.0953	1,867,387	2,045,000	361,000	6,845,000	483,000	Yes

1. This column subtracts yearly savings from the estimated capital cost of the proposed WTP.
2. Estimated capital cost of the three proposed WTP.
3. Accounts for half of the average annual water consumption.

The above analysis assumes the treatment plants are all operational mid-way through 2021. The 'O&M Cost per Year' column includes a 2% increase per annum to reflect wage and other cost increases. Additionally, it should be noted that the interest costs of borrowing and lost interest revenue were not included in the simple payback calculations.

Currently there is approximately \$360,000 of capital funding available, in *project WTR1002 – Water Quality Alternatives,* to proceed with design, if authorized by Council. The remaining funding required for construction is proposed to be included in the 2021 budget approval process.

Optional Recommendations/Alternatives:

Staff have also considered the following alternatives:

1. Construct the recommended treatment plants in a phased approach between 2021 and 2023. This would allow the \$6,000,000 in required capital for construction to be funded over three years. However, a phased approach would result in inefficiencies with tendering and construction, increased costs of purchasing additional water from Metro Vancouver, and increased payback periods.

2. Leave the wells off and continue with supplying only Metro Vancouver purchased water to Murrayville and Brookswood. This option has an increased cost to the Township water utility of approximately \$1,552,000 in 2021. This would need to be offset by increases in Township water utility rates and is set to increase yearly due to rising Metro Vancouver rates. Relying solely on Metro Vancouver also puts the Township at higher risk of water

shortages during periods of high demand and a lessened ability to provide alternate water supply during maintenance, repair, and emergency interruptions to the Metro Vancouver water system.

3. Turn the wells back on without treating the groundwater for iron and manganese. This option would have the least financial impact to the water utility. However, it is not recommended as the well water regularly exceeds the Aesthetic Objectives stated in the GCDWQ, which would result in further complaints from residents regarding discoloured or dirty water. Furthermore, water from Brookswood Well #10 would be unusable, without treatment, as it exceeds Health Canada's MAC value for manganese in drinking water.

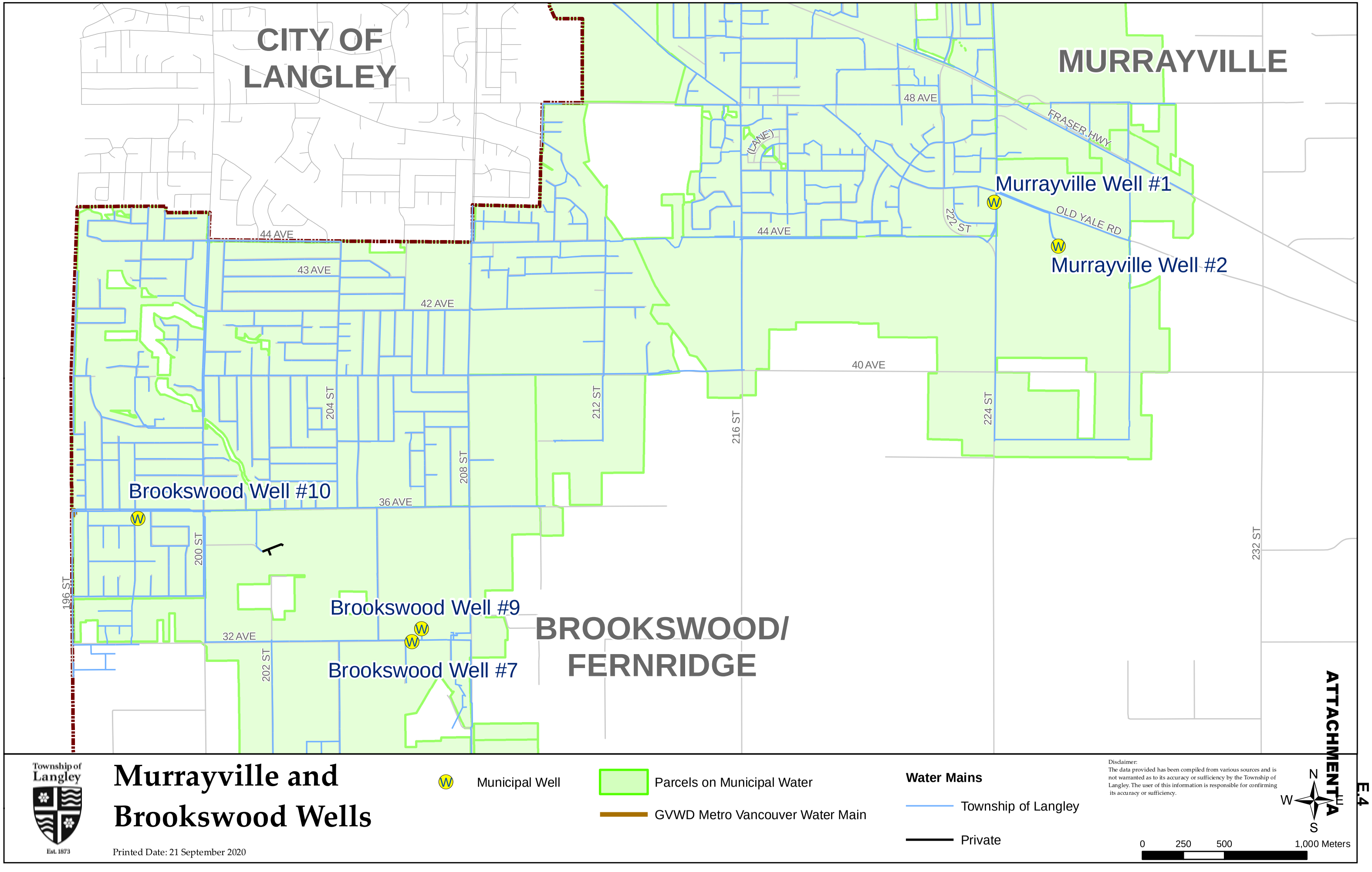
Respectfully submitted,

Roeland Zwaag
DIRECTOR, PUBLIC WORKS
for
ENGINEERING DIVISION

This report has been prepared in consultation with the following listed departments.

CONCURRENCES	
Division / Department	**Name**
FINANCE DIVISION	S. Ruff

ATTACHMENT A Map - Murrayville and Brookswood Well Locations
ATTACHMENT B Murrayville Water Quality Improvement Feasibility Study



Township of Langley
Est. 1873

Murrayville and Brookswood Wells

Printed Date: 21 September 2020

Municipal Well

Parcels on Municipal Water

GVWD Metro Vancouver Water Main

Water Mains

Township of Langley

Private

Disclaimer:
The data provided has been compiled from various sources and is not warranted as to its accuracy or sufficiency by the Township of Langley. The user of this information is responsible for confirming its accuracy or sufficiency.

N W E S

0 250 500 1,000 Meters

ATTACHMENT A

ATTACHMENT B

KERR WOOD LEIDAL
consulting engineers

Greater Vancouver
200 - 4185A Still Creek Drive
Burnaby, BC V5C 6G9
T 604 294 2088
F 604 294 2090

Technical Memorandum

DATE: September 24, 2020

TO: Alexandru Almasan
Acting Utilities Operations Superintendent
Township of Langley

FROM: Irfan Gehlen, P.Eng.

RE: **TOWNSHIP OF LANGLEY**
Murrayville Water Quality Improvement Feasibility Study
Final Revision 2
Our File 0647.148-300

Introduction

This technical memorandum has been prepared for the Township of Langley (Township) to summarize the feasibility findings to treat water from five (5) groundwater wells that supply water to the Murrayville and Brookswood areas. Water quality data collected during 2018 and 2019 indicate that iron and manganese levels in the well water exceed the acceptable guidelines.

The purpose of the feasibility study is to investigate available options to treat the water to enable the Township to ultimately provide the residents with potable water that meets the *Guidelines for Canadian Drinking Water Quality* (GCDWQ). This technical memorandum will address the following items:

1. Investigate three potential treatment options to address water quality concerns in the Brookswood and Murrayville water system;
2. Evaluate and recommend a treatment option and provide more in-depth analysis of this option;
3. Provide Capital and Operation and Maintenance (O&M) cost opinion for the recommended option; and
4. Complete a payback period comparison of the recommended option to purchasing Metro Vancouver Water.

Background

Water quality results from the Brookswood and Murrayville supply wells report iron and manganese levels exceeding the Aesthetic Objectives (AO) of 0.3 mg/L for iron and 0.02 mg/L for manganese stated in the GCDWQ. At the Brookswood system manganese levels also exceed the Maximum Allowable Concentration (MAC) of 0.12 mg/L stated in the GCDWQ.

Currently, Metro Vancouver provides water to the Brookswood and Murrayville areas at a rate of $\$0.7836/m^3$ to the Township, with annual increases to $\$1.0953/m^3$ by 2024.

Existing Distribution System

The existing groundwater system is made up of five (5) wells that provide water to the southwest communities of Brookswood and Murrayville. The existing system provides chlorine injection to each of the groundwater sources, but no other treatment processes are in place with respect to reduction of iron or manganese in the raw water.

Water from each well source is blended with Metro Vancouver water that is provided from nearby Greater Vancouver Regional District (GVRD) transmission mains. [1]

The Brookswood system has two above ground reservoirs located at 20679 32nd Avenue. The Murrayville system has one above ground reservoir located at 22566 Old Yale Road. The Brookswood Pump Station located near the GVRD sources provides additional system pressure by adjusting the reservoir water levels at the Brookswood and Murrayville reservoirs. The Brookswood Pump Station operates when the GVRD source is unable to maintain the pressure. Both reservoirs were lasted cleaned in June 2019.

The Brookswood and Murrayville wells are currently shut off due to issues related to colour and stains caused by water due to the presence of iron and manganese in it.

Brookswood Well System

The Brookswood well systems consist of three groundwater wells identified as Brookswood Well #7, #9 and #10. Table 1 summarizes the location, well depths, pump design flows and head for each of the groundwater wells, as well as the approximate distance between each well to the Brookswood Reservoirs.

Table 1: Brookswood Well Information

Well	Location	Well ID	Design Flow [1] (L/s)	Design Head [1] (m)	Well Depth [1] (m)	Distance to Reservoir (m)
Brookswood Well 7	20650 32nd Ave	Well-12	30	90	57	280
Brookswood Well 9	20679 32nd Ave	Well-14	39	83	42	275
Brookswood Well 10	19840 36th Ave	Well-15	30	72	31	2,730

1. As per Pump Set Records prepared by Precision Service and Pumps Inc, provided by the Township on March 23, 2020.

[1] 2018 Annual Water Quality Report, prepared by Township of Langley, July 11, 2019.

Murrayville Well System

The Murrayville well systems consist of two groundwater wells identified as Murrayville Wells #1 and #2. Table 2 provides the location, well depths, pump design flows and head for each of the groundwater wells, as well as the approximate distance between each well to the Murrayville Reservoir.

Table 2: Murrayville Well Information

Well	Location	Well ID	Design Flow [1] (L/s)	Design Head [1] (m)	Well Depth [1] (m)	Distance to Reservoir (m)
Murrayville Well 1	4505 244th St	Well-16	13	213	114	600
Murrayville Well 2	22566 Old Yale Rd	Well-17	38	58	<48[2]	30

1. As per Pump Set Records prepared by Precision Service and Pumps Inc, provided by the Township on March 23,2020.
2. Well depth was not provided in well pump report for Murrayville Well#2. 48 m is the total height from the well casing to the bottom of the well pump motor.

Well Water Quality

Water Analysis Data

Table 3 and Table 4 summarize the manganese and iron levels in the water samples collected during the period between August 30, 2018 and December 18, 2019.

Table 3: Manganese Concentration Levels Between August 2018 and December 2019

Well	# of Samples	Minimum	Maximum	Average	# of Samples above GCDWQ MAC < 0.12 mg/L	# of Samples above GCDWQ AO < 0.02 mg/L
Brookswood Well 7	4	0.0501	0.0587	0.0536	0	4
Brookswood Well 9	4	0.0878	0.1590[1]	0.1100	1	4
Brookswood Well 10	4	0.1050	0.2060[1]	0.1443	1	4
Murrayville Well 1	4	0.0988	0.1030	0.1007	0	4
Murrayville Well 2	4	0.0908	0.109	0.0962	0	4

1. Readings above MAC occurred on December 18, 2019

Water quality readings show that the groundwater from the source wells exceed manganese AO in all samples collected between the specified time period. In December 2019, water quality samples were above the MAC for manganese at Brookswood Well #9 and Murrayville #2.

Table 4: Iron Concentration Levels Between August 2018 and December 2019

Well	# of Samples	Minimum	Maximum	Average	# of Samples above GCDWQ AO < 0.3 mg/L
Brookswood Well 7	4	0.099	0.176	0.140	0
Brookswood Well 9	4	0.046	0.714[1]	0.215	1
Brookswood Well 10	4	0.030	0.067	0.039	0
Murrayville Well 1	4	0.030	0.046	0.034	0
Murrayville Well 2	4	0.172	0.531[1]	0.267	1

1. Readings above AO occurred on December 18,2019

Groundwater at Risk of Containing Pathogens (GARP)

Based on the report titled Hazard Screening and Preliminary Assessment of Potential Groundwater at Risk of containing Pathogens (GARP), 14 Production Wells, prepared by Golder Associates Ltd., dated April 3, 2019, indicates all Brookswood and Murrayville wells are considered groundwater at risk of containing pathogens. From this report, a summary of identified hazards for the Brookswood and Murrayville wells, as well as their respective hazard category numbers as per the Guidance Document for Determining GARP (Version 3, September 2017) are provided below:

1. Wells located within 30 m setback from sources of contaminations (B1);
2. Wells located near sources of viruses (B4);
3. Presence of surface seals unable to be identified (C1);
4. Potential of standing water to drain back into the well pits (C3);
5. Well not meeting minimum case stick-up requirement of 0.3 m (C4);
6. Comprised well head protection as a result of integrity and grading of the concrete floor in well pit (C4);
7. Water quality tests detecting microbiological results and higher levels of turbidity (A1 and A2); and
8. Wells connected to a vulnerable aquifer indicating a high vulnerability to contamination (D2).

It is recommended that the Township address the identified hazards listed above, as some of the existing hazards may influence the overall water quality to a degree where the proposed treatment plant may not be able to adequately treat the water to potable standards.

Well Water Demand

Table 5 summarizes annual water demands between 2015 and 2019. Discussion with Township staff indicates that each well (except Murrayville Well # 1) generally operates at 20 L/s.

Table 5: Summary of water demand (m^3) between 2015 and 2019

Wells	Well Yield (L/s)	2015	2016	2017	2018	2019	Average
Brookswood Well 7	32	420,419	401,700	433,744	415,558	359,945	406,273
Brookswood Well 9	30	462,363	363,841	332,667	357,000	317,000	366,574
Brookswood Well 10	27	300,099	389,853	397,500	395,509	304,125	357,417
Murrayville Well 1	14	193,356	183,008	174,247	119,538	160,365	166,103
Murrayville Well 2	38	645,816	563,486	544,185	602,615	498,994	571,019
Total	**-**	**2,022,053**	**1,901,888**	**1,882,343**	**1,890,220**	**1,640,429**	**1,867,387**

Based on the total average amount of pumped water at each well and typical operating well pump flow of 20 L/s, the well pumps are estimated to operate on average from 6 to 22 hours per day.

Regulatory Requirements

Potable water systems such as the Township of Langley Water System are required to comply with the *Drinking Water Protection Act* and *Drinking Water Protection Regulation*. The Regulation stipulates potable water be free of total coliforms and *E. coli*. The Act requires that all potable water systems hold a valid Operating Permit at all times and a valid Construction Permit when making changes to a potable water. In the Act and Regulation, the Drinking Water Officer is given the authority to grant and enforce the regulations in water systems. The Drinking Water Officer is an agent of the Regional Health Authority, which for the Township is the Fraser Health Authority's Drinking Water Officer.

The Drinking Water Treatment Objectives (Microbiological) for Ground Water Supplies in British Columbia (November 2015) are a province-wide guideline adopted by all health authorities, requires groundwater sources at risk of containing pathogens, at a minimum be disinfected to meet requirements equivalent to surface water supplies. The requirements of these objectives are as follows and are formally known as the '4-3-2-1-0 Requirements':

- 4-log reduction or inactivation of viruses;
- 3-log inactivation or inactivation of *Giardia* and *Cryptosporidium*;
- at least 2 treatment processes;
- Less than or equal to 1 NTU turbidity in finished water at all times; and
- No detectable *E. coli*, fecal coliforms, and total coliforms in treated water.

The Drinking Water Treatment Objectives above are explicitly for surface water sources. For GARP source water like the ones at Brookswood and Murrayville, disinfection for bacteria and viruses are generally required as a minimum treatment process to meet the regulatory requirements.

Well Water Treatment

The treatment objectives should include treating the well water to meet with the quality requirements stated in the GCDWQ and the GARP water treatment guidelines. The existing chlorination will be used as part of the treatment. In addition, treatment is required for reducing the iron and manganese in the water.

The following three water treatment processes were considered for treating the water to reduce the iron and manganese.

Option 1: Oxidation and Filtration using Catalytic Media

Most iron and manganese removal treatment processes require oxidation as the first step of treatment to precipitate the iron and manganese dissolved in the water. Normally this is done by injecting the source water with chlorine or potassium permanganate. Once oxidized, the precipitates can be settled or filtered out.

Media filtration with GreenSandPlus™ media is an effective and proven means for reducing both precipitated iron and dissolved or precipitated manganese in raw water. In a GreenSandPlus™ media filter the media acts as a catalyst for the manganese oxidation process. As water passes through the filter bed, the oxidized iron and manganese are retained by the filter media and their concentration in the water reduces as water progresses downward through the filter. GreenSandPlus™ media will require periodic backwashing to remove accumulated precipitate.

GreenSandPlus™ media can remove both iron and manganese but removal efficiency of each parameter varies depending on the pH of the water as well as the concentrations of other constituents in the water. Pilot testing is usually completed to establish the removal efficiency of iron and manganese in a specific water. As a minimum, bench scale testing with the actual water should be completed prior to full-scale implementation.

Option 2: Oxidation and Media Filtration

This treatment process incorporates oxidation of iron and manganese in the water to convert the dissolved forms of the metals to a solid. Normally air, ozone and other oxidizing agents are used in the oxidation process. Following the oxidation process, water passes through sand media filters for filtering out the precipitate formed.

Sand media filters are either gravity or pressure type. The filters are backwashed periodically for removing the precipitated material on the surface of the filters.

Option 3: Sequestration

Sequestration is a form of treatment in which a sequestering agent (i.e., blended phosphates, sodium silicate, and sodium polyphosphate), is added to groundwater source. The sequestering agent forms a bond with iron and manganese ions and inhibit precipitation.

During the sequestration process, the dosing amounts of the sequestering agent need to be adjusted based on metal ion levels, water temperature and pH levels of the groundwater. This will require close monitoring of each well source and continuous changes to the dosing amounts by operator staff.

Discussion on Treatment Technologies

Table 6 lists the advantages and disadvantages of the treatment options for the existing groundwater source.

Table 6: Comparison of Technologies to Treat Existing Groundwater Source

Water Treatment Technology	Advantages	Disadvantages	O&M Requirements
Oxidation and Catalytic Media Filtration	• Can effectively remove both iron and manganese in combination with oxidation. • Relatively simple operation.	• Generation of backwash wastewater. • Process efficiency depends on many variables	• Periodic backwashing or replacement of catalytic media. • Oxidant chemical usage.
Oxidation and Media Filtration	• Relatively simple operation.	• Not as effective at filtering out manganese compared to catalytic media. • Generation of backwash wastewater.	• Periodic backwashing or replacement of adsorption media. • Oxidant chemical usage
Sequestration	• Potentially lower capital costs.	• Significantly increased O&M complexity and requirements. • Release of iron and manganese in the outer portions of the distribution systems. • Negative interaction with chlorine. • Complex chemistry prone to risk of localized water quality issues in the distribution system.	• Periodic water quality monitoring at wells and at outer edges of distribution. • Continuous adjustments to sequestration dosing rate. • Upkeep of metering pumps.

Recommended Water Treatment Process

Oxidation and catalytic media (GreenSandPlus™) filtration for the specific removal of iron and manganese is the preferred treatment option for the existing source based on the information summarized in Table 6.

The installation of sequestration equipment would have a lower capital cost than the other options but would require more O&M requirements. Concerns also arise when aged water in outer sections of the distribution release iron and manganese due to the breakdown of the sequestration agent.

The sequestration process can also be affected by iron and manganese that have been oxidized by chlorine prior to the sequestration process resulting in precipitates formation in the distribution system. This early oxidation process will require operators and Township staff to complete more flushing of water mains if precipitation forms before sequestration can occur.

The catalytic filtration process is similar to the oxidation and filtration using sand media filters. Both filtration processes will require some form of oxidation as pre-treatment prior to the filtration process and will require periodic backwash to remove accumulated iron and manganese precipitate. However, the catalytic media filtration has proven more effective in the removal of iron and manganese.

The chlorine injection followed by catalytic media (GreenSandPlus™) filtration to remove iron and manganese from the source water is recommended due to its relatively simple operation, lower chemical requirements, and more effective capture efficiency of iron and manganese compared to other available technologies.

Water Treatment Plant Facility

Based on the current situation at each site, location, and recommended treatment option, KWL proposes a total of three (3) separate prefabricated water treatment plants (WTP) be built to treat all groundwater sources at the Brookswood and Murrayville systems. The following sections provides an in-depth analysis of the recommended option.

Proposed Water Treatment Building

WTPs can be contained within custom prefabricated buildings, shipping containers, or standard concrete buildings. Standard concrete buildings would provide a more aesthetic look and provide an opportunity to customize the building layout to suit site and treatment conditions as well as any operator preferences. Where a prefabricated building would generally consist of a shipping container 2.4 m (8 ft) in width and 6.1 to 12.2 m (20 to 40 ft) in length or a steel frame building complying to CSA A660 and A277 standards.

The benefits of installing the prefabricated shipping container over a standard concrete plant include:

- lower capital cost for the project;
- less disruption to the site;
- shorter construction period;
- less generated waste during construction; and
- the ability to relocate the building should a new groundwater source become available in the future.

In addition to this, the prefabricated shipping container could be hidden by modified landscape or by installing the container in a Township maintained property near the reservoir.

The Township can also install a prefabricated building instead of a shipping container to gain additional space compared to shipping containers. The prefabricated building will have similar benefits like those of a shipping container as listed above.

Based on benefits noted above and discussion with Township, it is proposed the WTP be installed in a prefabricated building.

Dedicated Lines to WTPs

In order to reduce the need to have a WTP for each groundwater well, it is recommended to combine wells that are in close proximity and treat the water in a combined WTP. The dedicated watermains will need to bring the well water to the WTP prior to entering the distribution system.

There are two potential methods to combine wells to a single WTP. First, by closing existing valves on the pipe network to generate a dedicated line to the proposed WTP. Second, to construct a new dedicated line from the specific well to the proposed WTP location. Construction of new dedicated mains would be more expensive and would require road closures and rerouting of traffic routes. Anticipated costs of dedicated lines are provided at the end of this section. If costs to construct a dedicated main are considered too substantial by the Township, the Township could instead investigate drilling of a new well closer to the proposed WTP site.

Based on discussion with the Township, it was determined closing existing valves to produce dedicated lines would affect the distribution system.

For planning purposes, a newly constructed 150 mm diameter dedicated main from Murrayville Well#1 to the proposed WTP locations approximately 600 m away is anticipated to cost approximately $300,000.

A newly dedicated 200 mm main approximately 275 m long constructed along 32nd Avenue for Brookswood Wells #7 and #9 is anticipated to cost approximately $165,000. These items have been included as part of the Class D capital cost opinion.

The Township has also indicted a capital works project to replace the existing 300 mm pipe with a 450 mm pipe on 32nd Avenue between 205 Street and Brookswood Well#9 is scheduled to be installed in 2021. This could potentially provide an opportunity to reduce capital cost of the dedicated line should the capital works project and dedicated line be completed at the same time.

Infrastructure Requirements

Electrical

Proposed water treatments will require a minimum of 110 and 220-volt single phase power.

Based on site visits, 3-phase power is available near Brookswood and Murrayville Reservoirs, as well as the area near Brookswood Well#10. Building service electrical requirements and any additional services will need to be evaluated in a subsequent detail design phase.

Sanitary Systems

There are no existing sanitary mains near any of the proposed WTP locations that would be able to accept any wastewater from the proposed WTPs. Therefore, wastewater generated from backwashing of media filters, instrumentation, or any maintenance procedures will need to be captured and collected in tanks for disposal.

To reduce the overall trucking and associated disposal costs, the proposed WTPs would include a backwash collection tank with submersible pumps that recycle decanted water back to the front of the plant for treatment. A separate, sludge collection tank will also be used, to collected solids that have settled in the backwash collection tank. A sludge pump will be installed to transfer the solids to the sludge collection tank for storage and disposal.

It should be noted, the proposed WTP that treats both the Murrayville wells could include an approximate 600 m new watermain that connects to the sanitary line at Old Yale Road and 224th Street. This would eliminate the need for the backwash settling, recycle, and sludge collections tanks and reduce operational costs associated with disposal at the proposed WTP but would require additional cost for construction. This option should be further evaluated in preliminary design phase.

It is assumed a washroom will not be included at any of the proposed WTP so that domestic waste disposal is not required.

Chlorine Disinfection and Chlorine Contact

Chlorine disinfection will provide primary treatment for bacteria and viruses. It will also provide a lasting residual to the services for secondary disinfection. Furthermore, chlorine injection will provide oxidation to the iron and manganese to form precipitates and removal in filters as well as the necessary regeneration requirement to the filter media.

It is proposed chlorine injection locations remain in their existing locations (i.e., near well discharge) to meet the required chlorine contact time for treatment. Where chlorine contact time is expressed as the product of the free chlorine residual (in mg/L) and the contact time between the chlorine and water (in minutes).

All wells except for the Brookswood Well#10 will meet required chlorine contact time to meet 4-log inactivation of bacteria and viruses. To achieve adequate primary disinfection of viruses, the WTP at Brookswood Well#10 will need a clearwell tank with baffles or be tied into the 600 mm steel main located north of the property to provide

the necessary effective contact time to reach 4-log inactivation of viruses. Based on cost and available space at Brookswood Well#10, it is proposed connecting into the 600 mm is the preferred option of the two.

Detailed calculations will be required during the subsequent future detailed design process.

Potential Well Pump Upgrades and Domestic Booster Pumps

It is anticipated that existing well pumps will need to be evaluated to determine whether they have the capacity to pump water through the proposed WTP. Based on information provided by the Township, the existing age of pumps are near end of life or will require some form of well re-development in the near future.

Domestic booster pumps may also need to be installed to provide the required pressure boosting to pump water to the reservoir heights or to maintain pressures in the distribution system. Requirements will need to be reviewed during the design phase.

Allowances for well pump replacements and domestic pump installation have been included in the Class D cost opinions enclosed.

Summary of Proposed Water Treatment Plants

The following summarises the proposed plants to treat all water from the Brookswood and Murrayville wells:

1. WTP treating combined well water from Murrayville Wells #1 and #2. The prefabricated WTP would be in an area near the Murrayville Reservoir;
2. WTP treating combined well water from Brookswood Wells #7 and #9. The prefabricated WTP would be in an area near the Brookswook Well #9; and [2]
3. WTP treating well water from Brookswood Well #10. The prefabricated WTP would be located near the well.

Table 7: Summary Table of the Proposed WTP

Design Parameters	WTP – MV 1/2 Murrayville Wells #1 & #2	WTP – BW 7/9 Brookswood Wells #7 & #9	WTP – BW 10 Brookswood Well #10
Treatment Flow Rate	40 L/s	40 L/s	20 L/s
Proposed Building Footprint	55 m^2	55 m^2	40 m^2
Access to Sanitary Line	No	No	No
Backwash Settling Tank	15 m^3	15 m^3	15 m^3
Sludge Holding Tank	20 m^3	20 m^3	10 m^3

[2] Alternate location of this WTP to be confirmed during detail design.

Cost Options for Water Treatment System

Limitations

The projected capital costs presented in this report are based on Class D Capital Cost Opinions. These costs opinions are order-of-magnitude level costs prepared without detailed site information and should be used for planning purposes only. The costs may be subject to change upon receipt of significant new site or other information. A 60% allowance (40% contingency and 20% engineering) has been applied to the cost options to reflect their high-level nature.

Cost Opinion Summary

Class D capital cost opinions and Operation and Maintenance (O&M) cost opinions for each option have been developed.

Capital and O&M cost opinion tables for each option are attached to this table. A summary of the cost opinions is provided in Table 8.

Table 8: Summary of Cost Opinions

Item	WTP – MV Murrayville Wells #1 & #2	WTP – BW 79 Brookswood Wells #7 & #9	WTP – BW10 Brookswood Well #10
General	$115,500	$106,400	$66,100
Site Works	$444,600	$320,600	$126,000
Concrete	$54,000	$54,000	$37,800
Building	$134,400	$134,400	$98,400
Equipment	$792,100	$792,100	$497,200
Mechanical	$10,800	$10,800	$10,800
Electrical	$68,000	$63,000	$39,000
Subtotal	$1,619,400	$1,481,300	$875,300
Detail Design Engineering (10%)	$161,900	$148,100	$87,500
Construction Contract Administration (10%)	$161,900	$148,100	$87,500
Contingency (40%)	$647,800	$592,500	$350,100
Total	$2,591,000	$2,370,000	$1,400,400

1. This WTP includes a clearwell tank with baffles to provide the necessary effective contact time to reach 4-log inactivation of viruses.

Total cost for all three proposed WTP is $6,362,000. The total O&M cost for all three proposed WTP is $333,500 per year.

A break down of the Class D capital and O&M cost opinions are attached to this report.

Simple Payback Period

Information provided by the Township indicates the average water produced between 2015 to 2019 by Brookswood and Murrayville groundwater wells is approximately 1,867,000 m^3/year. With the GVRD selling water to the Township at a cost of \$0.7836/m^3 in 2020 and increasing to a projected cost of \$1.0953/m^3 in 2024.

Currently, all five groundwater wells are non-operational due to high levels of iron and manganese. This has resulted in GVRD to supply the water once provided by the five (5) groundwater wells. It is estimated, based on average volumes and water rates that the Township will need to pay up to \$1.4 Million/year to 2.0 Million/year should the groundwater wells remain non-operational and water consumption remains the same. [3]

Table 9 summaries the payback period of the project. This scenario assumes the following:

1. Proposed WTPs are operational mid-way through 2021;
2. Operation and maintenance costs of \$333,500 per year with a 2% per annum increase;
3. Increases to water rates every year; and
4. Water consumption volumes remain the same throughout the years.

Table 9: Simple Payback Table for all three proposed WTP

Year	GVRD Water Rate ($/m³)	Average Volume per Year (m³)	Savings per Year ($)	O&M Cost per Year ($)	Cumulative Savings ($)	Cumulative Cash Flow [1] ($)	Return on Investment Met
2020	0.7836	-	-	-	-	-6,362,000 [2]	-
2021	0.8315	933,694 [3]	776,000	167,000	609,000	-5,753,000	No
2022	0.9049	1,867,387	1,690,000	340,000	1,959,000	-4,403,000	No
2023	0.9949	1,867,387	1,858,000	347,000	3,470,000	-2,892,000	No
2024	1.0953	1,867,387	2,045,000	354,000	5,161,000	-1,201,000	No
2025	1.0953	1,867,387	2,045,000	361,000	6,845,000	483,000	Yes

1. This column subtracts yearly savings from the estimated capital cost of the proposed WTP.
2. Estimated capital cost of the three proposed WTP.
3. Accounts for half of the average annual water consumption.

If the proposed treatment plants were to be constructed mid-way through 2021 at a capital cost of \$6.4 million, the annual savings in 2021 will begin at \$0.8 and increase to \$2.0 Million/year by 2024, it would take five (5) years to payback the initial capital investment of all three proposed WTPs. [4] Table 10 provides a summary simple payback period for each proposed WTP.

Table 10: Simple Payback Table for each proposed WTP

Item	WTP – MV12 Wells #1 & #2	WTP – BW 79 Wells #7 & #9	WTP – BW10 Well #10
Capital cost	\$2,591,000	\$2,370,000	\$1,400,400
Average volume per year[1]	737,122 m^3	772,847 m^3	357,417 m^3
Average saving per year[2]	\$664,000	\$696,000	\$322,000
Average O&M cost per year[3]	\$125,000	\$125,000	\$65,000
Simply Payback Period	<5 years	<4 years	<5 years

1. Average volume demand based on data collected between 2015 to 2019
2. Average savings based on GVRD water rates and anticipated volumes between 2021 to 2025.
3. Average O&M between 2021 to 2025 with 2% annum increase.

[3] \$1.4 Million is the cost associated with water use during 2020.
[4] \$0.8 Million is the cost associated with savings for half of 2021.

Overall Discussion and Summary

Three proposed WTP are required to treat the five (5) groundwater wells to meet requirements of the GCDWQ. Two plants will operate at 40 L/s with one being located near the Brookswood Reservoirs, and the second proposed WTP located near the Murrayville Reservoir. The third proposed WTP will operate at 20 L/s and will be located near Brookswood Well#10.

In order to combine and reduce the number of required WTP and to prevent short circuiting of the raw water into the distribution system, dedicated water mains from the groundwater well sources to the proposed WTP will be required. This will require either the closing of existing valves on the distribution or construction of dedicated mains to the proposed WTP.

The treatment process at each of the three proposed WTP will consist of oxidation by chlorination and filtration by GreenSandPlus™ media. Oxidations by chlorine disinfection will promote precipitate formation of iron and manganese and provide primary and secondary disinfection of the water. Catalytic media filtration with GreenSandPlus™ will further react with the iron and manganese to promote further precipitate formation which will then be trapped in the filter media.

Periodic backwash of the GreenSandPlus™ filter media will be required to remove the accumulated iron and manganese in the filter. The backwash water will be sent to backwash collections tank where settling of solids will occur. To reduce the amount of liquid waste for disposal, a recycle pump will pump the supernatant liquid to the front of the WTP for treatment. Solids in the backwash collection tank will settle to the bottom, where a sludge pump will transfer the solids to a sludge collection tank for storage and disposal. It is anticipated, disposal of solid waste will occur approximately once to twice per month at each of the WTP but will significantly depend on the actual volume of water being treated.

The capital cost of the three proposed WTP is estimated to be $6.4 million. With O&M costs estimated to be $333,500 per year. It is anticipated, the Township will incur costs up to $1.4 to 2.0 million per year if they continue to purchase water from GVRD instead of using water from the five groundwater wells. Should the Township move ahead with the proposed WTP, it would take approximately five years to reach the payback period if all groundwater wells were to operate at their existing operating conditions. Should the Township increase water production at all the groundwater wells while maintaining the 20 L/s for treatment, the payback period could be further reduced.

Conclusions and Recommendations

Conclusions

Based on the scope of this feasibility study, several conclusions have been reached and are listed below:

1. The existing Brookswood and Murrayville groundwater have elevated iron and manganese water levels that do not meet the requirement for the Guideline for Canadian Drinking Water Quality;
2. Currently, the Great Vancouver Regional District is providing an additional volume of 1,867,000 m^3/year as a result of the groundwater wells being off;
3. It is estimated the Township could pay approximately $1.4 million in 2020 to make up the water demands originally provided by groundwater wells. Should the groundwater wells continue to be non-operational, the cost of water to the Township can range from 1.6 to 2.0 million per year from 2021 to 2024. Annual costs are expected to increase with increased water rates and water use;
4. The proposed water treatment process of oxidation with chlorine injection and catalytic media filtration (GreenSandPlus™) will provide adequate treatment and disinfection to the water coming out of the GARP wells;
5. The construction of a three proposed WTP is anticipated to cost $6.4 million with O&M maintenance costs expected to cost $333,500 per year. Should the Township move forward with the proposed three WTPs, it would take approximately 5 years to pay back the initial investment of the proposed WTP. The following tables breaks down capital and O&M costs and simply payback period for each WTP:

Table 11: Costs and Payback Period for Each WTP

Item	WTP – MV Murrayville Wells #1 & #2	WTP – BW 79 Brookswood Wells #7 & #9	WTP – BW10 Brookswood Well #10
Capital Cost	$2,591,000	$2,370,000	$1,400,400
O&M Cost per year	$133,300	$133,300	$66,900
Simply Payback Period	<5 years	<4 years	<5 years

6. The Township needs to review and implement recommendations outlined in Hazard Screening and Preliminary Assessment of Potential Groundwater at Risk of containing Pathogens (GARP), 14 Production Wells, prepared by Golder Associates Ltd., dated April 3, 2019.

Recommendations

Based on the conclusions of this study, a list of recommendations is provided below.

1. Proceed with pre-liminary design of the water treatment system for the wells in the Murrayville and Brookswood area;
2. Complete site surveys to identify potential locations for the three (3) proposed water treatment plants; and
3. Review with a hydrogeologist to investigate whether new groundwater wells can be installed near proposed WTP.

KERR WOOD LEIDAL ASSOCIATES LTD.

Prepared by:

Reviewed by:

Alfred Louie, P.Eng.
Project Engineer

Irfan Gehlen, P.Eng.
Project Manager

AL/sk

Encl.: Table A-1: Summary – Class D Capital Cost Opinion
Table A-2: Class D O&M Cost Opinion

Statement of Limitations

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Revision History

Revision #	Date	Status	Revision Description	Author
A	May 20, 2020	Draft	For client review and comment	AL
0	June 26, 2020	Final	Issued as Final	AL
1	August 26, 2020	Final Rev 1	Issued as Final	AL
2	September 24, 2020	Final Rev 2	Issued as Final, adjustment to simple payback	AL

OQM CERTIFIED

Township of Langley
647.148

Water Quality Improvement Feasbility Study
Cost Opinion for Capital Works Project
August 26, 2020

Table A-1: Summary - Class D Capital Cost Opinion

Item	Description	Unit	Estimated Quantity	Material Cost	Total Price $	Comment
1	**General**					
1.01	Bonding and Insurance					
	Bonding and Insurance - Brookswood Well #10	%	2%	$2,025,000	$40,500	
	Bonding and Insurance - Brookswood Well #7 & #9	%	2%	$3,435,000	$68,700	
	Bonding and Insurance - Murrayville Well #1 & #2	%	2%	$3,760,000	$75,200	
	Bonding and Insurance Subtotal				**$184,400**	
1.02	Mobilization and Set up, Demobilization					
	Mobilization and Set up, Demobilization - Brookswood Well #10	%	3.5%	$462,857	$16,200	
	Mobilization and Set up, Demobilization - Brookswood Well #7 & #9	%	3.5%	$785,714	$27,500	
	Mobilization and Set up, Demobilization - Murrayville Well #1 & #2	%	3.5%	$860,000	$30,100	
	Mobilization and Set up, Demobilization Subtotal				**$73,800**	
1.03	Commissioning and Documentation					
	Commissioning and Documentation - Brookswood Well #10	LS	1	$9,400	$9,400	
	Commissioning and Documentation - Brookswood Well #7 & #9	LS	1	$10,200	$10,200	
	Commissioning and Documentation - Murrayville Well #1 & #2	LS	1	$10,200	$10,200	
	Commissioning and Documentation Subtotal				**$29,800**	
	General Subtotal				**$288,000**	
2	**Site Works**					
2.01	Excavation and Backfilling					
	Excavation and Backfilling - Brookswood Well #10	LS	1	$18,000	$18,000	
	Excavation and Backfilling - Brookswood Well #7 & #9	LS	1	$20,000	$20,000	
	Excavation and Backfilling - Murrayville Well #1 & #2	LS	1	$20,000	$20,000	
	Excavation and Backfilling Subtotal				**$58,000**	
2.02	Structural Excavation and Backfilling					
	Structural Excavation and Backfilling - Brookswood Well #10	LS	1	$73,000	$73,000	
	Structural Excavation and Backfilling - Brookswood Well #7 & #9	LS	1	$75,600	$75,600	
	Structural Excavation and Backfilling - Murrayville Well #1 & #2	LS	1	$75,600	$75,600	
	Structural Excavation and Backfilling Subtotal				**$224,200**	
2.03	Paved Areas					
	Paved Areas - Brookswood Well #10	LS	1	$10,400	$10,400	
	Paved Areas - Brookswood Well #7 & #9	LS	1	$13,000	$13,000	
	Paved Areas - Murrayville Well #1 & #2	LS	1	$13,000	$13,000	
	Paved Areas Subtotal				**$36,400**	
2.04	Buried Utilities					
	Buried Utilities - Brookswood Well #10	LS	1	$11,000	$11,000	
	Buried Utilities - Brookswood Well #7 & #9	LS	1	$26,000	$26,000	
	Buried Utilities - Murrayville Well #1 & #2	LS	1	$15,000	$15,000	
	Buried Utilities Subtotal				**$52,000**	
2.05	Modification to Fencing					
	Modification to Fencing - Brookswood Well #10	LS	1	$10,000	$10,000	
	Modification to Fencing - Brookswood Well #7 & #9	LS	1	$12,000	$12,000	
	Modification to Fencing - Murrayville Well #1 & #2	LS	1	$12,000	$12,000	
	Modification to Fencing Subtotal				**$34,000**	
2.06	Site Restoration					
	Site Restoration - Brookswood Well #10	LS	1	$3,600	$3,600	
	Site Restoration - Brookswood Well #7 & #9	LS	1	$4,000	$4,000	
	Site Restoration - Murrayville Well #1 & #2	LS	1	$4,000	$4,000	
	Site Restoration Subtotal				**$11,600**	
2.07	Dedicated Watermain					
	Dedicated Watermain - Brookswood Well #10	LS	1	$0	$0	
	Dedicated Watermain - Brookswood Well #7 & #9	LS	1	$170,000	$170,000	
	Dedicated Watermain - Murrayville Well #1 & #2	LS	1	$305,000	$305,000	
	Dedicated Watermain Subtotal				**$475,000**	
	Site Works Subtotal				**$891,200**	
3	**Concrete**					
3.01	Foundation Slab & Sidewalk					
	Foundation Slab & Sidewalk - Brookswood Well #10	LS	1	$37,800	$37,800	
	Foundation Slab & Sidewalk - Brookswood Well #7 & #9	LS	1	$54,000	$54,000	
	Foundation Slab & Sidewalk - Murrayville Well #1 & #2	LS	1	$54,000	$54,000	
	Foundation Slab & Sidewalk Subtotal				**$145,800**	
	Concrete Subtotal				**$145,800**	
4	**Building**					
4.01	Container Building					
	Container Building - Brookswood Well #10	LS	1	$51,100	$51,100	
	Container Building - Brookswood Well #7 & #9	LS	1	$79,600	$79,600	
	Container Building - Murrayville Well #1 & #2	LS	1	$79,600	$79,600	
	Container Building Subtotal				**$210,300**	
4.02	Finishes					
	Finishes - Brookswood Well #10	LS	1	$5,000	$5,000	
	Finishes - Brookswood Well #7 & #9	LS	1	$5,000	$5,000	
	Finishes - Murrayville Well #1 & #2	LS	1	$5,000	$5,000	
	Finishes Subtotal				**$15,000**	
4.03	Building Accessories					
	Building Accessories - Brookswood Well #10	LS	1	$3,500	$3,500	
	Building Accessories - Brookswood Well #7 & #9	LS	1	$5,000	$5,000	
	Building Accessories - Murrayville Well #1 & #2	LS	1	$5,000	$5,000	
	Building Accessories Subtotal				**$13,500**	
4.04	Backwash Tank					
	Backwash Tank - Brookswood Well #10	LS	1	$20,600	$20,600	
	Backwash Tank - Brookswood Well #7 & #9	LS	1	$20,600	$20,600	
	Backwash Tank - Murrayville Well #1 & #2	LS	1	$20,600	$20,600	
	Backwash Tank Subtotal				**$61,800**	
4.05	Sludge Holding Tank					
	Sludge Holding Tank - Brookswood Well #10	LS	1	$18,200	$18,200	
	Sludge Holding Tank - Brookswood Well #7 & #9	LS	1	$24,200	$24,200	
	Sludge Holding Tank - Murrayville Well #1 & #2	LS	1	$24,200	$24,200	
	Sludge Holding Tank Subtotal				**$66,600**	
	Building Subtotal				**$367,200**	

Township of Langley
647.148

Water Quality Improvement Feasbility Study
Cost Opinion for Capital Works Project
August 26, 2020

Table A-1: Summary - Class D Capital Cost Opinion

Item	Description	Unit	Estimated Quantity	Material Cost	Total Price $	Comment
5	**Equipment**					
5.01	Treatment Equipment					
	Treatment Equipment - Brookswood Well #10	LS	1	$421,800	$421,800	
	Treatment Equipment - Brookswood Well #7 & #9	LS	1	$676,900	$676,900	
	Treatment Equipment - Murrayville Well #1 & #2	LS	1	$676,900	$676,900	
	Treatment Equipment Subtotal				**$1,775,600**	
5.02	Onsite Supervision, Commissioning and Training					
	Onsite Supervision, Commissioning and Training - Brookswood Well #10	LS	1	$16,800	$16,800	
	Onsite Supervision, Commissioning and Training - Brookswood Well #7 & #9	LS	1	$18,000	$18,000	
	Onsite Supervision, Commissioning and Training - Murrayville Well #1 & #2	LS	1	$18,000	$18,000	
	Onsite Supervision, Commissioning and Training Subtotal				**$52,800**	
5.03	Well Pump Upgrade / Domestic Pump Allowance					
	Well Pump Upgrade / Domestic Pump Allowance - Brookswood Well #10	LS	1	$38,600	$38,600	
	Well Pump Upgrade / Domestic Pump Allowance - Brookswood Well #7 & #9	LS	1	$77,200	$77,200	
	Well Pump Upgrade / Domestic Pump Allowance - Murrayville Well #1 & #2	LS	1	$77,200	$77,200	
	Well Pump Upgrade / Domestic Pump Allowance Subtotal				**$193,000**	
5.04	Backwash Recycle Pump					
	Backwash Recycle Pump - Brookswood Well #10	LS	1	$10,000	$10,000	
	Backwash Recycle Pump - Brookswood Well #7 & #9	LS	1	$10,000	$10,000	
	Backwash Recycle Pump - Murrayville Well #1 & #2	LS	1	$10,000	$10,000	
	Backwash Recycle Pump Subtotal				**$30,000**	
5.05	Backwash Sludge Pump					
	Backwash Sludge Pump - Brookswood Well #10	LS	1	$10,000	$10,000	
	Backwash Sludge Pump - Brookswood Well #7 & #9	LS	1	$10,000	$10,000	
	Backwash Sludge Pump - Murrayville Well #1 & #2	LS	1	$10,000	$10,000	
	Backwash Sludge Pump Subtotal				**$30,000**	
	Equipment Subtotal				**$2,081,400**	
6	**Mechanical**					
6.01	Process Piping					
	Process Piping - Brookswood Well #10	LS	1	$5,000	$5,000	
	Process Piping - Brookswood Well #7 & #9	LS	1	$5,000	$5,000	
	Process Piping - Murrayville Well #1 & #2	LS	1	$5,000	$5,000	
	Process Piping Subtotal				**$15,000**	
6.02	Onsite Connection					
	Onsite Connection - Brookswood Well #10	LS	1	$4,600	$4,600	
	Onsite Connection - Brookswood Well #7 & #9	LS	1	$4,600	$4,600	
	Onsite Connection - Murrayville Well #1 & #2	LS	1	$4,600	$4,600	
	Onsite Connection Subtotal				**$13,800**	
6.03	Safety Equipment & Accessories					
	Safety Equipment & Accessories - Brookswood Well #10	LS	1	$1,200	$1,200	
	Safety Equipment & Accessories - Brookswood Well #7 & #9	LS	1	$1,200	$1,200	
	Safety Equipment & Accessories - Murrayville Well #1 & #2	LS	1	$1,200	$1,200	
	Safety Equipment & Accessories Subtotal				**$3,600**	
	Mechanical Subtotal				**$32,400**	
7	**Electrical**					
7.01	Control Panels					
	Control Panels - Brookswood Well #10	LS	1	$2,000	$2,000	
	Control Panels - Brookswood Well #7 & #9	LS	1	$2,000	$2,000	
	Control Panels - Murrayville Well #1 & #2	LS	1	$2,000	$2,000	
	Control Panels Subtotal				**$6,000**	
7.02	Electrical Connection & Distribution					
	Electrical Connection & Distribution - Brookswood Well #10	LS	1	$27,000	$27,000	
	Electrical Connection & Distribution - Brookswood Well #7 & #9	LS	1	$46,000	$46,000	
	Electrical Connection & Distribution - Murrayville Well #1 & #2	LS	1	$50,000	$50,000	
	Electrical Connection & Distribution Subtotal				**$123,000**	
7.03	Instrumentation					
	Instrumentation - Brookswood Well #10	LS	1	$2,000	$2,000	
	Instrumentation - Brookswood Well #7 & #9	LS	1	$2,000	$2,000	
	Instrumentation - Murrayville Well #1 & #2	LS	1	$2,000	$2,000	
	Instrumentation Subtotal				**$6,000**	
7.04	Building Services Electrical					
	Building Services Electrical - Brookswood Well #10	LS	1	$8,000	$8,000	
	Building Services Electrical - Brookswood Well #7 & #9	LS	1	$13,000	$13,000	
	Building Services Electrical - Murrayville Well #1 & #2	LS	1	$14,000	$14,000	
	Building Services Electrical Subtotal				**$35,000**	
	Electrical Subtotal				**$170,000**	
	Subtotal Items 1 to 7				**$3,976,000**	
	Detailed Design Engineering			10%	$397,600	
	Construction Contract Administration and Field Review			10%	$397,600	
	Contingency			40%	$1,590,400	
	Total (excl. GST)				**$6,361,600**	

This estimate has been based on the pre-design work completed to date and reflects the estimated budget required complete the project.

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Purpose:
Description of Work

Water Quality Improvement Feasibility Study
Cost Opinion for Capital Works Project
August 26, 2020

Table A-2: Class D O&M Cost Opinion

Item	Description	Unit	Estimated Quantity	Unit Rate $	Total Price $	Comment
1	**Basic Operating Costs**					
1.01	Electricity - Treatment Equipment	kWh	8,000	$0.10	$800	
1.02	Electricity - Backwash Recycle Pumps	kWh	10,000	$0.10	$1,000	
1.03	Electricity - Sludge Pumps	kWh	3,000	$0.10	$300	
1.04	Electricity -Ventilation	kWh	3,290	$0.10	$329	
1.05	Electricity - Heating	kWh	4,380	$0.10	$438	
1.06	Electricity - Lights and Other Equipment	kWh	4,380	$0.10	$438	
1.07	Electricity - Basic Charge	allow	3	$150	$450	
	Subtotal, Basic Operating Costs				**$3,800**	
2	**Labour**					
2.01	Routine Labour	person hours	2,080	$35	$72,800	Two operators, 20 hours/week to maintain all WTP.
2.02	Filter Media Replacement Labour	person hours	24	$35	$840	Two operators, 40 hours every 10 years/ WTP.
2.03	Spent Filter Backwash Sludge Disposal	person hours	72	$35	$2,520	One operator, 2 hours/month/WTP.
2.04	After-hours Response Labour	person hours	32	$53	$1,680	One operator, 8 hours every 3 months, paid out at time and a half
2.05	Additional labour allowance, annual checks and repairs	allow	3	$1,500	$4,500	
2.06	Allowance for Remote Technical Support Services	allow	1	$5,000	$5,000	
	Subtotal, Labour				**$87,300**	
3	**Monitoring**					
3.01	Water Quality Monitoring - Sample Collection					Metal samples collected 4 times/year/filter.
	Brookswood Well #10	allow	4	$200	$800	
	Brookswood Well #7 & #9	allow	4	$350	$1,400	
	Murrayville Well #1 & #2	allow	4	$350	$1,400	
3.02	Water Quality Monitoring - Sample Collection Labour					This labour cost is separated in case it is done by others, 2 hours/sample collection/WTP
	Brookswood Well #10	allow	8	$35	$280	
	Brookswood Well #7 & #9	allow	8	$35	$280	
	Murrayville Well #1 & #2	allow	8	$35	$280	
	Subtotal, Monitoring				**$4,400**	
4	**Consumables**					
4.01	Manganese Removal Media	ft^3	9.0	$200	$1,800	est. 3% annual loss and degradation, + shipping
4.02	Manganese Replacement after 10 years	ft^3	30.0	$200	$6,000	Assume Manganese will need to be replaced every 10 years. Cost of media, $200/$ft^3$.
4.03	Sodium Hypochlorite	usg	3,300	$5	$16,500	12% sodium hypochlorite, based on double increase for oxidation and regeneration of filters.
4.04	Miscellaneous Consumables	allow	1	$4,000	$4,000	Includes consumables for on-site water quality testing equipment.
	Subtotal, Consumables				**$28,300**	
5	**Waste Management**					
5.01	Spent Filter Backwash Sludge Disposal	haul	72	$1,500	$108,000	Hauling twice per month/WTP
5.02	Exhausted Manganese Media Disposal	haul	0.6	$1,500	$900	Hauling of material to occur every 5 years/WTP
	Subtotal, Waste Management				**$108,900**	
6	**Maintenance**					
6.01	Treatment Replacement	allow	1/25	$1,775,600	$71,024	Replace all treatment equipment every 25 yrs.
6.02	Recycle Pump Replacement	allow	1/10	$30,000	$3,000	Replace all pumps every 10 yrs.
6.03	Backwash Waste Tank Sludge Pump Replacement	each	1/10	$30,000	$3,000	Assume pump needs to be replaced every 10 yrs.
6.04	Maintenance of Treatment Equipment	%	1%	$1,775,600	$17,756	% of treatment & source capital cost, includes cost of filtration equipment.
6.05	Maintenance of Treatment Buildings	%	1%	$367,200	$3,672	% of building capital cost (Section 4)
6.06	Maintenance of Mechanical Works	%	2%	$32,400	$648	% of mechanical capital cost
6.07	Maintenance of Electrical Works	%	1%	$170,000	$1,700	% of electrical capital cost
	Subtotal, Maintenance				**$100,800**	
	Subtotal Annual Estimated O&M Costs				**$333,500**	

Notes:

1. Estimates prepared on basis of Class "A" capital cost estimate.

2. Estimate indicates the approximate magnitude cost of the O&M tasks, for planning purposes. The estimate is derived from unit costs for similar projects.

3. All subtotals and totals rounded to 2 decimals.

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