# APPENDIX

# I

STAGE 1 WASTEWATER TREATMENT OPTIONS

PRELIMINARY WASTEWATER TREATMENT LONG LIST OPTIONS
FOR DISCUSSION ONLY

# COMOX VALLEY REGIONAL DISTRICT LIQUID WASTE MANAGEMENT PLAN

JANUARY 18, 2019

**WASTEWATER TREATMENT OPTIONS**

**Overview**

The wastewater treatment options presented here are based on the level of treatment to be implemented (i.e., the effluent quality that will be produced). This is the level of analysis that is appropriate for a Liquid Waste Management Plan (LWMP). More detailed engineering analysis is then undertaken in feasibility and predesign studies (normally following completion of the LWMP), to select and size the treatment processes that will be used to achieve the recommended effluent standards.

Other aspects of wastewater treatment included in LWMPs typically include identification of wastewater treatment service areas (present and future), and the number and location of treatment facilities. For the CVRD LWMP, the study area is based on the service areas for the existing Comox Valley Water Pollution Control Centre (CVWPCC), namely the Town of Comox, the City of Courtenay, and Canadian Forces Base Comox.

The CVWPCC is a secondary treatment facility located at 445 Brent Road in Comox, that is owned and operated by the Comox Valley Regional District (CVRD). Treated wastewater is discharged from the CVWPCC to the Strait of Georgia through a submerged outfall pipe with diffuser that extends 2,825 metres from shore near Cape Lazo, with the outfall terminus 60 metres below the water surface at low tide.

**Location and Number of Treatment Facilities**

In some LWMPs, sites for one or more new treatment facilities must be selected.
Identifying one or more locations for a new wastewater treatment plant is a challenging undertaking. One of the challenges is to identify a suitable location for a new outfall discharge; among other things, this requires a right-of-way for the land section of the outfall from the treatment plant site to the water's edge, where the marine (submerged) section of the outfall pipe begins. The discharge itself is preferably located far from shore in deep water, so that swimming beaches and shellfish beds are not impacted. It is often practical to begin with identification of one or more feasible locations for an outfall discharge, and then identify potential sites for treatment facilities that are within a reasonable distance of the outfall location, and where a feasible route for the land section of the outfall can be developed. Environmental Impact Studies of the receiving environment are required when selecting the location of the outfall discharge; these studies typically consider receiving water ecology and use (marine flora and fauna, recreational use, etc.), local currents, prevailing winds, expected migration and dilution of the discharge plume, etc. The environmental impacts of construction (e.g. in the intertidal zone) must also be evaluated and mitigated.

The costs and benefits of a single wastewater treatment plant versus several smaller plants located throughout a service area (sometimes referred to as "distributed treatment") have been extensively evaluated in British Columbia at a number of locations (e.g., the Greater Victoria area, North Vancouver, and a number of smaller communities such as Powell River). In general, the evaluations have resulted in selection of the single treatment plant approach, due to the significantly higher costs associated with construction and operation of multiple treatment facilities, and the difficulties associated with finding multiple locations for treatment plants and outfall discharges that are acceptable to local residents and that meet all of the technical and regulatory requirements.

As mentioned earlier, a single existing wastewater treatment facility (located at Brent Road near Cape Lazo) and outfall serves the communities of Courtenay and Comox as well as CFB Comox. The existing treatment plant site has adequate unused area for major expansion of the facilities in future as required. Attempting to locate a site for a second treatment facility within the existing service area would be very difficult, partly due to the challenges associated with finding a suitable location for a second outfall to deep water. In this case, there is no apparent driver for constructing additional treatment plants and outfalls to serve the Comox/Courtenay/CFB area, and consequently this does not form part of the wastewater treatment options analysis.

It is possible that a location may be identified within the service area where there is potential for significant use of reclaimed water (e.g., for irrigation or other purposes); in this case, it may be feasible to locate a water reclamation facility near the user(s) of reclaimed water, and direct a portion of the untreated wastewater to that location, thereby reducing the wastewater load to the CVWPCC at Brent Road. This possibility will be explored in the Resource Recovery part of the LWMP.

**Costs of Wastewater Treatment**

The costs of constructing wastewater treatment facilities have risen dramatically in recent years. Capital costs for constructing new facilities can sometimes be partially offset by grants from senior government. However, ongoing operating and maintenance (O&M) and replacement (asset management) costs are entirely borne by the local government. In general, the higher the effluent standards, the greater the capital and ongoing O&M costs of treatment. In general, it is more economical to have a single treatment plant, unless the service area is relatively large with development concentrated in nodes that are far apart.

For the purposes of the LWMP, it is important to carefully consider the capital and O&M costs of wastewater treatment, since these costs are borne by taxpayers. Therefore, it is essential to balance the desire for implementing the highest treatment standards possible with the financial resources available to the community; this particularly applies to O&M costs, which are not eligible for grant funding and fall entirely on local taxpayers.

**Emerging Contaminants**

Emerging Contaminants have been defined as *"Constituents, which have been identified in water, that are considered for regulatory action pending the development of additional information on health and environmental impacts"* (from Metcalf & Eddy, 2014). Examples of Emerging Contaminants may include pharmaceutically active compounds (e.g., antibiotics), endocrine disrupting compounds that affect natural hormones in animals and humans, personal care products, and disinfection byproducts. Many of these products are known to be potentially harmful, but much remains to be learned about their behavior in the environment, and potential methods of treatment. As it stands, domestic wastewater treatment plants are not specifically designed to remove this type of contaminant, although some may be degraded or transformed in the treatment processes, and some may be incorporated into the waste solids.

According to Water Research Foundation Fact Sheet (2016): *Detecting a compound in water does not mean that adverse health effects will occur or are likely. In general, no relationships have been established between pharmaceuticals in water at environmental levels and adverse effects in human Strategies for preventing endocrine disrupting compounds (EDCs) and pharmaceuticals and personal care products (PPCPs) from entering water supplies include improved wastewater treatment and other source water protection strategies. Once EDCs and PPCPs have entered a utility's water supply, no single treatment process can remove them all due to their wide range of physicochemical properties. In general, both conventional and advanced water treatment systems have the capability to reduce the concentration of EDCs and PPCPs in water to some degree, though removal by conventional treatment processes is limited. Advanced treatment processes such as nanofiltration, reserve osmosis, and activated carbon are more effective but can be expensive and energy-intensive.*

Metals may also be a concern where they accumulate to toxic concentrations. Domestic wastewater treatment plants are not designed to remove metals from the wastewater stream. However, it has been shown that many of the so-called "heavy metals" tend to associate with solid particles in water. Thus removal of suspended solids from wastewater will result in at least partial removal of these associated metals as well (the solids must also be dealt with but are much less in volume than the wastewater stream).

Microplastics have recently been identified as a concern as well. According to Water Research Foundation (2018): *Studies have found that WWTPs removed between 90-99% of microplastics (<0.5 cm), with most being captured in the sludge. However, when dealing with large volumes of effluent, even a small concentration of microplastics being released can result in a significant contribution to the environment. Current research indicates that the microplastics in the environment has not caused adverse effects on aquatic wildlife as opposed to macroplastics, which can cause physical harm to fish-eating birds, aquatic mammals, reptiles and fish. If it is shown that microplastics should be removed from effluent, filtration is likely the best treatment, though more research on removal of microplastics, particularly for sizes smaller than 300 um, is needed.*

**Options for Treatment**

For the purposes of Stage 1 of the LWMP, four options for treatment were identified for discussion with the TAC/PAC. The four options are based on the effluent quality to be produced as stated at the beginning of this discussion, and are presented as concepts for planning of future expansions and/or upgrades. Option 1 would be to meet the provincial and federal discharge standards; these standards have been developed to protect the receiving environment, and the provincial regulation allows the regulating body to impose additional standards in specific cases where this is shown to be needed to protect the environment. Options 2, 3 and 4 are based on voluntarily enhancing effluent quality beyond what is required by the regulations. Options 1 through 4 are described on the following pages. Note that Option 2 describes the current configuration of the CVWPCC, with the addition of disinfection.

| Long-List Option No. 1 | Meet Regulatory Discharge Standards |
|---|---|

**Description**

Option 1 would meet federal and provincial regulatory requirements for secondary treatment with discharge to open marine waters (the CVWPCC outfall extends 2,825 metres from shore at Cape Lazo into the Strait of Georgia and the discharge diffuser is 60 metres below water at low tide). As with the other options, an updated Environmental Impact Study (EIS) would be required to identify any additional treatment requirements that might be needed to address protection of the receiving environment according to provincial regulations. If the EIS did not identify any additional requirements beyond what is required to meet the secondary treatment discharge standards set out in the B.C. Municipal Wastewater Regulation (MWR) and the Canada Wastewater Systems Effluent Regulations (WSER), the following treatment and discharge standards would apply to Option 1:

**MWR**

Secondary treatment for flows up to two times average dry weather flow (2xADWF):

- 5-day Biochemical Oxygen Demand ($BOD_5$): max. day 45 mg/L
- total suspended solids (TSS): max. day 45 mg/L
- pH 6 to 9
- ammonia concentration does not cause chronic toxicity at the edge of the initial dilution zone (IDZ)

Primary treatment for flows in excess of 2xADWF (interim):

- 5-day Biochemical Oxygen Demand ($BOD_5$): max. day 130 mg/L
- total suspended solids (TSS): max. day 130 mg/L
- note that if flows are > 2xADWF during a storm or equivalent snowmelt event with a less than 5-year return period, a discharger must (have a liquid waste management plan or specific study and implement the plan's or study's measures.

**WSER**

- 5-day Biochemical Oxygen Demand ($BOD_5$): monthly avg. not to exceed 25 mg/L
- total suspended solids (TSS): monthly avg. not to exceed 25 mg/L
- total residual chlorine < 0.02 mg/L
- un-ionized ammonia < 1.25 mg N/L at 15°C
- note that the WSER standards apply to the combined discharge – this may require chemical addition to enhance primary treatment or other measures to ensure that the secondary treatment bypass does not cause the combined effluent to exceed the WSER discharge standards for $BOD_5$ and TSS

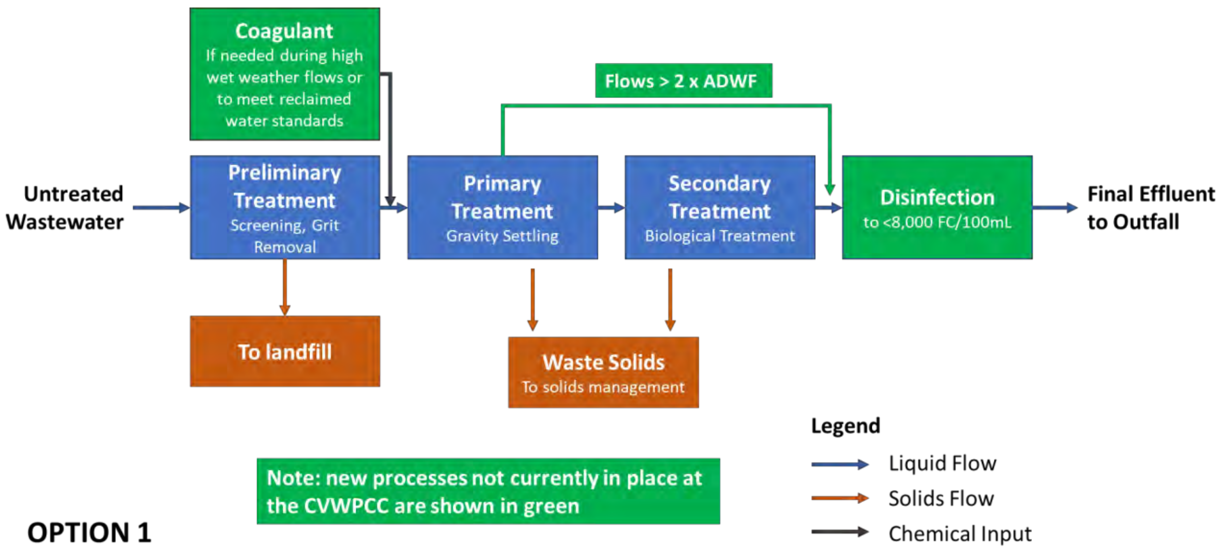
An EIS was completed for the CVWPCC discharge in 2010; this showed that disinfection of the effluent to achieve a fecal coliform count of less than 8000/100 mL in the CVWPCC discharge would be required to protect local shellfish resources outside the initial dilution zone (IDZ). Disinfection to this standard was assumed for Option 1.

Note that plant data from 2013 to 2017 show that the number of days when flows exceeded 2xADWF ranged from 0 days (2013) to 31 days (2015) – over the 5 years of record, flow exceeded 2xADWF on a total of 58 days (the total volume of flow greater than 2xADWF represented only about 1% of the total plant flow over that period)

| Advantages | Disadvantages |
|---|---|
| • meets regulatory requirements for discharge to open marine waters<br>• avoids the cost of subjecting relatively infrequent high wet weather flows to secondary treatment | • flows in excess of 2xADWF would bypass secondary treatment and so would not receive biological treatment |

| | |
|---|---|
| • coagulating chemicals can be added to enhance primary treatment if needed when flows exceed 2xADWF<br>• includes disinfection to protect shellfish resources outside the IDZ | |

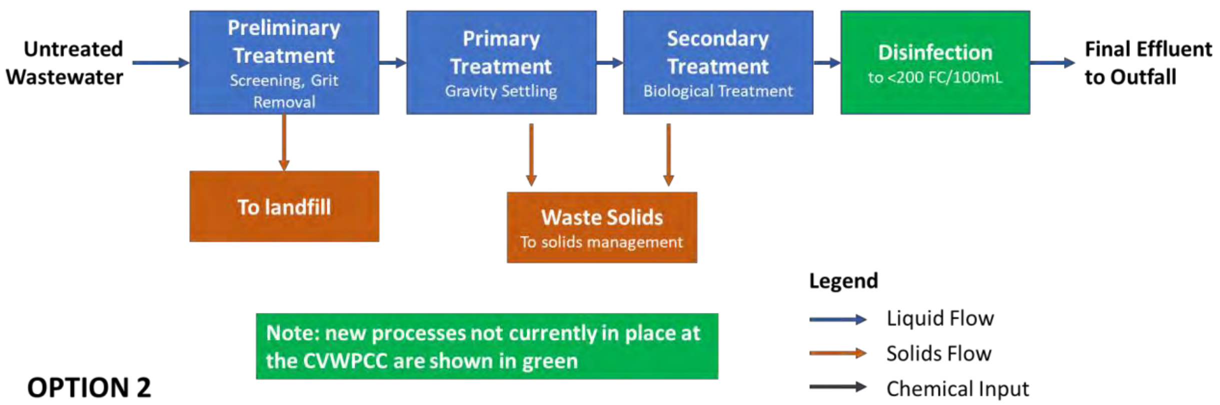
**Process Schematic for Option 1**



<table>
<tr><th>Long-List Option No. 2</th><th>Provide Secondary Treatment for all Flows</th></tr>
<tr><td>Description</td><td>
Option 2 is similar to Option 1, except that there would be no wet weather bypass of flows in excess of 2xADWF around secondary treatment. For Option 2, the entire plant influent flow would pass through secondary treatment (this is the current configuration of the CVWPCC). As with the other options, an updated Environmental Impact Study (EIS) would be required to identify any additional treatment requirements that might be needed to address protection of the receiving environment. For Option 2, it was assumed that the disinfection process would be designed to achieve recreational standards (i.e. 200 FC/100 mL) in the undiluted effluent. The following treatment and discharge standards would apply to Option 2.<br><br>
Secondary treatment for the entire plant flow:
<ul>
<li>5-day Biochemical Oxygen Demand ($BOD_5$): max. day 45 mg/L, monthly avg. not to exceed 25 mg/L</li>
<li>total suspended solids (TSS): max. day 45 mg/L, monthly avg. not to exceed 25 mg/L</li>
<li>pH 6 to 9</li>
<li>ammonia concentration does not cause chronic toxicity at the edge of the initial dilution zone (IDZ)</li>
<li>total residual chlorine $< 0.02$ mg/L</li>
<li>un-ionized ammonia $< 1.25$ mg N/L at 15°C</li>
<li>disinfection - fecal coliforms not to exceed 200 FC/1900 mL</li>
</ul>
</td></tr>
</table>

| Advantages | Disadvantages |
|---|---|
| • exceeds regulatory requirements for discharge to open marine waters<br>• entire plant flow is subjected to secondary (biological) treatment<br>• includes enhanced disinfection to protect shellfish resources<br>• effluent meets standards for reclaimed water use for lower exposure potential | • secondary treatment must be sized accommodate all wet weather flows, increasing capital and operating costs compared to Option 1 |

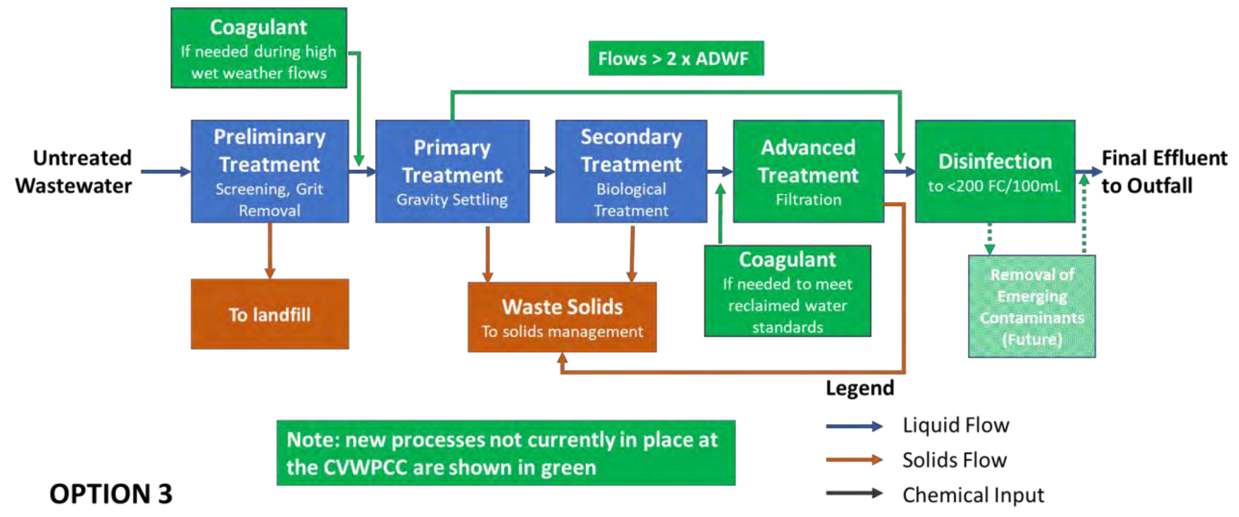
**Process Schematic for Option 2**



| Long-List Option No. 3 | Advanced Treatment for up to 2xADWF |
|---|---|
| Description | Option 3 would incorporate the same preliminary, primary and secondary treatment processes as Option 2. In addition, Option 3 would include advanced filtration of the secondary treated effluent for flows up to two times the average dry weather flow (2xADWF) to enhance removal of suspended solids. As with the other options, an updated Environmental Impact Study (EIS) would be required to identify any additional treatment requirements that might be needed to address protection of the receiving environment. For Option 3, it was assumed that the disinfection process would be designed to achieve standards for lower exposure potential (i.e. 200 FC/100 mL) in the undiluted (combined) effluent. The following treatment and discharge standards would apply to Option 3.<br><br>Advanced treatment (filtration) for flows up to 2xADWF:<br>• 5-day Biochemical Oxygen Demand ($BOD_5$): max. day 10 mg/L, avg. 5 mg/L<br>• total suspended solids (TSS): max. day 10 mg/L, avg. 5 mg/L<br>• pH 6 to 9<br>• ammonia concentration does not cause chronic toxicity at the edge of the initial dilution zone (IDZ)<br>• total residual chlorine < 0.02 mg/L<br>• un-ionized ammonia < 1.25 mg N/L at 15°C<br>• future addition of processes that are proven for removal of emerging contaminants at municipal wastewater plants<br>Primary treatment for flows in excess of 2xADWF (interim):<br>• 5-day Biochemical Oxygen Demand ($BOD_5$): max. day 130 mg/L<br>• total suspended solids (TSS): max. day 130 mg/L<br>• note that if flows are > 2xADWF during a storm or equivalent snowmelt event with a less than 5-year return period, a discharger must (have a liquid waste management plan or specific study and implement the plan's or study's measures.<br>Disinfection of combined effluent - fecal coliforms not to exceed 200 FC/100 mL<br><br>note that plant data from 2013 to 2017 show that the number of days when flows exceeded 2xADWF ranged from 0 days (2013) to 31 days (2015) – over the 5 years of record, flow exceeded 2xADWF on a total of 58 days (the total volume of flow greater than 2xADWF represented only about 1% of the total plant flow over that period) |

| Advantages | Disadvantages |
|---|---|
| • exceeds regulatory requirements for discharge to open marine waters<br>• majority of plant flow is subjected to advanced treatment<br>• includes enhanced disinfection to protect shellfish resources<br>• combined effluent meets standards for reclaimed water use for lower exposure potential<br>• ability to increase coagulation and disinfection to meet standards for moderate or greater exposure potential | • higher capital and operating costs than Options 1 and 2<br>• flows > 2xADWF do not pass through advanced treatment<br>• higher operational costs if treating reclaimed water to greater exposure potential standard |

Process Schematic for Option 3



| Long-List Option No. 4 | Advanced Treatment for all Flows |
|---|---|

**Description**

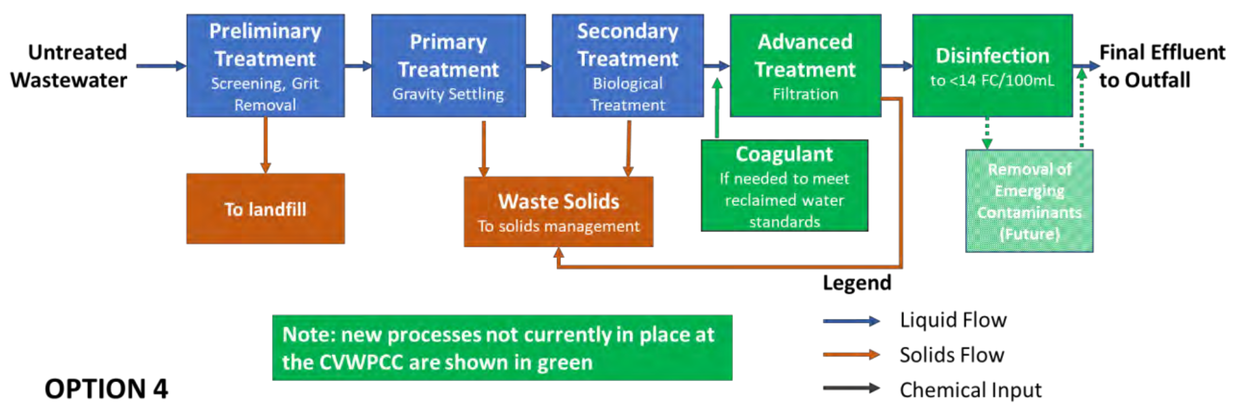
Option 4 would incorporate the same preliminary, primary, secondary, and advanced treatment processes as Option 3. However, for Option 4, the entire plant influent flow would pass through advanced filtration to enhance removal of suspended solids. As with the other options, an updated Environmental Impact Study (EIS) would be required to identify any additional treatment requirements that might be needed to address protection of the receiving environment. For Option 4, it was assumed that the disinfection process would be designed to achieve shellfish standards (i.e. 14 FC/100 mL) in the undiluted effluent, and disinfection could be increased to meet the reclaimed water standards for greater exposure potential (<1FC<100mL) if desired. The following treatment and discharge standards would apply to Option 4.

Advanced treatment for the entire plant flow:

- 5-day Biochemical Oxygen Demand ($BOD_5$): max. day 10 mg/L, avg. 5 mg/L
- total suspended solids (TSS): max. day 10 mg/L, avg. 5 mg/L
- pH 6 to 9
- ammonia concentration does not cause chronic toxicity at the edge of the initial dilution zone (IDZ)
- total residual chlorine < 0.02 mg/L
- un-ionized ammonia < 1.25 mg N/L at 15°C
- disinfection - fecal coliforms not to exceed 14 FC/100 mL
- future addition of processes that are proven for removal of emerging contaminants at municipal wastewater plants

| Advantages | Disadvantages |
|---|---|
| • exceeds regulatory requirements for discharge to open marine waters<br>• entire plant flow is subjected to advanced treatment<br>• includes enhanced disinfection to protect shellfish resources<br>• effluent meets standards for reclaimed water use for greater exposure potential | • higher capital and operating costs than Options 1, 2 and 3<br>• higher operational costs if treating reclaimed water to greater exposure potential standard |

**Process Schematic for Option 4**



# APPENDIX

# J

## STAGE 2 WASTEWATER TREATMENT FEASIBILITY ASSESSMENTS

# MEMO

**TO:** CVRD LWMP TACPAC Committee

**CC:** Kris La Rose, P.Eng., CVRD, Zoe Berkey, EIT, CVRD, Paul Nash

**FROM:** Tyler Barber, MASc, P.Eng., Aline Bennett, MASc, P.Eng., Al Gibb, PhD, P.Eng.

**SUBJECT:** **CVRD LWMP – Stage 2 Wastewater Treatment Level Assessments**

**DATE:** **February 12, 2020**

## INTRODUCTION

The Comox Valley Regional District (CVRD) has retained WSP Canada Group Ltd. to complete the Liquid Waste Management Plan (LWMP) for the District. As part of the work, WSP has completed the Stage 2 wastewater assessment for the Comox Valley Water Pollution Control Centre (CVWPCC). This work is a high-level review of the estimated capacity of the existing infrastructure at the CVWPCC, what is required for expansion to handle 2040 flows and loads into the CVWPCC and costing different level of wastewater treatment options for the CVWPCC.

This memo provides the following information:

- Updated CVWPCC population, flow and load projections;
- High-level review of the capacity of each unit process (attached in the Appendix);
- Cost estimates for upgrading the plant to meet 2040 capacity requirements and providing different levels of wastewater treatment including:
  - Option 1: was not advanced from the long-list
  - Option 2: Secondary treatment for entire flow with disinfection (base case)
  - Option 3: Addition of advanced treatment for 2xADWF
  - Option 4: Addition of advanced treatment for the entire flow
  - Option 5: Addition of reclaimed water for in plant use, which can be common to all options

Note that Option 1: was not advanced from the long-list, since this would represent a step back from current practice in terms of effluent quality.

The objective of this assessment is to enable decision making on the appropriate level of wastewater treatment to provide at the CVWPCC by comparing the costs and benefits of the different options. The *CVWPCC Capacity Assessment* completed by ISL Engineering and Land Services in 2016, was a significant input to this assessment.

## REGULATORY REQUIREMENTS AND EFFLUENT QUALITY

The Wastewater Systems Effluent Regulations (WSER) is the only federal regulation that exists to control domestic wastewater discharges nationwide. The WSER is established under the Fisheries Act and includes mandatory minimum effluent quality standards that must be achieved through secondary wastewater treatment. The WSER applies to wastewater treatment systems that treat more than 100 $m^3$ of wastewater per day. The regulated compounds are total suspended solids (TSS), carbonaceous biochemical oxygen demand ($cBOD_5$), total residual chlorine, and un-ionized ammonia. In the case of the CVWPCC, the characteristics of the effluent must be equivalent to or better than an average monthly $cBOD_5$ and TSS concentrations of 25 mg/L.

The Provincial Municipal Wastewater Regulation (MWR) regulates wastewater discharges to waters in BC. Under the MWR, compounds such as pH, $cBOD_5$, TSS, and in some cases total phosphorus and ortho-phosphate are monitored, and their release to the receiving environment is controlled. The MWR requires that the CVWPCC effluent maximum day concentration of a $cBOD_5$ and TSS not exceed 45 mg/L.

The CVWPCC discharge is not currently registered under the MWR. Authorization of the discharge is grandfathered under Permit No. 5856. Under this Permit, the CVRD is required to meet the discharge criteria for a maximum daily discharge rate (18,500 $m^3$/d), maximum day $BOD_5$ (45 mg/L) and maximum day TSS (60 mg/L).

The CVWPCC effluent quality data was reviewed and analyzed for the period from 2014 to 2019. The effluent was sampled and analyzed for $cBOD_5$ and TSS at least once a month as required by the discharge permit ($cBOD_5$ and $BOD_5$ were both measured every 2 weeks). It should be noted that $cBOD_5$ analyses started in October 2014; prior to that, total BOD measurements were used.

The plant effluent concentration of TSS from 2014 to 2019 is shown in Figure 1 (monthly average concentration) and Figure 2 (daily concentration). The monthly average TSS concentration exceed the WSER criteria of 25 mg/L once in 2017 (Figure 1). As shown in Figure 2, the effluent daily TSS concentration was below the allowable maximum specified in both Permit No. 5856 (60 mg/L) and the MWR (45 mg/L). Study of Figure 2 shows that the monthly average effluent TSS concentration was typically in the range of 5 mg/L to 15 mg/L from 2014 to the present.

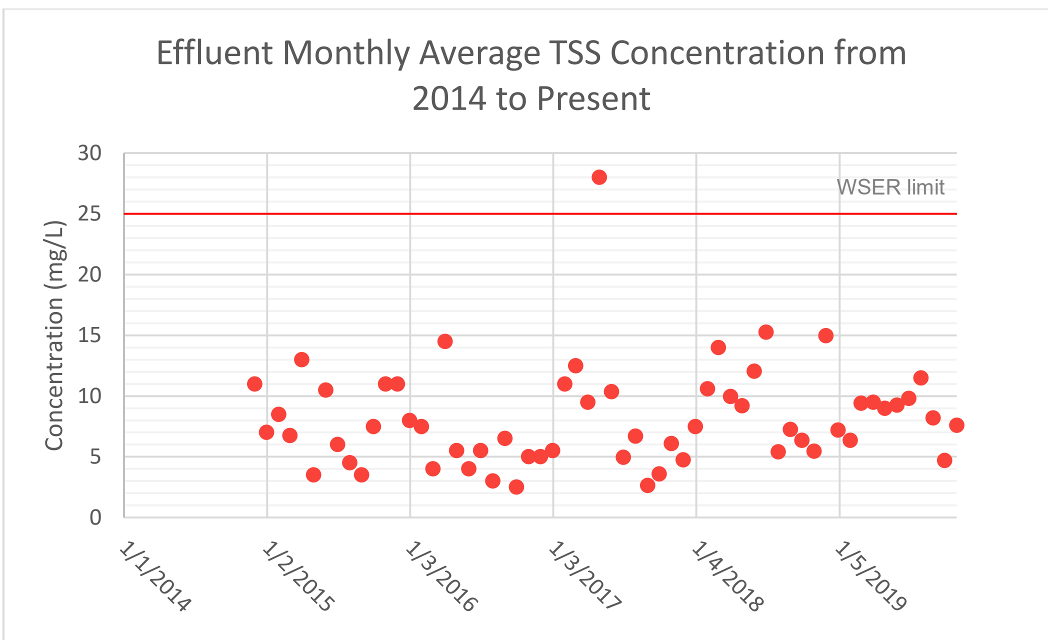



*Figure 1 Effluent Monthly Average TSS Concentration (2014-2019)*

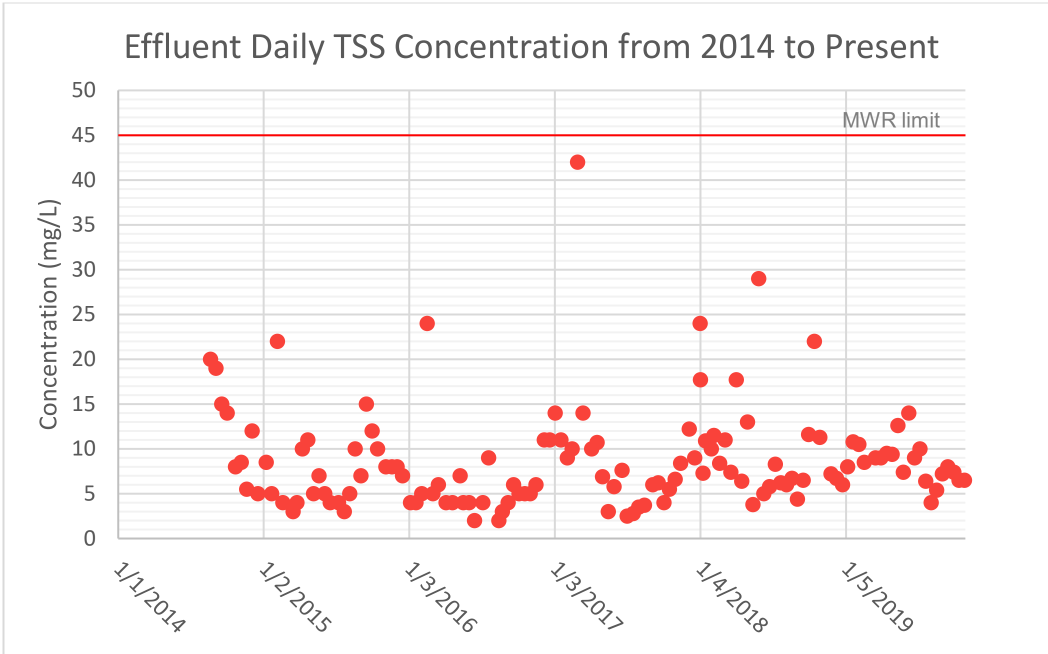



*Figure 2 Effluent Daily TSS Concentration (2014-2019)*

The plant effluent quality for $cBOD_5$ is shown in Figure 3 (monthly average) and Figure 4 (daily). All of the values are within the regulatory limits specified in the WSER, the MWR and Permit No. 5856. Similar to the data for TSS, the monthly average $cBOD_5$ concentration was typically in the range of 5 mg/L to 15 mg/L.

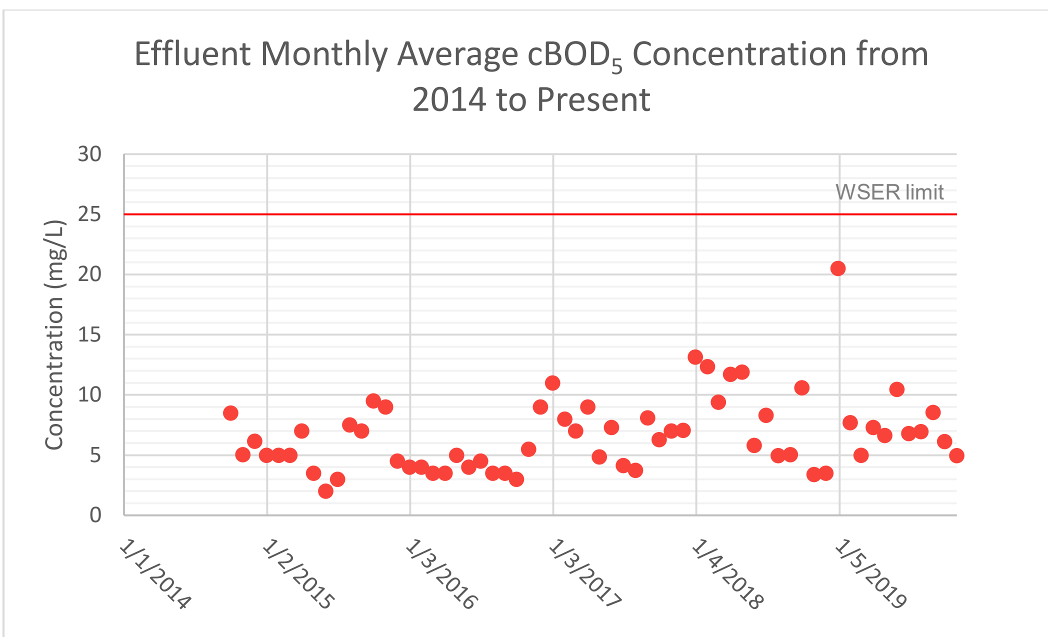



*Figure 3 Effluent Monthly Average $cBOD_5$ Concentration (2014-2019)*

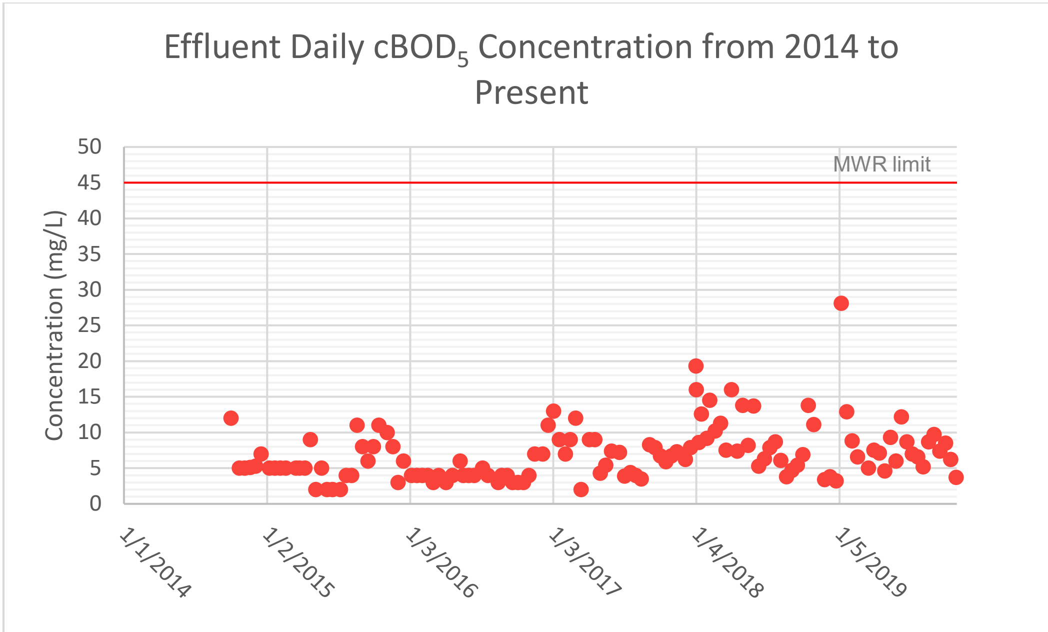



*Figure 4 Effluent Daily cBOD₅ Concentration (2014-2019)*

A statistical analysis of effluent quality data is shown in Figure 5. The log-normal distribution of effluent $cBOD_5$ and TSS concentration data was used, where a particular sample value is a function of sample size and the rank of the particular sample. The sample values are ranked from smallest to largest and the corresponding plotting position is determined using the following formula:

$$Plotting\ Position, \% = \left(\frac{m}{n+1}\right) \times 100$$

where, m is the rank serial number and n is the number of observations.  As shown in Figure 5, the effluent concentration of $cBOD_5$ was 14 mg/L or less 95% of the time, and the TSS concentration was 20 mg/L or less 95% of the time over a period of record.  The steep rise in the curves beyond 95% show that a small number of data points (5%) significantly exceeded these values.

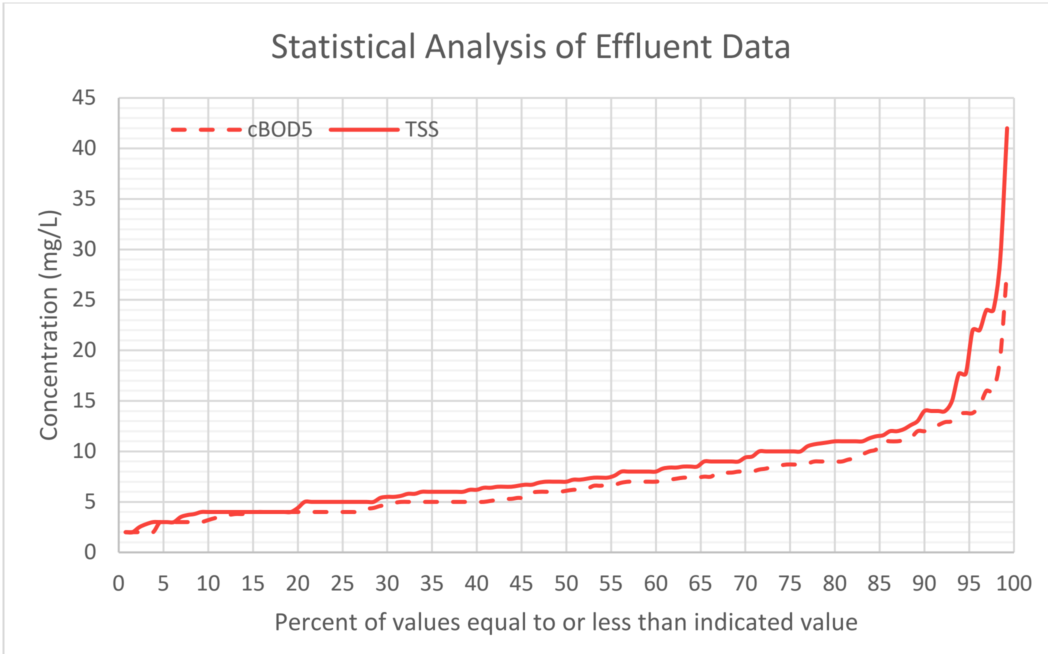



*Figure 5 Statistical Analysis of Effluent Quality Data*

## TSS AND CBOD$_5$ REMOVAL RATES

The performance of the CVWPC treatment processes was assessed in term of removal of TSS and cBOD$_5$ from wastewater. The results are presented in Figure 6. The assessed period is from October 2014 to December 2017 due to a limited amount of influent data available for both parameters. There was no influent cBOD$_5$ data available, instead the influent BOD$_5$ data was used to estimate the cBOD$_5$ removal. The influent cBOD$_5$ and BOD$_5$ concentrations are expected to be similar as nitrifying bacteria are not commonly present in the influent wastewater. The average percentage removal of TSS and cBOD$_5$ during the assessed period (Oct 2014 to Dec 2017) was 97%. The removal rate for TSS was consistently high ranging from 95% to 99% most of the time with an average effluent concentration is less than 9 mg/L. The removal rate of cBOD$_5$ was above 93% and an average effluent concentration of less than 8 mg/L. Removal rates can be expected to decline as loading to the plant increases.

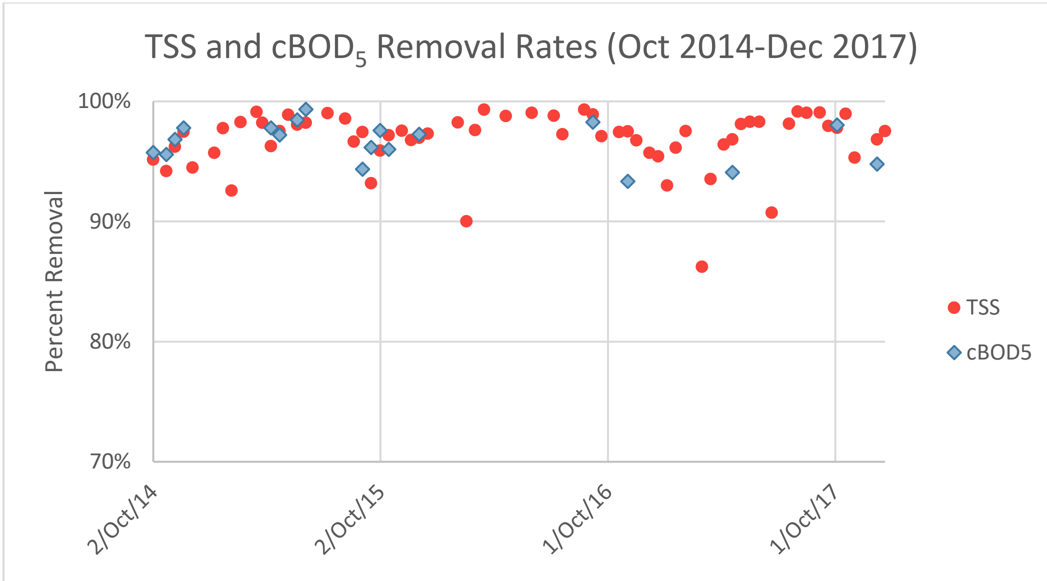



*Figure 6 TSS and cBOD₅ Removal Rates*

# POPULATION, FLOW AND LOAD PROJECTIONS

## CVWPCC POPULATION PROJECTIONS

Population for the CVWPCC service area is projected based on expected growth rates for the area. Current service areas to the CVWPCC include the City of Courtenay, the Town of Comox, CFB Comox and K'ómoks First Nation (KFN). Historical population for the City of Courtenay and the Town of Comox (includes KFN) was obtained from the BC Stats database. According to the 2016 ISL *CVWPCC Capacity Assessment* report, future connections to the CVWPCC service area include 400 single-family units referred to as the CVRD Annexation; this is also included in the population assessment shown in Table 1. Service area growth is projected using the annual growth rates used by ISL in their 2016 *CVWPCC Capacity Assessment*. Table 1 shows the historical and projected populations for the service area; as shown, the CVWPCC.

*Table 1: Historical and Projected CVWPCC Service Population to Year 2060*

| YEAR | CITY OF COURTENAY [1] | TOWN OF COMOX [2] | CFB COMOX | CVRD ANNEXATION [3] | K'OMOKS FIRST NATION [4] | TOTAL |
|---|---|---|---|---|---|---|
| **2013** | 24,815 | 13,933 | 966 | - | | 39,714 |
| **2014** | 25,187 | 14,216 | 966 | - | | 40,369 |
| **2015** | 25,782 | 14,518 | 966 | - | | 41,266 |
| **2016** | 26,736 | 14,652 | 966 | - | | 42,354 |
| **2017** | 27,146 | 14,850 | 966 | - | | 42,962 |
| **2018** | 27,533 | 14,706 | 966 | - | 293 | 43,498 |
| **2019** | 28,117 | 14,994 | 966 | - | 293 | 44,370 |

| YEAR | CITY OF COURTENAY [1] | TOWN OF COMOX [2] | CFB COMOX | CVRD ANNEXATION [3] | K'OMOKS FIRST NATION [4] | TOTAL |
|---|---|---|---|---|---|---|
| **Projected Population** | | | | | | |
| **2020** | 28,713 | 15,281 | 966 | | 299 | 45,259 |
| **2030** | 33,053 | 17,558 | 966 | 1,098 | 343 | 53,018 |
| **2040** | 37,759 | 20,057 | 966 | 1,274 | 392 | 60,448 |
| **2050** | 43,135 | 22,913 | 966 | 1,478 | 448 | 68,940 |
| **2060** | 49,277 | 26,176 | 966 | 1,716 | 511 | 78,645 |

1 2020 – 2021 growth rate of 2.12% and 2022 – Future growth rate of 1.34% from ISL 2016
2 2020 – 2021 growth rate of 1.92% and 2022 – Future growth rate of 1.34% from ISL 2016
3 2020 – Future growth rate of 1.5% used from ISL 2016
4 Assuming 122 units, with 2.4 people per connection. Growth rate of 1.34%. .

## FLOW PROJECTIONS

The 2013 to 2017 flow rates provided in Table 2 were used to generate average per capita flow rates into the CVWPCC. These were applied to future year population projections to determine future flow rates to year 2060. The flow rates were determined as follows:

— Average Dry Weather Flow (ADWF): Minimum 30-day rolling average flow for the year;
— Average Daily Flow (ADF): Average flow during the year;
— Average Wet Weather Flow (AWWF): Maximum 30-day rolling average flow for the year;
— Max day flow (MDF): Maximum single day flow in the year;
— Peak Hourly Flow (PHF): Peaking factor developed by ISL (2016) was used to determine projected PHF (3.0 x ADF); and
— Maximum Instantaneous Flow: Peaking factor developed by ISL (2016) was used to determined projected maximum instantaneous flow (3.2 x ADF).

*Table 2: Historical Flows, 2013-2017*

| | | HISTORICAL FLOWS [1], $M^3$/DAY | | | | UNIT FLOWS, L/C/D | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Year** | **Population** | **ADWF** | **ADF** | **AWWF** | **MDF** | **ADWF** | **ADF** | **AWWF** | **MDF** |
| 2013 | 39,714 | 12,142 | 13,249 | 15,029 | 21,225 | 306 | 334 | 378 | 534 |
| 2014 | 40,369 | 11,906 | 14,221 | 20,000 | 38,462 | 295 | 352 | 495 | 953 |
| 2015 | 41,266 | 11,504 | 13,732 | 21,914 | 37,253 | 279 | 333 | 531 | 903 |
| 2016 | 42,354 | 11,518 | 15,462 | 23,533 | 39,998 | 272 | 365 | 556 | 944 |
| 2017 | 42,962 | 11,694 | 14,328 | 19,650 | 34,965 | 272 | 334 | 457 | 814 |
| | | | | | **Average** | **285** | **343** | **484** | **830** |

1 From Daily Influent Plant Data.

With the data available to WSP at the time of completing this memo, peak hourly flows (PHF) and maximum instantaneous flow were not able to be determined with the data, therefore the peaking factors from ISL (2016) were used. Table 3 shows these projected future flows from 2020 to 2060. These flow projections use the same per capita flows determined in Table 3.

*Table 3: Flow Projections, 2020-2060*

| | 2020 | 2030 | 2040 | 2050 | 2060 |
|---|---|---|---|---|---|
| **Population Projection** | 45,259 | 53,018 | 60,448 | 68,940 | 78,645 |
| **Flow Projections** | | | | | |
| Average Dry Weather Flow (ADWF) ($m^3/d$) | 12,885 | 15,094 | 17,210 | 19,627 | 22,390 |
| Average Day Flow (ADF) ($m^3/d$) | 15,542 | 18,206 | 20,758 | 23,674 | 27,007 |
| Average Wet Weather Flow (AWWF) ($m^3/d$) | 21,887 | 25,640 | 29,233 | 33,339 | 38,033 |
| Max Day Flow (MDF) ($m^3/d$) | 37,547 | 43,984 | 50,148 | 57,193 | 65,244 |
| Peak Hour Flow [1] (PHF) ($m^3/d$) | 46,626 | 54,619 | 62,274 | 71,022 | 81,020 |
| Maximum Instantaneous [2] ($m^3/d$) | 49,734 | 58,260 | 66,425 | 75,757 | 86,421 |
| Maximum Instantaneous (L/s) | 576 | 674 | 769 | 877 | 1,000 |

1 Peaking Factor of 3.0 was adapted from the ISL CVWPCC Capacity Assessment (2016).

2 Peaking Factor of 3.2 was adapted from the ISL CVWPCC Capacity Assessment (2016).

## LOAD PROJECTIONS

Table 4 summarizes the historical (2013 to 2017) CVWPCC influent 5-day Biochemical Oxygen Demand ($BOD_5$) and Total Suspended Solids (TSS) loadings used to develop average per capita unit loading rates. The $cBOD_5$ and TSS data are taken from weekly composite samples. Average $BOD_5$ and TSS influent loads to the CVWPCC are shown in Table 4.

*Table 4: CVWPCC Historical Influent Loading, 2013-2017*

| | | HISTORICAL INFLUENT LOADING [1] KG/D | | | | INFLUENT UNIT LOADING `G/C/D | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Year** | **Population [2]** | **Average $BOD_5$** | **Max Month $BOD_5$** | **Average TSS** | **Max Month TSS** | **Average $BOD_5$** | **Max Month $BOD_5$** | **Average TSS** | **Max Month TSS** |
| 2013 | 39,714 | 3,327 | 4,085 | 3,425 | 4,383 | 84 | 103 | 86 | 110 |
| 2014 | 40,369 | 3,720 | 8,983 | 4,144 | 6,198 | 92 | 223 | 103 | 154 |
| 2015 | 41,266 | 3,675 | 5,641 | 3,977 | 5,351 | 89 | 137 | 96 | 130 |
| 2016 | 42,354 | 2,605 | 6,919 | 4,412 | 6,988 | 62 | 163 | 104 | 165 |
| 2017 | 42,962 | 2,946 | 4,306 | 4,116 | 5,189 | 69 | 100 | 96 | 121 |
| | | | | | **Average** | **79** | **145** | **97** | **136** |

1 Plant Data. We have assumed this data includes all return streams from the plant.

2 Population was obtained from BC Stats.

The average per capita loading for $BOD_5$ and TSS were rounded to 80 and 100 g/c/d. These values compare to the ISL (2016) per capita values used of 90 g/c/d and 100 g/c/d for $BOD_5$ and TSS, respectively. We have assumed that the loads from ISL (2016) and the data WSP analyzed includes the additional loading received from septage and return flows in the plant.

We note that the peaking factor between average and max month $BOD_5$ per capita loading (1.8) is more than what would be expected for typical domestic wastewater. Therefore, we have removed the 223 g/c/d data point for the year 2014 and are using an average max month per capita loading of 126 g/c/d for $BOD_5$. TSS max month loading was found to be 136 g/c/d. This compares with the max month loading from ISL (2016) of 117 g/c/d and 120 g/c/d for $BOD_5$ and TSS, respectively.

No data was available for Total Kjeldahl Nitrogen (TKN), therefore loading data is based on per capita unit rates from ISL (2016). The TKN loading determined in ISL (2016) was based on 13 g/c/d, which is considered typical for domestic wastewater without any industrial loading. They also determined a peaking factor of 1.1 between average and max month loading. These same values were carried forward for projecting TKN load to the CVWPCC. Table 5 shows the projected future loads to the CVWPCC for $BOD_5$, TSS, and TKN.

*Table 5: Load Projections, 2020-2060*

| | **2020** | **2030** | **2040** | **2050** | **2060** |
|---|---|---|---|---|---|
| **Population Projection** | 45,259 | 53,018 | 60,448 | 68,940 | 78,645 |
| **Load Projections** | | | | | |
| **$BOD_5$** | | | | | |
| Average $BOD_5$ (kg/d) | 3,621 | 4,241 | 4,836 | 5,515 | 6,292 |
| Max month $BOD_5$ (kg/d) | 5,693 | 6,669 | 7,603 | 8,672 | 9,892 |
| **TSS** | | | | | |
| Average TSS (kg/d) | 4,526 | 5,302 | 6,045 | 6,894 | 7,865 |
| Max month TSS (kg/d) | 6,155 | 7,210 | 8,221 | 9,376 | 10,696 |
| **TKN** | | | | | |
| Average TKN (kg/d) | 588 | 689 | 786 | 896 | 1,022 |
| Max month TKN (kg/d) | 647 | 758 | 864 | 986 | 1,125 |

# CVWPCC UPGRADE OPTIONS

## EXISTING WASTEWATER TREATMENT SYSTEM

The CVWPCC is a secondary treatment level activated sludge plant that was constructed in 1982 and receives flow from five (5) pump stations. The plant has the following treatment processes at the facility:

— Preliminary treatment with two coarse bar screens and three pre-aeration grit removal tanks;
— Three primary clarifiers;
— Three activated sludge aeration basins;
— Three secondary clarifiers;

- Effluent outfall and pump station for peak flows;
- Two gravity thickeners for the primary sludge (PS);
- Two dissolved air flotation (DAF) units for waste activated sludge (WAS) thickening;
- One combined (PS and WAS) thickened sludge storage tank;
- Two centrifuges for dewatering;
- Ancillary process such as odour control and grit classification.

A capacity assessment for each unit process is provided in the Appendix, which reviews the technical details for each of the unit processes and estimates the capacity for treatment. This assessment did not investigate the condition of the assets and assumes any infrastructure planned for reuse is in a serviceable condition.

## OPTIONS FOR ASSESSMENT

The following options (Table 6) were developed from the Stage 1 LWMP long-list in January 2019. All the options, except for Option 1 were advanced to the Stage 2 shortlist for more detailed assessment. Option 1 was not carried forward since it represents a step-back form the existing treatment system.

*Table 6: Options for Assessment*

| OPTION | DESCRIPTION | ADVANCE TO STAGE 2? |
|---|---|---|
| **Option 1 – Secondary treatment for flows up to 2xADWF with disinfection** | Secondary treatment for flows up to 2 x ADWF:<br>— 5-Day $BOD_5$: Max day <45 mg/L; monthly average <25 mg/L<br>— TSS: Max day <45 mg/L, monthly average <25 mg/L<br>— pH 6 – 9<br>— Ammonia does not cause chronic toxicity at the edge of the IDZ<br>— Total residual chlorine < 0.02 mg/L<br>— Un-ionized ammonia < 1.25 mg/L at 15°C<br>— Disinfection – fecal coliforms not to exceed 200 MPN/100 mL (end of pipe)<br>Primary treatment for flows in excess of 2 x ADWF:<br>— 5-day $BOD_5$: Max day <130 mg/L<br>— TSS: Max day < 130 mg/L<br>— In this scenario, primary treated flows >2xADWF are bypassed around secondary treatment and then blended with the secondary treated flow. | No |
| **Option 2 - Secondary treatment for entire flow with disinfection (base case)** | Secondary treatment for the entire plant flow:<br>— 5-Day $BOD_5$: Max day <45 mg/L; monthly average <25 mg/L<br>— TSS: Max day <45 mg/L, monthly average <25 mg/L<br>— pH 6 – 9<br>— Ammonia does not cause chronic toxicity at the edge of the IDZ<br>— Total residual chlorine < 0.02 mg/L<br>— Un-ionized ammonia < 1.25 mg/L at 15°C<br>— Disinfection – fecal coliforms not to exceed 200 MPN/100 mL (end of pipe) | Yes |

| OPTION | DESCRIPTION | ADVANCE TO STAGE 2? |
|---|---|---|
| **Option 3 – Addition of advanced treatment for 2xADWF** | Secondary treatment for the entire plant flow (as outlined in Option 2 – Base Case), and also include:<br>— Advanced treatment (filtration) of the secondary treated effluent up to 2 x ADWF, with flows in excess of 2 x ADWF being bypassed around the effluent filters, and the two streams then blended prior to disinfection.<br>— UV disinfection fecal coliform not to exceed < 200 MPN/100 mL for all flows (end of pipe). | Yes |
| **Option 4 - Addition of advanced treatment for entire flow** | Secondary treatment for the entire plant flow (as outlined in Option 2 – Base Case), and also include:<br>— Advanced treatment (filtration) of the entire secondary treatment flow<br>— UV disinfection on all filtered wastewater. Fecal coliform not to exceed 200 MPN/100 mL. | Yes |
| **Option 5 – Reclaimed Water** | Reclaimed water for in-plant use. Can be applied to any of Options 2, 3 or 4. | Yes |

## DESIGN CRITERIA

The options outlined below are based on the following design conditions and information available at the time of completing this assessment:

— Design horizon: 20-year design horizon to 2040
— Flows and loads as outlined for year 2040 in Table 3 and Table 5.
— We have assumed similar technologies that are currently in use will be used for expansion and have not compared other possible process options for treatment.
— Disinfection is to be included.
— Provincial and Federal effluent quality requirements are applicable, as outlined in Table 7.
— The purpose of this review is to provide sufficient information to decide on the treatment level to be implemented at the CVWPCC.

*Table 7: Effluent Quality Criteria*

| EFFLUENT PARAMETER | PROVINCIAL REQUIREMENTS (MWR) | FEDERAL REQUIREMENTS (WSER) |
|---|---|---|
| 5-day Biochemical Oxygen Demand | Max day < 45 mg/L | Monthly average < 25 mg/L |
| Total Suspended Solids (TSS) | Max day < 45 mg/L | Monthly average < 25 mg/L (carbonaceous $BOD_5$) |
| pH | 6 – 9 | N/A |

| EFFLUENT PARAMETER | PROVINCIAL REQUIREMENTS (MWR) | FEDERAL REQUIREMENTS (WSER) |
|---|---|---|
| Un-Ionized Ammonia | N/A | <1.25 mg/L |
| Total Residual Chlorine | N/A | <0.02 mg/L |
| Fecal Coliforms [1] | <14 MPN/100 mL at the edge of the initial dilution zone (IDZ) | N/A |

1 Requirements for shellfish receiving waters

## KEY CONSIDERATIONS

Several considerations should be given to how the plant might be laid out for future upgrades, and how new infrastructure components can fit into the existing plant and mesh with future plans for the facility. A new offline equalization tank is currently being constructed at the CVWPCC to handle peak flows to the treatment plant, and this should be incorporated into future planning of conceptual layouts if possible. A Master Plan should be undertaken to determine the optimum plant layout for future expansions and upgrades once the level of treatment has been identified.

Key considerations that have been identified for potential future upgrades and expansions of the CVWPCC are summarized in Table 9.

*Table 8: CVWPCC Key Consideration Identification*

| KEY CONSIDERATION | RISK | POTENTIAL MITIGATION OPTIONS |
|---|---|---|
| *1. How is new infrastructure integrated with the existing plant?* | **A.** By 2040 the existing infrastructure will be 60 years old. Condition assessments may find that some of the assets may be at the end of their useful life and may not be in the plans for future expansions to 2060.<br>**B.** The available head in the hydraulic profile is limited and may limit options to avoid pumping between unit processes.<br>**C.** New equalization tank under construction reduces the available area for construction of other facilities in future. | **A.** Ensure new infrastructure can be used well into the future.<br>**B.** Incorporate flow control options within plant layout, or allow for tie-in to future flow control options to maintain equal division of flows to multiple process units and allow addition of future processes and upgrades. |

| KEY CONSIDERATION | RISK | POTENTIAL MITIGATION OPTIONS |
|---|---|---|
| *2. How much longer can the existing infrastructure be used?* | **A.** The generally harsh conditions from $H_2S$ exposure, can erode concrete and mechanical components in the headworks and primary clarifiers. Re-use of these systems beyond 2040 may be limited and new facilities will likely be required. | **A.** Condition assessments can be completed on these components that outline faulty or weak components and repairs can be designed to extend the life of the systems. This would be included for aeration basins and secondary clarifiers as well to ensure life beyond 2040. |
| *3. What will the solids handling components look like in the future?* | **A.** The wastewater treatment plant currently hauls dewatered waste solids to a composting facility. Changes in regulations, cost-benefit analysis, and other factors can drive decisions for future solids handling options such as anaerobic digestion where gas and energy can be recovered.<br>**B.** Age of current solids handling equipment might require refurbishment to ensure the equipment will last until at least 2040. | **A.** Future space considerations for anaerobic digestion with resource recovery (biogas, fertilizer pellets) should be included when developing future plant layouts. Digestion could potentially be part of a future overall solids handling system upgrade.<br>**B.** A condition assessment of structural and mechanical components on the thickeners (gravity and DAF units) can provide insight into repairs that may be needed to ensure the life of the equipment will last until at least 2040, as the components do have the capacity. |
| *What are the geotechnical conditions of the site and post-disaster structural considerations?* | **A.** Building codes and the status of wastewater facilities have become more stringent. New infrastructure at wastewater treatment plants now has to be "post-disaster", which means operable after a natural disaster, such as a major earthquake. | **A.** Complete geotechnical assessments to evaluate the ground conditions at the site in light of the new regulations.<br>**B.** Complete a structural condition assessment to review the existing infrastructure, expected lifespan, and possible upgrades that may be required to make the infrastructure meet post-disaster requirements. |

| KEY CONSIDERATION | RISK | POTENTIAL MITIGATION OPTIONS |
|---|---|---|
| *What are the odour concerns?* | **A.** New infrastructure should not create increased odours in the area | **A.** Include allowances for odour connections and odour control measures in new infrastructure. It should be noted we have not reviewed the capacity of the existing odour control system. |

## OPTION 2 – SECONDARY TREATMENT WITH DISINFECTION FOR ENTIRE FLOW

Option 2 is the base case scenario that will provide secondary treatment for the entire wastewater flow, as is currently the case at the CVWPCC. The provincial and federal effluent criteria outlined in Table 9 are used in addition to the capacity in the existing system to determine upgrades required to provide capacity until 2040.

A UV disinfection system is included to disinfect the wastewater to not exceed 200 MPN/100 mL fecal coliform concentration at the end of the outfall pipe. Based on the dilution modelling in the Initial Dilution Zone (IDZ), there will be sufficient dilution at the edge of the IDZ to stay below the 14 MPN/100 mL requirement for protection of shellfish. The design criteria used to size the UV system are shown in Table 9.

*Table 9: UV System Design Criteria*

| CRITERIA | |
|---|---|
| No. of Units | 2 |
| Design Flow: 2040 75% PHF per Unit ($m^3$/d) | 46,706 |
| Influent to Disinfection Process | 30 mg/L TSS |
| UV Transmittance[1] | 55% |

1 A measure of the ability of UV light to penetrate wastewater and disinfect organisms. Typically determined from wastewater testing, which the CVRD has completed with a vendor previously.

The configuration of the UV system would be two UV disinfection channels with each UV bank be designed to treat 75% of the design flow with the largest unit out of service, in accordance with the provincial MWR Reliability Requirements. The UV system can be placed outside in concrete channels and does not need to be in a building. (However, in the Option 3 and Option 4 assessments, a building should be constructed for the disk filters, and we have assumed some additional floor area in the same building to house the UV system as well).

In this base case, the following items were identified as items requiring a capacity increase. A detailed condition assessment of some of the structures should be completed to fully assess the suitability of re-using some of the plant's existing infrastructure.

### PRELIMINARY TREATMENT

- Upgraded grit removal is required and will benefit the plant in several ways, including improved sludge thickening in the primary clarifiers.

### PRIMARY CLARIFIERS

- The existing primary clarifiers have adequate capacity to 2040.

### AERATION BASINS

- There is not enough capacity in the existing three aeration basins to handle 2040 loads and a fourth aeration basin is required (refer to the Appendix for the capacity assessment).
- We have assumed that the existing blower room can be re-used and that there is sufficient blower capacity in the existing system (refer to capacity assessment). Although installing new, higher efficiency blowers, may be desired and would be evaluated in a pre-design.

### SECONDARY CLARIFIERS

- A fourth secondary clarifier is required and would be installed to the north of the existing clarifiers.
- A new flow splitting box should be installed to ensure equal flow to the four clarifiers, if determined feasible during a pre-design.

### UV SYSTEM

- A new UV disinfection system would be installed outdoors with the design criteria outlined in Table 9. The system is assumed to be a Trojan UV Signa system with 96 UV lamps.

The items identified are believed to make-up a possible upgrade scenario for the CVWPCC to meet treatment objectives until 2040 and provide flexibility for expansion beyond 2040. Investigating the feasibility of various upgrade options and scenarios, together with alternative treatment technologies, optimum plant layout, and a condition assessment of the existing infrastructure, should be completed during a Master Plan or Pre-Design to confirm the recommended approach.

## OPTION 3 – ADDITION OF ADVANCED TREATMENT FOR 2XADWF

Option 3 includes the Option 2 components plus the inclusion of disk filters for advanced treatment to produce a higher quality effluent, i.e. less than 10 mg/L TSS and $BOD_5$, for flows up to 2xADWF. It is anticipated in this scenario a type of flow control weir would be installed to divert higher flows exiting secondary treatment around the disk filters and directly to UV disinfection. Disk filters, or cloth media filters, are disks covered in a cloth material that are placed in a channel where the wastewater meets the filters. The filters and the wastewater continue through the filters and to the outfall. A rendering from a disk filter proposal we received is shown in Figure 7.

*Figure 7: Disk Filter Rendering (from Nexom Proposal in Appendix)*

The disk filters were sized for the 35,000 $m^3$/d with an influent TSS concentration of 25 mg/L. Each unit is sized to treat 8,750 $m^3$/d. Four disk filter units are proposed to handle the 2040 flows, which provides 75% redundancy. The disk filters are recommended to be placed inside a building. Based on the size of the disk filters required to handle flows up to 2 x ADWF, we have used a building size of 20 by 15 meters. The building was sized to include the UV system, since the UV system has a generally small footprint and inclusion of the UV system indoors would have many benefits at a minimal cost.

## OPTION 4 – ADDITION OF ADVANCED TREATMENT FOR ENTIRE FLOW

Option 4 is the same as Option 3, except the disk filters are sized for the entirety of the flow (62,000 $m^3$/d). This disk filter system is assumed to include eight disk filters, each sized for 8,750 $m^3$/d, providing a redundant unit. The larger disk filter footprint would require a building approximately 20 by 20 meters and would also include the UV system. The UV system in this scenario would be the smallest since the entire flow is treated to a higher standard and provide the highest quality. In this scenario, the UV system is assumed to be a Trojan Signa with 60% UVT and an influent TSS of 10 mg/L. This system would require a total of 56 UV lamps.

## COST COMPARISON FOR OPTIONS 2, 3 AND 4

Preliminary planning capital cost estimates are based on the ISL report and other considerations developed by WSP during the capacity assessment to upgrade the treatment plant to handle the 2040 design flows and loads. These estimates provide a general outline for the work that may be required. A detailed Pre-design study with treatment process modelling will be needed to develop more detailed estimates and upgrade staging scenarios.

Included in the Option 3 cost estimate are the base case estimates described for Option 2 and inclusion of advanced treatment with disk filters. A benefit of the disk filter system is the higher quality water that is then sent for UV disinfection. With the higher quality wastewater, i.e. fewer solids, the UV system can be downsized. With disk filters there is a higher UV Transmittance (UVT) and thus fewer light bulbs are required in the UV system. In this scenario it is assumed that the Trojan Signa system would have 64 lamps, a UV transmittance of 60%, and TSS of 15 mg/L in the blended effluent.

The capital cost summary from the ISL (2016) report is summarized Table 10. The ISL (2016) report stages the work, therefore we have taken the Phase I (year 2017), Phase II (year 2024), and Phase III (year 2033/2034) cost estimates as they are the most comparable to the base case costs developed in this assessment. The cost numbers have been adjusted in the ISL (2016) report to be in 2019 Canadian dollars using the Engineer News-Record (ENR) indexing values. Note that the costs are taken from the recommended 'Option 3' in the ISL report. Additionally, we note that the ISL option includes disk filters for the full flow for initial removal of solids before a new secondary clarifier is installed, therefore we have removed the disk filter estimate component and provided it as a separate item, although in the ISL (2016) staging plan the disk filters would be required before the secondary clarifier is installed. Note that the ISL (2016) estimate does not include UV treatment which is included in all options developed in this assessment.

The estimates prepared in this assessment represent a total amount that would be required to meet 2040 treatment objectives. We have not phased the work as this would typically be completed during a Pre-design or Master Plan. We have compared the ISL (2016) estimates with the WSP estimates in Table 10, since they are both based on plans going forward to achieve the same treatment objectives for 2040. The ISL (2019 adjusted) estimate not including disk filters ($27.6M) would be comparable to Option 2 in this assessment and the ISL (2019 adjusted) estimate to include disk filters ($38.4M) would be comparable to Option 4 in this assessment, including disk filters to treat the entirety of the flow.

We note that the ISL (2016) estimate included more detail beyond 2040, therefore the total life cycle cost estimates for only the items selected to meet 2040 expansion could not be determined and compared to the WSP estimate. However, we would expect them to be similar.

Table 11 shows the ISL (2019 adjusted) cost estimate and the WSP Option 2 estimate which represent the estimated total cost for the CVRD to expand the plant to handle 2040 flows and loads assuming secondary treatment for all flows. The Option 3 and 4 estimates shown the incremental increase in cost associated with adding effluent filtration for 2xADWF and all flows, respectively. We note the estimates in this assessment include a 5% greater (45% vs 40%) engineering and contingencies amount than the ISL (2016) estimate. The actual path forward, and staging of the expansion, would be determined during a Pre-Design step.

*Table 10: ISL (2016) Report - Option 3 Cost Estimate Comparison*

| STAGE | ISL ESTIMATE 2016 CDN$ | ISL ESTIMATE 2019 CDN$[1] | ISL ESTIMATE 2016 CDN$ | ISL ESTIMATE 2019 CDN$[1] |
|---|---|---|---|---|
| | ISL Option 3 Not Including Disk Filters | | ISL Option 3 Including Disk Filters | |
| Phase I (2017) | $ 5,774,000[2] | $ 6,289,000 | $ 11,063,000[2] | $ 12,050,000 |
| Phase II (2024) | $4,721,000[3] | $5,142,000 | $4,721,000[3] | $5,142,000 |
| Phase III (2033/2034) | $7,651,000[4] | $8,333,000 | $9,410,000[5] | $10,249,000 |
| Engineering & Contingencies (40%) | $7,258,400 | $7,906,000 | $10,077,600 | $10,976,000 |

| STAGE | ISL ESTIMATE 2016 CDN$ | ISL ESTIMATE 2019 CDN$[1] | ISL ESTIMATE 2016 CDN$ | ISL ESTIMATE 2019 CDN$[1] |
|---|---|---|---|---|
| Total Capital Cost Estimate | $25,404,400 | $27,670,000 | $35,271,600 | $38,417,000 |

1 ENR Index Values used for 2016: 10,339 and ENR Index Values used for 2019: 11,261
2 From ISL (2016) Table 12.1 for Option 3 – with and without disk filters line item.
3 From ISL (2016) Table 12.2 for Option 3
4 From ISL (2016) Table 12.3 for Option 3 Primary Clarifiers + Process Building – Year (2033) Line Item
5 From ISL (2016) Table 12.3 for Option 3 Primary Clarifiers + Process Building – Year (2033) Line Item and Upgrade Media Cloth Filter – Year (2034) Line Items.

*Table 11: Capital Cost Comparison*

| | ISL (2019) ESTIMATE | OPTION 2 | OPTION 3 | OPTION 4 | ISL (2019) ESTIMATE |
|---|---|---|---|---|---|
| | **Not Including Disk Filters** | **Secondary Treatment for Entire flow w/ Disinfection** | **Addition of Advanced Treatment for 2XADWF** | **Addition of Advanced Treatment for Entire Flow** | **Including Disk Filters** |
| Total Capital Cost Estimate | $27,670,000 | $29,700,000 | $38,000,000 | $40,300,000 | $38,417,000 |
| 20 Year Life Cycle Cost Estimate | - | $32,000,000 | $40,500,000 | $43,000,000 | - |

## OPTION 5 – RECLAIMED WATER FOR IN-PLANT USE

Option 5 evaluated including reclaimed water around the CVWPCC for equipment wash water and other reuse items. Reclaimed water standards are set-out in the provincial regulation (MWR) and are classified by exposure potential to the public. Reclaimed water use within the treatment plant would need to meet the lowest exposure potential standards as the reclaimed water would be controlled in the plant setting.

The MWR requires, for low exposure potential, a maximum TSS and $BOD_5$ concentration of 45 mg/L, a disinfection to 200 MPN/100 mL, and maintaining a pH between 6.5 and 9. Additionally, the MWR requires the reclaimed water to be chlorinated to have a minimum of 0.5 mg/L chlorine residual in the reclaimed water at the point of use.

We have designed several reclaimed water systems for wastewater treatment plants in British Columbia. We have assumed a similar sized system would be installed at the CVWPCC. This system would include a pressure filter to remove TSS and a chlorination system to maintain a residual of 0.5 mg/L total chlorine. There would be a reclaimed water distribution pumping and piping network installed around the plant to service the various mechanical equipment, or onsite irrigation as maybe desirable.

The design criteria for the reclaimed water system is shown in Table 12.

*Table 12: Reclaimed Water Design Criteria*

| CRITERIA | |
|---|---|
| Capacity | 50 $m^3$/d |
| Pressure Filter Capacity (L/min) | 100 |
| Chlorine Dosing System Capacity (mL/min) | 10 – 110 |
| Distribution Pump Capacity (L/s) | 5 |
| Reclaimed Water Clearwell Tank (m3) | 100 – 150 |
| Chlorination Dosing | 12% Sodium Hypochlorite @ 15 mg/L |

A detailed investigation into the wash water requirements for the reclaimed water system was not included in the scope of work. However, our experience with using this sized system at other wastewater treatment plants indicate sufficient capacity to service most equipment around a wastewater treatment plant. We also have sodium hypochlorite cost estimates for approximately $1,000 per 1,100L tote, and have assumed approximately 1 tote every 3 months would be required. A cost estimate for Option 5 is shown in Table 13.

The cost estimate shown in Table 13 would be for a system treating Option 2 secondary effluent to reclaimed water standards. If disk filters are included and provide a higher quality effluent (Option 3 and 4), the reclaimed water system overall cost could potentially be reduced by approximately $100,000 - $150,000.

*Table 13: Option 5 Cost Summary*

| OPTION 5 - RECLAIMED WATER | AMOUNT |
|---|---|
| Civil Works | $ 24,000 |
| Process Mechanical | $ 130,000 |
| Structural Components | $ 180,000 |
| Plumbing & HVAC | $ 8,000 |
| Electrical | $ 68,000 |
| General Requirements | $ 109,000 |
| **Subtotal Option 5 Cost Estimate** | **$ 519,000** |
| Engineering (15%) | $ 78,000 |
| Contingency (30%) | $ 179,000 |
| **Total Option 5 Cost Estimate** | **$ 776,000** |
| Estimated Annual O&M Addition | $ 6,900 |
| PV Annual O&M (20 years, 5% Discount Rate) | $ 88,000 |
| **Total Net Present Value Option 5** | **$ 864,000** |

## SUMMARY

A summary of the cost estimates for the different treatment level options is shown in Table 14. We note that due to the relatively similar amounts between ISL (2019) and the estimates developed by WSP in this assessment, the estimates developed in this assessment will be used for comparison purposes.

This estimate also includes the estimate from the ISL (2016) *Cape Lazo Outfall Capacity Assessment* for 'Option 3' of approximately $24.4M which is carried to indicate future capital upgrade requirements for the outfall. Also note that Option 5 is only for including reclaimed water and does not represent a standalone option for the District in terms of upgrading the secondary treatment capacity.

Upgrades to meet federal and provincial requirement by implementing secondary treatment upgrades are effective in protecting the receiving environment, removing microplastics and disinfecting the effluent prior to release in the receiving environment.

Currently, advanced treatment is not a regulatory requirement for an ocean discharge, and advanced treatment is not strictly required to meet the regulatory treatment objectives for the CVWPCC with appropriate expansion of the existing systems. To provide advanced treatment for the entire flow with disk filters, it is currently estimated as a 35% to 40% increase in capital costs (~$11M). To provide advanced treatment for 2xADWF with disk filters, it is estimated as an approximate 25% to 30% increase in capital costs (~$8M).

The added benefit of disk filters includes treating the effluent to a slightly higher standard, enhanced removal of microplastics, and additional removal of other contaminants associated with the solids in the effluent. As shown in Table 14, and in Figure 6, the CVWPCC currently achieves excellent removal of TSS and $BOD_5$, with average values for both parameters less than 10 mg/L; this would be expected to improve to less than 5 mg/L average with the addition of disk filters. If phosphorus removal becomes a regulatory requirement in the future, the disk filters would provide additional filtration to reduce phosphorus concentrations following chemical coagulation. Additionally, implementation of disk filters would meet the effluent standards for reclaimed water, enabling a wide range of uses. However, in the absence of a user for large scale reclaimed water, the estimated 35% increase in capital cost between Options 2 and 3 or 4 may not justify installation of disk filters for advanced treatment at this point in time.

A summary of the costs, risks and benefits of the different options is shown in Table 14.

*Table 14: Summary of Wastewater Treatment Level Options*

| | OPTION 2 | OPTION 3 | OPTION 4 |
|---|---|---|---|
| | **Secondary Treatment w/ Disinfection Base Case** | **Advanced Treatment for 2xADWF** | **Advanced Treatment for Entire Flow** |
| Sub-Total CVWPCC Upgrade Capital Costs | $ 29,700,000 | $ 38,000,000 | $ 40,300,000 |
| Sub-Total Outfall Upgrades[1] | | $24,400,000 | |
| **Total** | **$ 54,100,000** | **$ 62,400,000** | **$ 64,700,000** |
| Subtotal Reclaimed Water (Option 5) | | $800,000 | |
| **Total** | **$ 54,900,000** | **$ 63,200,000** | **$ 65,500,000** |
| | | | |
| **Benefits** | – Upgrade path to meet capacity and regulatory requirements for the next 20 years<br>– Secondary treatment removes 90% of organic material and solids on average (note that the CVWPCC currently achieves greater than 95% removal of TSS and greater than 93% removal of $BOD_5$)<br>– Secondary treatment removes 80-95% of microplastics on average<br>– Disinfection to meet shellfish standards<br>– Reclaimed water can be incorporated.<br>– Design can incorporate space for installation disk filters if required in the future.<br>– Typical CVWPCC effluent quality for daily $BOD_5$ consistently less than 20 mg/L and TSS less than 25 mg/L, with average values less than 10 mg/L. | – Base case secondary treatment upgrades apply<br>– Advanced treatment (filtration) for up to 2xADWF accounts for approximately 99% of the annual flow being treated to advanced standards.<br>– Addition of advanced treatment filtration removes 96% of organic material and solids on average, a marginal increase of 6% over secondary treatment<br>– Addition of disk filters removes 95-97% of microplastics on average, a marginal increase of 15-17% over secondary treatment<br>– Large scale effluent reuse can be implemented<br>– Disk filters can be implemented in the future once a user for reclaimed water is identified<br>– Typical effluent quality for up to 2xADWF for daily $BOD_5$ and TSS consistently less than 10 mg/L, with average values less than 5 mg/L. | – Base case secondary treatment upgrades apply<br>– Addition of disk filters removes 96% of organic material and solids on average, a marginal increase of 6% over secondary treatment<br>– Addition of advanced treatment filtration removes 95-97% of microplastics on average, a marginal increase of 15-17% over secondary treatment<br>– Large scale effluent reuse can be implemented<br>– Disk filters can be implemented in the future once a user for reclaimed water is identified<br>– Typical effluent quality for entire flow for $BOD_5$ and TSS consistently less than 10 mg/L, with average values less than 5 mg/L. |
| **Risks** | – Capital costs are dependent on condition assessment and outcome of a Pre-design study. | – Cost premium of approximately $8M for addition of disk filters to treat 2xADWF<br>– Advanced treatment to the level provided by disk filters is not a regulatory requirement<br>– Without a user for the reclaimed water, costs may not be justified at this point in time | – Cost premium of approximately $10.7M for addition of disk filters to treat the full flow<br>– Advanced treatment to the level provided by disk filters is not a regulatory requirement<br>– Without a user for the reclaimed water, costs may not be justified at this point in time |

[1] From ISL (2016) Cape Lazo Outfall Capacity Assessment, to be updated.

[2] Cost estimates are in $2019 CAD. Estimates are appropriate for the purposes of comparing options.

A detailed Pre-design and Condition Assessment for the wastewater treatment plant is recommended. The purpose of these studies would be to:

- Detail the suitability of reusing existing infrastructure and identify any repairs that should be carried out before re-using;
- Create a process model for the treatment plant to identify if there are any modifications that can be done to the existing system to increase performance and capacity;
- Evaluate existing structures and geotechnical conditions that consider post-disaster seismic standards currently required by the B.C. Building Code (BCBC);
- Evaluate plant wide odour control systems and necessary upgrades;
- Complete a pre-design study that provides a detailed, staged expansion plan for the CVWPCC for the next 50 years and beyond;
- Undertake a complete hydraulic assessment of the plant systems;
- Review the plant electrical, controls, and SCADA systems;
- Complete detailed composite sampling to confirm loading in the influent and primary effluent.

A staged approach to upgrading the treatment plant would provide the greatest flexibility and assurance to the CVRD that the appropriate measures have been taken for the decisions that will be made about the future of the plant. The staging would involve completing a condition assessment first to assess the possibility of re-using certain assets and identifying their anticipated life expectancy. After this, a Pre-design Study can be completed knowing the specific condition of assets and creating a process model to identify and evaluate upgrade options so that the best upgrade path and site layout is selected. A preliminary cost estimate to complete these two studies is shown in Table 15.

*Table 15: Pre-design and Condition Assessment Estimates*

| ITEM | ESTIMATE |
| --- | --- |
| CVWPCC Pre-Design Study | $150,000 |
| Asset Condition Assessment | $150,000 |

We note that repairs to assets are not included in the estimate, nor is the engineering design for the repairs. The scope of work that would be required would be identified in the condition assessment report and an estimate of the repairs required would be provided then.

A possible timeline for completing plant upgrades for the 2040 horizon is shown in Figure 8. This estimated timeline would provide an upgraded facility for the CVRD by 2024 or 2025, and this timeline would be updated in a Pre-Design Study to confirm whether any upgrades need to be accelerated or can be delayed.

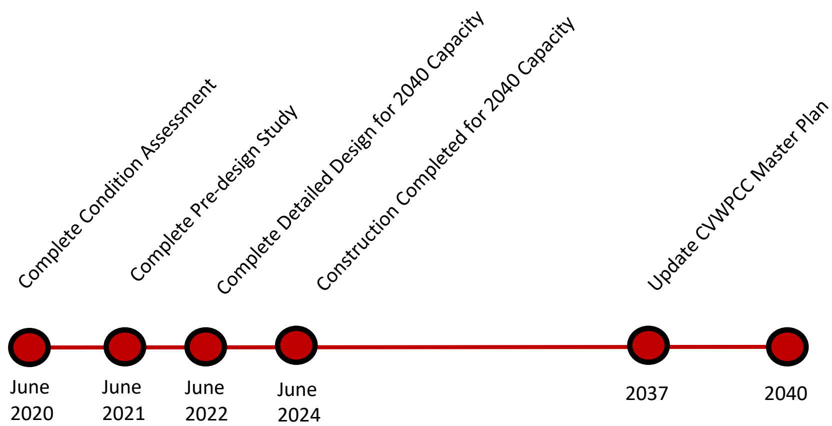



*Figure 8: Project Timeline*

APPENDIX