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TECHNICAL MEMORANDUM #5 File 2053-2

DATE: December 11, 2023
TO: Sunshine Coast Regional District
ATTN: Stephen Misiurak, P.Eng., Manager Capital Projects
FROM: Joel McAllister, P.Eng., Stephen Bertulli, P.Eng.

RE: Proposed Chapman Water System Improvements Overview Technical Memorandum

1 Introduction

The Sunshine Coast Regional District (SCRD) is looking to improve the capacity of the Chapman Water System (CWS) by introducing new water sources from the Langdale wellfield. Onsite Engineering (OEL) has worked with Kalwij Water Dynamics Ltd. (KWD) and the SCRD to review multiple configurations for connecting Langdale wellfield water to the CWS. The purpose of this memorandum is to summarize the options reviewed to date and the current preferred approach.

2 Background

The SCRD manages multiple independent water systems throughout the regional district. The CWS is the largest water system and extends from Wood Bay to Hopkins Landing, supplying about 85% of the SCRD's serviced population (approximately 25,000). Water is supplied by the Edwards Lake and Chapman Lake reservoirs, as well as recently developed wells on Church Road. A water demand analysis in 2018 showed that the SCRD required an additional 2 million cubic metres of annual water supply to meet 2025 demand. In order to provide this additional volume new water sources and related infrastructure are required. The SCRD plans to connect new wells at the Langdale wellfield to the CWS to help reduce this shortfall.

3 Summary of Proposed System Improvements

The works required to connect Langdale wells to the CWS can be broken down into four separate projects:

1. **Langdale Wellfield Upgrades** – Construct pumping infrastructure to deliver raw water to a new treatment plant.

2. **Raw Water Transmission Main** – Construct a new raw water watermain to convey Langdale well water to a new water treatment plant.

3. **Water Treatment Plant** – Construct a new water treatment plant (WTP) to treat the water to Canadian Water Quality Guidelines (CWQG) standards.

4. **Treated Water Transmission Main** – Construct a new treated water transmission main to connect treated Langdale water to the CWS.

Figure 1 shows the extents of where these projects are in relation to the overall project.

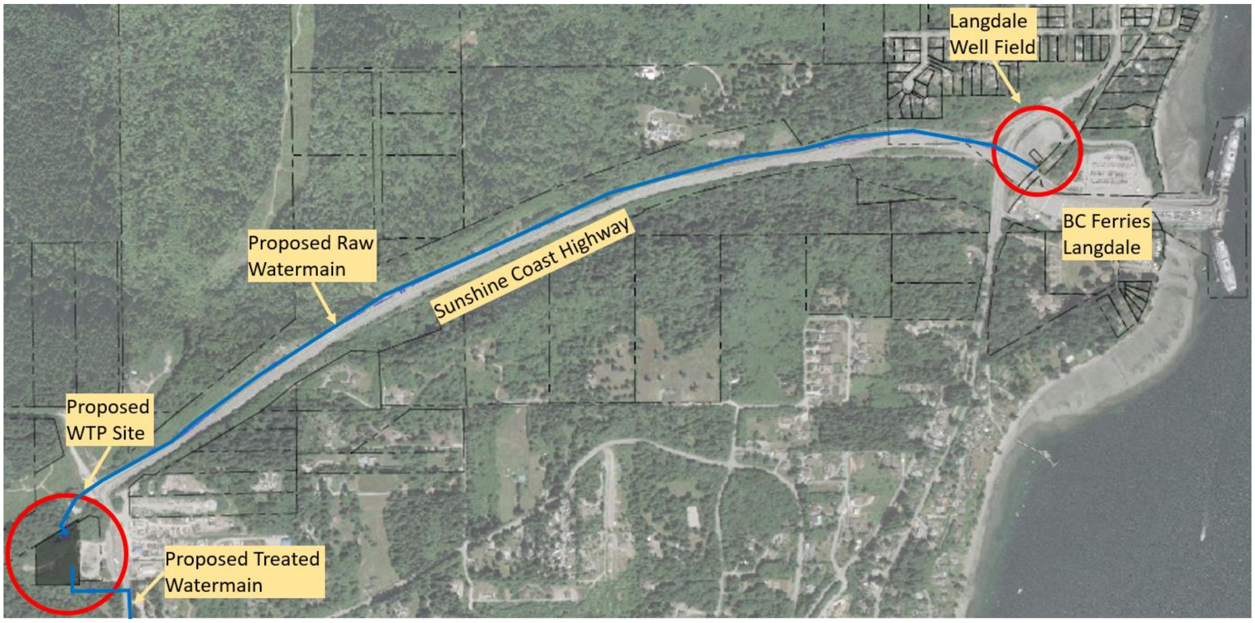

Figure 1: Water System Improvement Project Area

3.1 Langdale Wellfield

The Langdale wellfield, located at the BC Ferries (BCF) terminal in Langdale, has recently developed two new groundwater wells which are intended to supply the CWS with additional water. The water must be pumped to a separate lot for treatment, thus the wells need to be sized for pumping at a high head or be connected to a booster pump station.

The wells dedicated to a new CWS source would be limited to a flow of 61 L/s (967 GPM); the existing Langdale well, which serves the Langdale water system, operates at 14 L/s. Regulations limit groundwater withdrawal from an aquifer to 75 L/s before an environmental assessment is required (an onerous and lengthy process). Thus, in the interest of providing water as soon as possible, withdrawal is being limited for this project.

The infrastructure upgrades at the wellfield include:

- Drilled wells with pitless units (existing) and submersible pumps (new).
- Gated access for wellhead protection and would include a parking and maintenance area.
- New building to house electrical and control equipment. This may also include an equipment storage and maintenance working area.
- Backup generator capable of allowing pumping to the new WTP for 24-hour period.

- Well flushing station with environmental controls and discharge to existing storm system.
- Provision for future well expansion.

The wellfield site is located within the BCF terminal staging area, and the expansion will need to occupy part of the adjacent MOTI right-of-way. Design will require coordination and approvals from both stakeholders.

3.2 Raw Water Transmission

A new raw water transmission main will be required to convey water pumped from the Langdale wells to the new WTP. Three potential alignments were considered, and were discussed in TM#3, appended to this memo. The three options included:

1. Adjacent to the Sunshine Coast Highway (north side)
2. Along Marine Drive to Parker Road
3. Along Marine Drive to North Road

Option 1 is the preferred alignment; it is the shortest and most direct route. Options 2 and 3 required obtaining new property easements and extensive road restorations, respectively.

At this time, it is envisioned that Option 1 will be within the MOTI Right-of-Way (ROW), where there are also existing BC Hydro power poles for about half of the alignment. A thorough environmental review will be required to ensure that all sensitive habitats are identified so that the design can mitigate environmental and habitat disruption as best as possible.

The current scope of work for Option 1 includes:

- Approximately 3 km of 400 mm ø (16”) watermain (anticipated to be ductile iron), running adjacent to the Sunshine Coast Highway (north side), capable of handling the anticipated maximum pressure of 2070 kPa (300 psi).
- Pigging stations at the terminus of the alignment and possibly one mid-alignment.
- Two trenchlessly installed and cased crossings – one at Port Mellon Highway and one at Stewart Road.

3.3 Water Treatment Plant

The groundwater quality has been tested and has been shown to have elevated dissolved iron and manganese concentrations, both of which exceed the aesthetic objective (AO) set out in the Canadian Water Quality Guidelines (CWQG). The high iron and manganese content in the groundwater can precipitate out of solution when oxidized, which becomes an operational risk to the water system, so it is important to reduce the concentrations before connecting the CWS. The precipitate can cause scaling within the water network and can cause plugging issues in equipment and service connections. Additionally, it is a nuisance to the users because it can cause staining of food and appliances in households.

Two treatment options were considered, and were discussed in TM#4, appended to this memo:

1. Pre-packaged greensand filtration plant – Removing iron and manganese via chemical treatment and filtration.
2. Blending with CWS – Blending raw water with treated CWS water to bring iron and manganese concentrations down through dilution.

Option 1 is preferred approach. Option 2 (blending) is not feasible as it would require 2.5 parts CWS water to 1 part Langdale water. With the desired capacity of the WTP being 61 L/s, this would require 152 L/s CWS water, which would put excessive strain on the existing water system (for context 150 L/s is minimum fire flow for an institutional development).

Further, there is no redundancy with Option 2 as it is dependent on CWS water being available for blending. In scenarios where less than 152 L/s is available (such as during high demand), this new source would need to be throttled and would have a negative impact to water supply when it is needed the most.

The SCRD has identified a potential site for a new WTP, located southwest of the intersection at the Sunshine Coast Highway and Stewart Road, west of the Visitor Information Park. The civic address for the site is 1235 Stewart Road (Folio 746.04145.250).

Treatment for dissolved iron and manganese is well established and is a relatively simple process. A combination of oxidation and filtration will be sufficient to reduce the dissolved metals to below AO. A technical discussion of iron and manganese treatment was provided in TM#2 and is appended to this memo.

It is important to note that the WTP has a waste stream, which is comprised of all the material filtered out of the raw water. The filters flush on a routine basis, and there needs to be provision to either store the waste on site or to convey the waste to a wastewater treatment plant (WWTP). At this time, it is envisioned that there will be a waste lagoon on site to accept and store waste. The nearest WWTP in the Town of Gibsons and the ability of this plant to accept WTP waste requires an independent study.

3.3.1 Water Treatment Plant Infrastructure

The anticipated requirements for a new WTP include:

- 250 m^3 (67,000 USgal) raw water reservoir with provisions for routine cleaning/flushing.
- Booster station to pump water through the treatment plant.
- Pre-packaged greensand filtration water treatment plant.
- Two (2) 2,000 m^3 (530,000 USgal) treated water reservoirs.
- Waste residual handling and management area.
- Backup generator capable of powering the treatment plant and booster station for 24 hours.

3.3.2 Operations & Maintenance

Water treatment plant operation requirements are relatively low. The process is automated, so as long as the system is connected to a SCADA system, the WTP can be monitored and controlled remotely. Daily visits by an operator are ideal for visual checks on the equipment and to verify the system is operating as observed on SCADA.

The chemical requirements are limited to hypochlorite, which is used both as an oxidizer and as a disinfectant. Hypochlorite usage is anticipated to be around 10 kg/day.

The filtration media require replacement every 10 years on average. The media is a manufactured product and the treatment building would be designed to accommodate. While the replacement is a large lump sum cost when it occurs, the annualized cost for the media is minor when considered from a day-to-day perspective. Based on a preliminary assessment, operations and maintenance for the plant (considering power, chemicals, and media replacement) is about $50,000 - $75,000 per year. This does not consider managing waste or operator costs.

3.3.3 Waste Residual

It is anticipated that waste residuals will be stored in a lagoon on site. Waste is generated by backwashing the treatment tanks, and it is estimated that the backwash will generate 25 m^3 of waste per cycle, with a cycle every 10 days. This equates to about 915 m^3 of waste annually.

Routine lagoon maintenance will be required to make sure there is always capacity to discharge waste. In the warm/dry months evaporation can help rid water from the lagoon, but in cold/wet months vactor trucks may be required to service the lagoon to maintain capacity.

The nearest wastewater treatment plant (WWTP) is located in the Town of Gibsons. It may be possible to connect the WTP waste discharge to the Gibsons sanitary system; however, a separate study would be required to confirm if the WWTP has the capacity and capability to treat the waste.

3.3.4 Provision for Future Water Sources

In future water well investigation programs, new well sources may be found that have lower levels of dissolved iron and manganese, which may or may not exceed the AO. The new WTP could be designed to accommodate new raw water sources. If there are any provisions to modify the routing through the treatment stream, they would be subject to review and approval by the MoH, as there would be potential for cross contamination.

If new raw sources are found which have lower dissolved iron and manganese, but still exceeds the AO, blending could be done in the raw reservoir which would reduce contaminant loading on the greensand filters, reducing operational costs and waste residuals.

If new raw sources are found to have dissolved iron and manganese below the AO, filter bypasses can be included in the design to route this ‘cleaner’ water into the treated water reservoir after it is chlorinated.

3.4 Treated Water Transmission Main

From the proposed WTP site, there are two possible connection points: at the intersection of North Road and Stewart Road, or at the intersection of North Road and Reed Road.

The connection at North Road and Stewart Road is the nearest connection point, which is 600 m away and is a 150 mm ø pipe. If the connecting pipe is similarly sized at 150 mm ø the velocity would be 3.45 m/s at 61 L/s (the WTP capacity). This is greater than the MMCD design guidelines of 2.0 m/s during peak hour demand, thus this connection is not recommended.

The connection at the intersection of North Road and Reed Road would be to the recently completed watermain that was part of the Church Road project. This connection point is 1.5 km away and it is assumed this main size is 300 mm ø. The new WTP could connect with a 300 mm ø, which would limit pipe velocity to 0.86 m/s at 61 L/s, which would allow for additional wells to be brought on line in the future. The ideal connecting pipe size would be determined via water model assessment.

It is envisioned that the new WTP reservoirs will be set to have the same top water level (TWL) as the reservoirs on Henry Road. This would allow connection to the CWS without any pressure regulation or boosting.

3.5 Stakeholders

There will be multiple stakeholders involved throughout the project to ensure all regulatory requirements are being met and proper consultation is done. The following stakeholders will include, but may not be limited to:

- Sunshine Coast Regional District
- Squamish First Nations and other First Nations within the consultation area
- Ministry of Transportation and Infrastructure (MOTI)
- BC Ferries (BCF)
- Ministry of Health (MOH)
- BC Hydro
- Ministry providing Grant (if applicable)
- BC Hydro

4 Class D Cost Estimate

A ‘Class D’ cost estimate has been prepared to capture the major project components and their anticipated costs based on the current level of project definition. As the project advances, cost estimates will be revised and updated accordingly to ensure that all costs are being captured, and to identify potential cost efficiencies during design.

Table 1 shows the estimated costs for the CWS improvements, broken down by project. A Class D breakdown is appended to this memo.

Table 1: CWS Improvement Class D Cost Estimate

Project Area	Cost
Langdale Wellfield Upgrades	$1,600,000
Raw Water Transmission Main	$4,215,000
Water Treatment Plant	$7,660,000
Treated Water Transmission Main and Connections	$1,525,000
Total Construction Costs	**$15,000,000**
Engineering and Contingency	$6,500,000
Project Sub-Total	**$21,500,000**

5 Closure

This Report (the "Report") has been prepared by Onsite Engineering Ltd. ("Onsite") for the benefit of the Sunshine Coast Regional District ("Client"). The information, data, recommendations and conclusions contained in the Report:

- are subject to the scope, schedule, and other constraints and limitations and qualifications contained in the Report (the "Limitations");
- represent Onsite's professional judgement in light of the Limitations and industry standards for the preparation of similar reports;
- may be based on information provided to Onsite which has not been independently verified;
- have not been updated since the date of issuance of the Report and their accuracy is limited to the time period and circumstances in which they were collected, processed, made or issued;
- must be read as a whole and sections thereof should not be read out of such context;
- were prepared for the specific purposes described in the Report;
- in the case of subsurface, environmental or geotechnical conditions, may be based on limited testing and on the assumption that such conditions are uniform and not variable either geographically or over time.

Unless expressly stated to the contrary in the Report, Onsite:

- shall not be responsible for any events or circumstances that may have occurred since the date on which the Report was prepared or for any inaccuracies contained in information that was provided to Onsite;
- agrees that the Report represents its professional judgement as described above for the specific purpose described in the Report, but Onsite makes no other representations with respect to the Report or any part thereof;
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- as required by law;
- for use by governmental reviewing agencies.

Any use of this Report is subject to these Qualifications. Any damages arising from improper use of the Report or parts thereof shall be borne by the party making such use.

Onsite Engineering Ltd.

Prepared by:	Reviewed by:
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Technical Memorandum #2

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TECHNICAL MEMORANDUM #2

DATE: July 10, 2023
TO: Sunshine Coast Regional District
ATTN: Ineke Kalwij, Ph.D., P.Eng.
CC: Sachindra Wijayabandara
FROM: Joel McAllister, P.Eng., Stephen Bertulli, P.Eng.

Re: Water Treatment Technology Review for Elevated Dissolved Iron and Manganese

The following memo is developed for the Sunshine Coast Regional District (SCRD) to provide a high-level overview of available treatment methods for iron and manganese removal from groundwater.

1 Introduction

1.1 Purpose

The SCRD has begun to develop additional water sources with the goal to increase the capacity of the Chapman water system. In 2022, two new wells were developed into production-sized test wells at the Langdale wellfield, located at the Langdale BC Ferries terminal, and are potential sources.

A water quality test has been collected from one of the wells, which shows that dissolved iron and manganese are higher than the Canadian Water Quality Guidelines aesthetic objectives. This memo provides information on available treatment technologies capable of removing dissolved iron and manganese from raw water.

1.2 Canadian Water Quality Guidelines

The Canadian Water Quality Guidelines (CWQG) provides recommended treatment objectives for water providers. The CWQG considers health effects, aesthetic effects, and operations when listing recommended concentrations of the various constituents. Acceptable levels are based on Maximum Allowable Concentrations (MAC) and Aesthetic Objectives (AO).

1.3 Well No. 1 Water Quality

A water quality sample was collected in February 2023 from Well No. 1, the results are appended to the memo. The results show that there are elevated levels of dissolved iron (0.54 mg/L) and dissolved manganese (0.047 mg/L). Both elements exceed the CWQG AO, dissolved manganese is below the MAC. To note, there is no MAC for dissolved iron. Additionally, hardness is reported at 38 mg/L equivalent $CaCO_3$, which is considered soft water, summarized in Table 1.

Table 1 – Water Quality Results for Iron and Manganese in Well No. 1

Element	Well No. 1 (mg/L)	MAC (mg/L)	AO (mg/L)
Dissolved Iron	0.54	n/a	0.3
Dissolved Manganese	0.047	0.12	0.02
Hardness	38 (equivalent $CaCO_3$)	n/a	n/a

The consequence of having elevated levels of dissolved iron and manganese is staining and discolouration. If levels are above AO, staining of household fixtures, laundry, and food can be significant, which is a primary concern when it comes to consumer confidence in the quality of water.

Hardness is a measure of the level of dissolved polyvalent metals present in the water and is expressed in mg/L equivalent $CaCO_3$. With increasing concentrations of equivalent $CaCO_3$, the water hardness will also increase. If water hardness is high (hard water is > 120 mg/L $CaCO_3$ equiv.), then the water can deposit scale, which is unsightly, but also can pose operational problems due to deposits clogging pipes and fixtures. If water hardness is low (soft water is < 60 mg/L $CaCO_3$ equiv.), it can create corrosion issues through leeching of elements into the water, thereby degrading pipes.

Based on the test result, the water needs to be treated for dissolved iron and manganese to meet the AO, which will also provide benefit to operations over the long-term. Following treatment, the hardness of the water may need to be adjusted to be suitable for distribution.

2 Overview of Typical Treatment Processes

Removal of dissolved iron and manganese is a common requirement for groundwater sources. There are multiple methods for treatment, but in general, they incorporate the following:

- **Oxidation** – An oxidant is added to the raw water which will combine with the dissolved metals and bring them out of solution, creating a precipitate.

  There are multiple types of oxidants, including, but not limited to, aeration, chlorine (such as from hypochlorite), permanganates (such as potassium permanganate), and ozone. The preferred oxidant depends on the raw water properties, how quickly the oxidant needs to react, and the type of treatment used by downstream processes.

- **Clarification** – If the raw water contains a high combined concentration of dissolved iron and manganese then clarification is likely required. Typically, this threshold is 5 mg/L, and is required in order to prevent excessive sediment loading on downstream processes.

  Clarification uses gravity settling to remove solids, which can be done through several methods including conventional sedimentation, high rate settling, ballasted flocculation, or solids contact.

- **Filtration** – The raw water is filtered through specific media to capture particulate and to remove remaining dissolved iron and manganese that may not have been oxidized or removed in prior processes.

The three main types of filtration are gravity filtration, membranes, and pressure filtration. Typically, groundwater is filtered in pressure vessels unless it is under the influence of surface water, in which case there are bacterial and virus considerations at this step.

There is a wide range of filtration media available which is specified to meet treatment targets based on the specific treatment processes and raw water quality. The filtration media in pressure vessels can be inorganic or organic granular media, biological media, or ionized media.

2.1 Residuals

Residuals are the waste product leftover from the treatment processes. For iron and manganese removal, the main byproduct is an iron and manganese oxide sludge, but other constituents in the source water and treatment chemicals also impact the composition of residuals.

These residuals typically have a high-water content, which impacts how they are disposed. If there is centralized sewerage treatment available (i.e. local wastewater treatment plant), the discharge to the local sewer system is the ideal approach to residual management. However, if centralized treatment is not available, then a dedicated residual management system needs to be included in the water treatment system design. In general, a residual management system includes:

- A dewatering method to reduce the water content of the waste, thereby increasing solids content. This can be done passively (e.g. settling) or mechanically (e.g. centrifuge). The water can be discharged to the environment if it meets regulations, or in some situations recycled back into the treatment process.
- A method to deal with the dewatered solids. Dewatered solids can be stockpiled and/or shipped off site. It is important to understand the composition of the solids, as there may be restrictions for ultimate disposal.

3 Available Treatment Options

The following section describes provides a brief overview of the oxidation, chlorination, and residuals management and the difference options within these treatment steps. Since the SCRD water quality shows that the combined dissolved iron and manganese concentration is ~0.6 mg/L, it is assumed clarification is not required, and is not discussed.

3.1 Oxidation Options

Oxidation, also referred to as pre-treatment, involves dosing the raw water with an oxidant to remove the undesired dissolved metals from solution. There are numerous types of oxidizers available which all act on the same premise of electron exchange to take dissolved iron and manganese out of solution. However, not all oxidizers are equal, and which type of oxidant to use needs to consider the quality of the source water as well as the different steps in the treatment process.

The main consideration when assessing the quality of the source water is how much organics are present. Organics oxidize as well, meaning that source water with a higher organics content will require a higher dose of oxidant to remove dissolved metals. Some oxidizers, such as chlorine, will react with organics to create disinfection by-products which are undesirable. Additionally, organics can combine with dissolved metals to create complexed forms which behave differently then more basic forms and can complicate the treatment process.

The other factor that affects oxidation is the pH of the water, which impacts the rate of reactions (temperature also plays a role in reaction rates, but much less than pH). Oxidants with slower reaction times will require more time upstream of other treatment processes in order to fully react. In general, dissolved manganese requires longer reaction times compared to dissolved iron and may impact the preferred oxidizer. Below is a summary of the typical oxidants available.

3.1.1 Aeration (O_2)

Aeration involves adding air into the raw water which allows atmospheric oxygen to dissolve into solution. This can be done by injecting air into the piping/tanks or can be done by creating turbulent conditions, such as with cascading towers.

Aeration is effective in removing dissolved iron out of solution but is much less effective for manganese due to the long reaction time. If manganese removal is required, it would typically be done following aeration either with a chemical oxidant or through the filtration process.

Generally, aeration is most suitable when there is a very high dissolved iron and manganese concentration (> 5mg/L). It is a cost-effective step to remove a large amount of dissolved iron, which helps limit the amount of chemical oxidant needed to complete the oxidation process. Aeration also benefits raw water which has organics that may cause disinfection by-products if chlorine is a part of the process.

3.1.2 Chlorine (Cl_2)

Chlorine can be added to raw water either by injection of chlorine gas or addition of a chlorine solution, such as sodium hypochlorite. Chlorine is effective at oxidizing dissolved iron above a pH of 8.0; however, it is not effective at oxidizing dissolved manganese due to the long reaction time. If dissolved manganese also needs to be treated, the chlorine cannot be relied upon and is a factor in designing the treatment process.

Chlorine as an oxidant is suitable for groundwater that has low organic matter, to avoid disinfection by-products, and in systems where breaking head is undesirable. Chlorine has the additional benefit of being able to provide a chlorine residual through the treatment process which helps with achieving required chlorine contact times.

3.1.3 Permanganate (MnO_4)

Permanganate is available in two forms, as a solid potassium permanganate and as a liquid sodium permanganate. Permanganate is highly reactive and is very effective at oxidizing both dissolved iron and manganese very quickly. Due to the high reactivity, it is also more hazardous relative to other options, increasing safety requirements for storage and handling.

Permanganate is suitable when dissolved manganese is the primary issue in the raw water, when there is limited detention time for reaction, or to pre-treat raw water when disinfection by-products are a concern.

3.1.4 Chlorine Dioxide (ClO_2)

Chlorine dioxide is a highly reactive oxidizer and is effective at oxidizing both iron and manganese. It is a gas which is injected into the treatment process, and it is usually generated on site. Chlorine dioxide may create disinfection by-products that include chlorites and chlorates, both of which have a MAC of 1 mg/L in the CWQG; this is generally not an issue for chlorine (Cl_2) or permanganate. The use of chlorine dioxide as an oxidizer requires very strict control to minimize these by-products.

Chlorine dioxide is most suitable when a high reaction rate is required (i.e. when there is not enough detention time for chlorine or permanganate to react), when there is a high concentration of organics in the raw water preventing the use of chlorine, or when complex forms of iron and manganese are present.

3.1.5 Ozone (O_3)

Ozone is similar to chlorine dioxide in that it is highly reactive and is effective at oxidizing both iron and manganese, and is also effective at oxidizing organic material without creating chlorinated disinfection by-products. If bromides are present ozonation can produce bromates, which are undesirable and have a MAC 0f 0.01 mg/L in the CWQG. The cost of producing ozone is generally prohibitive for smaller plants, and due to the high reactivity, dosing is more complicated compared to alternatives.

Ozone is most suitable when a high reaction rate is required (i.e. when there is not enough detention time for chlorine or permanganate to react), when there is a high concentration of organics in the raw water preventing the use of chlorine, when complex forms of iron and manganese are present, and when there is low bromide concentrations in the raw water.

3.2 Filtration Media Options

3.2.1 Manganese Sand Media

Manganese sand media refers to media that has the ability to both filter out particulate (iron and manganese oxides) and to adsorb the dissolved iron and manganese that has not been oxidized (i.e. is still in solution). Adsorption refers to the dissolved elements attaching to the media surface as the method of removal.

The most common type of manganese sand media are Manganese Greensand, Manganese Dioxide-Coated Sand, and Manganese Dioxide Ore (Pyrolusite). Depending on the design of the treatment process, additional layers of anthracite/coal above the manganese sand media may be included to assist with filtration by reducing the sediment load on the manganese media, thereby extending run times.

Each type of media requires regeneration and backwashing. Regeneration refers to regenerating the adsorbing capacity of the media, which is consumed over time during treatment, and requires an oxidant to be washed over the media. Backwashing refers to running the filter in reverse to flush out the filtered material to maintain the hydraulic capacity of the filter. The details of backwashing and regeneration depend on the raw water quality as well as the type of media used.

Typically, backwashing and regeneration occur simultaneously, where the backwash water contains a regeneration agent, and so the backwash both cleans the media and restores the adsorbing capacity. However, regeneration can also be done while the filter is active during the treatment process, if the source water quality allows. When regeneration is done as part of the backwash process the operation mode is referred to as 'intermittent regeneration', and when the regeneration is done as part of the treatment process it is referred to as 'continuous regeneration'.

Intermittent regeneration is where iron is oxidized prior to filtration and manganese removal is done through adsorption to the media. Once the adsorption capacity of the media is consumed, the media is regenerated during the backwash process only; thus, regeneration of media is intermittent. Regeneration can be done through either chlorine or permanganate. Generally, this approach is used when dissolved iron levels are below 0.5 mg/L.

Continuous regeneration (i.e. catalytic oxidation) is where both iron and manganese are oxidized prior to filtration. Enough oxidizer is dosed so that it remains in the treatment stream and through the filter. Any dissolved metals that were not removed via oxidation will be removed via adsorption, and the capacity of the filter is continuously regenerated due to the remaining oxidizer. Backwash is only required once the filter is no longer able to effectively remove particulate.

3.2.1.1 Manganese Greensand

Manganese greensand is a glauconite ore that is coated with manganese dioxide. Glauconite ore is a granular media that has a greenish colour and appears sand-like; once coated with manganese dioxide it turns to a dark purple. The term 'manganese greensand' is generally used to refer to media that uses naturally occurring glauconite ore, which is becoming limited in supply; traditional manganese greensand not specified in new treatment plant designs due to this issue.

Manganese greensand typically utilizes a coal (anthracite) top layer in the filter increases the efficiency of the greensand media. The coal layer generally has a higher porosity (higher void area), which allows for the particulate to flocculate and settle before the greensand layer. This reduces the sediment loading on the greensand layer which has many benefits: backwashing is simplified, manganese removal is more efficient, and filter run times can be extended.

3.2.1.2 Manganese Dioxide-Coated Sand

Manganese dioxide-coated sand differs from greensand in that the sand media is not glauconite ore; however, it is coated with the same manganese dioxide as greensand, giving it very similar properties and is a suitable, cost-effective alternative for manganese greensand. Functionally, it works on the same principles, but the operating parameters, such as hydraulic loading rate and adsorption capacity, may differ.

Manganese dioxide-coated sand is a manufactured product, and as such, the operating parameters are dependent on the specific media product. Typically, it operates through continuous regeneration with chlorine as an oxidizer. A separate regeneration process is usually not required, reducing the need for permanganate in the treatment process.

3.2.1.3 Manganese Dioxide Ore (Pyrolusite)

Pyrolusite is a naturally occurring manganese dioxide ore, and can be used instead of a coated sand. The primary benefit of pyrolusite is that there is no coating that can wear, so any removal of the ore surface (i.e. through abrasion or other methods) exposes a fresh surface of manganese dioxide.

Pyrolusite can be used in a continuous or intermittent regeneration process with chlorine as an oxidizer. Which regeneration process is typically determined based on the source water quality and the potential for chlorinated disinfection by-products. If by-products are a concern, chlorine regeneration is used intermittently.

The primary drawback for pyrolusite is that it requires more energy for backwash and cleaning, as it is about 1.6 times as heavy compared to sand media.

3.2.2 Biological Filtration Media

Biological filtration media operates by having bacteria growth inside the pressure vessel which is able to oxidize the iron and manganese. Over the course of operation, dense precipitates build up within the filter; these precipitates are denser compared to those that are formed with pre-treatment oxidation. As a result, biological filters have a higher retention capacity. Also, biological media does not require oxidation beforehand, as it is done within the media.

In order to remain effective, biological filters require specific environmental conditions so that the oxidizing bacteria can remain alive and active; this requires a high degree of control for the treatment process. Backwashing is required, similar to the manganese media, to maintain the effectiveness of the filters by removing precipitate as it builds up.

Biological media filters generally have longer run times before backwash is required; however, this benefit is offset by the fact that separate filters are required for iron and manganese removal, as the environmental conditions required to oxidize the elements are different. This effectively doubles the number of vessels required for treatment.

3.2.3 Ion Exchange Media

Ion exchange operates by swapping charged particles from the raw water with similarly charged particles on the media filter. For iron and manganese, sodium is typically used as the exchange ion. The primary difference between ion exchange and traditional filtration media is that the iron and manganese are not oxidized prior to the ion exchange filter. Rather, the iron and manganese are kept in solution to allow the elements to adsorb to the exchange media.

Since the elements are kept in solution, there is no risk to filter plugging; however, once the exchange capacity of the media is depleted breakthrough occurs. Breakthrough refers to when iron and manganese are able to pass through the filter without being removed. To maintain the filter, and prevent breakthrough, the exchange media is backwashed with a regenerating solution to restore the exchange capacity, well before breakthrough can occur. The waste from ion exchange is a brine solution with a high concentration of iron and manganese.

Ion exchange is typically used in point-of-use situations and where hardness removal is also desired. For larger systems, it is less efficient compared to traditional filtration as there is a high volume of backwash produced and the process generally requires more control to provide effective treatment.

3.2.4 Membrane Filtration

Membrane filtration involves filtering water through membranes that have specific pore sizing to remove constituents from the water. Typically, membrane filtration is used where treatment for pathogen removal is required, such as for groundwater under direct influence of surface water (GUDI).

Membranes are capable of treating water with high levels of dissolved metals, but it is important to understand the type of dissolved metals in the source water. If organics are present, the organically complexed versions of manganese may not be sufficiently removed.

Aside from the pathogen aspect, membranes are beneficial when there is limited footprint available, but have the operation drawbacks of being more complex systems and requiring special knowledge for operation and maintenance.

3.3 Residual Options

For typical sand filtration, the residuals are an iron and manganese oxide sludge, but also contains constituents present in the source water. Technically, off-gas from the treatment is considered a residual as well, if aeration is used, but for the purpose of this memo it is not considered.

The amount of dry residual produced on a per day basis can be determined based on the treatment system flow rate and the total concentration of contaminants. However, the actual volume of residuals depends on the water content, which can be significant depending on the level of treatment the residuals go through. Methods of residual treatment are similar to water treatment, but instead of meeting drinking water requirements, they need to meet disposal requirements. Thus, it is important to understand the disposal regulations, composition of the residual (both chemical composition and water content), available disposal locations and land use area, and the ability of the environment to accept liquids from the treatment process.

Generally, if there is no centralized sewer system available to dispose of the residuals, then dewatering is required to concentrate the solids to a suitable level. Typical methods of dewatering include thickening/clarification, non-mechanical dewatering, and mechanical dewatering.

3.3.1 Thickening/Clarification

Thickening/clarification consists of settling the sludge out of suspension to increase the solids content of the sludge and decanted water can be recycled back into the treatment process or released to the environment.

The ability to recycle the water back into the treatment process is dependent on the process and the quality of the decanted water. For example, the pH of the decanted water may need to be adjusted prior to reintroducing to the treatment stream to avoid upsetting any pre-treatment oxidation. Likewise, the ability to discharge decanted water to the environment requires an understanding of water quality regulations and the receiving environment.

The thickened sludge can be transported off-site to an appropriate disposal area, such as a nearby wastewater treatment plant. Disposal costs may depend on the final destination but would factor in disposal volume and quality. These processes can generate a waste sludge that has a solids concentration between 2% and 4%; the level of thickening is usually determined during design in conjunction with disposal costs.

3.3.2 Non-Mechanical Dewatering

Dewatering resulting a high solids content sludge, typically 12% or higher, and contains no free liquid. The resulting product is referred to as a 'cake' and is not free flowing. The presence of free liquid is based on a 'paint filter test;' simply put, if the cake drips when placed on a wire mesh then it is said to contain free liquid.

The premise of non-mechanical dewatering involves allowing the sludge to passively dry through evaporation or infiltration, where water is slowly removed until it reaches the necessary solids content. Typical non-mechanical methods of dewatering include lagoons and sand drying beds. A lagoon is a large basin where water can evaporate or infiltrate (if permitted) over time. Sand drying beds are where the sludge is spread out over a large porous layer and is able to dewater via gravity; an underdrain to collects the leachate so it can be disposed of as required.

The ability to use these methods depend on the available land and the climate, where substantial areas are generally needed as well as a warmer (and sometimes drier) climate. Structures can be installed overtop of lagoons and sand beds in wetter regions if it determined to be economically feasible. Generally, the leachate cannot be recycled back into the water treatment process if the source water is groundwater.

3.3.3 Mechanical Dewatering

Mechanical dewatering uses equipment to physically remove water to produce the cake. Polymers may be required to help form and generate the cake. There are multiple types of equipment which can dewater sludge including, but not limited to, belt press, plate press, frame press, centrifuge, and screw press.

Mechanical dewatering equipment generally has a small footprint and is an efficient way to collect the solid residuals. Since most machines require the use of a polymer, the water can not be recycled back into the treatment process as the polymer may have adverse effects on the water treatment systems, but it may be able to be recycled back into the dewatering process. Also, discharge of the water to the environment may be possible but is determined once the polymers to be used are known.

4 Conclusion

The above discussion has provided a high-level introduction to the oxidation, filtration, and residuals management treatment steps required to remove elevated dissolved iron and manganese from raw water. The goal of providing this information is to assist the SCRD in understanding the treatment process and help develop questions that will guide the decision making for treatment system selection.

4.1 Treatment Process Selection

The raw water sample indicates that treatment requirements are not complicated, as there is only elevated iron and manganese are present above the AO of the CWQG. The sample also indicates very low (possibly none) organic carbon or and no coliforms. This indicates the water source is not under the influence of surface water, simplifying the treatment process.

Pre-packaged water treatment systems are available for removal of iron and manganese, which are convenient and reliable as they can be purchased, constructed, and tested by the vendor before being shipped to site. These are an economical solution to provide simple treatment and can be integrated into the full WTP. Discussions with the vendor will allow for all technology options to be reviewed in detail so the capital and operational costs for the different configurations can be understood.

4.2 Next Steps

It is noted that these pre-packaged systems only form one piece of the overall WTP plant. A prudent next step for the SCRD would be to develop a Project Definition Report, which would review and consolidate all the different aspects needed to understand how best to design, build and integrate a new WTP into the Chapman water system. This will allow for an accurate preliminary project budget and schedule, which will be able to be improved at the project develops.

The Project Definition Report may include, but would not be limited to, identifying stakeholders and consultation requirements, funding availability and requirements, review of permits and approvals, power supply requirements, operational requirements, preliminary water treatment plant design, integration into the Chapman water system, waste management, environmental requirements, schedule and critical path review, and procurement and delivery option analysis.

5 Closure

This Report (the "Report") has been prepared by Onsite Engineering Ltd. ("Onsite") for the benefit of the Sunshine Coast Regional District ("Client"). The information, data, recommendations and conclusions contained in the Report:

- are subject to the scope, schedule, and other constraints and limitations and qualifications contained in the Report (the "Limitations");
- represent Onsite's professional judgement in light of the Limitations and industry standards for the preparation of similar reports;
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- were prepared for the specific purposes described in the Report;
- in the case of subsurface, environmental or geotechnical conditions, may be based on limited testing and on the assumption that such conditions are uniform and not variable either geographically or over time.

Unless expressly stated to the contrary in the Report, Onsite:

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- as required by law;
- for use by governmental reviewing agencies.

Any use of this Report is subject to these Qualifications. Any damages arising from improper use of the Report or parts thereof shall be borne by the party making such use.

Onsite Engineering Ltd.

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Report Transmission Cover Page

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Attn:	Ineke Kalwij	Project Name:	SCRD Langdale Wellfield	Control Number:	
Sampled By:		Project Location:	Well No. 1(63382)	Date Received:	Feb 21, 2023
Company:		LSD:		Date Reported:	Mar 6, 2023
		P.O.:		Report Number:	2849871
		Proj. Acct. code:			

Contact	Company	Address
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Delivery	Format	Deliverables
Email	PDF	COC / Test Report
Email	Standard Crosstab Without Tabs	Test Report
Email - Merge	PDF	COA
Email - Merge	PDF	COA / COC
Email - Merge	PDF	COC / Invoice

Notes To Clients:

- Mar 06, 2023 - Report was issued to include addition of Health Canada Drinking Water Quality Guideline interpretations requested by Ineke Kalwij of Kalwij Water Dynamics Inc. on March 6, 2023.
  Previous report 2845623.

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Analytical Report

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		P.O.:		Report Number:	2849871
		Proj. Acct. code:			

Reference Number	1633519-1
Sample Date	February 20, 2023
Sample Time	08:36
Sample Location	
Sample Description	Well No. 1(63382) / 5.3 °C
Sample Matrix	Water

Analyte		Units	Result	Nominal Detection Limit	Guideline Limit	Guideline Comments
Aggregate Organic Constituents						
UV Transmittance		%/cm	95.0	0.1		
Inorganic Nonmetallic Parameters						
Ammonium - N		mg/L	<0.025	0.025		
Kjeldahl Nitrogen	Total	mg/L	<0.10	0.1		
Sulfide	Total	mg/L	<0.002	0.002	0.05	Below AO
Organic Carbon	Total Nonpurgeable	mg/L	0.5	0.5		
Metals Extractable						
Aluminum	Extractable	mg/L	<0.002	0.002	0.1 OG; 2.9 MAC	Below OG
Antimony	Extractable	mg/L	<0.0002	0.0002	0.006	Below MAC
Arsenic	Extractable	mg/L	0.0039	0.0002	0.01	Below MAC
Barium	Extractable	mg/L	0.003	0.001	2.0	Below MAC
Boron	Extractable	mg/L	0.010	0.002	5	Below MAC
Cadmium	Extractable	mg/L	<0.00001	0.00001	0.007	Below MAC
Chromium	Extractable	mg/L	<0.0005	0.0005	0.05	Below MAC
Copper	Extractable	mg/L	<0.001	0.001	1 AO; 2 MAC	Below AO
Lead	Extractable	mg/L	<0.0001	0.0001	0.005	Below MAC
Molybdenum	Extractable	mg/L	0.003	0.001		
Nickel	Extractable	mg/L	<0.0005	0.0005		
Selenium	Extractable	mg/L	<0.0002	0.0002	0.05	Below MAC
Silver	Extractable	mg/L	<0.00001	0.00001		
Uranium	Extractable	mg/L	<0.0005	0.0005	0.02	Below MAC
Zinc	Extractable	mg/L	0.011	0.001	5	Below AO
Trace Metals Dissolved						
Digestion	Dissolved		Field filtered and Pres Dissol			
Titanium	Dissolved	mg/L	<0.002	0.002		
Aluminum	Dissolved	mg/L	0.001	0.001	0.1 OG; 2.9 MAC	Below OG
Antimony	Dissolved	mg/L	<0.00002	0.00002	0.006	Below MAC
Arsenic	Dissolved	mg/L	0.0035	0.0001	0.010	Below MAC
Barium	Dissolved	mg/L	0.0034	0.0001	2.0	Below MAC
Beryllium	Dissolved	mg/L	<0.00005	0.00005		
Bismuth	Dissolved	mg/L	<0.0001	0.0001		
Boron	Dissolved	mg/L	0.012	0.002	5	Below MAC
Cadmium	Dissolved	mg/L	<0.00001	0.00001	0.007	Below MAC
Chromium	Dissolved	mg/L	<0.00005	0.00005	0.05	Below MAC
Cobalt	Dissolved	mg/L	<0.00002	0.00002		
Copper	Dissolved	mg/L	<0.0005	0.0005	1 AO; 2 MAC	Below AO
Iron	Dissolved	mg/L	0.54	0.002	0.3	Above AO

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Analytical Report

Bill To:	Kalwij Water Dynamics Inc P.O. Box 684 Station Main Port Coquitlam, BC, Canada V3B 6H9	Project ID:		Lot ID:	**1633519**
		Project Name:	SCRD Langdale Wellfield	Control Number:	
		Project Location:	Well No. 1(63382)	Date Received:	Feb 21, 2023
		LSD:		Date Reported:	Mar 6, 2023
Attn:	Ineke Kalwij	P.O.:		Report Number:	2849871
Sampled By:		Proj. Acct. code:			
Company:					

Reference Number	1633519-1
Sample Date	February 20, 2023
Sample Time	08:36
Sample Location	
Sample Description	Well No. 1(63382) / 5.3 °C
Sample Matrix	Water

Analyte		Units	Result	Nominal Detection Limit	Guideline Limit	Guideline Comments
Trace Metals Dissolved - Continued						
Lead	Dissolved	mg/L	0.00003	0.00001	0.005	Below MAC
Lithium	Dissolved	mg/L	0.0012	0.0005		
Manganese	Dissolved	mg/L	0.047	0.001	0.02 AO; 0.12 MAC	Above AO
Molybdenum	Dissolved	mg/L	0.0033	0.00002		
Nickel	Dissolved	mg/L	<0.0002	0.0002		
Selenium	Dissolved	mg/L	<0.0002	0.0002	0.05	Below MAC
Silver	Dissolved	mg/L	<0.00001	0.00001		
Strontium	Dissolved	mg/L	0.030	0.0001	7.0	Below MAC
Tellurium	Dissolved	mg/L	<0.00005	0.00005		
Thallium	Dissolved	mg/L	<0.00001	0.00001		
Thorium	Dissolved	mg/L	<0.00005	0.00005		
Tin	Dissolved	mg/L	<0.0001	0.0001		
Uranium	Dissolved	mg/L	0.00001	0.00001	0.02	Below MAC
Vanadium	Dissolved	mg/L	<0.00005	0.00005		
Zinc	Dissolved	mg/L	0.018	0.0005	5.0	Below AO
Zirconium	Dissolved	mg/L	<0.0001	0.0001		
Metals Total						
Mercury	Total	mg/L	<0.000005	0.000005	0.001	Below MAC
Calcium	Total	mg/L	7.4	0.01		
Magnesium	Total	mg/L	4.6	0.02		
Potassium	Total	mg/L	2.4	0.04		
Silicon	Total	mg/L	17	0.005		
Sulfur	Total	mg/L	4.5	0.02		
Sodium	Total	mg/L	6.4	0.1	200	Below AO
Titanium	Total	mg/L	<0.002	0.002		
Physical and Aggregate Properties						
Colour	Apparent, Potable	Colour units	5	5	15	Below AO
Turbidity		NTU	0.9	0.1	0.1/0.3/1.0 OG	
Routine Water						
pH			7.21	1	7.0-10.5	Within OG Range
Electrical Conductivity	at 25 °C	µS/cm	114	1		
Calcium	Extractable	mg/L	7.4	0.2		
Magnesium	Extractable	mg/L	4.8	0.2		
Sodium	Extractable	mg/L	6.2	0.4	200	Below AO
Potassium	Extractable	mg/L	2.4	0.4		
Iron	Extractable	mg/L	0.53	0.01	0.3	Above AO
Manganese	Extractable	mg/L	0.049	0.005	0.02 AO; 0.12 MAC	Above AO

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Attn: Ineke Kalwij
Sampled By:
Company:

Project ID:
Project Name: SCRD Langdale Wellfield
Project Location: Well No. 1(63382)
LSD:
P.O.:
Proj. Acct. code:

Lot ID: **1633519**
Control Number:
Date Received: Feb 21, 2023
Date Reported: Mar 6, 2023
Report Number: 2849871

Reference Number	1633519-1
Sample Date	February 20, 2023
Sample Time	08:36
Sample Location	
Sample Description	Well No. 1(63382) / 5.3 °C
Sample Matrix	Water

Analyte		Units	Result	Nominal Detection Limit	Guideline Limit	Guideline Comments
Routine Water - Continued						
Chloride	Dissolved	mg/L	2.3	0.4	250	Below AO
Fluoride		mg/L	<0.05	0.05	1.5	Below MAC
Nitrate - N		mg/L	<0.01	0.01	10	Below MAC
Nitrite - N		mg/L	<0.005	0.005	1	Below MAC
Sulfate (SO4)	Extractable	mg/L	14	0.9	500	Below AO
T-Alkalinity	as CaCO3	mg/L	41	5		
Total Dissolved Solids		mg/L	61	1	500	Below AO
Hardness	as CaCO3	mg/L	38			
Langelier Index	Extractable		-1.6			
Saturation pH	Extractable	pH	8.8			
Calcium	Dissolved	mg/L	7.4	0.01		
Magnesium	Dissolved	mg/L	4.6	0.02		
Potassium	Dissolved	mg/L	2.6	0.04		
Silicon	Dissolved	mg/L	17	0.005		
Sodium	Dissolved	mg/L	6.2	0.1	200	Below AO
Sulfur	Dissolved	mg/L	4.3	0.02		
Hardness	as CaCO3 (dissolved)	mg/L	38	5		
Trace Metals Total						
Aluminum	Total	mg/L	0.001	0.001	0.1 OG; 2.9 MAC	Below OG
Antimony	Total	mg/L	<0.00002	0.00002	0.006	Below MAC
Arsenic	Total	mg/L	0.0034	0.0001	0.010	Below MAC
Barium	Total	mg/L	0.0030	0.0001	2.0	Below MAC
Beryllium	Total	mg/L	<0.00005	0.00005		
Bismuth	Total	mg/L	<0.0001	0.0001		
Boron	Total	mg/L	0.012	0.002	5	Below MAC
Cadmium	Total	mg/L	<0.00001	0.00001	0.007	Below MAC
Chromium	Total	mg/L	0.00010	0.00005	0.05	Below MAC
Cobalt	Total	mg/L	<0.00002	0.00002		
Copper	Total	mg/L	<0.0002	0.0002	1 AO; 2 MAC	Below AO
Iron	Total	mg/L	0.53	0.002	0.3	Above AO
Lead	Total	mg/L	0.00003	0.00001	0.005	Below MAC
Lithium	Total	mg/L	0.0013	0.0005		
Manganese	Total	mg/L	0.046	0.001	0.02 AO; 0.12 MAC	Above AO
Molybdenum	Total	mg/L	0.0033	0.00002		
Nickel	Total	mg/L	<0.0002	0.0002		
Selenium	Total	mg/L	<0.0002	0.0002	0.05	Below MAC
Silver	Total	mg/L	<0.00001	0.00001		

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Sampled By:
Company:

Project ID:
Project Name: SCRD Langdale Wellfield
Project Location: Well No. 1(63382)
LSD:
P.O.:
Proj. Acct. code:

Lot ID: **1633519**
Control Number:
Date Received: Feb 21, 2023
Date Reported: Mar 6, 2023
Report Number: 2849871

Reference Number	1633519-1
Sample Date	February 20, 2023
Sample Time	08:36
Sample Location	
Sample Description	Well No. 1(63382) / 5.3 °C
Sample Matrix	Water

Analyte		Units	Result	Nominal Detection Limit	Guideline Limit	Guideline Comments
Trace Metals Total - Continued						
Strontium	Total	mg/L	0.029	0.0001	7.0	Below MAC
Tellurium	Total	mg/L	<0.00005	0.00005		
Thallium	Total	mg/L	<0.00001	0.00001		
Thorium	Total	mg/L	<0.00005	0.00005		
Tin	Total	mg/L	<0.0001	0.0001		
Uranium	Total	mg/L	0.00001	0.00001	0.02	Below MAC
Vanadium	Total	mg/L	0.00013	0.00005		
Zinc	Total	mg/L	0.0099	0.0005	5.0	Below AO
Zirconium	Total	mg/L	<0.0001	0.0001		

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Project ID:
Project Name: SCRD Langdale Wellfield
Project Location: Well No. 1(63382)
LSD:
P.O.:
Proj. Acct. code:

Lot ID: **1633519**
Control Number:
Date Received: Feb 21, 2023
Date Reported: Mar 6, 2023
Report Number: 2849871

Reference Number	1633519-2
Sample Date	February 20, 2023
Sample Time	09:35
Sample Location	
Sample Description	Well No. 1(63382) / 5.3 °C
Sample Matrix	Water

Analyte		Units	Result	Nominal Detection Limit	Guideline Limit	Guideline Comments
Microbiological Analysis						
Total Coliforms	Enzyme Substrate Test	MPN/100 mL	<1.0	1.0	0 per 100 mL	Below MAC
Fecal Coliforms	Enzyme Substrate Test	MPN/100 mL	<1.0	1		
Escherichia coli	Enzyme Substrate Test	MPN/100 mL	<1.0	1.0	0 per 100 mL	Below MAC
Heterotrophic Count - Aerobic	SimPlate	MPN/mL	156	2		
Approximate Iron Related Bacteria Population	BART Kit	CFU/mL	9000			
Approximate Sulfate Reducing Bacteria Population	BART Kit	CFU/mL	<1			

Approved by: Max Hewitt
Max Hewitt
Operations Manager

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Methodology and Notes

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Company:		LSD:		Date Reported:	Mar 6, 2023
		P.O.:		Report Number:	2849871
		Proj. Acct. code:			

Method of Analysis

Method Name	Reference		Method	Date Analysis Started	Location
Alkalinity, pH, and EC in water	APHA	*	Alkalinity - Titration Method, 2320 B	Feb 22, 2023	Element Edmonton - Roper Road
Alkalinity, pH, and EC in water	APHA	*	Conductivity, 2510 B	Feb 22, 2023	Element Edmonton - Roper Road
Alkalinity, pH, and EC in water	APHA	*	pH - Electrometric Method, 4500-H+ B	Feb 22, 2023	Element Edmonton - Roper Road
Ammonium-N in Water	APHA	*	Automated Phenate Method, 4500-NH3 G	Feb 24, 2023	Element Edmonton - Roper Road
Anions (Routine) by Ion Chromatography	APHA	*	Ion Chromatography with Chemical Suppression of Eluent Cond., 4110 B	Feb 23, 2023	Element Edmonton - Roper Road
Approval-Edmonton	APHA		Checking Correctness of Analyses, 1030 E	Feb 24, 2023	Element Edmonton - Roper Road
Carbon Organic (Total) in water (TOC)	APHA		High-Temperature Combustion Method, 5310 B	Feb 22, 2023	Element Edmonton - Roper Road
Chloride in Water	APHA	*	Automated Ferricyanide Method, 4500-Cl- E	Feb 22, 2023	Element Edmonton - Roper Road
Colour (Apparent) in water	APHA	*	Visual Comparison Method, 2120 B	Feb 27, 2023	Element Edmonton - Roper Road
Fecal Coliforms- Colilert (VAN)	APHA		Enzyme Substrate Test, APHA 9223 B	Feb 21, 2023	Element Vancouver
Heterotrophic (Standard) Plate Count (Aerobic SP) - VAN	APHA		Enzyme Substrate Method, 9215 E	Feb 21, 2023	Element Vancouver
Iron Reducing and Oxidizing Bacteria	IRB-BART		Iron Related Bacteria - BART Method, IRB-BART	Feb 21, 2023	Element Vancouver
Mercury (Total) in water	EPA	*	Mercury in Water by Cold Vapor Atomic Fluorescence Spectrometry, 245.7	Feb 23, 2023	Element Edmonton - Roper Road
Metals ICP-MS (Extractable) in water	APHA/USEPA	*	Metals By Inductively Coupled Plasma/Mass Spectrometry, APHA 3125 B / USEPA 200.2, 200.8	Feb 23, 2023	Element Edmonton - Roper Road
Metals ICP-MS (Extractable) in water	US EPA	*	Determination of Trace Elements in Waters and Wastes by ICP-MS, 200.8	Feb 23, 2023	Element Edmonton - Roper Road
Metals SemiTrace (Dissolved) in water (VAN)	US EPA	*	Metals & Trace Elements by ICP-AES, 6010C	Feb 23, 2023	Element Vancouver
Metals SemiTrace (Total) in Water (VAN)	US EPA	*	Metals & Trace Elements by ICP-AES, 6010C	Feb 23, 2023	Element Vancouver
Metals Trace (Extractable) in water	APHA		Hardness by Calculation, 2340 B	Feb 23, 2023	Element Edmonton - Roper Road
Metals Trace (Extractable) in water	APHA	*	Inductively Coupled Plasma (ICP) Method, 3120 B	Feb 23, 2023	Element Edmonton - Roper Road
Sulfate Reducing Bacteria - BART	SRB-BART		Sulfate Reducing Bacteria - BART Method, SRB-BART	Feb 21, 2023	Element Vancouver
Sulfide in water	APHA	*	Gas Dialysis, Automated Methylene Blue Method, 4500-S2- E	Feb 23, 2023	Element Edmonton - Roper Road
Total and E-Coli - Colilert - DW (VAN)	APHA		Enzyme Substrate Test, APHA 9223 B	Feb 21, 2023	Element Vancouver
Total and Kjeldahl Nitrogen (Total) in Water	ISO	*	Water Quality - Determination of nitrogen, ISO/TR 11905-2	Feb 22, 2023	Element Edmonton - Roper Road

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Methodology and Notes

Bill To:	Kalwij Water Dynamics Inc P.O. Box 684 Station Main Port Coquitlam, BC, Canada V3B 6H9	Project ID:		Lot ID:	**1633519**
		Project Name:	SCRD Langdale Wellfield	Control Number:	
		Project Location:	Well No. 1(63382)	Date Received:	Feb 21, 2023
		LSD:		Date Reported:	Mar 6, 2023
Attn:	Ineke Kalwij	P.O.:		Report Number:	2849871
Sampled By:		Proj. Acct. code:			
Company:					

Method Name	Reference		Method	Date Analysis Started	Location
Trace Metals (dissolved) in Water (VAN)	US EPA	*	Determination of Trace Elements in Waters and Wastes by ICP-MS, 200.8	Feb 23, 2023	Element Vancouver
Trace Metals (Total) in Water (VAN)	US EPA	*	Determination of Trace Elements in Waters and Wastes by ICP-MS, 200.8	Feb 24, 2023	Element Vancouver
Turbidity in Water	APHA	*	Turbidity - Nephelometric Method, 2130 B	Feb 27, 2023	Element Edmonton - Roper Road
Ultraviolet Transmittance in Water	APHA	*	Ultraviolet Absorption Method, 5910 B	Feb 23, 2023	Element Vancouver

** Reference Method Modified*

References

APHA	Standard Methods for the Examination of Water and Wastewater
APHA/USEPA	Standard Methods For Water/ Environmental Protection Agency
EPA	Environmental Protection Agency Test Methods - US
IRB-BART	IRB-BART. Std Methods for the App. of BART Testers, DBI
ISO	International Organization for Standardization
SRB-BART	SRB-BART. Std Methods for the App. of BART Testers, DBI
US EPA	US Environmental Protection Agency Test Methods

Guidelines

Guideline Description	Health Canada GCDWQ
Guideline Source	Guidelines for Canadian Drinking Water Quality, Health Canada, Sept 2020
Guideline Comments	MAC = Maximum Acceptable Concentration AO = Aesthetic Objective OG = Operational Guideline for Water Treatment Plants (does not apply to private groundwater wells). Refer to Health Canada for complete guidelines at www.hc-sc.gc.ca

Comments:

- Mar 06, 2023 - Report was issued to include addition of Health Canada Drinking Water Quality Guideline interpretations requested by Ineke Kalwij of Kalwij Water Dynamics Inc. on March 6, 2023.
  Previous report 2845623.

The comparison of test results to guideline limits is provided for information purposes only. This is not to be taken as a statement of conformance / nonconformance to any guideline, regulation or limit. The data user is responsible for all conclusions drawn with respect to the data and is advised to consult official regulatory references when evaluating compliance.

Please direct any inquiries regarding this report to our Client Services group.
Results relate only to samples as submitted.
The test report shall not be reproduced except in full, without the written approval of the laboratory.

Technical Memorandum #3

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DRAFT

TECHNICAL MEMORANDUM #3

DATE: September 27, 2023
TO: Sunshine Coast Regional District
ATTN: Stephen Misiurak, P.Eng., Manager Capital Projects
FROM: Joel McAllister, P.Eng., Stephen Bertulli, P.Eng.

RE: Alternative Options for Raw Water Transmission Main Alignment Technical Memorandum

1 Introduction

This memorandum has been prepared for the Sunshine Coast Regional District (SCRD) to provide high level options for a raw water transmission main alignment that does not parallel the Sunshine Coast Highway.

2 Background

The SCRD is looking to incorporate two new groundwater wells, located at the Langdale Wellfield, into the Chapman Water System (CWS). The initial assessment considered routing the raw water transmission main along the Sunshine Coast Highway, which is a Ministry of Transportation and Infrastructure Right-of-Way (MOTI ROW) to connect the wells to the Water Treatment Plant (WTP), shown in Figure 1. There are many technical challenges with this alignment, as there are multiple gullies and creek crossings. Additionally, it will be subject to a rigorous approval process as it is along the main highway within the Sunshine Coast. Thus, the SCRD would like to review alternative options for the raw water transmission main alignment.

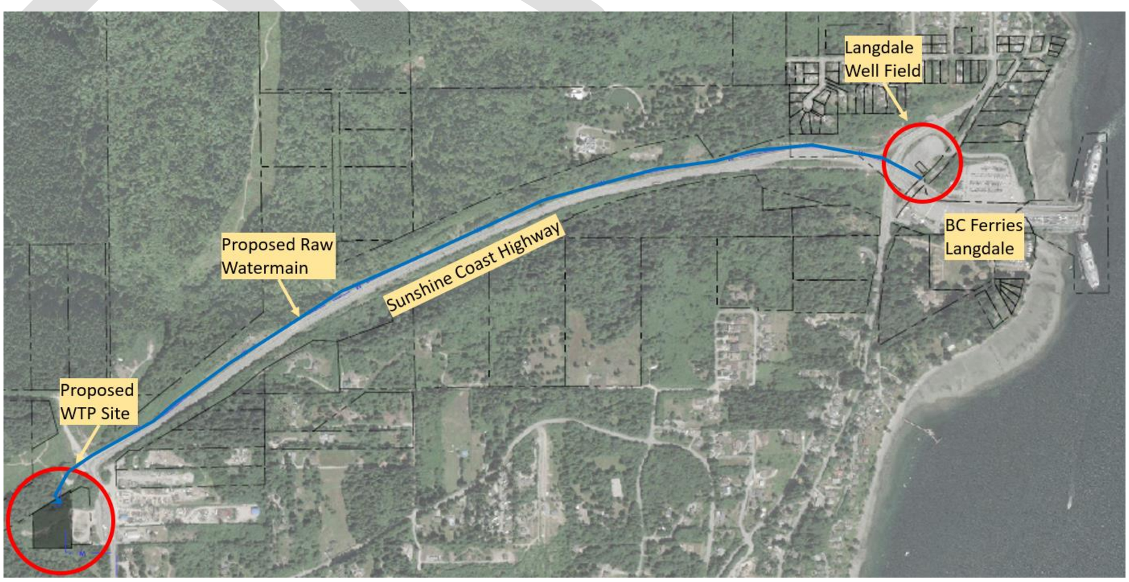

Figure 1: Initial Raw Watermain Alignment

3 Alternative Option 1 – Parker Drive

The most direct route between the Langdale wellfield and proposed WTP, while avoiding the Sunshine Coast Highway, is along Parker Drive, shown in Figure 2. The alignment is approximately 3 km. This road ROW is also MOTI controlled; however, it is assumed that the requirements for building along this alignment will be less stringent.

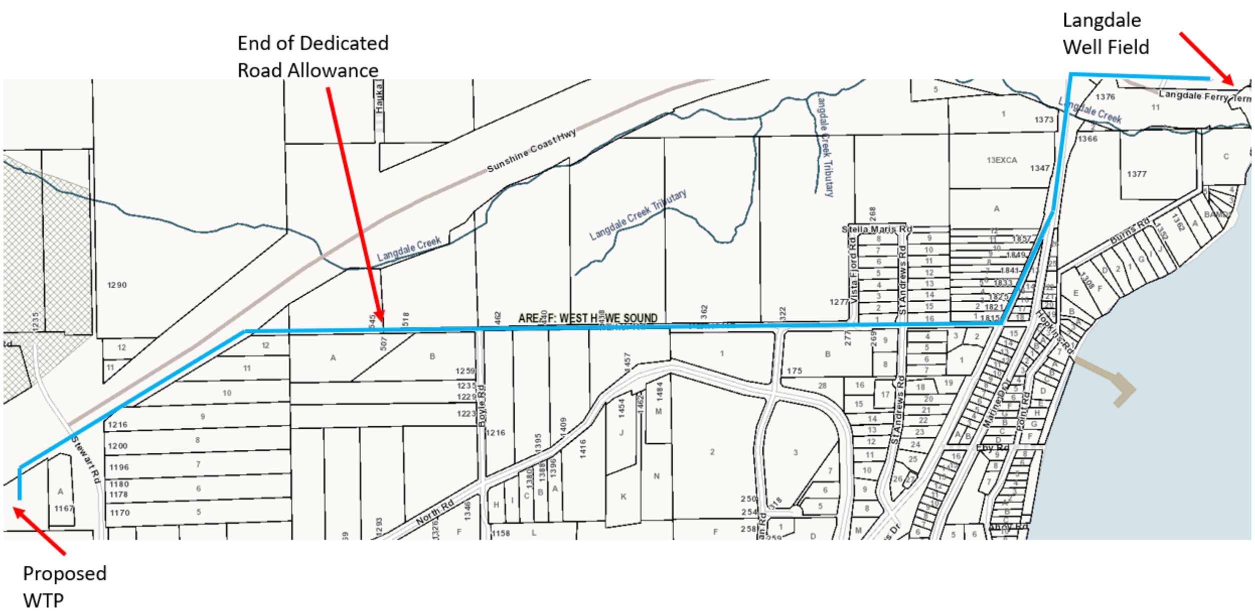

Figure 2: Alternative Raw Watermain Alignment Along Parker Road

There is a dedicated ROW extending from Marine Drive westward that connects to Parker Drive (Figure 3). This dedicated ROW terminates at the boundary between properties 516 and 545. In order to minimize the raw watermain alignment, an additional ROW through the 545 property and adjacent lot (unidentified in the SCRD Cadastre) is required. This would allow the forcemain to follow the south side of the Sunshine Coast Highway for approximately 500 m.

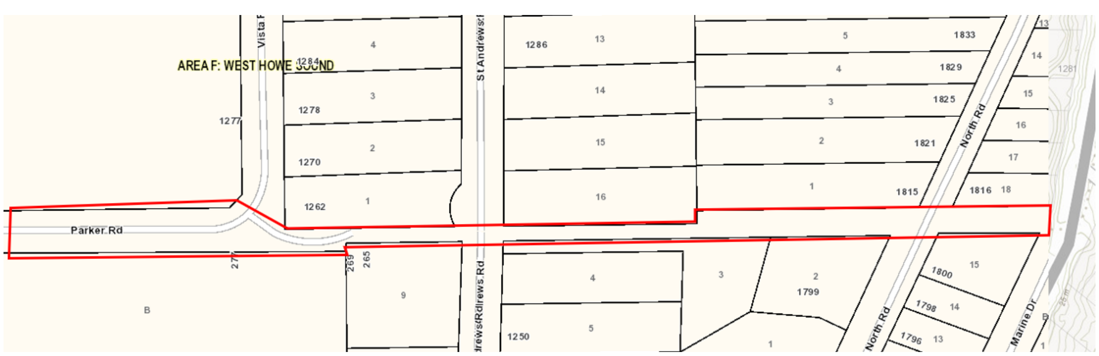

Figure 3: ROW from Marine Drive to Parker Road

The road ROW connecting Marine Drive to Parker Road is currently not developed for road works. There are multiple properties built up, and it appears there are dwellings within the ROW. It may be possible to trenchlessly install a transmission main through this ROW. This would need to be reviewed during the design phase.

The west boundary of the Parker Road ROW appears to provide access to 545 Parker Road (Figure 4). The small triangular property adjacent belongs to 1290 Stewart Road, majority of which is adjacent to the north side of the highway. The Parker Road ROW will need to be extended through both properties to the highway, or a dedicated ROW for the watermain be obtained.

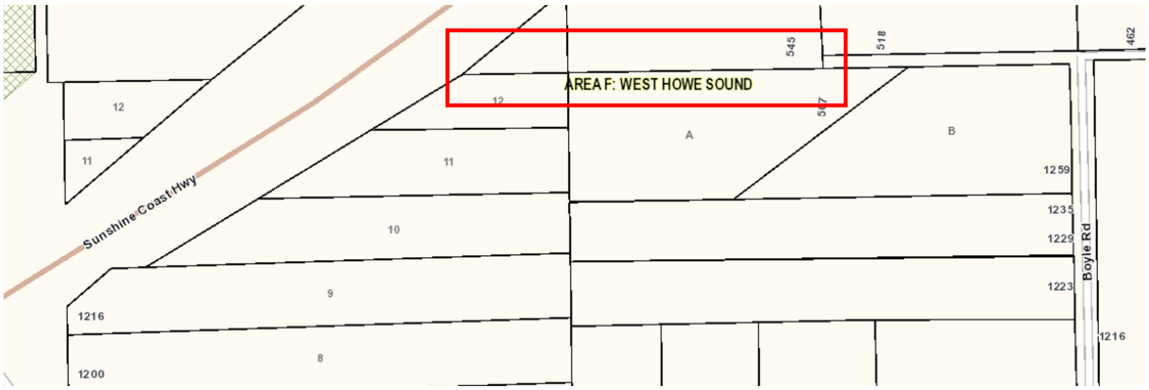

Figure 4: Area requiring new ROW for 545 Parker Road

4 Alternative Option 2 – North Road

An alternative route which could keep the transmission main within an existing road way /ROWwould be to route along North Road (Figure 5). This alignment is approximately 4 km.

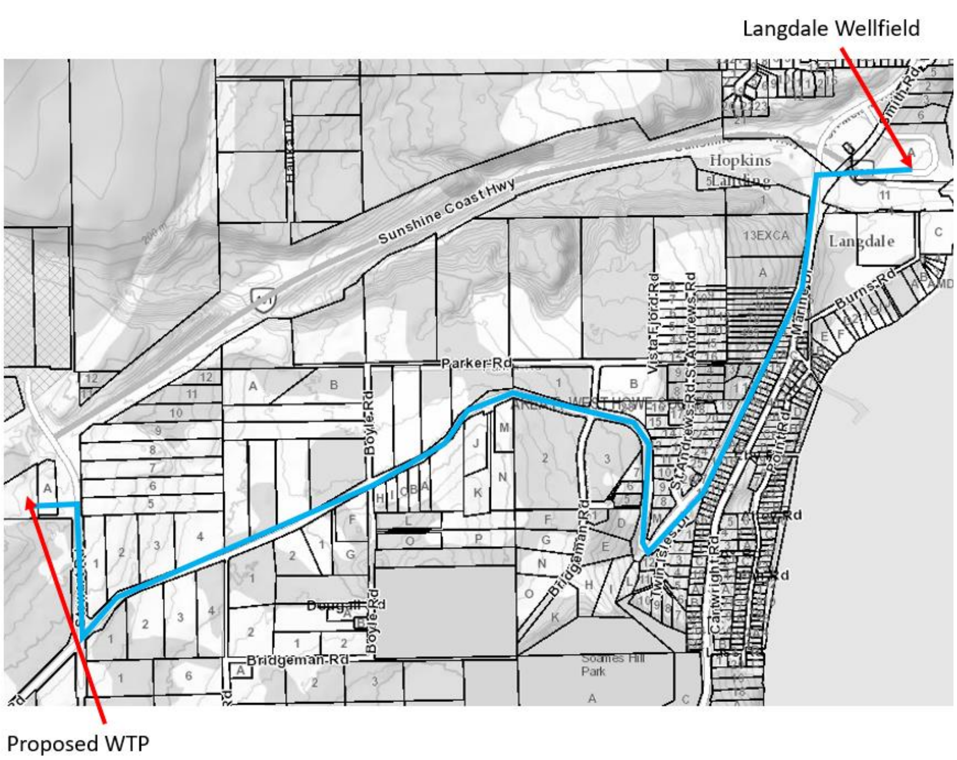

Figure 5: Alignment Along North Road

The SCRD already has a watermain along North Road, which is part of the CWS. This option would remove the need to obtain new road ROW dedication and avoids dealing with the stretch of ROW connecting Marine Drive to Parker Road. However, the alignment is about 35% longer. Additionally, North Road is a paved road (unlike much of Parker Road), so any work along North Road will have increased restoration requirements.

5 Cost Comparison Estimate

A 'Class D' cost estimate has been prepared to compare the cost between the three options. Based on construction cost comparisons, the route along Parker Drive is the most economical option. However, there are subjective requirements that may factor into the decision making for which is the best option. This may include factors such as MOTI coordination efforts, ROW negotiations, trenchless feasibility, and construction impacts.

	Unit	Quantity	Unit Rate	Total Cost
Original Alignment (Along Sunshine Coast Highway)				
400 mm diameter DI raw water transmission main	LM	2,700	$ 1,200	$ 3,240,000
Port Mellon Hwy Crossing (trenchless)	LM	230	$ 2,000	$ 460,000
Stewart Rd Crossing (trenchless)	LM	60	$ 2,000	$ 120,000
		Sub-Total		**$ 3,820,000**
Alternative Option 1 - Parker Drive				
400 mm diameter DI raw water transmission main along Marine Dr	LM	1,000	$ 1,000	$ 1,000,000
Trenchless connection Marine Drive to Parker Road	LM	400	$ 2,000	$ 800,000
400 mm diameter DI raw water transmission main along Parker Road	LM	1,300	$ 800	$ 1,040,000
400 mm diameter DI raw water transmission main along Highway	LM	500	$ 1,200	$ 600,000
Stewart Rd Crossing (trenchless)	LM	60	$ 2,000	$ 120,000
		Sub-Total		**$ 3,560,000**
Alternative Option 2 - North Road				
400 mm diameter DI raw water transmission main along Marine Dr	LM	4,000	$ 1,000	$ 4,000,000
Stewart Rd Crossing (trenchless)	LM	60	$ 2,000	$ 120,000
		Sub-Total		**$ 4,120,000**

6 Closure

This Report (the "Report") has been prepared by Onsite Engineering Ltd. ("Onsite") for the benefit of the Sunshine Coast Regional District ("Client"). The information, data, recommendations and conclusions contained in the Report:

- are subject to the scope, schedule, and other constraints and limitations and qualifications contained in the Report (the "Limitations");
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- as required by law;
- for use by governmental reviewing agencies.

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Onsite Engineering Ltd.

Prepared by:	Reviewed by:
Stephen Bertulli, P.Eng.	Joel McAllister, P.Eng.

Technical Memorandum #4

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DRAFT

TECHNICAL MEMORANDUM #4

DATE: September 28, 2023
TO: Sunshine Coast Regional District
ATTN: Stephen Misiurak, P.Eng., Manager Capital Projects
FROM: Joel McAllister, P.Eng., Stephen Bertulli, P.Eng.

RE: Alternative Options for Raw Water Transmission Main Alignment Technical Memorandum

1 Introduction

This memorandum has been prepared for the Sunshine Coast Regional District (SCRD) to provide potential alternative configurations to treat water from the Langdale wellfield before connecting to the Chapman Water System (CWS).

2 Background

The SCRD is looking to incorporate two new groundwater wells, located at the Langdale Wellfield, into the (CWS). The SCRD has identified a suitable location for water treatment infrastructure at 1235 Stewart Road. TM #1 discussed a conceptual water treatment plant (WTP), and considered full treatment and storage, as well as other amenities such as an operator's building and general equipment storage. As the anticipated cost for this type of WTP is large the SCRD would like to explore options to lower the capital costs for the WTP.

This Langdale water source would connect to the existing CWS, and as such will need to meet Canadian Water Quality Guidelines (CWQG), avoid upsetting existing treatment practices, or unintentionally create unwanted byproducts when combining different sources of water. It is noted that the CWS is currently served by a surface water source, where as the Langdale water is a ground water source.

3 Approval Requirements

The following provides the minimum requirements for connecting Langdale wellfield water into the CWS:

- Ministry of Health approvals – The construction of new drinking water infrastructure will require a permit from the Ministry of Health (MoH). Through this process, the MoH will review the level of treatment, source water quality, and existing water system to be connected to, among other items. Any options discussed in this memo have not been discussed with the MoH, thus, are subject to comment and approvals.
- Water to Meet CWQG – The Langdale water has been shown to have elevated dissolved iron and manganese, above the aesthetic objective (AO) of the CWQG. Treatment to reduce the

dissolved metals to below AO is readily available; however, as the water is being combined with water of different quality there may be some additional processes involved (after treatment) before combining waters.

4 Alternative WTP Options

The following present two options for discussion on how to reduce capital costs for a new WTP.

4.1 Reduced Scope WTP

The following are the requirements for a reduced scope WTP, assuming use of a pre-packaged treatment plant as discussed in TM#1. Note that a separate sizing exercise is required to confirm that new infrastructure is appropriately sized for the intended purpose, but not larger than necessary.

- Raw Water Reservoir – A raw water reservoir would be required to provide a buffering volume upstream of the treatment process. The size of this tank can be relatively small, as the purpose is to break hydraulic head between the groundwater well pumps and the treatment process. For the purpose of this exercise, a 250 m^3 tank is assumed.
- Treatment Booster Station – A small booster station would be required to pressurize water from the raw water tank through the treatment process.
- Pre-Packaged Treatment Plant – A pre-packaged treatment plant would provide removal of the dissolved iron and manganese to below CWQG. This plant is also able to provide chlorination prior to discharge. This plant generates residual waste that needs to be managed. This building would include chemical storage and monitoring equipment.
- Treated Water Reservoir – A reservoir downstream of the treatment will provide contact time for chlorine. The water level of the reservoir would be designed to match the hydraulic grade line (HGL) of the CWS, allowing it to passively feed the CWS on demand. Typically, reservoirs are sized to meet MMCD design standards; however, if the purpose of the reservoir is not to contribute to fire flow capacity in the CWS, then the sizing can be reduced to provide contact time only. For the purpose of this exercise a single 500 m^3 tank is assumed.
- Residual Management Plan – The pre-packaged treatment plant has a waste stream that requires a discharge point. A waste lagoon is likely the most economical solution for storage, but a plan is required to maintain the sustainability of the lagoon.

4.2 Blending Treatment Option

In lieu of a pre-packaged water treatment plant, a blended water approach may be a viable option. Blending aims to reduce the level of dissolved metals by mixing with a separate source water that has lower concentrations. Once the dissolved metals are below the CDQG threshold level, the water can be combined with the CWS.

- Raw Water/Settling Reservoir – A reservoir would be required to allow for precipitation and settling of dissolved metals. An oxidant is required to assist in the precipitation; chlorine dosing is likely the simplest and most effective method and would primarily remove iron, leaving the majority of dissolved manganese in solution. The chlorine will also provide the necessary disinfection residual. This reservoir would need to be large to provide adequate retention time.

- Blending Reservoir – A blending reservoir would be used to blend CWS water with the 'treated' Langdale water. This approach aims to reduce the dissolved manganese concentration below the AO (0.02 mg/L) through dilution. The Langdale water has a dissolved manganese concentration of 0.047 mg/L. The ratio of blending is dependent on the relative concentrations of dissolved manganese in the two water sources. Assuming a concentration of 0 mg/L in the CWS water, a blending ration of 2.5 parts of CWS water to 1 part Langdale water is required. The water level of the reservoir would be designed to match the HGL of the CWS, allowing it to passively feed the CWS on demand.
- Residual Management – The settling and blending reservoirs would accumulate residuals over time, and they would need to be designed such that they can be cleaned reliably and routinely. A plan is required to prevent excessive build-up of residuals in the tanks.
- General Purpose Building – A building will be required to house necessary equipment for the plant such as chemical storage, monitoring equipment, and other items required by the process.

As noted above, in order to achieve sufficient blending to reduce the iron and manganese concentrations below the AO, a ratio of 1 part Langdale water to 2.5 parts CWS water is required. To fully utilize the capacity of the new Langdale wells (60 L/s), a flow rate of 150 L/s from the CWS is required.

5 Cost Comparison Estimate

A 'Class D' cost estimate has been prepared to compare the cost between the three options. Based on construction cost comparisons, a blended treatment approach may be more economical from a capital cost perspective. However, the actual cost is highly dependent on three factors: MoH requirements actual tanks sizes required for the settling and blending, and ability of the CWS to provide enough water for blending on top of providing typical usage. Costs that would be common to both options, such as land acquisition, are not included.

Reduced WTP Option	Unit	Qty	Unit Price	Amount
Raw Water Reservoir (300 m3)	m3	250	$600	$150,000
Treatment Plant Booster Station	LS	1	$500,000	$500,000
Pre-Package Fe/Mn Treatment Plant incl. chlorination	LS	1	$2,000,000	$2,000,000
Treated Water Reservoir (500 m3)	m3	500	$600	$300,000
Site Civil, Groundworks, Piping, Electrical, SCADA	LS	1	$2,000,000	$2,000,000
Boosting Pump Station	LS	1	$500,000	$500,000
Residuals Management	LS	1	$250,000	$250,000
	Sub-Total (Construction)			**$5,700,000**
Design, Permits, and Construction Management	LS	10%		$570,000
Contingency	LS	40%		$2,280,000
	Sub-Total (Eng., Construct, Contingency)			**$8,550,000**

Blending Option	Unit	Qty	Unit Price	Amount
Settling Reservoir (1000 m3)	m3	1000	$600	$600,000
Blending Reservoir (1000 m3)	m3	1000	$600	$600,000
General Purpose Building	LS	1	$1,000,000	$1,000,000
Site Civil, Groundworks, Piping, Electrical, SCADA	LS	1	$1,000,000	$1,000,000
Boosting Pump Station	LS	1	$500,000	$500,000
Incoming CWS piping	LS	1	$200,000	$200,000
Residuals Management	LS	1	$250,000	$250,000
	Sub-Total (Construction)			**$4,150,000**
Design, Permits, and Construction Management	LS	10%		$415,000
Contingency	LS	40%		$1,660,000
	Sub-Total (Eng., Construct, Contingency)			**$6,225,000**

6 Closure

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Onsite Engineering Ltd.

Prepared by:	Reviewed by:
Stephen Bertulli, P.Eng.	Joel McAllister, P.Eng.