STAGE 2 LWMP

July 19, 2018

VILLAGE OF CUMBERLAND

Stage 2 - Liquid Waste Management Plan

Reference: 1018-01-2018-R-(Rev0) VOC Stage 2 LWMP - FINAL

Distribution:

1 Electronic Copy – Village of Cumberland
1 Hard Copy – Village of Cumberland
1 Hard Copy – Troy David Vassos Inc.

Executive Summary

Liquid Waste Management Plan Process

The Environmental Management Act (EMA) includes a provision for local governments to develop a Liquid Waste Management Plan (LWMP) for approval by the Minister of Environment for comprehensively managing community wastewater in place of site specific Discharge Permits or Discharge Registrations. In accordance with operational certificates, the approved LWMP authorizes a local government to implement the wastewater management measures described in the plan to meet current and future development needs, while ensuring the measures contained in the LWMP are sufficiently protective of public health and the environment. Public and stakeholder consultation are essential for the development of a LWMP, as authorization includes the ability to borrow and commit municipal funds, and the minister must be satisfied that there has been adequate public review and consultation during the development of the LWMP before approving the plan. The Local Government Act and the Community Charter require elector approval for municipal government to borrow funds to finance wastewater infrastructure capital works. An approved LWMP allows local governments to borrow money without the need to seek approval of electors; therefore, the public consultation process must provide opportunities for elector participation during the development and amendment of a plan, as there is no mechanism to appeal a LWMP once approved. Consequently, the LWMP needs to consider the financial capacity of the community including both capital construction and operation costs, and the LWMP should establish long range financial plans to ensure resources will be available when they are needed. The impact of costs on the taxpayer must be estimated for in the Stage 2 evaluation process and must form part of the Stage 3 LWMP, and the potential for senior government grants and the use of development cost charges to reduce capital costs versus the potential for a no-grant scenario.

In addition to meeting the provincial Municipal Wastewater Regulation, the LWMP must also address federal discharge criteria and the province has endorsed the Canadian Council of Ministers for the Environment (CCME) Canada-wide Strategy for the Management of Municipal Wastewater Effluent. The goals and objectives as well as the growth and development of the community should form the basis for the development of a LWMP, and include other water related impacts of development including stormwater management, drinking water supply (capacity and contamination risks), and non-point source pollution. The LWMP development process should also identify and assess opportunities for water conservation, resource recovery (e.g. heat recovery), energy efficiency and generation, greenhouse gas emissions reduction, climate change adaptation and mitigation.

The LWMP planning process typically requires a minimum of two to three years, and the scope of work is specific to each local government. It is developed in three stages and the report produced by the advisory committee(s), and approved by council, should be submitted to the director for review before proceeding to the next stage. At the conclusion of Stage 3, local governments should make a resolution to accept the final Stage 3 report (after review by the advisory committees and the director), and then submit the LWMP report to the minister for approval, with a copy to the director.

This document addresses the Stage 2 requirements for the development of a LWMP. It is intended to be a detailed evaluation of a short list of options, and of the preferred option(s). Specific elements of the Stage 2 process includes continued input from advisory committees, continued public consultation, an examination of short-list options and associated costs in detail, consideration for an Environmental Impact Study to further refine options, identify and discuss requirements for operational certificates, and preparing the scope of work for Stage 3.

Because of the length of time that has passed since the approval of Cumberland's Stage 1 LWMP in 2001, this report also contains updates to essential Stage 1 information such as the community goals, population statistics and flow and load projections, and the regulatory framework.

This Stage 2 LWMP report consists of 19 Chapters and begins with a statement of the document purpose and scope and a confirmation of the community's LWMP goals and the evaluation system chosen by the community and advisory committees and confirmed by Council. The regulatory framework is then described whereby the community currently has a Discharge Permit in place that effectively authorizes it to implement measures to improve effluent water quality, reduce phosphorus levels, implement effluent disinfection and seek alternative discharge locations.

LWMP Goal Setting

The establishment and authorization of a LWMP will transition the community from the conditions contained in the Discharge Permit to compliance with the current Municipal Wastewater Regulation and the federal regulations. There are limited options available to the community with respect to alternative discharge locations, as the redirection of effluent discharges from Maple Lake Creek and the Trent River would have a severely detrimental impact on those water bodies during the dry summer months when the effluent represents a high percentage of water. However, prior studies and consultations with Environment Canada indicate the wetlands located to the north of the existing treatment lagoons could serve as an alternative discharge location taking advantage of the wetlands to "polish" the effluent draining to Maple Lake Creek and, hence, to the Trent River, further improving water quality and reducing phosphorus levels.

A Wastewater Advisory Committee (WAC) was established during the Stage 2 process in April 2016, and six members of the public were appointed by Cumberland Council.

Other members of the committee included, as per the LWMP guidelines, representatives from;

- Komox First Nation
- Vancouver Island Health Authority
- Cumberland staff – Chief Administrative Officer and Manager of Operations
- Cumberland Council – one representative and an alternate
- Consultants – Project Coordinator and Technical consultants
- Ministry of Environment (ex-officio)
- Federal Dept of fisheries and Ocean

A set of project goals was established by the WAC through a brainstorming session that was subsequently compared to the major Cumberland planning documents, including the Village of Cumberland Official Community Plan, the Village of Cumberland 2016 Corporate Strategic Priorities, the 2010 Comox Valley Sustainability Strategy and the Village of Cumberland Social Procurement policy, before being presented to the community through an open house and then recommended to an ratified by the Steering Committee.

A scoring system was established based on these goals, to be used to evaluate the long list of options to the short list, and eventually to evaluate the short list to determine the preferred option. Each of the goals was categorized with respect to affordability and economic, environmental, and social benefits and then scored and ranked before being presented to the public for comment. The goals and evaluation system were presented at a public Open House on July 14, 2016, where the public was in substantial agreement with them, but with an emphasis on affordability as being the most important single goal. Noting the importance of affordability, and the emphasis placed on it at the open house, the WAC increased the importance of affordability relative to the other economic social, and environmental goals as compared to the rankings that were originally arrived at during the initial goal-setting (brainstorming) process. The final recommended weights were 40% for affordability and 20% for each of economic, environmental and social factors.

The WAC, by unanimous vote, recommended that the goals and methodology for option evaluation be adopted by the Steering Committee (Council) as the official Goals and Evaluation System for the Liquid Waste Management Plan and Council accepted those recommendations on August 8, 2016.

Regulatory Framework

A review of the current Discharge Permit noted that the discharge conditions do not conform with the minimum 10:1 dilution requirements under the current Municipal Wastewater Regulation (MWR) during dry weather conditions. However, the MWR does have provision for augmenting stream flows during extreme low flow conditions without consideration for dilution if the effluent water quality meets the Greater Exposure Potential reuse water quality requirements. While the existing Discharge Permit is grandfathered, once a major amendment is required to the Discharge Permit conditions, the discharge must comply with the current MWR requirements. The most common need to seek a major amendment is with respect to the authorized discharge rate, which is currently 910 m3/d. A request to modify this flow rate by more than 10 percent is expected to trigger the need to comply with and be registered under the MWR. Taking the dilution requirements of the MWR into consideration, a continued direct discharge to Maple Lake Creek during the summer months would only be possible if the water quality met the Greater Exposure Potential, enabling the reclaimed wastewater to be reused for stream augmentation purposes without regard for dilution. This reuse water quality would also enable the reclaimed wastewater to be used for a wide range of non-potable water applications; noting that Maple Lake Creek and the Trent River could be negatively impacted by a reduction in flow as a result of significant reuse applications.

Accordingly, the following is the expected water quality criteria for the upgraded wastewater treatment process with a continued year-round direct discharge into Maple Lake Creek:

Greater Exposure Potential Water Quality Requirements for Non-Potable Water Reuse

- $BOD_5 \leq$ 10 mg/L (maximum);
- TSS $\leq$ 10 mg/L (maximum);
- Turbidity $\leq$ 2 NTU (average), and $\leq$ 5 NTU (maximum);
- Fecal coliforms $\leq$ 1 CFU/100mL (median), and $\leq$ 14 CFU/100mL (maximum);
- pH 6.5 – 9; and
- Chlorine Residual > 0.5 mg/L (minimum) at point of reuse application.

Additional Water Quality Requirements for Discharge to Surface Waters

- Total Phosphorus $\leq$ 1.0 mg-P/L (maximum) (see note 1);
- Ortho-Phosphate $\leq$ 0.5 mg-P/L (maximum) (see note 1);
- Un-ionized Ammonia $\leq$ 1.25 mg-N/L at 15 ^{o}C +/- 1 ^{o}C (maximum) (see note 2); and
- Chlorine Residual $\leq$ 0.05 mg/L (maximum) (see note 2).

(1) Phosphorus criteria required for discharges to streams, rivers and estuaries with dilutions greater than 10:1, or lakes with surface areas $\geq$ 100 ha, and maximum daily flows greater than 50 m^3/d).

(2) Federal Fisheries Act - Wastewater Systems Effluent Regulations requirement for discharges of 100 m^3/d or more to surface water bodies.

The concept of continued direct discharge to Maple Lake Creek of reclaimed wastewater for the purpose of stream augmentation will also require a policy change by the Ministry of Environment. The Ministry have been requiring proponents of reclaimed wastewater systems to have alternative effluent disposal options in the event reuse water quality criteria cannot be met. This policy requirement will either have to be waived by the Director, or an alternative disposal method be developed. Consequently, two alternative discharge options were considered in developing the LWMP, specifically:

1. Seasonal (summer) storage with winter release; and
2. Sub-surface discharge into the wetlands (fens) to the north of the existing lagoons.

The latter could be considered as a routine discharge location, requiring a lower water quality level and avoiding a direct discharge to a surface water body.

Receiving Environment

A review of environmental monitoring data collected within Maple lake Creek and the Trent River shows that a series of natural wetlands and beaver ponds have formed within Maple Lake Creek that reduces BOD and TSS to less than analytical detection limits, and phosphorus to 0.2 mg/L. This wetland system is noted to also treat stormwater runoff within the Maple Lake Creek catchment and thereby protect water quality within the Trent River. The environmental water quality benefits of these wetlands are such that there is concern that compliance with the current Discharge Permit requirement to reduce effluent phosphorus concentrations to 1.0 mg/L may have a detrimental impact on the ability of the wetlands to protect water quality in the Trent River. Accordingly, it is recommended that the required phosphorus reduction be carried out gradually while assessing the impact on the wetlands and downstream water quality in the Trent. Directing a portion of the treated effluent to the natural wetlands to the north of the wastewater treatment lagoons would facilitate this assessment, and provides an alternate discharge means. While the habitat that is provided by the bog communities north of the lagoons and west of Maple Lake Creek are considered sensitive and environmentally valuable; the 'sensitive' area does not include the reed canary grass dominated habitat (Wet Meadow community) located immediately adjacent and to the north of the lagoons.

Flows and Loads

One of the most critical operating difficulties affecting treatment quality at Cumberland is the extreme increase in wet weather flows. While average dry weather flows are less than 800 m^3/d, wet weather stormwater influenced flows exceed 15,000 m^3/d in most years, for a very high peaking factor averaging of 18 to 1. While it is desirable to reduce the peaking factor down to 2, it is likely this target cannot be reached within a reasonable 20-year design timeframe, and so the treatment system must be designed for continued handling of large wet weather flows. Consequently, f*or flow modelling purposes*, the following have been assumed;

1. current (2017) per capita ADWF is 212 L/d/capita.
2. current (2017) population of 3750 will increases by 3% per year to a population of 7000 in year 2038.
3. for treatment facility design purposes, the per capita ADWF contribution is conservatively assumed to be 250 L/d/capita resulting in a total ADWF of 1800 m^3/d for 2038;
4. the treatment facility design flow will be based on 2 x ADWF = 3,600 m^3/d (referred to as the “baseflow”);

5. the design $CBOD_5$ and TSS concentrations at ADWF will both be 300 mg/L, consistent with current ADWF $CBOD_5$ and TSS concentrations;
6. design TKN and Total Phosphorus raw wastewater concentrations at ADWF of 50 mg-N/L and 6 mg-P/L, respectively;
7. current (2017) Peak wet weather flow (PWWF) of 14,400 m^3/d (referred to as the "full flow", and peaking factor of 8 compared to ADWF);
8. PWWF will decrease by an average of 500 m^3/d per year as the storm separation program proceeds;
9. incremental population growth will add wet weather flow at a ratio of 2:1 compared to the incremental ADWF;
10. peak flow factor does not go below 4:1, therefore the 20-year PWWF will be 7,200 m^3/d; and
11. *as the current PWWF is greater than the future PWWF, the design PWWF will be the current value of 14,400 m^3/d.*

Discharge Options and Maple Lake Creek Environmental Monitoring

In 2016, the LWMP committee identified that finding a suitable alternate discharge location was a major issue of the Cumberland LWMP. By removing the water to another watershed, or storing for winter release, then the phosphorus is also removed from Maple Lake Creek, in summer. This was driven mainly by a desire to avoid the 0.005 mg-P/L summertime in-stream phosphorus criteria of the Trent River, that was thought to be impossible or very expensive to achieve. Part of this thinking – the need to meet an effluent quality of close 0.005 mg-P/L - stems from a 2011 "pulsed discharge" study of phosphorus in Maple Lake Creek and the Trent River, where it was assumed that Maple lake Creek "acts like a conduit" to the Trent River, with minimal dilution

The environmental monitoring program of 2017 was intended to closely evaluate the variation in stream flow rates and resulting effluent dilutions, and the variation in phosphorus concentration within Maple Lake Creek, and it yielded two major results;

1. in dry summer flow conditions, the lagoon effluent is effectively 100% of the flow in Maple Lake Creek, and 50% of the flow in the lower Trent River; and
2. the natural wetlands in Maple Lake Creek under critical dry summer flow conditions, are removing approximately 97 % of the phosphorus before the water reaches the Trent River. This is a removal performance that exceeds all but the best mechanical treatment plants using chemical phosphorus removal, and is at best only 0.1 mg/L higher than the best available control technology achievable using chemical removal.

The implication of the first result is that sending the all water to another watershed, or diverting the discharge to storage during the dry summer months, would effectively dry up the Maple Lake Creek during the summer, with associated environmental consequences for the creek and the lower Trent River.

The implication of the second result is that reducing the treated effluent total phosphorus concentration from the current levels of 5-6 mg-P/L to less than 1 mg-P/L could have a significant detrimental impact on the growing conditions within the wetlands along Maple Lake Creek, potentially negatively affecting the stormwater runoff treatment benefits provided by the wetlands. With less phosphorus benefiting wetland growth, the ability of the wetlands to absorb residual phosphorus may be negatively impacted. As the lowest effluent phosphorus level that can be expected to be achieved with chemical treatment is about 0.1 mg/L, without residual phosphorus removal through the wetlands, the phosphorus objective set for the Trent River of less than 0.005 mg-P/L cannot be met.

It is expected that in targeting a treated water phosphorus concentration of 1 mg-P/L, that an average concentration of 0.5 mg-P/L can reliably be achieved. This represents an overall reduction of about 5.7 kg-P/day, whereas the natural wetlands downstream of the lagoon discharge to Maple Lake Creek are currently removing 5.9 kg-P/d. A significant reduction of 80 to 90 percent in the phosphorus load to the Maple Lake Creek wetlands is expected to put them into a growth condition that will scavenge phosphorus, and better conditions will be created to attain the Ministry of Environment (summertime) in-stream objective of 0.005 mg-P/L in the Trent River. While it is also expected that a higher effluent total phosphorus concentration of between 2 to 3 mg-P/L would result in similar total phosphorus concentrations in the Trent River, the existing Discharge Permit established in 1997 requires an effluent total phosphorus concentration of less than 1 mg-P/L be met.

With these two important results, the philosophy of the LWMP has changed from one of *removing* the water to one of *retaining* the water in order to maintain the summertime flow into Maple Lake Creek and the lower Trent River, as a seasonal discharge would dry up Maple Lake Creek and virtually dry up the Trent River. Thus, a continued year-round discharge to MLC, directly or indirectly, became the only viable discharge option.

Treatment Performance of Existing Lagoon system

The summer 2017 monitoring program included detailed study of the treatment performance of the existing lagoons, the objective being to determine if they could be upgraded to meet both short and long term capacity and regulatory requirements. Table A summarizes the data collected from April to September, 2017

Table A. Water Quality Data Collected April Through September 2017

LOCATION	Total CBOD (mg/L)	Soluble CBOD (mg/L)	TSS (mg/L)	TP (mg-P/L)	Ortho-P (mg-P/L)	$NH4^+$ (mg-N/L)	E. coli	Fecal Coliform
							CFU/100mL	
Influent	292	175	282	6.8	4.08	41.4	1,350,000	2,176,750
Aerated Lagoon	38	8	100	6.4	4.46	43.2	16,100	115,500
Final Effluent	17	< 6	49	4.7	3.50	24.6	2,692	12,618
After MLC wetlands	< 6	< 6	< 4	0.2	0.231	0.366	48	398
Trent 100 m U/S of MLC	< 6	< 6	<4	< 0.005	< 0.005	0.235	3	34
Trent 100 m D/S of MLC	< 6	< 6	< 4	0.035	0.024	0.132	10	55

The data indicates the lagoons are effective in reducing BOD, but water quality is being affected by high suspended solids due to algae growth. As expected the lagoons remove only a minimal amount of phosphorus, but the data reveals the natural wetlands along Maple Lake Creek are polishing the lagoon effluent, reducing both BOD and TSS to less than the analytical detection limit, and removing up to 97% of the total phosphorus - exceeding the performance of many advanced wastewater treatment plants.

The results suggest that if the algae and some phosphorus can be removed at the lagoons, and the effluent disinfected, then the wetlands can polish this higher quality water even further. It also suggests that the dispersion of treated effluent to the wetlands to the north of the lagoons could achieve similar polishing results before the water enters Maple Lake Creek.

As a result of this monitoring, an upgraded lagoon-based system can be considered for one of the treatment options.

Treatment Options

The discharge location, and streamflow conditions, determine the treatment water quality requirements. While Cumberland's Discharge Permit does not require this, as the community grows and the wastewater flows increase, the Permit will eventually have to be relinquished and the discharge will need to meet current regulatory water quality criteria. Under the current Municipal Wastewater Regulation (MWR), a discharge to Maple Lake Creek, a surface water body with less than 10:1 dilution, can only be done as a means of stream augmentation requiring a "Greater Exposure Potential" reuse water quality, with a maximum BOD and TSS concentration of 10 mg/L, and would require tertiary filtration. However, if the discharge location were changed to the wetlands on the north side of the lagoons, the water quality requirement would be a BOD and TSS concentration of 25 mg/L, and tertiary filtration would not be required.

Although the number of fecal coliform bacteria in Maple Lake Creek below the wetlands is comparable to that achieved by an effluent disinfection process, effluent disinfection will be the first incremental change to the existing treatment process.

Ultraviolet transmissivity testing carried out during the summer concluded that UV disinfection is not a feasible option due to extremely low UV transmissivity levels determined in filtered wastewater and water samples collected through the lagoon system and along Maple Lake Creek. A UV system would also have to be sized to handle the 20:1 peak wet-weather flow peaks. Chemical disinfection is better suited to responding to wide flow variations. Because the of the environmental concerns regarding using chlorine for chemical disinfection, it is recommended that Peracetic Acid (PAA) disinfection be used instead.

The next incremental change to meet the current Discharge Permit and MWR requirements is to add phosphorus treatment to reduce effluent total phosphorus concentrations to less than 1 mg-P/L. This could be done in numerous ways, including the use of chemicals to precipitate phosphorus (e.g. lanthanum chloride, alum or ferric chloride), or by zero-valent iron reduction as a colloidal reactive barrier incorporated into a reed-bed filtration system. This reed-bed would also incorporate carbon media designed to adsorb toxic and complex organic and inorganic contaminants of concern – including emerging contaminants such as pharmaceuticals and endocrine disrupting chemicals. This measure specifically addresses on of the "action-one" aspirational goals set by the Wastewater Advisory Committee of "removing man made toxins".

Finally, the un-ionized ammonia and associated effluent toxicity requirements are being met by the current lagoon system, and are expected to continue to be met by any improved lagoon or fully mechanical treatment process.

After due consideration of alternative treatment approaches, three primary treatment Options were selected for detailed evaluation.

- Option 1 – an upgraded lagoon based system, with mechanical and chemical enhancements. This Option can be implemented in several Phases;
    - Phase 1 - Lagoon optimization with mechanical solids-liquid separation, chemical phosphorus removal and peracetic acid disinfection. This is the "minimal scope" project to achieve compliance with the existing Discharge Permit (910 m^3/d) and Federal effluent conditions, and does not meet long term population growth nor MWR requirements. Thus, Option 1, Phase 1 cannot be an LWMP endpoint, only an intermediate phase.
    - Phase 2A – upgrade to Phase 1 to increase treatment capacity to 3,600 m^3/d and 7000 people, compliance with MWR "Moderate Exposure Potential" water quality criteria, and relocation of

the discharge to augment flows through the natural wetlands to the north of the existing lagoons.

- Phase 2B - upgrade to compliance with MWR GEP water quality criteria by adding both primary and tertiary filtration equipment and allowing continued direct discharge to Maple Lake Creek, with an alternative discharge to the natural wetlands to the north of the existing lagoons.

- Option 2 – "baseflow" mechanical treatment process including primary solids separation, biological treatment, tertiary filtration and disinfection, meeting the MWR GEP water reuse effluent water quality, with excess wastewater flows greater than 3,600 m^3/d bypassing the mechanical treatment process into the existing lagoon system for biological treatment followed by disinfection.
- Option 3 – "full flow" mechanical treatment process including primary solids separation, biological treatment, secondary solids separation, tertiary filtration and disinfection, with all flows greater than 3,600 and up to 14,400 m^3/d passing through at least portions of the mechanical treatment process, including disinfection. For this option the existing lagoons are decommissioned.

Option 1, Phase 1 is the minimal project required to achieve compliance with the current Discharge Permit. It involves optimizing the treatment performance and capacity of the existing lagoons as the primary means of BOD removal, with additional enhancements to meet other permit criteria. This will be accomplished by:

- switching the function of the two existing lagoons by aerating the larger lagoon to increase the facility's biological treatment capacity, and converting the current smaller aerated lagoon into a facultative lagoon for removing suspended solids;
- moving the existing surface aerators from the small lagoon to the large lagoon, and adding additional surface aerators to the larger lagoon to increase the amount of mixing and oxygen available for aerobic biological treatment;
- reducing the potential for short-circuiting within the larger aerated lagoon, and maximizing the average hydraulic retention time for treatment, by installing suspended (floating) baffle curtains;
- installing mechanical liquid-solids separation equipment to remove suspended solids and algae, with provision for chemical addition for phosphorus removal;
- providing a passive geofabric waste biosolids (sludge) dewatering system; and
- disinfection using peracetic acid.

Implemented as a single initial phase of work, Phase 1 focusses on achieving the necessary BOD, TSS, total phosphorus, and indicator bacteria water quality reductions to comply with the Village's current Discharge Permit requirements and allow the performance of the upgraded system to be evaluated and verified before further modifications are considered and implemented.

With that accomplished, a second phase can be carried when required in the future to expand treatment capacity and meet MWR requirements by adding additional mechanical equipment components. As the Village Cumberland was directed by the Ministry of Environment to consider alterative discharge locations for the purpose of phosphorus removal, discharge to the wetlands located to the north of the lagoons, without immediate or direct public access, would require a water quality essentially the same water quality under the MWR as is currently required by the Discharge Permit (i.e. meeting the Moderate Exposure Potential (MEP) reclaimed water quality).

Option 1, Phase 2A is intended to meet MEP water quality for flows up to 3,600 m^3/d, with the primary discharge to the natural wetlands to the north of the lagoons, and indirectly to MLC. To meet the MEP water quality for the increased discharge, additional solids-liquid separation and disinfection equipment will be required as follows:

- add a second influent screen, and second chemically enhanced separation unit, to meet the MWR redundancy requirements;
- add a pumping system to transfer up to 3,600 m^3/day of disinfected (MEP quality) reclaimed water to the natural wetlands (and optional Reed-bed) along with a subsurface distribution gallery or channel to disperse the reclaimed water to the north natural wetlands – with drainage and indirect discharge to Maple Lake Creek.
- Optionally, construct a Reed-bed at the discharge location to the natural wetlands.

Option 1, Phase 2B would enable continued or resumed direct discharge into MLC by improving the effluent water quality to meet the MWR Greater Exposure Potential (GEP) water quality for reclaimed water use for stream augmentation. Under this scenario, the wetlands discharge becomes the secondary (alternative) discharge location required under the MWR in the event the GEP water quality isn't being met. As the existing lagoons have only a finite capacity to remove BOD, rather than increase the size of the lagoons to handle future BOD load increases, Option 2B provides a more cost-effective method of BOD reduction in the form of enhanced mechanical primary solids separation using a fine primary-filtration device. The GEP reclaimed water quality is suitable for beneficial stream augmentation into MLC without the need for dilution, and can also be used for other non-potable water applications if desired.. Excess wet-weather flows beyond 3,600 m^3/d would bypass the primary and tertiary treatment components and directed through the lagoon for treatment system. All flow streams will be disinfected using peracetic acid prior to discharge.

Option 2 involves constructing a mechanical biological treatment process to treat the "baseflow" of up to 3,600 m^3/d of wastewater to a MWR GEP water quality standard to allow continued discharge to Maple Lake Creek as a stream-augmentation beneficial-reuse application. A Membrane Bioreactor (MBR) system was chosen as the model mechanical treatment system for the purpose of evaluating options, but other forms of advanced secondary treatment and tertiary filtration could also be considered. Wet weather flows in excess of 3,600 m^3/d would be diverted through the existing lagoon treatment system in its current configuration, prior to merging with the baseflow for disinfection and discharge to MLC.

This Option provides an "all-new" Cumberland treatment plant that would meet the current MWR standards for treated water quality and equipment redundancy. A continued discharge to Maple Lake Creek under the MWR would require a reclaimed water standard meeting Greater Exposure Potential (GEP) conditions due to low dilution in the receiving environment. Mechanical treatment is well suited to producing a high-standard reclaimed water quality with a tightly controlled treatment process.

Option 3 also provides mechanical treatment and disinfection capable of achieving a MWR GEP reclaimed water quality suitable for beneficial stream augmentation into MLC without the need for dilution, for up to 3,600 m^3/d. It also provides mechanical treatment, and disinfection, to achieve a secondary water quality for excess flows up to 14,400 m^3/d. A moving bed biofilm reactor (MBBR) process was specifically selected for Option 3 as this process can handle large wet weather flow peaks without washout of biomass. This option provides suitable mechanical treatment for the high winter flows, and the lagoons could be decommissioned or re-purposed.

A key consideration in the development of the treatment options was the ability to do a "phased implementation". Each Option can be implemented as either a single, or two-phased implementation. While a two-phase approach allows deferring some works and cost to the future, it also increases the total cost over a one-phase execution – estimated to be approximately 10%.

Table B provides a summary of the capital and operating costs for the selected LWMP Stage 2 wastewater treatment alternatives.

Table B. Summary of Treatment Option Capital and Operating Costs

	Option 1			Option 2	Option 3
	Phase 1	Phase 2A	Phase 2B		
Capital Cost for 1-Phase execution	$5.6M	$8.7M*	$10.6M	$ 9.3 M	$14.8 M
Capital Cost for 1-Phase with Wetland	$6.6M	$8.7M*	$11.6M	$10.2M	$15.8M
Capital cost for 2-Phase execution	n/a	$9.5M*	$ 11.7M	$10.2M	$16.3M
Capital cost for 2-Phases with Wetland	n/a	$9.5M*	$12.7M	$11.2M	$17.3M
Annual Operating Cost	$350k	$375k	$425k	$450k	$500k

* Includes the wetland augmentation as this is integral to Phase 2A

Emerging Contaminants, and Removal by Biochar Media Reed-bed

The Stage 2 LWMP also considers the potential for treating the wastewater to remove emerging contaminants including endocrine disruptive compounds, pharmaceuticals, contaminants from personal care products, heavy metals and persistent organic pollutants. This was identified by the Wastewater Advisory Committee as an aspirational goal. This is an emerging area of interest and research focus in the field of wastewater treatment; however, activated carbon filtration has been demonstrated to be effective, albeit expensive, in removing many of the emerging contaminants. A potentially less expensive alternative to activated carbon is “biochar”, which is charcoal made from organic materials. Prepared for the specific purpose of being used as an adsorbent filter material, biochar has proven effective in removing emerging contaminants from wastewater. Another technology that has emerged as a means of removing emerging contaminants is a “reed-bed”, which is an engineered constructed-wetland that provides a range of biochemical conditions to adsorb and degrade some of these emerging contaminants.

For Cumberland, the proposed approach is to combine both activated carbon and wetland treatment in the form of a reed-bed that contains biochar as part of the granular media. The biochar is intended to adsorb the various micro-contaminants and by retaining them provide greater opportunity for the microbial community to break down and digest the more complex organic contaminants. The carbon from the biochar can also support bacterial growth and biodegradation within the reed-bed. A full-scale biochar media reed-bed, for the purpose of filtering stormwater, was constructed at the Port of Tacoma in 2014, and has is reported to perform very successfully.

At this concept stage, there are still several unknowns to be resolved before a biochar-enhanced reed-bed project can proceed. These include:

- source and cost of the biochar and gravel media;
- practical size of the reed-bed;
- construction considerations – excavation, berms, piping etc.

It is planned to address these unknowns through further study by a field pilot test in 2018-2019

For the purpose of the Stage 2 LWMP a “placeholder” budget of $1M was adopted for the reed bed, with the intention of building as much reed-bed as this budget will allow.

The biochar component results in substantial carbon sequestration that, if validated and accepted by the relevant authorities, would make the entire wastewater facility carbon negative for its operational life. This would be the first documented carbon-negative wastewater facility in the world.

The biochar media reed-bed has the potential to address almost all the Wastewater Advisory Committee's Environmental Goals and is the only one that is carbon negative. It also makes for a good prospect for funding under federal and provincial infrastructure funds, and environmental leadership funds. Since the reed-bed is not needed for meeting regulatory requirements, its use at Cumberland is therefore entirely discretionary, and it can be added to any treatment system, at any time.

Biosolids

The method of managing waste biosolids greatly depends on the treatment option adopted. The aerated lagoon treatment options are expected to generate insufficient amounts of biosolids and frequencies to warrant consideration for all but a simple dewatering approach using geotextile dewatering bags and processing of dewatered biosolids by composting at the nearby Comox Valley Regional District facility. The CVRD organic composting facility provides indirect beneficial reuse. The proximity of the landfill and available volume within the landfill plus operating cost make the current management practice the optimal short-term approach. In addition, the periodic nature of collecting biosolids from the lagoons does not align well with providing dedicated biosolids management equipment. The mechanical treatment options generate a continuous stream of biosolids that would justify dedicated dewatering equipment.

Options for utilizing the valuable nutrient inherent in municipal sludge is a directive well supported by the Wastewater Advisory Committee. A phased approach is suggested whereby investment into the liquid portion of the plant must remain the focus. Once funding and detailing of the upgrade is complete, the community retains the advantage of having the landfill to manage the recovered solids. With the upgrade in place, the community can then review options for biosolids use. This may take advantage of the Cumberland owned forested areas for Silviculture projects. These projects are often challenged by seasonal restrictions, so this may be an approach of both landfill and silviculture. In public consultation sessions, expansion of agricultural activities – especially on the eco land had considerable support. Given the nature of the solids, the value of the biosolids may make the agricultural use a viable approach meeting sustainability directives and social values within the community.

Resource Recovery

Integrated Resource Recovery is also considered including: water reclamation and reuse; nutrient recovery; and energy recovery. The relatively small scale of the Cumberland wastewater treatment facility combined with the lagoon-based options under consideration does not provide significant opportunities for resource recovery. Potentially viable options for reuse water include non-potable water use at the nearby hospital laundry facility and potential decentralized wastewater reclamation and reuse opportunities as part of future land development projects; however, the critical need to augment flows in Maple Lake Creek and the Trent River using the treated effluent limits the amount of reclaimed water that can be reused in the community. The lagoon-based treatment system also inherently minimizes the quantity of waste biosolids that could be processed anaerobically to recover methane and soluble nutrients; however, if the community were to select Option 2 or Option 3, consisting of more mechanically intensive treatment processes, there may be some opportunity for anaerobic treatment. Finally, the lagoon options and high stormwater flows (and associated lower liquid temperatures) also limit the potential for thermal energy recovery in winter. There is one potentially viable energy recovery option which is heat recovery from the treated effluent in summer, for use by the adjacent hospital laundry, which is a large heat user. The lagoon system has the unusual characteristic of the summertime effluent being warmer than the influent – thus the lagoons are acting as large passive solar collectors. In summer, the gross heat resource of the effluent is greater than the total heat demand of the laundry. This heat recovery opportunity is being pursued in cooperation with the laundry facility, and the most likely operational model will be for Cumberland to "give" the laundry the treated effluent for them to extract as much heat as practical.

Comox Lake Area

This Stage 2 report also discusses the problems and concerns of the impact of the existing development around Comox Lake and, particularly, whether the existing onsite systems and continued practice of onsite wastewater servicing can protect lake water quality. In order to determine whether the status quo is satisfactory (subject to brining individual onsite systems up to current standards), or whether a cluster or centralized wastewater management system would provide a more sustainable level of servicing for the area, further study is required. It is recommended that the Stage 3 Liquid Waste Management Plan include a comprehensive study of the Comox Lake area within the Village boundaries to determine which of the three alternatives described in this Section are best suited to the area.

Water Conservation

Cumberland has made good progress on water conservation since the adoption of the first water conservation plan in 2005. Water meters were installed in 2011, and metered rates came into effect in spring of 2014. Since 2011, the average annual water consumption has dropped by almost 40% and the peak month water consumption has dropped by almost 60%. The impact on wastewater flows has been less dramatic, since most of the water conservation measures target outdoor water use. Even so, from 2009 to 2017 the average dry weather wastewater flow has decreased from 847 to 770 m^3/day, a 9% decrease. On a per capita basis, the decrease is more substantial, as population has grown during this period. The success of water conservation measures implemented by the Village of Cumberland is demonstrated by the reduction in the capita ADWF, which has decreased from 265 to 212 L/cap/day, an 18% decrease, over the same time period.

Cumberland is continuing to make good efforts on water conservation with excellent public information programs.

An "on site' reclaimed water project is proposed for the wastewater treatment upgrade, to use the final treated water for washing the influent screen. This is expected to result in a potable water saving of about 10 m^3/day, or 0.7% of the summer daily potable water use.

Combined Storm Sewers, Infiltration and Inflow

Efforts to separate the combined sewer system into sanitary and storm sewers have gradually been carried out since Permit 197 was first issued in 1967. Due to the long time-frame, documentation of these changes prior to 2000 is limited, though there have been two major projects since then. The 2017 Dunsmuir Ave storm separation created the trunk main to allow connection of side branches within the main combined system area. For 2018, the Village of Cumberland plans to extend the storm sewer in conjunction with planned road work on Egremont Road up to Ulverston Avenue to establish a new storm sewer pipeline that has sufficient capacity for future storm separation efforts in the area west of Egremont Road between Dunsmuir Avenue and Ulverston Avenue. The Village is also planning to complete a block of separation in the lane south of Maryport Avenue between Egremont Road and Silecroft Road later this year.

In addition to continued efforts to construct separate sanitary and storm sewers to replace combined sewers, the Village of Cumberland carries out an ongoing program every year to reduce inflow and infiltration (I&I) into sanitary and combined sewer systems. This work includes smoke testing, dye testing, and CCTV investigations. Village operations are hoping to start a formal process of cataloguing all the sewer camera work and testing that's been done to date. A visual inspection of the Hope Road sewer trunk-main manholes is planned to help narrow down where inflow is entering the sewer along that section.

Although the records show the combined sewer flows have increased despite the sewer separation efforts, once the effects of climate change (i.e. net increase in annual rainfall) are taken into consideration, the Village's efforts in sewer separation has, in fact, reduced the proportion of stormwater entering the sewer system. There has been a progressive reduction in the amount of wastewater generated per mm of rainfall since the sewer separation program began, falling from 425 m^3/d per mm of rainfall in 2013 to just over 350 m^3/d per mm of rainfall in 2017 (i.e. a net reduction in stormwater contributions of almost 20 percent over that period).

Funding Considerations

A key hurdle in Cumberland's ability to implement any wastewater treatment project is funding. Projects that exceed Cumberland's combined reserves and borrowing capacity can only proceed with the assistance of external grant funding. The opportunities, and constraints, for pursuing the major external grant funding avenues are summarized, with an analysis based on the recent history of grant programs available in 2015-2017, and discussions with various program administrators in December 2017. Funding that is discussed includes: Joint provincial-federal infrastructure funding; the Federal Gas Tax Fund; Provincial and Federal Specific Funds; Green Municipal Fund; Climate Innovation Fund; and non-innovation funds. An initial qualitative assessment of suitability of the different options for the various funding programs is provided based on previous experience and the evaluation information available from the funds themselves.

In the Cumberland context, financing of a wastewater project can come from three major sources; 1) Village of Cumberland wastewater reserves; 2) borrowing capacity; and 3) grants from outside funding sources, typically Provincial and Federal governments. While development of a sewer financing plan is a Stage 3 LWMP activity, the ability of Cumberland to pay for a project is a major factor in the decision making about preferred options, and so is included here. The financing position that Cumberland is in, for a wastewater project, is summarised as follows:

1. There are negligible reserves available, and they will increase too slowly to fund a near term project.
2. The maximum possible borrowing capacity is $7.1M
3. While all available grant opportunities will be pursued, it could take years before any funding is obtained

If a project is going to be less (or significantly less) than $7M, then Cumberland can decide to borrow and proceed without waiting for outside funding. If a project is going to be more than $7M, Cumberland will need to wait for securing of outside grants before it can be completed, thus making timing unpredictable. This financing framework, specifically the borrowing capacity, sets a limit on how much can be done immediately, thus necessitating a phased approach. The first phase would:

1. improve treatment quality to meet the current Permit and new Federal requirements;
2. cost less than $7M, thus allowing Cumberland to decide to proceed; and
3. be operational by 2020.

The second phase would:

1. deliver any further improvements in treatment quality that are needed, or desired (e.g. for reclaimed water);
2. create any additional capacity for future growth not delivered in the first phase, and
3. proceed when outside grants are obtained and/or reserve funds have built up sufficiently,

If grants are available, both phases can be done at the same time, and the ideal solution is one where a planned project meets all current and future needs, costs less than $7M and, thus, does not need to be phased. Once a project has started, or gone out to tender, it is not eligible for most funding programs (with the notable exception of the Green Municipal Fund) so it is ideal to pursue and secure grants before commencing the project. If grant funding is not obtained, and the project has not started, the scope can be changed and/or reduced to reduce the overall cost.

Public Engagement

The conduct of this Stage 2 process has involved extensive public engagement, as documented within this report. The Wastewater Advisory Committee contained six volunteer members of the public, and held fifteen meetings that were all open to the public, including three day-long workshops. Public events included a lagoon site tour and four different open houses held by the WAC, and there have been six public newsletters published while developing this Stage 2 LWMP. And, the Village of Cumberland Council served as the Wastewater Steering Committee. Overall the public engagement has been agreed to be very successful, and the WAC are to be thanked for their commitment and efforts.

Selection of Preferred Discharge and Treatment Options

The culmination of all the Stage 2 LWMP information is to select the preferred long term Discharge and Treatment Option. To do this, the Wastewater Advisory Committee used the goal based Evaluation System to evaluate and rank the short listed treatment options developed in the Stage 2 study.

The evaluation was carried out at WAC meetings #14 (Nov 30, 2017) and #15 (Jan 25, 2018).

The environmental study show that the need to maintain summertime flows in Maple Lake Creek meant that this is the only environmentally acceptable discharge location, but the discharge could be indirect to MLC via the north wetlands.

The Committee confirmed that the preferred effluent discharge location is a subsurface discharge to the wetlands along the north side of the lagoons with an indirect (drainage) release to Maple Lake Creek.

For treatment, the four long-term treatment options were evaluated (Option 1, Phase 1 was not evaluated as it is an interim option only). The results of the evaluation are summarized in Table C.

Based on the evaluation, the Wastewater Advisory Committee has selected Option 1, Phase 1+2A as the preferred long term treatment option.

The WAC also chose to;

1. Add the Biochar Media Reed-bed to the treatment option, subject to successful field testing.
2. Pursue grant funding for a complete project – Phase 1+ 2A, rather than just Phase 1; and
3. Because of the immediate need to achieve regulatory compliance, to move forward with implementation of the preferred treatment option using the regulatory approval of the existing Discharge Permit.

The long term authorization of discharge beyond the Permit limit, and the secondary liquid waste issues (storm sewer separation, Comox Lake area, reclaimed water, etc) will be the subject of study for the future Stage 3 of Cumberland's Liquid Waste Management Plan.

Table C. Long Term Treatment Option Evaluation Matrix

		Option 1 Upgraded Lagoon		Option 2	Option 3
	Category Score	**Phase 1 + Phase 2A**	**Phase 1+ Phase 2B**	**Baseflow Mechanical**	**Full Flow Mechanical**
Water Quality		MEP	GEP	GEP	GEP
Discharge Location		N. Wetland	MLC	MLC	MLC
Capital Cost		$8.7M	$10.6M	$9.3M	$14.8M
Annual Operating Cost		$375k	$425k	$450k	$500k
Affordability	40	36.6	27.5	26.7	11.4
Economic Benefits	20	12.9	11.5	8.8	9.3
Environmental Benefits	20	16.5	14.1	12.9	14.5
Social Benefits	20	13.9	12.4	10.4	10.4
Total Score	**100**	**79.8**	**65.6**	**58.8**	**45.7**

-//-

 The preparation of this feasibility study was carried out with assistance from the Green Municipal Fund, a Fund financed by the Government of Canada and administered by the Federation of Canadian Municipalities. Notwithstanding this support, the views expressed are the personal views of the authors, and the Federation of Canadian Municipalities and the Government of Canada accept no responsibility for them.

Table of Contents

List of Figures

List of Tables

1.0 DOCUMENT SCOPE

1.1 Document Purpose

This document represents the compendium of work undertaken by the Village of Cumberland to complete Stage 2 of the Liquid Waste Management Plan process, as defined by the BC Interim Guidelines for Preparing Liquid Waste Management Plans (2011).

This document also serves as the Feasibility Study Report for FCM Green Municipal Fund Project #15159

1.2 Document Structure

This report consists of the following 18 technical chapters

CHAPTER 2. LWMP GOALS AND EVALUATION SYSTEM

CHAPTER 3. REGULATORY FRAMEWORK

CHAPTER 4. RECEIVING ENVIRONMENT

CHAPTER 5. HISTORICAL AND PROJECTED FLOWS AND LOADS

CHAPTER 6. DISCHARGE OPTIONS

CHAPTER 7. EXISTING LAGOON TREATMENT PERFORMANCE

CHAPTER 8. TREATMENT OPTIONS

CHAPTER 9. COSTS

CHAPTER 10. EMERGING CONTAMINANTS

CHAPTER 11. EFFLUENT POLISHING BY BIOCHAR REED-BED

CHAPTER 12. BIOSOLIDS

CHAPTER 13. INTEGRATED RESOURCE MANAGEMENT (IRM)

CHAPTER 14. COMOX LAKE AREA SERVICING

CHAPTER 15. WATER CONSERVATION

CHAPTER 16. COMBINED SEWER SEPARATION

CHAPTER 17. GRANT FUNDING ANALYSIS

CHAPTER 18. FINANCING FRAMEWORK

CHAPTER 19. WASTEWATER ADVISORY COMMITTEE, PUBLIC CONSULTATION AND WASTEWATER STEERING COMMITTEE PROCESS AND STATUS

2.0 LWMP GOALS AND EVALUATION SYSTEM

2.1 Goal Development

The fundamental objective of the LWMP process is to set the desired outcomes, or goals, at the start of the process, and then work out how best to meet them. In a "systems approach", this can be stated as;

1. Identify the problem, and the goals of a successful solution
2. Identify, study and evaluate the alternative solutions
3. Select and implement the best solution

This closely matches the three stage LWMP process, with the addition of continuing public engagement during the process.

The goals encompass both the mandatory requirements – the "needs" and the aspirational goals of the community – the "wants". The aspirational goals should broadly match the goals set in major planning documents such as the Official Community Plan (OCP) and Sustainability Plan.

The first major task for the Wastewater Advisory Committee (WAC) was to develop a set of project goals and use these to create the evaluation system. The process used for developing these goals was through;

1. Familiarization of the WAC with the current situation by the site tour and briefings by the technical consultants.
2. A committee "brainstorming" session to develop and rank the goals.
3. Technical review by the Technical Consultants and Project Coordinator, and creation of the Evaluation System.
4. Comparison of the goals against the major Cumberland planning documents (OCP, 2016 Strategic Priorities, Comox Valley Sustainability Strategy and Social Procurement Policy).
5. Further discussion by the WAC.
6. Presentation to the public at an Open House.
7. A final review by the WAC.
8. Recommendation to the Steering Committee.

The final list of goals as determined by the WAC, and recommended to the Steering Committee, is reproduced In Table 2-1.

2.2 Evaluation System

The Goals, and their scores, give the relative importance of each goal, and category, which will form the basis of the evaluation system. The intent is to produce a system that groups goals into economic, environmental and social categories and uses numeric rankings to calculate an overall score for any given Option under consideration. This allows comparison of very different options on a common basis.

The scoring for the Goals was done by asking the eight WAC members present at the "goal setting meeting" (June 16, 2016) to rank the "importance" of each goal developed on a scale of 1 to 5. These scores were then summed for each goal to get a score out of 40.

Table 2-1 Final List of Goals

Category	Scores (max 40)	Ranking	Description	Goal Type
Affordability	40	1	Ensure tax burden on residents is sustainable. This is both capital and operating costs	Aspirational
Affordability	30	2	Attract grant funding to offset capital costs	Action
Economic	30	3	Productive use of reclaimed water - agriculture, industry (=job creation), potential for reduction in potable water infrastructure requirements	Action
Economic	25	4	Reduce energy use, pursue renewable energy production and obtain GHG credits	Action
Economic	24	5	Attract and retain industry and draw tourism through innovation in meeting community wide goals, and branding green	Aspirational
Economic	12	6	Artist based beautification	Action
Environmental	27	1	Innovation/Environmental leadership	Aspirational
Environmental	23	2	Support health of waterways with robust treatment	Action
Environmental	23	3	Use of existing ecosystems to control cost including low tech or bio solutions plus beneficial use of produced biosolids	Action
Environmental	20	4	Sustainability, Climate Change resilience/adaptation/robustness	Aspirational
Environmental	10	5	Clean air - reduction/avoidance of particulate air pollution	Aspirational
Environmental	9	6	Reduce manmade toxins in effluent (pharmaceuticals, hormones, bisphenol A, heavy metals, other trace chemicals, etc.)	Action
Social	37	1	Inclusivity of Cumberland to create an identity and positive legacy adding to the social license	Aspirational
Social	15	2	Inclusive costing/metered sewer – a socially equitable sewer rate system	Action
Social	12	3	Purple pipe ready -	Action
Social	8	5	Public education and participation about water, wastewater and related environmental issues	Action
Social	8	5	Garden/Zen/all year green lawns – value of keeping public and private parks and private gardens green even in drought conditions, with reclaimed water.	Action
Social	8	6	Coal Mine/Railroad Heritage – making the works	Aspirational
Social	1	7	Strengthen relationship with Comox Valley	Aspirational
Total Scores	**362**			

The goals and scoring were presented to the public at the Open House of July 14, 2016. Feedback from the Open House confirmed that affordability is the single most important goal. An economically, environmentally and socially beneficial solution is of no use if the community cannot afford to actually implement it.

The WAC discussed the affordability issue further at its July 28 meeting and voted to increase the importance of the affordability category, relative to the other benefits. The original and final rankings are shown in Table 2-2, showing the Wastewater Advisory Committee recommended the evaluation of the Options be weighted based on 40% for affordability, and 20% for economic, environmental and social factors.

Table 2-2 Sustainability Weighting Factors Established and Recommended by the WAC

Category	Scores	Percentage (Original)	Rounded Percentage	WAC Ranking (Final)
Affordability	70	19%	20%	40%
Economic	91	25%	25%	20%
Environmental	112	31%	30%	20%
Social	89	25%	25%	20%
Total	**362**	**100%**	**100%**	**100%**

The primary purpose of the goal setting exercise was to assist the Wastewater Advisory Committee members in establishing a value system and weightings for the purpose of screening and evaluating the various Options that were developed. For the LWMP, an Option is a combination of a discharge location and a suitable treatment system.

A two stage Evaluation System was developed to assist the Wastewater Advisory Committee in evaluating options presented by the study team.

Stage 1 involved the development of a long list of options which are screened by the WAC using the evaluation system to create a short list. This involves establishing a series of “decision gates”, most of which involve establishing a pass or fail assessment. Any option that fails any gate is eliminated from further study. This system is used to red flag options that are “showstoppers” – an issue, which if not resolvable, makes them unacceptable. The affordability category is purely subjective in Stage 1, and it is intended simply to rule out options that are “unaffordable” – so large or complex that the technical consultants deem them not worthy of further study. The decision gates used for Stage 1 screening are shown in Table 2-3, in order of application.

In Stage 2, the short list is subject to detailed study, and the options evaluated against the predetermined goals with the objective of selecting a Preferred Option for financial planning and implementation study in Stage 3.

All the Options that make it through this list are then carried through for detailed study in Stage 2.

For Stage 2, Options are studied in enough detail to establish models of the treatment systems and discharge means, and make meaningful estimates of capital and operating costs, probability of attracting grants, and the relevant economic, environmental and social goals that can be achieved, as summarized in Table 2-4, reflecting the sustainability weighting factors established by the WAC.

It should be noted that many of the goals such as “inclusive pricing” or “reclaimed water” are not specifically characteristic of a Treatment and Discharge Option. That is, they are discretionary and can be applied to any Option. As such, they may increase the benefits obtained at the potential cost of affordability. This is then a true test of the evaluation system – that the overall best value option will be the highest scoring one.

In order to score the Options, each Option is evaluated on the basis of how it addresses each of the 19 Goals.

Table 2-3 Stage 1 Decision Gates

Area	Criteria	Determined by	Basis	Decision Type
Regulatory	Environmental regulations/ effluent quality	Ministry of Environment Ministry of Health	Discharge location & time of year	pass/fail
Technical	Technical feasibility	Technical Consultants	Treatment system required to meet effluent quality	pass/fail
	Constructability	Technical Consultants	complexity, site requirements	high/low
	Time risk for 2021 deadline	Technical Consultants	complexity, permits, etc.	high/low
Political	Politically acceptable to Cumberland	WAC	Cumberland values	pass/fail
	Politically Acceptable Externally	WAC+Steering Committee	External Values	pass/fail
Affordability	Capital cost	Technical Consultants	Treatment + piping to discharge location - – is it so expensive as to be “unaffordable”	pass/fail
	Grant probability	PC+TC+staff	Everything	high/med/ low
	Ability to pay	Staff+Steering Committee	Reserves, borrowing capacity, DCC's	high/med/ low

Table 2-4 Stage 2 Evaluation System Summary

Criteria	Determined by	On basis of	Decision Type	Weighting	Comments
Affordability	Project Coordinator, Technical Consultant, Staff, Steering Committee	Capital and operating costs, grant funding potential, ability to pay	score	40%	Operating and maintenance costs to be evaluated as a net present value
Economic Benefits	WAC	4 Economic Benefit Goals	score	20%	Benefits that occur over the life of the project
Environmental Benefits	WAC	6 Environmental Goals	score	20%	Benefits that occur over the life of the project
Social Benefits	WAC	7 Social Goals	score	20%	Benefits that occur over the life of the project
Total				**100%**	

To score how well an Option achieves each individual Goal, a standardized system is used, similar to evaluating a Request for Proposals. The process is as follows;

1. The Option is given a Score from 0 to 5 for how well it achieves each Goal
2. The Score is multiplied by the Goal Value to get a Goal Score
3. All the Goal Scores are summed

4. The Option with the highest Total is deemed to be the preferred Option.

Table 2-5 shows the layout of the scoring system. The evaluation example shown is of the preferred treatment option that was selected in November, 2017.

Table 2-5 Scoring Table

Category and Goal	Type	Input from	Goal Value	Assigned Score per Goal (0-5, 5 =best)	Goal Score
Sustainable Tax Burden	Objective	Consultants, Staff	23	5.0	23.0
Attract Grant Funding	Subjective	Consultants, Staff	17	4.0	13.6
Subtotal Affordability			**40**		**36.6**
Productive use of reclaimed water	Subjective	Consultants	7	2.0	2.8
Reduce Energy Use and GHG's	Objective	Consultants	5	5.0	5.0
Attract industry and tourism through innovation	Subjective	All	5	3.0	3.0
Artist based beautification	Subjective	All	3	3.0	1.8
Subtotal Economic Benefits			**20**		**12.6**
Innovation/Environmental leadership	Subjective	All	5	4.0	4.0
Support health of waterways with robust treatment	Subjective	All	4	4.0	3.2
Use of existing ecosystems to control cost including low tech solution and or bio solutions plus beneficial use of produced biosolids	Subjective	All	4	5.0	4.0
Sustainability, Climate Change resilience/adaptation/robustness	Subjective	All	4	4.0	3.2
Clean air	Subjective	All	2	3.0	1.2
reduce manmade toxins	Objective	Consultants	2	4.0	1.6
Subtotal Environmental Benefits			**20**		**17.2**
Inclusivity of Cumberland to create an identity and or positive legacy adding to the social license	Subjective	Public	8	5.0	8.0
Inclusive costing/metered sewer	Objective	Staff	3	3.0	1.8
Purple pipe ready	Objective	Consultants	3	1.0	0.6
Aesthetics (Coal Mine/Railroad Heritage)	Subjective	Public, Staff	2	4.0	1.6
Public Education	Subjective	All	2	3.0	1.2
Garden/Zen/all year green lawns	Subjective	Public, Staff	2	1.0	0.4
Strengthen Comox Valley relationship	Subjective	Public, Staff	0.2	3.0	0.1
Subtotal Social Benefits			**20**		**13.7**
Total			**100**		**80.1**

2.3 Iterative Options development

While the Goals are used to eventually select the preferred option, they also serve an important role in guiding the development of the Options themselves. This is especially true for the discretionary goals, which can be applied to any Option.

Thus, the Stage 2 Option development itself becomes an iterative process of trying to develop Options that get the highest score. For a given Option, what can be changed to increase benefits without reducing affordability, and vice-versa. This can be given several iterations, looking at how to implement actions to achieve various benefits, or joint benefits, or attract more funding, or reduce cost. The overall objective is to make each Option the best it can be, so that a choice of several viable and desirable Options is presented.

This is directly comparable to preparing responses to a request for Proposals – the proponent uses the evaluation system to guide them on how to prepare a winning proposal, and runs through options to come up with the highest score possible.

2.4 Policy Implications

The set of 19 goals has been reviewed against Cumberland's major planning and policy documents;

- 2014 Official Community Plan. 2014
- Strategic Priorities, 2016
- Comox Valley Sustainability Strategy,2010
- Social Procurement Policy

This review serves several purposes;

1. To see if the goals developed are consistent with the policies
2. To identify any goals that might be against the policies
3. To identify any policy gaps arising from the goals
4. To identify any goal gaps arising from the policies

The results of the review are included with the July 25 Committee Report (Appendix XX).

Overall, all but one of the goals ("inclusive pricing") were supported by at least one of the plans, and several were supported by three of four. This shows the WAC has come up with goals that are consistent with the major planning policies, and if most of these goals can be achieved, then significant progress has been made in implementing these policies.

2.5 Council Confirmation

With Council confirmation of the proposed LWMP Goals and Evaluation System the WAC proceeded with the remaining steps of the Stage 1 LWMP process, which are to:

- Develop the "Long List" of "Options". It should be noted that the defining feature of an Option is not the "treatment system", but is the "discharge location" for the water. The discharge location, and time of year, determine the effluent quality requirements and the environmental approvals required. It is likely that several different discharge locations can use the same type of treatment. Thus, the real problem to be solved is not how to treat the water but where to send it (in summer).
- Use the decision gates to screen the Long List to the "Short List", that will go for detailed study in Stage 2
- Take the Short List to a public Open House #2 (September 22, 2016)
- Identify any knowledge gaps and other areas of study for Stage 2. Examples include;

- defining the population growth model to be used
- addressing houses on septic fields
- potential uses and customers for reclaimed water
- energy recovery options
- different treatment methods
- biosolids processing options

- Complete the Stage 1 Report (planned for November 30, 2016)

Two other issues were identified for consideration as the WAC moved towards the completion of Stage 1 LWMP.

1. The technical consultants recommended that Cumberland combine the Stage 1 and Stage 2 work into one report, to be submitted to the Ministry of Environment once the preferred option has been selected. The main benefit of this is that it would save time by going straight into the Stage 2 work without the delay of waiting for the Ministry response. The Stage 1 report would still be completed for Cumberland's benefit, to define the current status of the wastewater system. It would capture all the changes that have happened since the original Stage 1 report in 2001, and define the current status of, and future expectations for, the wastewater system. The combining of the two stages does not materially change the work to be done, but allows it to proceed faster. Approval must be sought from Ministry of Environment to combine stages, and it is done fairly regularly.
2. There is likely to be a call for funding applications to the Federal Clean Water and Wastewater Fund in fall of 2016. This is for projects that can be completed by March of 2018, and the funding is up to 50% of the cost. Cumberland could make an application to this fund, for certain elements of the treatment system, such as headworks improvements, lagoon upgrades, disinfection system and biosolids handling, all of which could be completed in this timeframe. These are all elements that will be part of any treatment system, regardless of the effluent quality or the discharge location. This will be studied further as more details of the funding call are released.

2.6 Strategic Objective

The Strategic Objective established Council in 2016 was to;

"Develop an environmentally sustainable method of treating the liquid waste that is produced by the Village"

The goals and evaluation system recommended by the WAC encompass this objective and build upon it.

The Stage 1 Decision Gates ensure that any Options are "environmentally sustainable" and "affordable."

The Stage 2 Evaluation system selects the Option that has the best combination of affordability and benefits.

In effect, the Strategic Objective set by the WAC is to;

"Develop a method of treating and discharging Cumberland's liquid waste that is not only environmentally sustainable but is also affordable and is economically productive, environmentally enhancing and socially beneficial."

2.7 Supporting Documents

The following summary documents were made available for public review and posted on the Village's web site, and are included in Appendix XX

1. WAC Committee Report, 25 July 2016, Results of public Open House
2. WAC Committee Report, 25 July 2016, Recommendation to council of Goals and Evaluation System

2.8 Summary

Through a series of meetings, the Wastewater Advisory Committee (WAC) has developed a set of goals (economic, environmental and social) for the Liquid Waste Management Plan, and specifically the future wastewater treatment and discharge system. These goals form the basis of a two-stage evaluation system to be used to screen and rank the various Options to be developed, and eventually choose the preferred option.

The goals have been reviewed against the major Cumberland policies such as the Village of Cumberland Official Community Plan, the Village of Cumberland 2016 Corporate Strategic Priorities, the 2010 Comox Valley Sustainability Strategy and the Village of Cumberland Social Procurement policy. All but one of the goals are supported by at least one of these policy documents, and some, such as innovation are strongly supported by all of them.

The goals and evaluation system were presented at a public Open House on July 14, 2016, where the public was in substantial agreement with them

The single most important goal identified is "affordability", being the combination of cost and grant funding opportunity. Noting the importance of this, and the emphasis placed on it at the open house, the WAC has increased the importance of affordability relative to the other economic social, and environmental goals as compared to the rankings that were originally arrived at during the initial goal-setting (brainstorming) process.

The WAC, by unanimous vote, recommended that the goals and methodology for option evaluation be adopted by the Steering Committee (Council) as the official Goals and Evaluation System for the Liquid Waste Management Plan and Council accepted those recommendations.

3.0 REGULATORY FRAMEWORK

3.1 Background

This chapter summarizes the current Regulatory Framework affecting liquid waste management planning for the Village of Cumberland, including an assessment of the existing Discharge Permit status and anticipated regulatory changes affecting the discharge in the near future.

3.2 Wastewater Treatment & Disposal Description

The Village of Cumberland is served by a combined sewer system that collects both domestic wastewater and stormwater from within the community and conveys it to a treatment facility consisting of mechanical screening followed by an aerated lagoon and a facultative (passive natural aeration) lagoon, with a discharge into Maple Lake Creek (MLC). MLC is a man-made drainage course that conveys the water from the facultative lagoon about 4 km to a confluence with the Trent River, which flows into Baynes Sound.

During the dry summer months, both MLC and the Trent River have extremely low flows, such that the discharge from the Cumberland lagoons makes up a high percentage of the flow in both water bodies during the summer. While the flow of water from the stabilization pond is obviously extremely important to the receiving environment in both MLC and the Trent River, phosphorus concentrations in the effluent are of concern due to the effects on primary productivity and algal growth within the Trent River, as evidenced by high chlorophyll-a levels measured in the Trent River downstream of the discharge. The BC Ministry of Environment considers the Trent River as an important fisheries resource and are concerned about phosphorus loading to the river.

The high proportion of lagoon discharge into the two water courses gives rise to concerns regarding the phosphorus loading and its effects on primary productivity and algal growth within the Trent River, as evidenced by high chlorophyll-a levels measured in the Trent River downstream of the discharge. The Ministry ambient water quality objective for the Trent River is 0.005 mg-P/L, which is the analytical detection limit for phosphorus. As will be discussed later, the phosphorus concentration in the Trent River sampled upstream of the confluence with MLC is consistently less than the detection limit of 0.005 mg-P/L throughout the year.

3.3 Existing Discharge Permit

The Village of Cumberland holds a Permit PE00197 issued on August 25, 1967 by the (then) Ministry of Environment Lands and Parks, under the provisions of the Waste Management Act (now Environmental Management Act). Since issued, the Permit was last amended on December 3, 1997, under the provisions of the Waste Management Act at that time.

The authorization is for "the discharge of effluent from a MUNICIPAL COLLECTION AND TREATMENT SYSTEM SERVING THE VILLAGE OF CUMBERLAND", and is further authorized as follows:

- Discharge to Maple Lake Creek based on an annual averaging period of 910 m^3/d with a maximum rate of discharge of domestic sewage and stormwater of 2,710 m^3/d
- $BOD_5 \leq 30$ mg/L; TSS ≤ 30 mg/L; Faecal Coliform < 200 MPN/100 mL; Total-P < 1.0 mg-P/L
- Authorized works at the time of permitting were mechanical screens, an aerated lagoon, a stabilization pond, and related appurtenances;
- After May 1, 1999, the authorized works are to include disinfection, and nutrient removal facilities or alternative methods;

- Prior written approval from the Regional Waste Manager is required prior to implementing changes to the authorized works;
- Plans and specifications for the disinfection and nutrient reduction facilities must be prepared by a professional licensed to practice in BC and submitted to the Regional Waste Manager for review before construction commences, and the works must be certified to have been constructed in accordance with the submitted plans by a qualified professional licensed to practice in BC.
- Standby auxiliary power facilities shall be provided to ensure continuous operation of the sewage treatment facility;
- Sludge and screenings shall be disposed of in a manner authorized by the Regional Waste Manager.
- Based on receiving environment monitoring data and/or other information obtained in connection with the discharge, additional treatment facilities may be required.
- Sufficient land shall be secured and held in reserve to allow for future expansion and upgrading of the sewage treatment facilities;
- If the Region does not develop a Liquid Waste Management Plan that includes the Cumberland area, or the Regional Waste Manager deems the plan is not progressing satisfactorily, the following activities shall be undertaken:
  - Source Control Program
  - Stormwater Management Plan
  - Sludge Wasting and Screening Disposal and Biosolids Management Plan
  - Inflow and Infiltration Control Program
  - Sanitary and Storm Sewer Separation Plan
- Terms of reference, development schedules, and implementation timetables for the above activities were to be submitted to the Regional Waste Manager for approval by December 31, 1999.

Table 3-1 summarizes the current status of compliance with the Permit requirements, and the status of efforts to bring the Village into compliance with its Permit.

3.4 Regulatory Changes

Since Discharge Permit PE00197 was issued in 1967, and even since it was amended in 1997, there have been a number of key changes to the associated municipal wastewater treatment and disposal regulations. The first major change was the promulgation of the Municipal Sewage Regulation (MSR) in 1999. The MSR replaced the Permit process with a Registration process in which a Qualified Professional is responsible for preparing support documentation demonstrating compliance with the MSR including an Environmental Impact Assessment (EIA) and Operations Plan (OP). A key aspect of this legislation was the elimination of government review and the permission associated with Permits, and transferring that responsibility to Qualified Professionals within the private sector. A second key feature was the formal introduction of standards for the reclamation and beneficial reuse of wastewater effluent for a wide range of applications including irrigation for forage and food crops, landscape irrigation and ornamental fountains, toilet and urinal flushing and stream and wetlands flow augmentation.

The second change was the revision of the MSR with the promulgation of the Municipal Wastewater Regulation (MWR) in 2012, which maintained the Registration process and introduced a few significant modifications including:

Table 3-3-1 Status of Permit Compliance

Item	Current Permit Requirements	Current Status
$CBOD_5$	30 mg/L	Usually compliant
TSS	30 mg/L	Usually compliant
Total Phosphorus	$\leq$1 mg-P/L	Not compliant
Fecal Coliforms	$\leq$ 200 MPN/100 mL	Not compliant
Add nutrient Removal	By 2015	Not built
Add disinfection	By 2015	Not built
Average flow	$\leq$ 910 m^3/day	***Compliant*** Currently 800-850 m^3/day in dry weather
Wet weather flow	$\leq$ 2,710 m^3/day	Not compliant > 15,000 m^3/day
Source Control Program		Implemented
Stormwater Management Plan		Developed and implemented
Sludge Wasting and Screening Disposal and Biosolids Management Plan		Part of current LWMP activities
Inflow and Infiltration Control Program		Developed and in progress
Sanitary and Storm Sewer Separation Plan		Developed and in progress

1. Introduction of a new wastewater reclamation standard for indirect potable reuse (e.g. replenishment of groundwater resources used as a potable water source).
2. Increased requirements for documentation at the time of Registration. In addition to the EIA and OP documents, the MWR now requires complete drawings be submitted.
3. Restrictions from proceeding with construction until Registration is approved (the MSR allowed construction to proceed after 90 days from submission of the Registration documents).

The MSR was subsequently changed and promulgated under the Environmental Management Act as the Municipal Wastewater Regulation in 2012. Like the MSR, the MWR has provision for discharges to ground equal to or in excess of 22.7 m^3/d, a discharge of any quantity from two or more dwellings to a surface body of water (stream, river, lake, or ocean) with a minimum dilution. For surface discharges the effluent quality depends on the type of water body (i.e. stream, river, lake or marine), the minimum dilution available or size of water body, and the environmental sensitivity of the water body.

In comparison with the Discharge Permit process, the MSR significantly reduced the time required to implement wastewater treatment and disposal facilities by eliminating the need for government review and approval of Permit applications, as well as inherently the Permit appeal process. The MWR requirement to prepare construction drawings before applying for Registration, and the prohibition on beginning construction until the government completes the Registration process made it extremely difficult to implement wastewater treatment and disposal projects on a timely basis.

The MWR considers discharges to surface water bodies, with effluent water quality requirements based on the discharge flow and available minimum dilution ratios. Further, if the available minimum dilution is less than 100:1, an environmental impact study must be carried out by a qualified professional to determine if the effluent quality requirements stated in MWR should be more stringent. Key dilution categories are 10:1 and 400:1 and 1000:1. Unless the discharge meets reclaimed wastewater reuse water quality criteria, a discharge with less than 10:1 is not permitted. If the discharge is to a fresh water body with dilutions of at least 10:1 but less than 40:1, the following conditions must be met:

1. the discharge meets advanced secondary treatment water quality requirements of $BOD_5 \leq 10$ mg/L; TSS $\leq$ 10 mg/L; total phosphorus $\leq$ 1 mg-P/L; and ortho-P $\leq$ 0.5 mg-P/L;
2. no other discharge options are available;
3. the discharge must be authorized by a director.
4. If the discharge is to recreational waters the median fecal coliform level at the edge of the initial dilution zone must be less than 200 MPN/100 mL; and
5. If the discharge is to shellfish bearing waters, the median fecal coliform level at the edge of the initial dilution zone must be less than 14 MPN/100mL

Although a discharge is not normally permissible if the dilution ratio is less than 10:1, wastewater that meets the following “Greater Exposure Potential” (GEP) reclaimed wastewater reuse water quality can be discharged into a surface water body if it is for beneficial purposes, in the case of Maple Lake Creek and the Trent Rivers, the beneficial application would be stream augmentation to increase summer flows:

- $CBOD_5$ & TSS $\leq$ 10 mg/L;
- Turbidity $\leq$ 2 NTU (average) & $\leq$ 5 NTU (maximum)
- Fecal coliform < 1 CFU/100 mL (median) & $\leq$ 14 CFU/100 mL (maximum)

Reclaimed water is discussed further this document.

The 2017 Environmental monitoring program confirmed that there is effectively no dilution in Maple Lake Creek during the summer, and there is probably less than 10:1 dilution even under winter conditions

The MWR also authorises the Ministry to impose additional treatment conditions if they deem it necessary to protect the environment, and the Ministry of Environment have established an “in-stream” objective for the Trent River of an average of 0.005 mg-P/L and maximum of 0.01 mg-P/L to be met on a seasonal basis of from May 1 to September 30 each year. As Cumberland is currently required to meet a phosphorus concentration of less than 1 mg-P/L, as an effluent requirement, it is unclear as to whether the Ministry’s objective is an addition to the Discharge Permit conditions, or whether the in-stream objective would only apply if Cumberland were required to register the discharge or establish a LWMP under the current Municipal Wastewater Regulation. The Ministry have indicated the seasonal in-stream phosphorus objectives do not apply to Maple Lake Creek – only to the Trent River.

With each change in provincial regulations previously authorized discharges were grandfathered and remained in effect. Grandfathering provisions allow existing Permits and Registrations that were created under previous legislation to remain valid until such time as a major change occurs or is required; however, historical precedence indicates the Ministry is willing to consider minor amendments to existing discharge authorizations. For example, a request to increased the authorized discharge flow by up to 10 percent has typically been considered to be a minor amendment. Although the Village of Cumberland is planning on making significant changes and improvements to their wastewater treatment process, as discussed in the next section, as long as the improvements are in line and in compliance with the works authorized under the current Discharge Permit PE00197, a requirement to conform and be in compliance with the MWR is not expected.

3.5 Federal Wastewater Systems Effluent Regulations

On July 12, 2012, the federal government, under the Fisheries Act, passed the Wastewater Systems Effluent Regulations (WSER) that include mandatory minimum secondary wastewater treatment effluent quality standards, along with requirements for monitoring, record-keeping, reporting and toxicity testing are specified in the Regulations. As of January 1, 2015, the following provisions of the Regulations came into effect:

- All treated effluent discharged into a surface water body must meet the following water quality standards:
  - (a) average carbonaceous biochemical oxygen demand (CBOD) must not exceed 25 mg/L;
  - (b) average total suspended solids must not exceed 25 mg/L;
  - (c) average total residual chlorine must not exceed 0.02 mg/L, if chlorine is used; and
  - (d) maximum un-ionized ammonia must be less than 1.25 mg-N/L at 15 ^{o}C +/- 1 ^{o}C.
- Unionized ammonia is calculated by the following formula:

  Unionized Ammonia = Total Ammonia / $(1 + 10^{(9.56 - pH)})$
- Effluent water quality averages are calculated annually if the hydraulic retention time is at least 5 days and the average daily flow does not exceed 2,500 m^3/d; or if the average daily flows exceed 2,500 m^3/d but are less than 17,500 m^3/d.
- For treatment systems with a hydraulic retention time of five or more days (e.g. lagoons), total suspended solids for the months of July, August, September and October are not included in the calculated average.
- Operate, maintain and annually calibrate equipment to measure the influent or effluent flow or volumes with a margin of error of +/- 15%, with reporting of discharge flows due on or before May 15, 2013.
- For average annual flows less than 2,500 m^3/d, either monthly grab or composite samples must be collected of the treated effluent, and for flows greater than 2,500 m^3/d and less than 17,500 m^3/d a composite sample must be collected at least every two weeks. For treatment systems with a hydraulic retention time of at least 5 days (i.e. lagoon) and average annual flows less than 2,500 m^3/d, the frequency of effluent grab or composite sampling can be reduced to quarterly.
- For average annual flows between 2,500 – 17,500 m^3/d, quarterly effluent toxicity analyses must also be carried out.

The above points capture the major water quality and monitoring requirements under the WSER, but are not comprehensive. For a full description of the requirements, the reader is referred to the federal legislation:

http://laws-lois.justice.gc.ca/eng/regulations/SOR-2012-139/FullText.html

The new federal regulation is of particular concern for many small communities across Canada who, like Cumberland, have up until now relied on a lagoon-based wastewater treatment process, and are now faced with having to upgrade their treatment systems, largely due to the effects of seasonal algae growth on effluent suspended solids levels. While the regulation requirements do not include consideration for reducing municipal effluent phosphorus concentrations, many small communities also discharge to watercourses that can be impacted by phosphorus, and are also influenced by non-point sources of phosphorus – as is the lower portion of the Trent River before it discharges into Baynes Sound. Many of these communities are also faced with addressing sewer separation and providing a high level of wastewater treatment under less than ideal hydraulic loading conditions as a result of peak stormwater influenced flows.

The BC government had committed to work towards an equivalency agreement and announced several years ago that it was in the process of establishing a harmonization agreement with the federal government to address existing Operational Certificates, Discharge Permits, and Registrations by registering all discharges and then transitioning the non-conforming registrations to the harmonized MWR to ensure they meet the federal WSER.

The initial plan of the BC government was that facilities operating under an existing Discharge Permit with effluent data showing the facility was capable of meeting the WSER requirements would be deemed registered under the harmonized MWR. Facilities that are not of meeting the WSER requirements would be deemed "Transitionally Registered" and the dischargers will continue to meet their former Permit requirements until their facility is upgraded or the federal timeline is reached (2020, 2030, or 2040) whichever comes first. No other sections of the MWR will apply while the discharge is Transitionally Registered.

https://www2.gov.bc.ca/assets/gov/environment/waste-management/sewage/changes-to-prov-municipal-wastewater-discharge-auth.pdf

However, late in the preparation of the Stage 2 LWMP, the Village of Cumberland was informed that as of May 2018 (May 5, 2018, e-mail from Sacha Clark, Environmental Authorization Technologist, BC Ministry of Environment and Climate Change Strategy) "at this time, BC doesn't have a harmonization agreement with the federal government. Consequently, Cumberland should continue to work with the federal government to meet WSER requirements.".

The BC government's original transitional registration would have likely deemed the existing Permit PE00197 as "Transitionally Registered", and Cumberland would have continued to be expected work towards being in compliance with the existing Discharge Permit requirements and the WSER water quality requirements until that compliance is achieved. The province was also planning to require dischargers to submit similar documentation to that normally required for registration under the MWR, specifically:

1. Environmental Impact Assessment
2. Operations Plan
3. As-built Construction Drawings.

As previously noted, the Village of Cumberland's current discharge Permit PE00197 includes the necessary regulatory authorization for treatment works to improve BOD, TSS, Total Phosphorus and disinfection treatment. The Ministry of Environment is aware of the Village's intent to upgrade the existing treatment works under the existing authorizations contained within the Permit, noting that the treatment works will be designed to comply with both the BC Municipal Wastewater Regulations and federal Fisheries Act - Wastewater Systems Effluent Regulations.

3.6 Liquid Waste Management Plans

3.6.1 BC Environmental Management Act - Liquid Waste Management Plan Description

The BC Environmental Management Act (EMA) allows local governments to develop a Liquid Waste Management Plan (LWMP) to protect public health and the environment, with public and stakeholder input, that is then submitted to the Minister of Environment for approval, and the minister must be satisfied that there has been adequate public review and consultation during the development of the LWMP. An approved LWMP allows local government to proceed with implementation, and there is no mechanism to appeal a plan once approved by the minister. The LWMP is a long-term plan for building, financing, and managing liquid waste infrastructure, and usually includes an implementation schedule that can be affected by technical issues, pace of development, and the availability of financing.

In addition to protecting public health and the environment, and obtaining public consultation, LWMP objectives include water conservation, drinking water source protection, resources from waste, energy conservation, climate change adaptation, and mitigation and sustainable financing and asset management.

It is generally expected the LWMP will incorporate regulatory requirements under the Municipal Wastewater Regulation (MWR), as well as the federal WSER requirements. Where the MWR standards are not currently met, the LWMP is used to establish a schedule for upgrading facilities to meet the MWR requirements.

The MWR and the Organic Matter Recycling Regulation (OMRR) under the EMA allow for the beneficial use as well as disposal of appropriately treated reclaimed wastewater and biosolids.

As the Local Government Act and the Community Charter require approval of electors to borrow funds to finance any wastewater infrastructure capital works, an approved LWMP allows local governments to borrow money without seeking public approval; therefore, public consultation is a critical aspect of developing a LWMP and is expected to foster acceptance and a feeling of ownership within the community. Both capital construction and operation costs of the infrastructure must be included, and the community should prepare long range financial plans to ensure resources will be available when they are needed.

LWMPs take into consideration expected urban and rural land development; timing, location and phasing of water and sewer services; and consideration for centralized, decentralized, and on-site servicing options. LWMP should consider the water, wastewater and stormwater infrastructure as interrelated systems, and minimize environmental impacts, reduce life cycle costs and provide flexibility for future expansion or upgrade of facilities. To avoid costly future changes, facilities should be located where long-term land use conflicts will be minimized, and where there is ample room to upgrade and expand.

Up-to-date regional growth strategies and official community plans are essential to establishing a LWMP, taking into consideration population projections, wastewater quantity and quality, water consumption, precipitation records, surface and groundwater water quality data, inventories of plant and animal species and their habitat, and information regarding soil, local drainage, aquifers, and groundwater flow regimes.

The scope of work for each LWMP is specific to each local government in reflecting the community goals and objectives and should be discussed at the outset of the process with the director (Ministry of Environment Regional Manager). Support of the scope of work should be received from the director and the advisory committee prior to starting work on each of the three stages of plan development.

Normally a LWMP is formally initiated with a resolution being passed by a local government. A copy of the local government resolution and their staff report providing justification for the process must be sent to the director, with copies and a covering letter going to the following agencies and groups:

- All municipalities, regional districts and First Nations within and adjacent to the LWMP area or who may be affected by the LWMP (e.g., downstream users);
- Environment Canada;
- Fisheries and Oceans Canada;
- Ministry of Agriculture;
- Ministry of Community, Sport and Cultural Development;
- Ministry of Health;
- Ministry of Transportation and Infrastructure; and
- Others as appropriate (e.g. as suggested by the director).

A scope of work should be completed and submitted to ministry staff at the beginning of each of the three stages of a LWMP planning process to guide the completion of a report for that stage. At the conclusion of each stage, local governments should seek endorsement of the report produced from the advisory committee(s). The final report should then be submitted to the director for review before proceeding to the next stage. At the conclusion of Stage 3, local governments should make a resolution to accept the final Stage 3 report (after review by the advisory committees and the director), and then submit the LWMP report to the minister for approval, with a copy to the director.

At the completion of the process, the minister will consider the advice of the director and ministry staff before responding to a request for approval of a LWMP. The minister must be satisfied that the LWMP has been prepared in accordance with the EMA and that adequate public consultation has taken place as no mechanism for appeal will be available after ministerial issues a letter of approval. This letter may incorporate additional requirements to be imposed upon local governments as a condition of plan approval.

At this point the plan monitoring committee should be activated to ensure proper plan implementation. The director will then issue operational certificates for each facility and the municipality can proceed with implementation.

3.6.2 Village of Cumberland LWMP Process

As described above, preparing a Liquid Waste Management Plan (LWMP) involves a three-stage process that develops a strategic plan for dealing with all aspects of liquid waste. From the Provincial Guidelines for LWMP's;

> *A LWMP provides opportunity for a community to develop a long-term plan for building, financing, and managing their liquid waste infrastructure. In addition, it allows local governments to obtain ministry authorization for reuse and disposal of treated liquid waste to the environment. The LWMP forms the implementation plan for the management of liquid waste from collection, through treatment and resource recovery, to residual disposal.*
>
> *Prior to proceeding with the LWMP process, a local government should satisfy itself that a LWMP will substantially benefit the community and the environment. Typically, the LWMP process will be an effective vehicle in areas where there is considerable growth and development or where there are known problems associated with existing infrastructure. Further, a LWMP allows community-specific solutions to be developed and sets a schedule to finance and upgrade infrastructure to ultimately meet the MWR requirements.*

A LWMP has several key points. It

- allows a delayed but defined timetable for meeting the current MWR requirements,
- is an alternate process of obtaining provincial approval, to registering under the MWR;
- mandates extensive public and stakeholder engagement in the LWMP process; and
- confers borrowing authority that normally must be gained by elector approval.

As previously noted, where the MWR standards are not currently met, the LWMP is used to establish a schedule for upgrading facilities to meet the MWR requirements, with the expectation that reasonable efforts are being made to prepare the LWMP.

Having obtained a Discharge Permit, the Village of Cumberland also began to develop a Liquid Waste Management Planning (LWMP) process in 1999 to comply with Discharge Permit conditions. The LWMP process has three stages of development, and the studies completed from 2009-2011 led the community to Stage 3 of the process, whereby the next step would have included construction of plant upgrades. However, the planned upgrades were not completed, despite grant funding having been obtained for the project as the Ministry of Environment officials were not satisfied with the option chosen by the Village, and, in 2011, Cumberland elected to investigate joining a proposed regional treatment plant.

The proposed regional treatment plant, called the South Sewer Project, was investigated in great depth, however, due to the high costs associated with participation the Village decided that it wasn't feasible to participate, and in March of 2016, Cumberland began the development of a new approach for the LWMP "to come up with a made in Cumberland" solution. A new Wastewater Advisory Committee (WAC) was formed to steer the process, with representation from the community, government agencies, First Nations, Village of Cumberland staff, and technical consultants. In addition to meeting regulatory needs, the WAC in coordination with the Cumberland Council required the upgrade to align with both the Cumberland Official Community Plan as well as the Comox Valley Regional plans. The overall objective can be summarized as;

- "Develop a method of treating and discharging Cumberland's liquid waste that is not only environmentally sustainable but is also affordable and, ideally, is economically productive, environmentally enhancing and socially beneficial."
- The upgrade is to provide a sustainable plant providing a high-quality treatment and resource recovery. The WAC also confirmed the community's desire to improve their treatment plant as quickly as possible to address the environmental impact.

The strategic goals for wastewater treatment established include:

- Bring the Village of Cumberland into compliance will all current federal and provincial environmental regulations and set the direction for wastewater treatment for the next 20 years.
- Address the distinct wastewater challenge of the high wet weather flows. The updated works must meet this challenge while not being "overbuilt" purely for these current wet weather peak flows. Cumberland has a program for combined sewer separation to reduce the peak flows, but this will take at least a decade to complete.
- The discharge to the receiving environments must meet the current, and foreseeable future provincial and federal standards. Of special note is the low summertime flows and corresponding low dilutions within Maple Lake Creek and the Trent River.
- Enable the use of reclaimed water for industrial, agricultural, municipal and (eventually) residential purposes, maximising potable water savings and enabling green parks and gardens instead of xeriscaping. This is in keeping with the (Provincially mandated) Comox Valley Sustainability Strategy has the specific wastewater treatment of goal to "treat to tertiary or reuse level".
- Explore options for storage of summertime treated water for winter discharge, to minimise discharge during the summertime phosphorus control period.
- Explore potential for on-site renewable energy generation, kinetic energy recovery, and heat recovery. There are numerous opportunities for the use of recovered heat, including a commercial laundry adjacent to the site

- Evaluate the carbon footprint, and on-going GHG emissions of the treatment plant, and reduce these as much as possible. GHG reductions are a reporting requirement for all BC municipalities and evaluation criteria for all federal funding programs.
- There is a preference for a simple and robust treatment process requiring minimal operator intervention. Preference will also be given to treatment processes that minimize energy and external input (e.g. process chemical) requirements.
- Preference will be given to treatment systems that are expected to remove pharmaceuticals, endocrine disruptive compounds, and other trace contaminants.
- Once the new plant is completed, the then redundant lagoons will be re-purposed into a publicly accessible constructed habitat wetland, fed by the treated water
- Processing of dewatered biosolids is presumed to be by composting at the nearby CVRD composting facility, but other innovative options will be considered
- The project will follow the recently adopted Village of Cumberland Social Procurement Policy.
- Provide a treatment system that represents the Cumberland attitude, and that the community can be proud of.

3.6.3 Current LWMP Status

Cumberland completed Stage 1 in 2016 and is currently engaged in Stage 2, with completion scheduled for early 2018. Once Stage 2 is submitted to, and reviewed by MoE, approval is then given to move on to Stage 3, which consists of developing the Implementation and Financing Plans. Upon completion of Stage 3, it is submitted to the Ministry for review, and eventual approval by the Minister. The Stage 3 process is expected to take one to two years from completion and approval.

While the objective of the LWMP is to eventually meet the MWR requirements, if Cumberland has the opportunity and funding to make upgrades that will meet MWR requirements, it can choose to register under the MWR instead of completing the LWMP process.

3.7 Reclaimed Water Use

Reclaimed water is municipal wastewater that has been treated to an appropriate level for the intended reuse purpose(s). It is not to be confused with “greywater”, which is untreated domestic wastewater from laundry bathroom uses.

The BC MWR defines four quality categories of reclaimed water according to their human exposure potential, as shown in Table 3-2.

Table 3-3-2 Reclaimed Water Quality Requirements

Reuse Category	Example uses	CBOD & TSS (mg/L)	Fecal Coliform (CFU/100mL)	Turbidity (NTU)
Indirect Potable Reuse	• Recharging an aquifer	≤ 5 (max)	< 1 (median) ≤ 14 (max)	< 1(max)
Greater Exposure Potential	• Irrigation of public parks • Food crops eaten raw • **Stream augmentation**	≤ 10 (max)	< 1 (median) ≤ 14 (max)	≤ 2 (avg) ≤ 5 (max)
Moderate Exposure Potential	• Irrigation of restricted access areas • Food crops that are cooked	≤ 25 (max)	≤ 100 (median) ≤ 400 (max)	N/A
Lower Exposure Potential	• Specific industrial uses • Forage crops or silviculture	≤ 45 (max)	≤ 200 (median) ≤ 1000 (max)	N/A

Reclaimed wastewater can be used to satisfy an extremely wide range of non-potable water demands including: toilet/urinal flushing; surface and subsurface irrigation of landscape, park, playground and agricultural vegetation; vehicle washing; building cooling; ornamental water features; recreational impoundments, dust suppression; fire fighting and suppression; recreational ice surfaces; etc. However, Ministry policy regarding the enabling BC regulation also requires that an alternative means of treated effluent disposal must be available for reuse applications to be implemented – in the event the reuse water quality is compromised there must be a means of disposing the sub-standard treated effluent. The single exception in the regulation is water that is used to beneficially augment water flows through wetlands, with the approval of the Ministry of Environment. Although not stated in the regulation, this is ostensibly because the wetlands could be designed as a back-up method of treating the effluent. Consequently, the release of reclaimed wastewater to benefit and enhance the natural habitat of the wetlands associated with Maple Lake Creek could be a key integrated water management strategy component.

Potential uses of reclaimed water that have been identified in Cumberland include: irrigation of parks, playing fields and gardens; commercial laundry; agriculture, stream and wetland augmentation; and industry uses. Water treated to Greater Exposure Potential is suitable for all these applications.

Before reclaimed water can be used, Cumberland would need to establish an approved LWMP or MWR registration that included reuse applications, as well as request authorization for those reuse applications from the ministry of Health. The intended reuse applications need to be included and considered in preparing the Operations Plan and Environmental Impact Assessment that are required to be submitted for registration.

3.8 EOCP Classification

The MWR requires that all wastewater treatment, (and collection) systems are classified by under the Environmental Operators Certification Program (EOCP). Classification is on a scale of 1 to 4 depending on the size and level of complexity of the plant.

The level of operator certification required to operate the proposed facility must equal the classification level of the facility. If it is to be classified as a small system it will need to be classified as a Class II, but the water reuse elements could result in a Class 3 or possibly Class 4 designation – depending on the operating complexity of the technology that is adopted and not simply because of the reuse applications. Higher level operators must be paid more and are fewer in number than lower level operators. Consequently, technology selection must consider the degree of complexity as well as the overall labour costs.

Application will need to be made at the time of commissioning of the treatment works. EOCP policy does not allow for applications prior to commissioning of a treatment facility or facility upgrade

3.9 Equipment Redundancy

The BC MWR includes equipment redundancy and auxiliary (backup) power supply requirements that are based on a Reliability Category assignment. A qualified professional is responsible for determining the appropriate Reliability Category based on information gathered through an Environmental Impact Study. Section 34 (2) of the regulation provides the following guidance:

(2) For the purposes of this regulation, reliability categories are defined as follows:

(a) category I, being wastewater facilities

(i) that discharge to ground or water, and

(ii) in respect of which short term effluent degradation could cause permanent or unacceptable damage to the receiving environment, including discharges near drinking water sources, shellfish waters or recreational waters in which direct human contact occurs;

(b) category II, being wastewater facilities

(i) that discharge to ground or water, and

(ii) in respect of which permanent or unacceptable damage to the receiving environment, including discharges to recreational waters and land, would not be caused by short term effluent degradation but would be caused by long term effluent degradation;

I category III, being wastewater facilities that do not fall within reliability category I or II.

As the proposed upgrade will be improving effluent quality and there is no evidence of long term damage to Maple Lake Creek or the Trent River as a consequence of the lagoon discharge over the past fifty years, it is likely that the facility can be classified as Category II. This will require 2 lagoon cells, dual solids/liquid secondary separation units with each unit capable of 50% of the design flow, dual filters with each filter capable of filtering at least 75% of the design flow, and dual disinfection units with each unit capable of 50% of the design flow. There are cost implications to meeting these redundancy requirements.

While a registered discharge under the MWR would require compliance with the equipment redundancy requirements, the authorized works under the existing Discharge Permit does not include redundancy requirements. However, the issue of equipment redundancy will need to be addressed in conjunction with the plans that the Discharge Permit requires be prepared by a qualified professional and submitted to the Ministry of Environment for review. If that submission is not in compliance with the requirements under the MWR, the Ministry could require full compliance as part of Phase 1, as an outcome of their review of a phased approach submission.

3.10 Existing Treatment System Status

The Village of Cumberland wastewater discharge has not been in compliance with most of the conditions and requirements stipulated in PE00197, as shown in Table 3-1. While the treated wastewater effluent BOD_5 and TSS concentrations have generally been in compliance, the requirements for disinfection and nutrient (phosphorus) removal required as of May 1, 1999, have not been implemented – largely due to the impracticality of operating such facilities with the extreme stormwater flows within the combined sewer system.

The Village has completed a number of combined sewer separation projects since 2006, some larger than others depending on what funding has been available, and they are committed to move forward with the design and construction of smaller separation projects as budgets permit. Additional projects are being planned for 2018 that will renew old sanitary collection pipes and install new storm-sewer mains at the same time within a common trench, as well as a continuation of the storm-sewer extension up Egremont Road, and there are more projects planned for 2019 and beyond. The Village is committed to move forward with further I&I investigation including smoke testing and CCTV of pipes. By accelerating sewer design projects over the next couple of years, the Village is anticipating they will be able to combine sewer separation work with other capital projects, based on available funding.

The community recognizes that it will take time to complete the separation program while in the meantime it is also important to provide environmental protection for the downstream environment and marine aquaculture industry. In spite of the severe hydraulic challenges posed by a combined sewer with wet-weather to dry-weather flow variations in excess of 20:1, the wastewater treatment process needs to be significantly upgraded to reduce effluent phosphorus concentrations and improve the overall water quality in MLC and the Trent River.

The 2017 environmental monitoring program (discussed further in Chapter 6.0) has confirmed that the effluent dilution in Maple Lake Creek, in summer, is less than 10:1, and is likely to remain so even under high wet weather flow conditions. As stated in the MWR, the only way treated water can be discharged under such conditions is if is treated to the reclaimed water standard for Greater Exposure Potential (GEP) reuse.

Once treated to the GEP standard, the water is suitable for a wide range of non-potable reuse applications. including irrigation and stream and wetland augmentation, specifically:

Greater Exposure Potential Water Quality Requirements for Non-Potable Water Reuse

- $BOD_5 \leq 10$ mg/L (maximum);
- TSS $\leq$ 10 mg/L (maximum);
- Turbidity $\leq$ 2 NTU (average), and $\leq$ 5 NTU (maximum);
- Fecal coliforms $\leq$ 1 CFU/100mL (median), and $\leq$ 14 CFU/100mL (maximum);
- pH 6.5 – 9; and
- Chlorine Residual > 0.5 mg/L (minimum) at point of reuse application.

Additional Water Quality Requirements for Discharge to Surface Waters

- Total Phosphorus $\leq$ 1.0 mg-P/L (maximum) (see note 1);
- Ortho-Phosphate $\leq$ 0.5 mg-P/L (maximum) (see note 1);
- Un-ionized Ammonia $\leq$ 1.25 mg-N/L at 15 ^{o}C +/- 1 ^{o}C (maximum) (see note 2); and
- Chlorine Residual $\leq$ 0.05 mg/L (maximum) (see note 2).

(3) Phosphorus criteria required for discharges to streams, rivers and estuaries with dilutions greater than 10:1, or lakes with surface areas $\geq$ 100 ha, and maximum daily flows greater than 50 m^3/d).

(4) Federal Fisheries Act - Wastewater Systems Effluent Regulations requirement for discharges of 100 m^3/d or more to surface water bodies.

Under the BC MWR, effluent meeting the above reclaimed water criteria can be used for beneficial reuse in application to stream augmentation as well as wetlands augmentation without the need for dilution.

The MWR also requires that reuse water quality applications also include an alternate means of effluent disposal and allows for wetland applications to be considered a satisfactory alternative where the director is satisfied the discharge to the wetlands does not pose an environmental or public health risk. In this regard any proposed works will also need to meet the redundancy and back-up power requirements of the BC MWR for reclaimed water treatment systems.

Due to extremely low dilution conditions, the upgraded treatment works will need to achieve a water quality under summer flow conditions that meets the GEP reclaimed wastewater reuse water quality requirements. The reclaimed water could be used to augment flows within Maple Lake Creek and the Trent River to improve environmental resource conditions.

3.11 Implications for the Village of Cumberland

For surface discharges the effluent quality depends on the type of water body (i.e. stream, river, lake or marine), the minimum dilution available or size of water body, and the environmental sensitivity of the water body.

For discharges greater than 50 m^3/d, a minimum dilution of 10:1 is required for discharges to streams and rivers with an effluent quality of $BOD_5 \leq 10$ mg/L, TSS $\leq$ 10 mg/L, total Phosphorus $\leq$ 1 mg-P/L and Ortho-Phosphate $\leq$ 0.5 mg-P/L.

In both cases if the discharge is to recreational waters the median fecal coliform level at the edge of the initial dilution zone must be less than 200 MPN/100 mL.

The existing Discharge Permit PE00197 directs and authorizes the Village of Cumberland to do the following:

- Improve and upgrade existing works including pre-treatment, biological treatment to reduce BOD and TSS, disinfection and phosphorus removal to achieve a secondary effluent quality consisting of
    - $CBOD_5 \leq 30$ mg/L;
    - TSS $\leq$ 30 mg/L;
    - Faecal Coliform $\leq$ 200 MPN/100 mL; and
    - Total-P $\leq$ 1.0 mg-P/L
- Professional licensed to practice in BC to prepare plans and specifications, and submit them to the Regional Waste Manager requesting written approval to implement works for disinfection and nutrient reduction to achieve:
- Provide standby auxiliary power facilities to ensure continuous operation of the sewage treatment facility;
- In addition, the following effluent quality requirements will have to be met to satisfy the federal WSER requirements:
    - Average Annual $CBOD_5 \leq 25$ mg/L;
    - Average Annual TSS $\leq$ 25 mg/L;
    - Average Annual Total Residual Chlorine $\leq$ 0.02 mg/L; and
    - Maximum Un-ionized Ammonia < 1.25 mg-N/L at 15 ^{o}C +/- 1 ^{o}C.

The Discharge Permit also notes that based on receiving environment monitoring data and/or other information obtained in connection with the discharge, additional treatment facilities may be required.

The Village of Cumberland is also required to carry out the following activities:

- Source Control Program (Regulations for source control are contained in the new Village of Cumberland Sanitary sewer regulation Bylaw 1025)
- Stormwater Management Plan
- Sludge Wasting and Screening Disposal and Biosolids Management Plan
- Inflow and Infiltration Control Program
- Sanitary and Storm Sewer Separation Plan

As Cumberland's Discharge Permit is grandfathered under previous legislation, it does not need to meet the MWR requirements until such time as a major amendment to the Discharge Permit is required. However, Cumberland will have to meet the WSER effluent water quality conditions. One key area that could trigger the need to become registered under the MWR is wastewater flow. By policy, a request for an increase in effluent discharge rates of up to 10 percent have been treated by the Ministry as a minor amendment. The Discharge Permit authorizes an average dry weather flow discharge of 910 m^3/d, so a request for an increase in the authorized average dry weather flow of up to about 1,000 m3/d could be considered as a minor amendment under the existing Discharge Permit, but a need to request authorization for a discharge greater than this amount would be expected to trigger a requirement to meet the conditions under the MWR. However, confirmation of the triggering conditions is subject to discussion and verification with the Ministry.

3.12 Summary

While the current Discharge Permit, with consideration for the federal WSER requirements, authorizes a secondary effluent quality discharge to Maple Lake Creek, such a discharge would not be capable of being authorized under current Municipal Wastewater Regulation. While existing discharges are typically grandfathered and exempted from having to meet with new regulatory requirements, the decision by the BC government to register all discharges under the harmonized Municipal Wastewater Regulation and/or increases in average annual wastewater flows greater than 10 percent of the current authorized flows of 910 m^3/d are expected to trigger a requirement for compliance with the MWR.

The MWR does not permit discharges into a surface water body where the dilutions are less than 10:1, and the summer flows in Maple Lake Creek and the Trent River primarily consist of water released from the wastewater lagoons with dilution ratios well under the minimum 10:1 dilution. Thus continued discharge to Maple Lake Creek during the summer months would not be permissible under the MWR unless a Greater Exposure Potential reclaimed wastewater water quality was achieved, enabling the reclaimed wastewater to be reused for stream augmentation purposes without regard for dilution. This reuse water quality would also enable the reclaimed wastewater to be used for a wide range of non-potable water applications; noting that Maple Lake Creek and the Trent River could be negatively impacted by a reduction in flow as a result of significant reuse applications.

Accordingly, the following is the expected water quality criteria for the upgraded wastewater treatment process with a continued year-round discharge into Maple Lake Creek:

Greater Exposure Potential Water Quality Requirements for Non-Potable Water Reuse

- $BOD_5 \leq 10$ mg/L (maximum);
- TSS $\leq$ 10 mg/L (maximum);
- Turbidity $\leq$ 2 NTU (average), and $\leq$ 5 NTU (maximum);
- Fecal coliforms $\leq$ 1 CFU/100mL (median), and $\leq$ 14 CFU/100mL (maximum);

- pH 6.5 – 9; and
- Chlorine Residual > 0.5 mg/L (minimum) at point of reuse application.

Additional Water Quality Requirements for Discharge to Surface Waters

- Total Phosphorus $\leq$ 1.0 mg-P/L (maximum) (see note 1);
- Ortho-Phosphate $\leq$ 0.5 mg-P/L (maximum) (see note 1);
- Un-ionized Ammonia $\leq$ 1.25 mg-N/L at 15 ^{o}C +/- 1 ^{o}C (maximum) (see note 2); and
- Chlorine Residual $\leq$ 0.05 mg/L (maximum) (see note 2).

(5) Phosphorus criteria required for discharges to streams, rivers and estuaries with dilutions greater than 10:1, or lakes with surface areas $\geq$ 100 ha, and maximum daily flows greater than 50 m^3/d).

(6) Federal Fisheries Act - Wastewater Systems Effluent Regulations requirement for discharges of 100 m^3/d or more to surface water bodies.

The concept of continued discharge to Maple Lake Creek of reclaimed wastewater for the purpose of stream augmentation will also require a policy change by the Ministry of Environment. The Ministry have been requiring proponents of reclaimed wastewater systems to have alternative effluent disposal options in the event reuse water quality criteria cannot be met. This policy requirement will either have to be waived by the Director, or an alternative disposal method be developed. Two alternatives are being considered later in this series of technical memos, specifically:

3. Storage with re-treatment; and
4. Sub-surface discharge into the wetlands (fens) to the north of the existing lagoons.

The latter could be considered as a routine discharge location, requiring a lower water quality level and avoiding a direct discharge to a surface water body.

The existing Discharge Permit is expected to remain in effect and deemed “Transitionally Registered” under the harmonized MWR until the treatment process can be upgraded, or the federal timeline is reached (2020, 2030, or 2040), whichever comes first. A requirement to be in compliance with the MWR will be triggered if the Village of Cumberland requests what the Ministry considers to be a Major Amendment to the Discharge Permit. The most likely condition to trigger this is an increase in the average dry weather flow in excess of the current 910 m^3/d. However, seeking authorization to reclaim wastewater for non-potable reuse applications is also expected to trigger a requirement for the discharge to be in compliance with the MWR and the discharge either registered under the MWR or an approved LWMP be in place.

Tables 3-3 through 3-5 provide a summary of the regulatory effluent and administrative requirements. Many of these have already been done, or will be completed as part of a completed Stage 3 LWMP

Table 3-3-3 Comparison of Regulatory Effluent Requirements

Item	Existing Discharge Permit	Federal WSER	BC MWR "Greater Exposure Potential "
BOD- TSS	< 30 mg/L (maximum)	< 25 (average)	< max 10-10
Total Phosphorus	< 1 mg-P/L	-	< 1 mg-P/L (for dilutions < 40:1) Special requirement < 0.005 mg-P/L in-stream in Trent River
Orthophosphate	-	-	< 0.5 mg-P/L (for dilutions < 40:1)
Fecal Coliforms	< 200 FCU/100mL	-	< 1 CFU/100 mL (median) < 14 CFU/100 mL (maximum)
Turbidity	-	-	<2 NTU (average) < 5 NTU (maximum
Un-ionised ammonia	-	< 1.25 mg-N/L	-
Authorised Average Annual Flow	≤ 910 m^3/day		-
Authorised Wet Weather Flow	≤ 2,730 m^3/day		-

Table 3-3-4 Reliability Categories - BC MWR

	Reliability Category					
	I		II		III	
Components	Treatment System	Power Source	Treatment System	Power Source	Treatment System	Power Source
blowers or mechanical aerators	multiple units	yes	multiple units	optional	2 minimum	no
aeration basins	multiple units[b]	yes	multiple units[b]	optional	single unit	no
disinfection basins	multiple units[b]	yes	multiple units[a]	yes	multiple units[a]	no
trickling filters	multiple units[b]	yes	multiple units[b]	optional	no backup	no
primary sedimentation	multiple units[a]	yes	multiple units[a]	yes	2 minimum[a]	yes
chemical sedimentation	multiple units[b]	optional	no backup	optional	no backup	no
final sedimentation	multiple units[b]	yes	multiple units[a]	optional	2 minimum[a]	no
degritting	n/a	optional	n/a	no	n/a	no
chemical flash mixer	2 minimum or backup	optional	no backup	optional	no backup	no
flocculation	2 minimum[a]	optional	no backup	optional	no backup	no
aerobic digesters	2 minimum[a]	yes	2 minimum[a]	optional	single unit	no
anaerobic digesters	2 minimum[a]	yes	2 minimum[a]	optional	2 minimum	no
effluent filters	2 minimum[b]	yes	2 minimum[b]	yes	2 minimum[b]	yes
facultative lagoons	2 cells[b]	n/a	2 cells	n/a	2 cells	n/a
aerated lagoons	2 cells[b]	yes	2 cells	optional	2 cells	no
package plants	multiple units or 48 hour repair	yes	2 units or 48 hour repair	yes	single unit	no

Notes: *(a) 50% of the design maximum flow where the notation "a" appears, or*
(b) 75% of the design maximum flow where the notation "b" appears.

Table 3-3-5 Comparison of Regulatory Administrative Requirements

Item	Existing Discharge Permit	Federal WSER	BC MWR "Greater Exposure Potential "
Source Control Program	Implemented		
Stormwater Management Plan	Developed and implemented		Required
Sludge Wasting and Screening Disposal and Biosolids Management Plan	Required		Required
Inflow and Infiltration Control Program	Implemented		Required
Sanitary and Storm Sewer Separation Plan	Implemented		Required
Redundancy	Not required		Required
EOCP classification	Required		Required
Detailed Reporting	Required	Required	Required

4.0 RECEIVING ENVIRONMENT

4.1 Background

The Village of Cumberland (VoC) wastewater treatment system discharges into Maple Lake Creek, which flows into the Trent River and eventually Baynes Sound. The discharge of phosphorus from the Cumberland lagoons into Maple Lake Creek has been continuous for over a hundred years. While there have been concerns raised in the past regarding the wastewater effluent phosphorus loading to the river and resulting excess primary productivity levels as evidenced by elevated chlorophyll-a levels measured in the Trent River, as well as the lack of an effluent disinfection process, the discharge from the lagoons is of significant value to the receiving environment as the majority of the water flowing in Maple Lake Creek and the upper reaches of the Trent River during the summer is from the lagoons.

The summer 2017 environmental sampling program demonstrated the natural wetlands along Maple Lake Creek have responded and adapted to the nutrients contained in the lagoon discharge, passively absorbing and taking up over 97 percent of the nitrogen and phosphorus as well as achieving an overall 4-Log reduction in fecal coliforms. The concept of having wetlands polish the effluent from the wastewater lagoons has been the subject of previous studies carried out on behalf of the VoC including reports by Ker, Priestman & Associates (1991), CK Ventures et al. (1998) and Wetlands Pacific (2002). However, these were largely based on constructing wetlands to either as a principle means of wastewater treatment, replacing the existing lagoon treatment system, or as an additional level of (add-on) treatment – versus enhancing and utilizing the existing natural wetlands within Maple Lake Creek.

The environmental impact of diverting wastewater effluent from Maple Lake Creek would be expected to have a significant detrimental impact on Maple Lake Creek and the Trent River, as a large proportion of the water in those streams during the summer months originates from the lagoons. As noted by Wetlands Pacific (2002) there are a number of limiting factors to productivity in the Trent River, but the low water flows due to extensive watershed disturbance, removal of beavers, and reduced mountain snow packs due to climate change are probably the main limiting factor to productivity within the Trent River, particularly during the late summer when there are little if any surface flows.

Consequently, the receiving environment within Maple Lake Creek and the Trent River will continue to be the primary focus of environmental impact considerations for future wastewater effluent discharges from Cumberland, regardless of whether the water is directly released to Maple Lake Creek, indirectly released through a discharge to the wetlands to the north, or seasonally discharged through storage ponds.

The most comprehensive environmental resource survey carried out to date is the 2001 survey conducted by Mimulus, Biological Consultants (Mimulus) in 2001, in conjunction with considerations for plans for the construction of additional lagoons and constructed wetlands.

4.2 Maple Lake Creek

Maple Lake Creek flows south past the VoC wastewater sewage lagoons, from Maple Lake to the Trent River, a distance of about 4.5 kilometers.

Water enters Maple Lake Creek from several sources. Water from Maple Lake travels via a series of wetlands to Maple Lake Creek which has been straightened along the section that passes past the lagoons. Treated wastewater effluent from the lagoons is released into the creek, and the water then continues to flow towards Dunsmuir Road, where it passes under the road via a culvert. Additional water enters the creek from storm and overland flows along the length of MLC.

Additional water enters the study site from storm and overland flows. Storm water enters the northwestern part of the site from Cumberland Road, where it flows both to the south and east. Overland flow also enters the site from the hillside along Union Road and from the forest on the western side,

The stretch of MLC just downstream of the outfall discharge consists of an industrial area to the west and willow and grasses to the east, classified as a shrub swamp, beginning just north of the discharge from the wastewater lagoons and extending south along the east bank of the creek. The area is dominated by Pacific willow and a mixture of reed canary grass and other introduced grasses. The east bank becomes a wet meadow/shrub swamp further downstream dominated by Reed canary grass and hardhack with patches of larger shrubs such as willow and dogwood. The soil in this area is silty with increasing clay content at deeper levels. The creek channel itself for the first kilometre downstream of the lagoons is a straight, man-made ditch, originally cut into the peat as an agricultural drainage channel. It is very flat gradient with no natural ponding.

The reach from one to three km downstream of the lagoons is a meandering natural stream bed, still of very low gradient, and with a series of beaver ponds. These ponds have created wide, shallow ponds over the original soil surface, and have been colonised principally by reed canary grass.

From three to 4km downstream of the lagoons, the stream becomes a steeper gradient, rock bed stream, with numerous cascades and pools. The in stream rocks support a biofilm of algal growth. At 4.5 km downstream of the lagoons, Maple Lake Creek enters the Trent River.

The lower reaches of Maple Lake Creek, directly above Trent River, are accessible to fish from Trent River, but the upper reaches past the lagoons are blocked from fish migration as the creek ends in marshland. The physical habitat in the first two reaches was concluded by Mimulus (2010) to be optimal for rearing salmonids:

> "*Cover and refugia in the form of cutbanks, pools, riparian vegetation, and woody debris represent critical components for salmonid nursery streams and each of these are fairly well represented in the lower reaches of Maple Lake Creek*". And it is noted that "*at a minimum, it will be important to maintain the current water quality level in Maple Lake Creek to protect the salmonid populations and the downstream fish habitat on which they depend*".

4.3 Trent River

The Ministry of Environment administers control over phosphorus release to the environment by developing recommendations on phosphorus levels in streams and lakes. For protection of aquatic life, it is 100 mg/m^2 of chlorophyll a and 50 mg/m^2 for aesthetics.

Chlorophyll-a measurements taken in the Trent River below the confluence of MLC are cited as being excessive include three data points of 10, 20, and 30 mg/m2 taken during the summer of 1997 (EMSDRR, 1997).

In 2005, as part of the Waste Liquid Management Planning process, the VoC and BC Ministry of Environment carried out a study in the Trent River to investigate the possibility of discharging effluent from the lagoons only during the evening to minimize phosphorus uptake in the river that would otherwise occur during the daytime. Unfortunately, that study was not successful for a number of reasons, but it did serve to provide some information on the chlorophyll-a levels within the lower reaches of the Trent River – which the Ministry attributed to the phosphorus released from the VoC lagoons.

While the Ministry report (MOE, 2011) on a phosphorus study in the Trent River concluded the lower reaches are subject to very high phosphorus inputs from the Village of Cumberland (VoC), inferring the lagoon discharge was the primary source of phosphorus released to the Trent River, the lower reaches are also affected by many sources of phosphorus-laden drainage and stormwater runoff not mentioned considered in the report. Noting that "coastal streams in BC are typically nutrient starved", the report comments that these streams are also more susceptible to algal growth and, while phosphorus addition at low levels can benefit such streams, "*phosphorus loading can quickly produce high and problematic amounts of algal biomass if not carefully managed*". The West Coast Region of MOE have developed objectives for total phosphorus on Vancouver Island, based on Vancouver Island specific data, and have established ambient water quality objectives of a maximum total phosphorus of 7 ug/L and a May – September average of 5 ug/L (i.e. 0.005 mg-P/L). As the summer average coincides with the analytical detection limit for phosphorus, this means the objective is to achieve a non-detect level within the Trent River.

The MOE report on phosphorus and primary productivity in the lower reaches of the Trent River indicate the chlorophyll α levels as high as about 160 mg/m2 (reference MOE, 2005 unpublished data), which exceeds both the aquatic life protection and aesthetics criteria.

The Trent River is affected by phosphorus contributions form many point and non-point sources within the catchment, and recommended chlorophyll-a levels are expected to be exceeded during the lowest flow periods.

4.4 Wetland Area to the North of the Existing Lagoons

The area to the north of the lagoons is a flat wetland area of peat soils. It was extensively farmed in the 1930's but was abandoned in the 50's. In that time, grasses, shrubs and trees have established, as further described below. In 2001, as part of Cumberland's then LWMP planning, it was proposed to build an engineered wetland on this area, as part for the wastewater treatment system. This area is now under consideration as a distribution area for the final treated water from the lagoons. This would supply water in the dry summers and allow for a planned revegetation and habitat enhancement program.

Vegetation in the wetland area to the north of the lagoons is described by Mimulus (2011) as receiving ground and surface water drainage from the wooded lands just to the north, and is described as having a high incidence of introduced species as well as a large diversity of habitat types, with evidence of many different mammal and bird species was apparent in this area. The terrestrial survey conducted by Mimulus describes seven distinct communities in this area:

1. Hardhack/Grass/Dogwood

   Higher density of taller shrub species (red- osier dogwood, Pacific crab apple, and several species of willows) at the northern end and more graminoid species in the southern end. Hardhack dominates the center of the area, and co-dominates with grasses along the southern end closest to the lagoons. The area includes many introduced species along the western side of this area.

2. Hardhack

   A small area composed almost exclusively of hardhack is located to the east of the Hardhack/Grass/Dogwood community noted above.

3. Bracken Fern/Labrador Tea

   This is a large community that includes clumps of tall shrubs, pocket bogs, and open areas dominated by bracken fern, sedges and various shrub species (Mimulus, 2011). The typical bog plants in this area include Labrador tea, sphagnum moss, bog laurel, and cloudberry. The substrate beneath this area is described as being primarily organic with pockets of deep (>40 cm.) peat.

4. Bracken/Hardhack

Supported a variety of plant species, Bracken fern is the most abundant species in this area with small areas of salmonberry, large-leaved avens, sword ferns, and vanilla leaf, as well as pockets of species typically associated with wetlands such as crabapple, hardhack and sedges. The organic substrate has deep mesic peat horizons.

5. Crabapple/Sedge

This area is a shrub swamp with most of the species exceeding three meters in height and includes Pacific crabapple, cascara, dogwood, and mountain ash. Sedges, bracken fern, creeping buttercup and lady fern are also common under the shrubs.

6. Wet Meadow

Water flows into this area from the wooded areas to the north and west, and it is dominated by introduced grasses. Water-filled channels, natural and anthropogenic, form a network through the area, and contribute to the mounded topography. Obligate wetland species in this area include cattails, burreed, and duckweed, and Hardhack is also common.

7. Willow Thicket

This area located along the northern boundary of the sewage lagoons is dominated by a good diversity of tall willow species as well as red alder, cascara, black twinberry, and a few cottonwood trees. There was evidence of flooding in this area as well as wildlife trails and bedding sites.

The habitat that is provided by the bog communities north of the lagoons and west of Maple Lake Creek are considered sensitive and environmentally valuable; however, the 'sensitive' area does not include the grass-dominated habitat (Wet Meadow community) located immediately adjacent and to the north of the lagoons. The introduction of reclaimed wastewater to this grass-dominated habitat would require a hydrological assessment to assess whether water recharge to the bog would not be affected by the dispersion of effluent from the lagoons. Bogs develop under nutrient poor conditions, and the addition of nitrogen and phosphorus from the lagoon effluent lagoons could have a detrimental effect on the adjacent bog habitat. Offsetting this concern is the augmented wetlands may be enhanced adding an additional type of wetland habitat to the existing mosaic.

5.0 HISTORICAL AND PROJECTED FLOWS AND LOADS

5.1 Population Modelling

Predictions of future flows must be made as part of any wastewater planning exercise, and population growth is the key driver of these flows. The normal planning horizon for wastewater is for 20 years, and that is what is being used for Cumberland.

The strategy for future growth is laid out in the 2014 update to the Cumberland Official Community Plan, which contemplates future land use changes and residential developments

In June of 2016, Koers and Associates produced a "Long Range Water Supply Strategy", which included a detailed analysis of population growth for Cumberland, for estimating future potable water consumption. Their analysis, providing the population projections to 2065, has been used here for estimating future wastewater flows. Figure 5-1 has been reproduced from their Final Report, dated June 9, 2016.

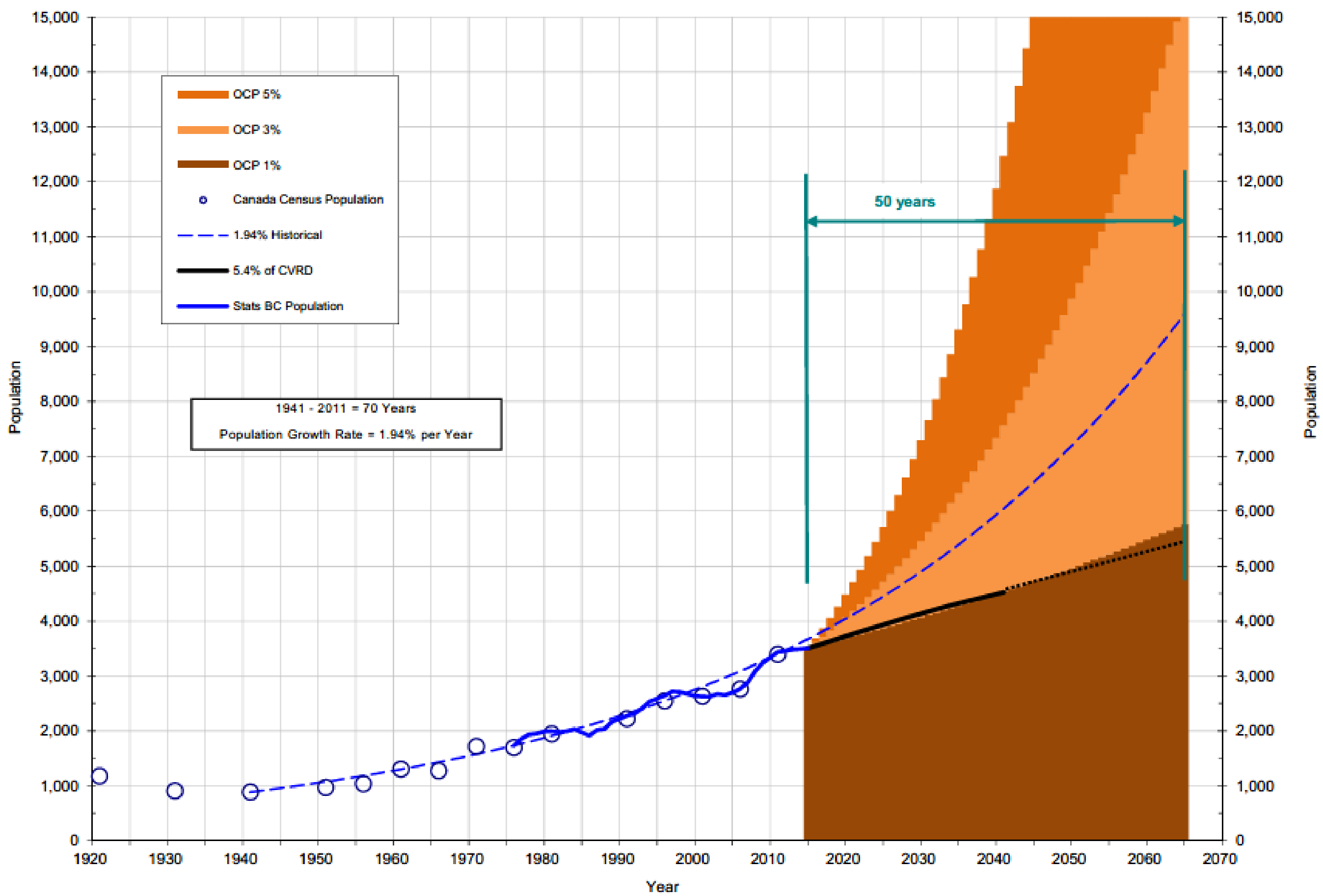

Figure 5-1 Koers' Village of Cumberland Population Growth Projection

The Koers analysis recommended the "moderate growth" scenario, of a 3% annual increase in population. With the project horizon at 20 years, and a starting year of 2018, the various growth scenarios are quantified in Table 5-1. If the community growth continues at the historical rate, a population of 7,000 would not be reached until 2049, and conversely, at 5% growth, it would be at 2030. The large growth scenario would likely be a result of large community development that may include some decentralization of sewage services, and would also accumulate significant Developer Cost Charges (DCC's) to help pay for an earlier than planned expansion, thus designing to the maximum projected growth is overly conservative and the 20-year project should match population growth and equipment replacement due to mechanical wear.

Table 5-5-1 Koers Population Models

Year	Growth		
	Historical	Moderate	High
	1.94%	**3%**	5%
2019	4000	**4000**	4000
2029	4755	**5219**	6205
2039	5762	**7014**	10108
2049	6983	**9426**	16465

In early 2017, after the Koers study was written, the official Canadian 2016 Census data was released, showing a Census population of Cumberland at 3,753 people. This is a 10% increase over the 2011 population of 3,398, and 36 % increase from the 2006 population of 2,762.

A special distinction needs to be made in the case of the wastewater system, in that not all houses and business are connected to the sewer system. There are numerous houses at Comox lake, and on Union Road that are not connected, in addition to some of the commercial industrial areas on Cumberland Road and East of Hwy 19. To make a modest allowance for these, a population deduction of 100 has been assumed.

For the purposes of flow modelling:

1. The connected population is set at 3650 for 2016;
2. A growth rate of 3% per annum has been used;
3. The starting year is 2019, the earliest a treatment system could be commissioned, with a population of 4000; and
4. The final year is 2039, a 20-year period, with a population of 7000.

5.2 Design Flows

The design flows take into consideration the minimum and maximum wastewater flows over the expected life of the wastewater treatment plant, which is typically from 20 to 30 years. The minimum flow is the projected residential, commercial and industrial wastewater generated within the community at the time the wastewater treatment plant is commissioned. The maximum flow is the projected residential, commercial and industrial wastewater generated within the community at the end of the wastewater treatment plant's operating life, plus intended stormwater drainage and unintended stormwater contributions as a result of surface inflow and subsurface groundwater infiltration (Inflow & Infiltration – I&I) into the sewage collection system. The projected residential, commercial and industrial wastewater is based on population growth and the type and extent of commercial and industrial development that is expected to occur. The intended stormwater contributions are based on the total area of surface drainage from roofs, roads and other surfaces that are intentionally drained to the sewer, plus drainage from building perimeter drains. The I&I is generally due to settled road manholes and aging or poorly constructed sewage collection systems that allow groundwater to enter manholes and pipelines.

The term Average Dry Weather Flow (ADWF) refers to wastewater flows from residential, commercial and industrial discharges without any precipitation-related drainage and, consequently, typically occurs during the dry summer months of July and August. The ADWF typically has the highest contaminant concentrations and is used to estimate the contaminant loading and is the basis for contaminant removal (treatment) design. For this study, the ADWF has been taken as the lowest value of the 14 day rolling average of wastewater flows. The data has been examined to exclude unusual events such as lagoon maintenance that can give artificially low or high flow values.

Although stormwater drainage can wash contaminants into the sewer, generally precipitation related contributions from stormwater drainage and I&I proportionately reduce the overall wastewater contaminant concentration, but the contaminant mass loading entering the treatment plant remains about the same as for dry weather conditions. The high precipitation affected flows have a shorter retention time within the treatment plant, and less time for treatment, than the wastewater flowing through the plant under dry weather conditions. This shortened treatment time must be taken into consideration when designing the size of tanks and other hydraulic structures, and can significantly increase treatment costs in proportion to the increased flow. Consequently, the Maximum Daily Flow or Peak Wet-Weather Flow is also a critical design parameter affecting treatment capital costs.

The Village of Cumberland's existing treated wastewater Discharge Permit (Amended Permit 197 – August 1, 2017) refers to two flow criteria:

1. Average Authorized Rate = 910 m^3/d
2. Maximum Authorized Rate = 2,710 m^3/d

5.2.1 Wastewater Flows and Influence of Precipitation

While the ADWF is a flow statistic that, by definition, is not influenced by precipitation events, both of the above criteria stated in the Permit are influenced by stormwater flows and management practices. A review of measured wastewater flows, precipitation and population for the nine-year period of 2009 to 2017 is shown in Table 5-2.

Table 5-5-2 Wastewater Flows and Precipitation

YEAR	2009	2010	2011	2012	2013	2014	2015	2016	2017	AVG
ADWF (m3/d)	828	874	840	780	953	742	705	809	765	811
AVG FLOW (m3/d)	2071	2731	2158	2,422	1,806	2,510	2,189	3,238	2,268	2,377
ANNUAL PRECIP. (mm)	1250	1854	1306	1,435	925	1,439	1,213	2,106	1,279	1423
PWWF (m3/d)	17781	15859	14471	16,623	7,254	18,892	14,737	14,094	12,408	14680
PWWF/ADWF	21	18	17	21	8	25	21	17	16	18
POPULATION	3144	3271	3398	3448	3499	3549	3600	3650	3750	3479
ADWF PER CAPITA (L/c/d)	263	267	247	226	272	209	196	222	204	234

The unusually high PWWF's are caused in large part by presence of the combined storm sewer area. While there is no correlation between peak flow and annual precipitation, there is a correlation between the annual precipitation and annual average daily flow, as shown in Figure 5-2.

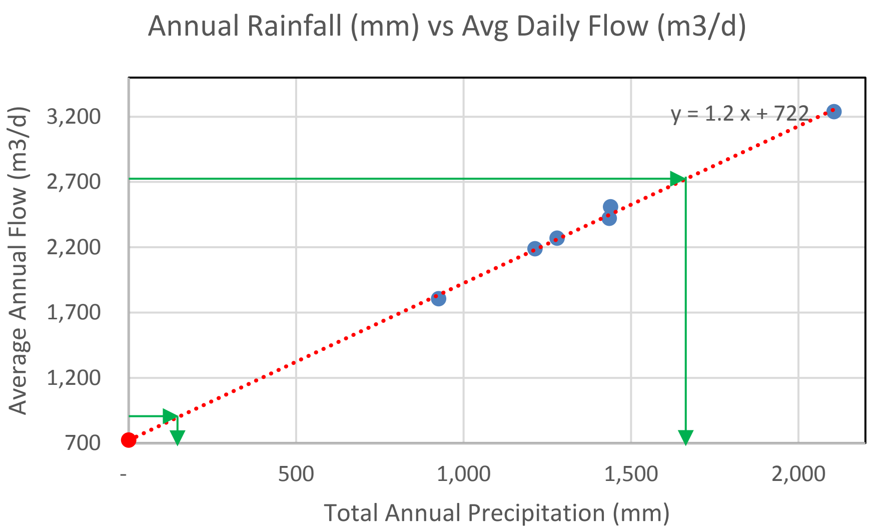

Figure -5-2 Relationship between Annual Precipitation and Annual Average Daily Wastewater Flows

Figure 5-2 illustrates the average annual flow is directly proportional to the amount of annual precipitation falling onto the community, with the projected ADWF of 722 m^3/d. This is slightly lower than the average ADWF estimate of 811 m^3/d shown in Table 5-2, which is based on the summer flows. Figure 5-2 also illustrates that the average annual flow of 910 m^3/d corresponds to a total annual precipitation of 156 mm per year. In comparison to the highest annual precipitation of 2,106 mm shown in Table 5-2, this also indicates a 95 percent reduction in stormwater and I&I related flows is required to meet the current Permit flow requirements.

5.2.2 Dry Weather Flows

The ADWF (average dry weather flow) is the best indication of the amount of sanitary wastewater (i.e. stormwater related contributions) generated within the community. It may include consists of "baseflow", which is groundwater infiltration even under dry conditions, and the actual wastewater generated by users on the collection system.

Using a 2016 baseline population of 3,650 people, the average ADWF value shown in Table 5-2 of 811 m^3/d corresponds to a per capita contribution of about 222 Llitres per capita per day(L/c/d). Even considering the hospital laundry and other commercial operations also contribute wastewater to the system, the inflated per capita wastewater flow is comparable to the generally accepted per capita contribution of 250 L/c/d.

Figure 5-3 shows the comparisons of maximum, minimum and median daily flows by month, from 2013 to 2016, indicating Cumberland has a significant Inflow and Infiltration problem. Figure 5-3 shows that the large flows, from rainwater inflow, can occur any time from September to March. Some of these flows are well over the maximum permitted discharge flow of 7600 m^3/d.

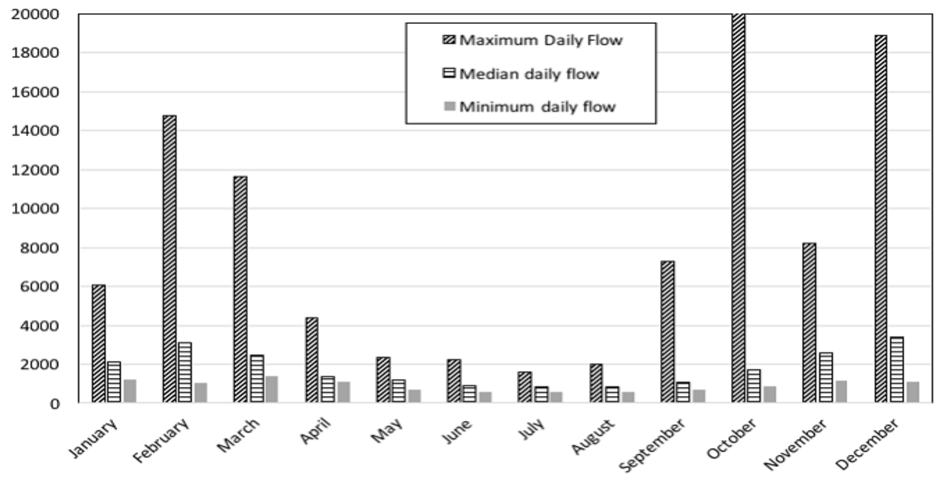

Figure 5-3 Cumberland Daily Wastewater Flows by Month (2013-2016)

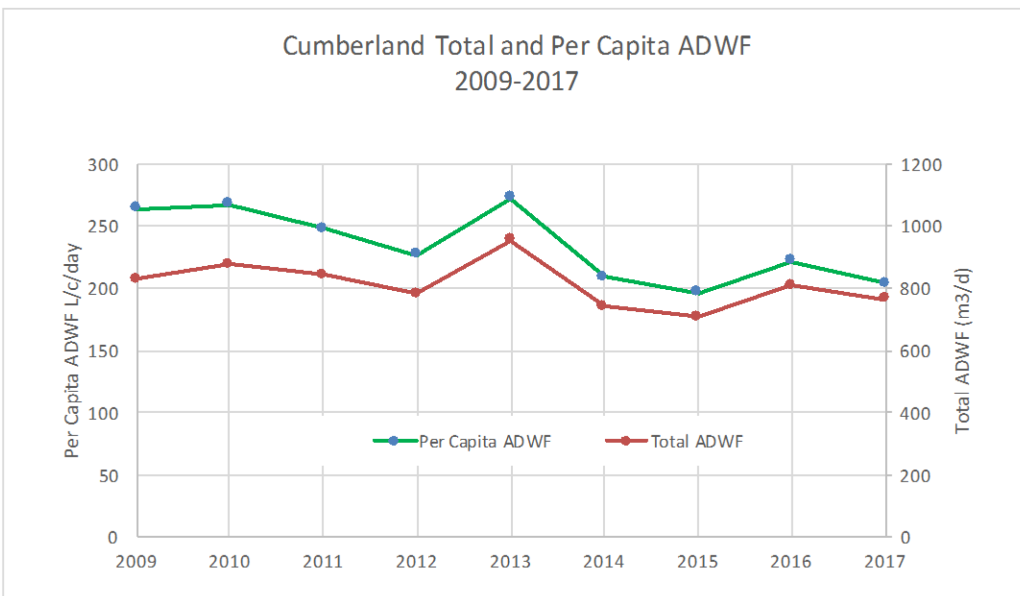

Figure 5-4 Cumberland per capita Average Dry Weather Flows (2009-2017)

Figure 5-4 shows the ADWF has fluctuated in recent years, with 2015 being very low due to a prolonged drought and imposed water restrictions. The figure shows the per capita ADWF has generally been steadily decreasing over the past decade, demonstrating that it is possible to lower the per capita wastewater flows through targeted water conservation initiatives, appropriate conservation bylaws, and reductions in dry weather infiltration. The higher summer flows in 2013 are considered to be due to inflow and infiltration during a wet summer, where extended “dry” conditions did not occur.

The average ADWF for 2014, 2016 and 2017 was 773 m^3/d, which on a per capita basis was 212 L/c/d. Data for 2015 is excluded as the wastewater flows are thought to have been unusually affected by drought related water restrictions that year.

Although the estimated current ADWF is 212 L/c/d, a flow of 250 L/c/d is recommended for use in design, as it allows for potential future commercial development. This equates to a 1750 m^3/d, and is rounded up to arrive at a design ADWF 1,800 m^3/d. During the detailed design stage, and prior to future upgrades, this flow model should be reviewed again, in the light of additional data and direction on water conservation initiatives.

5.2.3 Wet Weather Flows

Cumberland's wastewater flows increase in response to stormwater runoff. During the winter when soil is saturated with water, the increase in flow due to rainfall can last for several days following a major rainfall event as water continues to infiltrate into buried sewer lines.

While the Ministry of Environment is unlikely to increase the maximum discharge flow rate of 2,710 m^3/d, removing stormwater drainage contributions and I&I to the sewer is expected to be challenging and it would be prudent to consider the potential for continued high peak wet weather flows.

The ratio of PWWF to ADWF is called the "peaking factor" and is typically expected to be less than 2:1 – but can often range from about 1.5:1 to 3:1. For small systems the BC MWR requires treatment plants to treat up to 2 x ADWF, but may require treatment to 3 x ADWF under specific circumstances. Cumberland's wastewater peaking factor is about 25 x ADWF. In comparison to other municipalities, Cumberland's peaking factor is extremely high.

Cumberland has been gradually implementing a program to divert stormwater flows into a separate storm sewer. This is being done as old combined sewer pipes require replacement and eliminating stormwater connections to the sanitary sewer. However, the sewer separation program will take at least another decade to complete, with the timing dependent on funding for the design and construction of the new sewers. Consequently, plans for treatment system upgrading need to take into consideration the ongoing impact of peak wet weather flows.

Designing a treatment system to treat Cumberland's peak wet weather flows, with peaking factors in excess of 20:1, is extremely challenging both from a capital cost and operations perspective. Historical flow data was reviewed to determine the number of days in a year that specific wastewater flow rates, representing multiples of the design ADWF may be exceeded for both dry and wet years, as shown in Table 5-3.

Table 5-3 Number of Days per Year that Specific Wastewater Flows Have Been Exceeded

Flow	Design Peaking Factor	Days Per Year Exceeded "Dry" Year (2013-2014)	Days Per Year Exceeded "Wet" Year (2015-2016)
1,800	1 x ADWF	92 (25%)	156 (43%)
3,600	2 x ADWF	41 (11%)	71 (19%)
7,200	4 x ADWF	18 (5%)	44 (12%)
14,400	**8** x ADWF	0 (0%)	3 (1%)

Considering the frequency of flows exceeding 2 x ADWF, it is unlikely the excess stormwater runoff contribution will be eliminated to achieve a 0% exceedance within a 20-year timeframe.

Based on the forgoing, the following recommendations are made for consideration in design regarding wet weather flows;

1. adopt a peak wet weather flow (PWWF) of 14,400 m^3/d (i.e. 8 x current ADWF)
2. PWWF expected to decrease by 500 m^3/d, per year, as the sewer separation program proceeds.
3. Anticipate that PWWF:ADWF will not go below 4:1

Using the population model and design flows, the design flow model is calculated. This is detailed in Table 5-4.

Table 5-4 Flow Projections and Plant Design

Year	Population(1)	Per Capita ADWF (L/d/c)	ADWF (m^3/d)	PWWF (m^3/d)	PWWF:ADWF RATIO
2018	3850	212	816(2)	14,100	17
2019(3)	3966	212	841	13,750	16
2025	4735	212	1,004(4)	11,650	12
2030	5489	212	1,164	9,900	9
2035	6363	212	1,349	8,150	6
2038	6954	212	1,474	7,100	5
Design Values	7000	250	1,800	7,200	4(5)

Notes: *(1) 3% population growth assumed*
(2) Request Ministry to interpret Permit reference to 910 m^3/d as ADWF and request minor amendment increase of 10% to 1,001 m^3/d
(3) Assumed commissioning year – LWMP Authorization or MWR Registration with Peaking Factor of 4.0
(4) Exceeds minor amendment Permit flow of 1,001 m^3/d
(5) Meets peaking factor of 4.0

The flow projection assumes I&I reduction efforts will reduce the PWWF:ADWF ratio down to about 4:1 over a 20-year period. The PWWF establishes the hydraulic design criteria, as the system must manage the peak flows, regardless of whether the I&I reduction program proceeds faster or slower. Reducing stormwater contributions reduces the total volume of water being treated and affects both capital and operating costs.

5.3 Design Loading and Influent Criteria

The "load" in wastewater represents the mass of contaminants contained in the wastewater over a period of time, often expressed as kilograms per day (kg/d). Contaminant load estimates are used to size biological and chemical treatment components and estimate power and chemical consumptions and sludge production.

The biodegradable contaminant loading (i.e. kg/d of BOD) can be estimated using industry per capita normal values. The estimated contaminant concentrations based on industry norms under ADWF conditions, were within 10 to 20 percent of the influent samples collected during the summer of 2017, confirming the validity of the norms for this design. Table 5-5 provides the complete "Flow and Load" model, which sets the influent conditions for treatment system design

Table 5-5 Design Flows and Loads

Parameter		Units	2019	2039
Connected population		capita	4,000	7,000
Per capita ADWF		L/c/d	212	250
Average dry weather flow (ADWF)		m^3/d	850	1,800
Peak Wet Weather Flow		m^3/d	14,400	7,200
Maximum Summer Wastewater Temperature		ºC	22	22
Minimum Winter Wastewater Temperature		ºC	7	7
$CBOD_5$	- Average Per Capita Loading	g/c/d	65	65
	- Average Day Loading	kg/d	260	455
	- Concentration at ADWF	mg/L	306	253
TSS	- Per Capita Loading	g/c/d	65	65
	- Average Day Loading	kg/d	260	455
	- Concentration at ADWF	mg/L	306	253
TKN	- Per Capita Loading	g/c/d	12	12
	- Average Day Loading	kg/d	45	84
	- Concentration at ADWF	mg/L	53	47
TP	- Per Capita Loading	g/c/d	1.5	1.5
	- Average Day Loading	kg/d	5.4	10.8
	- Concentration at ADWF	mg/L	6	6
Grit	- Estimated Grit Quantities	$m^3/10^3m^3$	0.2	0.4

6.0 DISCHARGE OPTIONS

6.1 Background

The Village of Cumberland (VoC) currently has a Discharge Permit to discharge disinfected secondary effluent, with phosphorus removed to less than 1 mg-P/L, from the wastewater treatment lagoons to Maple Lake Creek, which drains to the Trent River, and eventually discharges into Baynes Sound. There are limited possible alternatives to discharging into Maple Lake Creek. For example, conveying treated wastewater effluent to Comox Lake was considered, and may be technically possible, but the costs combined with the use of Comox Lake as a potable water supply makes this option unfeasible.

The Discharge Permit has been in place for over 50 years and contributes water to the environment along that drainage course that otherwise would essentially be dry during the summer months. Consequently, the consideration of discharge options for treated effluent is logically limited to the manner in which a continued release to Maple Lake Creek and the watershed can be maintained.

In September 2016, the Wastewater Advisory committee selected the following short-list of effluent disposal for further study, as follows;

Winter (Oct-Apr);

1. Maple Lake Creek

Summer (May-Sep)

1. Maple Lake Creek
2. Seasonal Storage – store summer effluent and release into MLC during winter.
    a. Storage Wetland to be constructed on north side of lagoons
    b. Storage Reservoir in natural depression north of Teal Lake (2km NE of lagoons)

During the environmental study work in 2017, a new option, not previously considered, was developed – using the treated water for year-round “augmentation of the natural wetlands” to the north side of the lagoons.

6.2 Discharge to Maple Lake Creek

Maple Lake Creek is the current discharge location, and has been since the inception of the lagoons in 1968. It is the “default” discharge location, and given the large flow volumes to be handled in winter, is the only practicable location for winter discharge.

The water quality requirements for a continued discharge to Maple Lake Creek and the Trent River are expected to change as a result of the community’s anticipated increase in wastewater flow. The current and anticipated quality requirement are shown in Table 6-1. While the Ministry of Environment may be willing to approve maximum 10 percent increase (by policy and precedent deemed to be considered a minor amendment) to the Discharge Permit flow of 910 m^3/d, potentially increasing the authorized Discharge Permit flow to 1,001 m^3/d. Once this value is exceeded, or Cumberland chooses reclaim the wastewater and reuse the treated effluent for non-potable applications, the Village will need to meet the requirements of the MWR. The minimum dilution allowed under the MWR is 10:1. Because the minimum available dilution in Maple Lake Creek is much less than 10:1, the only way Cumberland can continue to release treated effluent to Maple Lake Creek under the MWR or a LWMP is if the water quality meets the Greater Exposure Potential reclaimed water quality standard. Additionally, the provoince have indicated the objective of 0.005 mg-P/L in-stream phosphorus concentration for the Trent River will also have to be met.

Table 6-6-1 Effluent Quality Targets for discharge to Maple Lake Creek

Item	Current Permit	MWR "GEP"
ADWF (m^3/day)	910	1,800
pH	No Requirement	6.5 - 9
BOD (mg/L)	≤ 30 (max) ≤ 25 (avg – WSER)	≤ 10
TSS (mg/L)	≤ 30 (max) ≤ 25 (avg – WSER)	≤ 10
Total Phosphorus (mg-P/L)	≤ 1	≤ 1
Orthophosphate (mg-P/L)	No Requirement	≤ 0.5
Fecal Coliforms (CFU/100 mL)	≤ 200 (max)	< 1 (median) ≤ 14 (maximum)
Turbidity (NTU)	No Requirement	≤ 2 (average) ≤ 5 (max)
Un-ionised ammonia (mg-N/L)	< 1.25	< 1.25
Trent River In-Stream Phosphorus Objective (May to Sep) (mg-P/L)	No Requirement	< 0.005 (average) < 0.01 (max)

Flow measurements were collected at various locations along Maple lake Creek and the Trent River in July and August 2017. This was done using a v-notch weir installed in temporary locations for spot measurements on July 31, and then installed at the end of the Maple Lake Creek wetlands ("Site 6A"), with an electronic level sensor, for August and September. The results of the measurements are shown in Table 6-2.

Table 6-6-2 Field Flow Measurements for discharge to Maple Lake Creek (July 31, 2017)

Location	Flow (m^3/d)	Measurement
MLC upstream of lagoons	Effectively zero	Visual observation
Lagoon discharge	800	Lagoon Measuring weir
End of MLC wetland reach (1 km upstream of Trent) "Site 6A"	660	Temporary measuring weir
Trent River at Hwy 19 (1 km upstream of MLC)	660	Temporary measuring weir
Estimated flow in Trent at MLC confluence	1,320	Visual observation

The flow measuring program of summer 2017 confirmed that the dilution ratio at the point of discharge from the lagoons is near zero during dry summer conditions. Several field measurements were made on July 31. Even though the temporary weir measurements may be +/-20 %, they confirm what had been already been observed – there is negligible dilution of the discharge from the lagoons into Maple Lake Creek or the Trent River.

The negligible dilution in MLC suggest that a withdrawal of effluent from MLC would cause the creek to be dry in the summer and halve the flow of the lower Trent. Consequently, a major reduction in the current level of discharge to MLC during the summer – from diversion to storage or reuse - would be expected to have a negative impact on the aquatic and riparian conditions of both streams. For winter conditions there is greater dilution in MLC and large dilutions in the Trent, and environmental flows are not expected to be an issue.

The primary reason for considering discharge location alternatives to MLC was to address the Ministry's concerns for phosphorus loading to the Trent River during the summer months, and meet the Ministry's new in-stream phosphorus concentration objective for the Trent River of 0.005 mg-P/L.

As illustrated in Table 6-3, the natural wetlands in Maple Lake Creek are very effective at removing the effluent phosphorus. The wetlands downstream of the lagoon discharge are removing approximately 97% of the phosphorus in the lagoon – performance that cannot reliably be achieved in any normal wastewater treatment process. The proposed treatment upgrades to meet the Permit and MWR phosphorus requirements of 1 mg-P/L will likely result in an average effluent total phosphorus concentration of 0.5 mg-P/L, or a 6.5 mg-P/L reduction in effluent total phosphorus, reducing the total phosphorus load to Maple Lake Creek from 6.12 kg-P/day to 0.45 kg-P/day, a reduction of 5.67 kg-P/d; whereas the wetlands are currently taking up 5.94 kg-P/d. The decrease in phosphorus load to the natural wetlands along Maple Lake Creek is expected the put the wetlands into a growth condition that will scavenge available phosphorus, and consequently it is expected the total phosphorus concentration at the end of MLC will be near the detection limit, and in-stream criteria of 0.005mg/L. While it is expected that a higher effluent total phosphorus concentration would result in similar in-stream total phosphorus conditions in Maple Lake Creek, the existing Discharge Permit established in 1997 requires an effluent total phosphorus concentration of less than 1 mg-P/L be met.

Table 6-6-3 Phosphorus removal along Maple Lake Creek and Trent River

Location	Avg. Total P (mg-P/L)	TP Load (kg-P/day)	Reduction
MLC upstream of lagoons		0	
Lagoon discharge	6.8	6.12	Effluent
End of MLC	0.2	0.18	97%
Trent River 100m upstream of MLC)	< 0.005	< 0.0045	Trent Baseline
Trent 100m downstream of MLC	0.035	0.063	99%

Key points about discharge to Maple Lake Creek;

- It is the only practical discharge location for high peak flow winter discharges;
- The current summer discharge is effectively 100% of the flow in Maple Lake Creek;
- It is environmentally desirable to maintain some or all of the current summer flow level in Maple Lake Creek;
- The wetlands downstream of the lagoon discharge into Maple Lake Creek are removing 97% of the total phosphorus loading to the Creek, and reducing it by about 5.7 kg-P/day;

- Treatment to reduce the total phosphorus concentration from 6.8 mg-P/L to an expected 0.5 mg-P/L will reduce the phosphorus loading to MLC to about 0.45 kg-P/day; whereas the current phosphorus uptake is about 5.9 kg-P/day. The deficit in phosphorus is expected to drop the phosphors concentration at the end of MLC to less than the provincial objective of 0.005 mg-P/L;
- The instream objective of 0.005 mg-P/L within the Trent River is expected to be met;
- The natural wetlands on Maple Lake Creek are a real-world example of an "eco-asset", performing a valuable function for Cumberland, including treating stormwater runoff within the catchement.
- As Cumberland grows, so too will the summer flow of treated water to Maple Lake Creek, eventually doubling from its current level. With improved treatment quality, this increase in flow will be beneficial to the downstream aquatic life in MLC and the Trent in summer droughts. It is a rare case of where urban growth will create a direct benefit to a local ecosystem!

6.3 Seasonal Storage

The motivation for the storage options is a different way to meet the summer instream phosphorus objective of 0.005 mg-P/L in the Trent River. Instead of reducing the effluent phosphorus concentration, all of the summer discharge would be stored, to be released during the winter when there is no instream phosphorus objective in the Trent River, and the dilution levels are much greater.

There were two specific storage options developed in 2016;

a. Storage Wetland to be constructed on north side of lagoons

b. Storage Reservoir in natural depression north of Teal Lake (2km NE of lagoons)

6.3.1 Option 2A: Storage "Wetland"

The Storage Wetland involves construction of a new pond on the wetland area north of the lagoons and east of Maple Lake Creek. It would occupy the same area the previous 2006 wetland concept, but the "pond" would be 2-3m deep to create storage volume, rather than a shallow "treatment" wetland. Construction of this storage would involve extensive earthworks to remove the peat and create the earthen berms that would define the pond. The concept arrangement is shown in Figure 6-1.

The storage would be landscaped and an island, bird nesting sites and other vegetation and habitat features, this being the "wetland" part of the concept.

If the stored water meets the quality requirements for "Greater Exposure Potential", the area can publicly accessible and does not need to be fenced. The perimeter could become public walking trails making it an attractive public amenity. If the water only meets the requirements for Moderate Exposure Potential, public access would need to be discouraged, at a minimum, or possibly restricted.

There would be some environmental assessment and approvals required to implement this concept.

The Storage Wetland is entirely on Village of Cumberland owned land.

The cost to build the wetland ponds for the 2006 wetland concept was estimated in the order of $5M. Even though this concept is half the area, the pond is twice the depth, and the berms would be twice as high. A detailed cost evaluation has not been done, but it is unlikely that this reservoir would be built for any less than the $5M estimate from 2006.

Figure 6-1 Option 2A - Storage Wetland Concept

6.3.2 Option 2B: Storage "Reservoir"

The Storage Reservoir would be built in natural depression near Teal Lake, and requires a pumping station at the lagoons and a 2.3km connecting pipeline. The highest elevation of the pipe is about 40m above the lagoons, so this is a moderate pumping head. This arrangement is shown in Figure 6-2. The natural depression is about 5m deep, and some earthworks would be required to make a 5-7 m high dam wall along the south-east side of the reservoir area. The depth of water in at the deepest point would be 10 m when full and about 5 m when "empty".

The storage could be habitat enhanced in a similar way to the wetland, but this is not an essential component to the Storage Reservoir concept.

If the stored water meets the quality requirements for "Greater Exposure Potential", the area can publicly accessible and does not need to be fenced. The perimeter could become public walking trails making it an attractive public amenity. If the water only meets the requirements for "Moderate Exposure Potential", public access would need to be discouraged, at a minimum, or possibly restricted.

There would be some environmental assessment and approvals required to implement this concept.

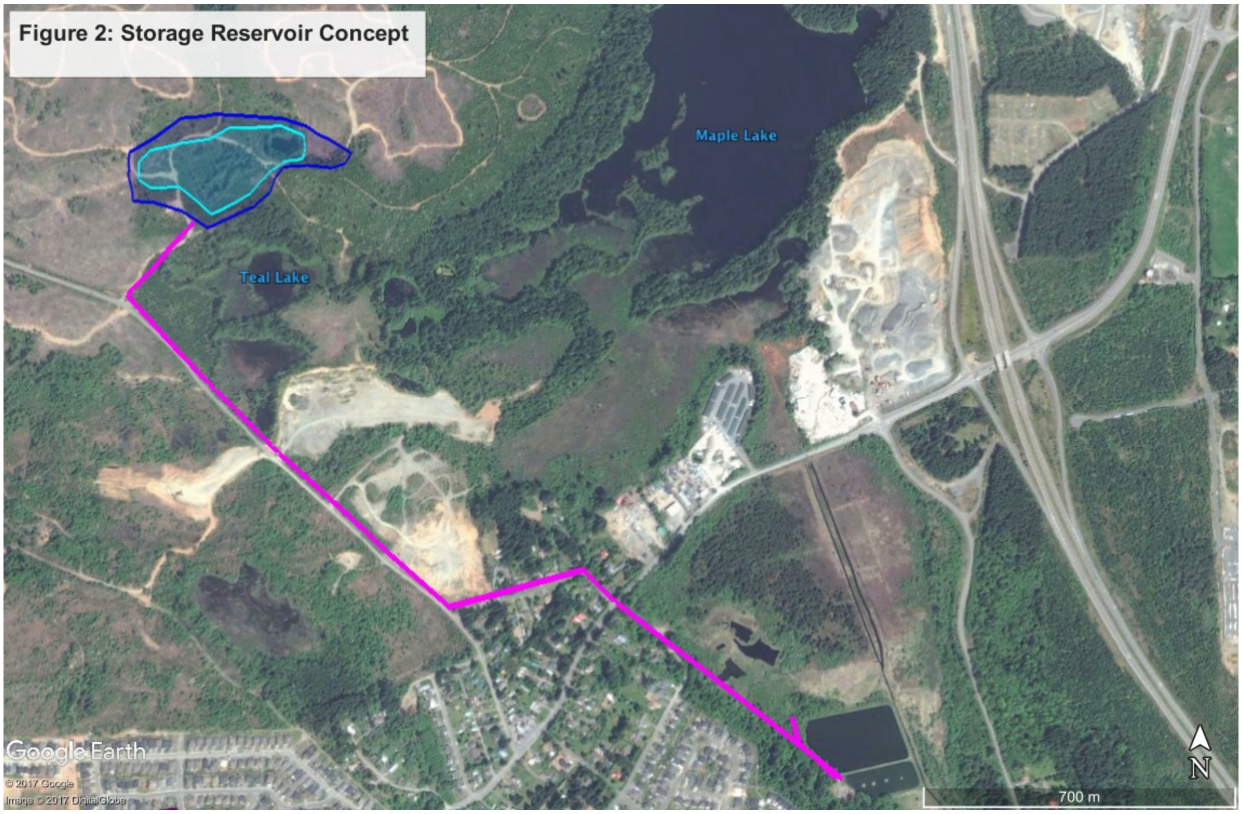

Figure 6-2 Option 2B - Storage Reservoir Concept

The Storage Reservoir is entirely on land owned by Comox Timber Ltd, so a possession agreement would need to be negotiated. The pipeline right of way is predominantly on Village of Cumberland roads and lands.

A detailed analysis of construction costs has not been made, but a "concept budget" is illustrated in Table 6-4.

Table 6-6-4 Option 2B - Storage Reservoir Concept Budget

Reservoir Earthworks	$1.0M
2.3km pipeline, 12 " HDPE, $500/metre laid	$1.15M
Pump station $0.15M	$0.15M
Subtotal $2.35M	$2.3M
Engineering @ 15% $	$0.35M
Land Acquisition Cost	Unknown
Contingency @50% (class D estimate)	$1.32M
Total	**$4.0M**

6.4 Analysis of Storage Options

For the seasonal storage to be feasible, it must be environmentally acceptable to divert all of the treated wastewater from Maple Lake Creek to storage.

One of the objectives of the summer 2017 environmental monitoring program was to assess the streamflow in Maple Lake Creek and the Trent, and the potential impact of its removal.

The streamflow monitoring confirmed that there was:

- Effectively zero dilution of effluent in MLC at the lagoon discharge location;
- Some loss of streamflow along the length of MLC; and
- Approximately a 1:1 dilution with the Trent River at the confluence with MLC.

To do a complete withdrawal of the effluent flows under these conditions is expected to have a detrimental impact on the environmental and habitat conditions along Maple Lake Creek and within the Trent River. A detailed habitat study was not conducted, but it is expected that a study would conclude that stream augmentation is needed and that more streamflow, not less, is needed, and that complete cessation of the Cumberland lagoon discharge would have a greater negative impact than the effects of the current phosphorus contributions from the Cumberland lagoons taking into consideration the phosphorus uptake due to the Maple Lake Creek wetlands.

Had the proposed Comox Valley Regional District "South Sewer Project" proceeded, it would have would have resulted in 100% of the Cumberland lagoon discharge being removed from the Maple Lake Creek catchment during the summer, and would have resulted in the near elimination of summer flows in Maple Lake Creek and an estimated halving of the summer flows in the Trent River with an expected consequential increase in ambient stream water temperature, and a concurrent reduction in dissolved oxygen within the Trent River during the summer as a consequence.

To make the storage options work, without adversely affecting summer water flows in Maple Lake Creek and the Trent River, it will be necessary to offset the loss of effluent flows to the creek by substituting an equivalent flow of fresh water.

Conceptually, this would involve releasing a volume of potable water equivalent to the wastewater generated by Cumberland, effectively doubling the domestic water demand during the summer - defeating all the metering and other water conservation initiatives, and depriving Cumberland of water capacity for population growth.

An alternative was considered, involving the construction of storage basins to collect stormwater runoff during the winter months, and release the stored water proportionately with the amount of wastewater effluent being diverted during the summer months. This would require building separate storage basins to enable stored stormwater to be released while treated wastewater effluent was stored, likely requiring two separate piping systems and (possibly) two pumping systems. A Provincial water licence might also be required if the stored freshwater water was diverted from a stream. Even without doing any detailed analysis, it is obvious that this "dual storage" system has doubled in cost and become unexpectedly complex.

A third option could be to create a single storage basin that would be used to store water during the winter, and then displace the stored water with treated wastewater during the summer, within the same common basin. Initially the release would be predominantly stored rainwater, and would gradually become dilute wastewater over the summer, depending on how or whether the storage basin was partitioned. The concentrations of phosphorus in the storage would gradually increase over the summer, depending on the degree of mixing occurring. This concept could quickly defeat the objective of "removing all the phosphorus by removing all the water" unless the storage was large.

Ultimately, the original rationale for the storage - *to remove the phosphorus from MLC by removing the water* -has to be questioned in the light of the phosphorus removal performance of Maple Lake Creek. With MLC removing 97% of the phosphorus, the incremental benefit of removing 100% of the phosphorus through storage, is questionable – achieving a very small benefit at a large cost.

Key points about storage options;

- The cost for the either of the single storage options is expected to be at least $4M
- With zero dilution in Maple Lake Creek, doing 100% withdrawal of summertime effluent, without any flow replacement, is environmentally unacceptable.
- Storing winter freshwater for flow replacement effectively doubles the cost and complexity of the storage system.
- 97% of the effluent phosphorus is already being removed by the natural wetlands in Maple Lake Creek;
- ***Based on the above, the recommendation of the Technical Consultant is that the storage options are neither practical nor needed, and that these options not considered further.***

6.5 Discharge to Natural Wetlands

A continued discharge to the Maple Lake Creek catchment and the Trent River is considered to be a necessary requirement due to the negative impact that would be caused by removing the discharge and the resulting extremely low flows in the two streams. While the current Discharge Permit authorizes a continued release of secondary treated effluent, a requirement to register the discharge and comply with the current Municipal Wastewater Regulation (MWR) would result in a need to upgrade the discharge water quality to be able to continue to discharge to MLC and the Trent River as a result of the low dilution (less than 10:1) during the summer months.

The water quality requirements under the MWR differ, depending on how the water is discharged to MLC. Because the dilutions in MLC are less than 10:1 during the summer, a direct discharge into MLC would require the water to meet Greater Exposure Potential reclaimed wastewater water quality conditions; whereas an indirect discharge to MLC through the wetlands to the north of the lagoons is expected to only require the water to meet Moderate Exposure Potential reclaimed wastewater water quality conditions. The reason for the difference is that a direct discharge to MLC has a greater potential for public contact than a subsurface discharge to the wetlands that can be implemented in manner that the public would not be expected to come into direct contact with the discharged water.

The Moderate Exposure Potential (MEP) water quality criteria is as follows:

- BOD5 $\leq$ 25 mg/L (maximum)
- TSS $\leq$ 25 mg/L (maximum)
- Fecal coliform $\leq$ 100 CFU/100 mL (median) and $\leq$ 400 CFU/100 mL (maximum)
- pH 6.5 - 9

While passage of the reclaimed wastewater through the wetlands is expected to result in a significant reduction in the phosphorus concentration due to plant uptake and mineralization, some chemical phosphorus treatment may be required prior to release to the wetlands.

The strategy would be to disperse MEP reclaimed water in a subsurface manner to the natural wetlands, allowing the water to flow through the wetlands and drain into Maple Lake Creek on a year-round basis, while discharging treated effluent flows greater than 2 x ADWF, and that exceed the wetlands hydraulic capacity, directly to Maple Lake Creek during the winter months.

The reclaimed water that is released to the wetlands will be subjected to passive treatment as it passes through the wetlands and eventually drains into Maple Lake Creek, including:

- residual BOD and TSS concentrations will be reduced as a result of bacterial treatment through the wetlands;
- ammonia will be nitrified to nitrate, and phosphorus and nitrogen concentrations will be reduced as a result of plant uptake and phosphorus mineralization.

The use of reclaimed wastewater to augment flows in the wetlands are also expected to enhance the wildlife habitat within the wetlands.

A hydrological assessment should be carried out to verify the ability of the wetlands to accept 3,600 m^3/day, representing 2 x ADWF. As algae is expected to exceed the maximum TSS criteria of 25 mg/L during the summer, some form of solids/liquid separation will likely be required following lagoon treatment prior to disinfection and release to the wetland. With the noted improvements to the lagoon system to meet the conditions of the current Discharge Permit, the MEP reclaimed wastewater water quality conditions are also expected to be met.

The wetland discharge can maintain free water ponds and soil moisture during extended summers, enhancing wildlife habitat and tree growth. A project of distributing water to the wetlands area would also open the way for a network of walking paths to be built in the area, increasing the public amenity of the wetlands. This was a desirable feature of the treatment wetland concept of 2005 - 2008 and could be a feature of a wetland augmentation. In effect, there is no need to construct the wetland as proposed in 2005, the water can just be taken to the wetland that is already there.

Additionally, a habitat enhancement program could be undertaken to remove some invasive plant species and plant native forest species, to be irrigated with the reclaimed water. With careful design implementation and maintenance, a highly functional habitat could be created on this abandoned farmland.

A good example of this concept is the award-winning Maleny Treatment Wetland, in Queensland, Australia. This involved a 13.8 ha forest planting, on former farmland, irrigated by subsurface drip effluent, and a 3ha constructed treatment wetland. All the effluent from the treatment plant of this town of 3500 people goes through the forest and then the wetland before reaching the local creek, which runs into a drinking water storage reservoir. Even though the reclaimed water is already of very high quality, significant polishing and nutrient removal happens as the water moves through the forest and wetland area. The project was a joint initiative with a local conservation group who did the tree plantings and maintenance, and is widely regarded as a success, winning a UN Environmental award in 2015. For more information go to the link at http://waterandcarbon.com.au/wp-content/uploads/2016/02/WCG-Case-Study-Maleny.pdf

6.6 Summary

In 2016, the LWMP committee identified that finding a suitable discharge location was a major issue of the Cumberland LWMP. This was driven mainly by a desire to avoid the 0.005 mg-P/L summertime in-stream phosphorus criteria of the Trent River, what was thought to be impossible or very expensive to achieve.

The environmental monitoring program of 2017 verified that not only is Maple Lake Creek removing 97 % of the phosphorus, but also that sending the all water to another watershed, or diverting the discharge to storage during the dry summer months, would effectively dry up the creek during the summer, with associated environmental consequences.

A modest effort to reduce treated wastewater total phosphorus concentration to less than 1 mg-P/L is expected to have a much greater impact on achieving the provincial instream phosphorus objective set for the Trent River of less than 0.005 mg-P/L. It is expected that in targeting a treated water phosphorus concentration of 1 mg-P/L, that an average concentration of 0.5 mg-P/L can reliably be achieved. This represents an overall reduction of about 5.7 kg-P/day, whereas the natural wetlands downstream of the lagoon discharge to Maple Lake Creek is currently removing 5.9 kg-P/d. The decrease in phosphorus load to the natural wetlands along Maple Lake Creek is expected the put the wetlands into a growth condition that will scavenge available phosphorus, and consequently it is expected the total phosphorus concentration at the end of MLC will be near the detection limit, and the Ministry of Environment in-stream objective of 0.005 mg-P/L is expected to be met in both MLC and the Trent River. While it is expected that a higher effluent total phosphorus concentration would result in similar in-stream total phosphorus conditions in Maple Lake Creek, the existing Discharge Permit established in 1997 requires an effluent total phosphorus concentration of less than 1 mg-P/L be met.

Consequently, the philosophy has changed from one of *removing* the water to one of *retaining* the water, to maintain the summertime flow into Maple Lake Creek.

7.0 EXISTING LAGOON TREATMENT PERFORMANCE

7.1 WASTEWATER TREATMENT SYSTEM DESCRIPTION

The Village of Cumberland has operated and maintained a lagoon wastewater treatment system since 1967 consisting of influent screens, a surface aerated lagoon and a facultative lagoon. The water from the lagoon flows into Maple Lake Creek (a man-made channel), and downstream through a natural wetland along Maple Lake Creek to a confluence point with the Trent River.

The aerated lagoon has a surface area of about 9,300 m^2, and a depth of 1.5 m, resulting in a volume of about 14,000 m^3. It has four surface (spray) aerators to add oxygen the lagoon and enhance aerobic biological treatment. At a nominal summer flow (including stormwater flows from rain events), the hydraulic retention time is about 14 days.

The facultative or stabilization lagoon has a surface area of about 25,700 m^2, and a depth of 1.5 m, resulting in a volume of about 39,000 m^3, with a nominal summer wastewater flow hydraulic retention time of about 39 days. It relies on passive diffusion of oxygen from the atmosphere to provide oxygen to support aerobic biological treatment within the lagoon.

No effluent disinfection or phosphorus removal is provided prior to release from the lagoons to Maple Lake Creek; however, the long retention time within the lagoons results in natural attenuation and reduction of pathogens, and water quality data collected from within Maple Lake Creek prior to the confluence with Trent River shows there is a high degree of natural phosphorus attenuation and removal occurring within the wetlands along Maple Lake Creek between the lagoons and the confluence with the Trent River.

7.2 COMBINED SEWER FLOW IMPACTS ON TREATMENT

The community's combined sewer system causes the wastewater flows entering the lagoon treatment system to increase dramatically during winter rainfall events, with recorded discharge flows to Maple Lake Creek exceeding 20,000 m^3/d, compared to average dry weather wastewater flows during the summer of around 900 m^3/d. The high stormwater influenced wastewater flows entering the lagoon system results in reduced hydraulic retention time – less time for treatment. A flow increase from 1,000 m^3/d to 10,000 m^3/d reduces the overall hydraulic retention time from just over 50 days to about 5 days.

The primary water quality parameter affected by the reduced hydraulic retention time is the Biochemical Oxygen Demand (BOD) which reflects the amount of oxygen required by bacteria over 5 days to consume the biodegradable organic contaminants in the wastewater. Any BOD not removed by the treatment process will enter the receiving environment (Maple lake Creek and Trent River), where bacteria in the environment will continue to consume and digest the residual BOD not removed during treatment. If the oxygen required by bacteria in the receiving environment exceeds the amount of oxygen that is naturally made available through diffusion from the atmosphere, the dissolved oxygen (DO) in the receiving environment could decrease – and the concern is that if the BOD loading is too great the dissolved oxygen concentration in Maple Lake Creek or the Trent River could drop to a level that would not support aquatic life in those streams. This effect is referred to as DO sag.

Taking the above into consideration, one of the reasons a lagoon system is generally a superior wastewater treatment process in comparison to a mechanical treatment facility under conditions with extremely large flow variations, is that it a lagoon system is generally less affected by wide variations in flow and hydraulic retention time. While under the scenario of a 10:1 increase in wastewater flows will reduce the hydraulic retention time in the Cumberland lagoons from 50 to 5 days, the comparable change in a mechanical treatment process would be from

10 hours to 1 hour. Further, mechanical solids liquid separation processes are even more susceptible to hydraulic fluctuations than lagoon systems. Generally, a quiescent period of about 2 hours is required to effect efficient settling of suspended solid particles (grown bacteria), and clarifiers serving mechanical treatment processes are often designed with nominal retention times between 2 to 4 hours. The impact of a 10:1 variation in flow on a clarifier serving a mechanical treatment process would be to reduce the hydraulic retention time from 2 to 4 hours down to 12 to 24 minutes while creating turbulence within what needs to be a quiescent zone; resulting in poor solids separation and high effluent TSS. In contrast the solids settling capabilities of a lagoon system is relatively unaffected as the proportion of the quiescent time within the lagoon is still in the order of days.

Major storm flow events also tend to “flush out” the sewer lines, washing grit and grease/scum off the pipes. This can lead to large loadings of grit, rags and Fats, Oils and Grease (“FOG’s”) reaching the headworks during storm events. The headworks consists of two parallel channels with a “Muffin Monster” macerator and screen in one of them (and designed for future screen installation in the second channel). During storm events, excess flow bypasses the screen and goes through the empty channel, carrying some of the grits, rags and FOG’s into the lagoons.

7.3 Summer 2017 Water Quality Monitoring Program

Review of the previous studies on water quality in the lagoons and Maple Lake Creek revealed some “data gaps” to be filled as part of the summer 2017 monitoring program. Specifically, it was desired to collect data from;

1. The influent to the lagoons and the effluent from the aerated lagoon to the facultative lagoon, to assess the performance of the aerated system, and
2. Locations within Maple Lake Creek, to investigate the behavior of phosphorus during the lowest flow (lowest dilution) periods.

Table 7-1 illustrates the results of a water quality survey carried out at various locations within the treatment process and receiving environment within Maple Lake Creek and the Trent River during this past summer between April 25 and September 26, 2017. Samples were collected from various locations to determine the degree of reduction in key contaminants as the wastewater flowed through the lagoons and along Maple Lake Creek to the Trent River.

Table 7-1 presents the average water quality parameter concentration at specific strategic locations for samples collected over a five-month period from April 25 to September 25

Table 7-7-1 Average Water Quality Parameter Concentrations (April 25 to September 25, 2017)

LOCATION	Total BOD (mg/L)	Soluble BOD (mg/L)	TSS (mg/L)	TP (mg-P/L)	Ortho-P (mg-P/L)	$NH4^+$ (mg-N/L)	E. coli CFU/100mL	Fecal Colif. CFU/100mL
Influent	292	175	282	6.8	4.08	41.4	1,350,000	2,176,750
Aerated Lagoon	38	8	100	6.4	4.46	43.2	16,100	115,500
Facultative Lagoon	17	< 6	49	4.7	3.50	24.6	2,692	12,618
Wetland Treatment	< 6	< 6	< 4	0.2	0.231	0.366	48	398
Trent 100 m U/S	< 6	< 6	<4	< 0.005	< 0.005	0.235	3	34
Trent 100 m D/S	< 6	< 6	< 4	0.035	0.024	0.132	10	55

With respect to BOD, the monitoring data shows the aerated lagoon alone achieves an advanced secondary treatment level with an average soluble BOD of less than 10 mg/L. While the average BOD values of 38 mg/L exceeds the Permit limit of 30 mg/L at that stage of treatment, the average filtered (soluble) BOD concentration of 8 mg/L indicates that 30 mg/L is associated with suspended solids, the majority of which in a lagoon system is algae. The influence of algae growth is also reflected in the average total suspended solids concentration in the aerated lagoon effluent of 100 mg/L. What this indicates is that if the suspended solids were removed through sedimentation and/or filtration, the water quality after the aerated lagoon would be well within the current Permit and federal WSER BOD requirements. Further, not shown in Table 7-1 is that the soluble (filtered) BOD concentrations from the aerated lagoon were all less than 12 mg/L, which is almost sufficient to meet the Greater Exposure Potential (GEP) water reuse criteria of BOD less than or equal to 10 mg/L. With filtration, the TSS concentration would also be less than the GEP water reuse criteria of less than 10 mg/L.

After additional aerobic treatment through the facultative lagoon, the average BOD concentration of 17 mg/L is well below the Permit and WSER criterion and the soluble BOD was consistently less than the BOD analytical detection limit of 6 mg/L. This indicates the BOD concentrations recorded were primarily due to suspended solids (i.e. algae) which were as high as 85 mg/L. Again, with adequate solids separation (e.g. filtration) both the BOD and TSS concentrations would be expected to meet the GEP water reuse criteria.

The summer 2017 monitoring data also illustrates the lagoons have little effect in removing or reducing the wastewater phosphorus concentrations, as well as negligible nitrification (i.e. bacterial conversion of ammonia to nitrate), as evidenced by the high ammonia concentrations in the discharge from the facultative lagoon and the relative absence of nitrate in the discharge. This is an important observation as the federal WSER water quality criteria requires low unionized ammonia concentrations. While some ammonia uptake is evident, particularly during period of rapid algal growth there is no evidence to support a significant degree of nitrification is occurring. Accordingly, any upgrade plans for the lagoon system must include a nitrification stage to reduce potential ammonia toxicity.

Although the lagoons have limited effect on reducing either total or ortho phosphorus concentrations, even during periods of rapid algal growth, there is evidence that phosphorus is rapidly taken up and/or adsorbed as the effluent from the lagoons travels along maple Lake Creek towards the Trent River. By the time the water reaches the Trent River, approximately 95 percent of the phosphorus leaving the lagoons is removed from the water, with the average total-phosphorus concentration in Maple Lake Creek (after passing through natural wetlands) of 0.20 mg-P/L.

Similarly, while the median fecal coliform and E.coli levels in the discharge from the lagoons into Maple Lake Creek are 12,600 MPN/100 mL and 2,700 MPN/100 mL, respectively, prior to the confluence with the Trent River the median levels in Maple Lake Creek drop to about 400 and 50 MPN/100 mL, respectively (i.e. indicating a 4-Log reduction in potential pathogens without a disinfection treatment stage).

Overall, the data collected indicates that following treatment through the lagoon and natural wetland systems along Maple Lake Creek, the following treatment performance is being achieved:

- Biochemical Oxygen Demand (BOD_5): maximum < 6 mg/L (98% removal)
- Total Suspended Solids (TSS): maximum < 4 mg/L (99% removal)
- Total Phosphorus (TP): average 0.20 mg-P/L (97% removal)
- Ammonia (NH_4^+): average 0.37 mg-N/L (99% removal)

- E. coli: median 48 MPN/100mL (4.4-Log removal)
- Fecal Coliform: median 398 MPN/100mL (3.7-Log removal)

While the existing Discharge Permit defines the point of discharge as the release of water from the facultative lagoon into Maple Lake Creek, treatment continues as the water flows along Maple Lake Creek to the Trent River. The development of wetlands along Maple Lake Creek is a natural occurrence and response to the nutrients being released to the creek and serves as a buffer or polishing stage to protect water quality in the Trent River.

7.4 Wastewater Treatment Achieved

The water quality within Maple Lake Creek is of particular importance during the summer months as the flow contribution from Maple Lake Creek represents a significant portion of the water flowing within the Trent River downstream of the confluence point, and the flow in Maple Lake Creek is almost entirely due to the water flowing from the Cumberland lagoon system.

Although the water from the lagoon system is not disinfected, the data shows that the lagoon system achieves a 2 to 3-Log reduction in indicator bacteria, which increases to a 3 to 5-Log reduction after the water has passed through the downstream wetlands along Maple Lake Creek. Again, noting the water flowing in the Trent River downstream of the confluence is comprised primarily of flows originating from Maple Lake Creek during the summer months, the fecal coliform and E. coli levels measured in the Trent River 100 metres below the confluence of the two streams indicates a net reduction in indicator bacteria (and associated potential pathogens that could be present of 5-Logs.

The level of treatment achieved by the lagoon and natural wetland systems combined is superior to most mechanical tertiary treatment processes. They reduce BOD and TSS to below their analytical detection limits, reduce the ammonia and phosphorus concentrations to levels that compare to the best-in-class nutrient removal processes, and achieve 3-5-Log-reductions in indicator bacteria. By association, this is a 3-5-Log reduction in potential disease-causing viruses, bacteria and parasites that could be present in the influent wastewater – comparable to what would be expected for a disinfection treatment process.

The water quality data shows that, with the combination of the lagoons and the Maple lake Creek wetlands, the Village of Cumberland is achieving a remarkable level of treatment with this passive wastewater treatment process during the summer months. Monitoring over many years demonstrates the indicated water quality levels are also maintained throughout the winter months when the flows in the Trent River are significantly greater than the discharge from Maple Lake Creek, despite a dramatic increase in wastewater flows due to the combined sewer system serving the community. Although the Permitted average dry weather flow (ADWF) discharge is 910 m3/d, peak wet weather flows can exceed 20,000 m^3/d. It is believed that the resulting reduction in treatment time through the lagoons and wetlands due to the higher flows is off-set by the reduced influent contaminant concentrations as a result of a dilution-effect from the stormwater flows.

While the overall water quality released from Maple Lake Creek to the Trent River represents a remarkable level of treatment for all constituents of concern, it is important to note that the current Discharge Permit is for the release of treated wastewater from the lagoons to Maple Lake Creek. It is considered unlikely that the Ministry of Environment would consider the natural wetlands along Maple Lake Creek to be a formal extension of the Village of Cumberland wastewater treatment process. While the Village could attempt to make a case for that inclusion, it is very likely the Ministry will continue to consider the discharge point to be where effluent enters Maple Lake Creek as a point discharge, and require the Village to meet water quality requirements at that location.

7.5 Implications for Treatment Upgrades

Because there is less than 10:1 dilution with ambient water in Maple Lake Creek or Trent River during the dry summer months, it is expected that GEP water reuse water quality will have to be met once the community growth and increase in wastewater flow is taken into consideration, as this would require a major Discharge Permit amendment and would trigger the need to comply with the MWR requirements. For discharges with less than 10:1 dilution, this implies having to meet GEP criteria or better at the point of release to Maple Lake Creek and improvements to treatment including:

- Filtration to remove total suspended solids to a maximum of 10 mg/L and turbidity to less than 2 NTU;
- Nitrification to meet un-ionized ammonia and effluent toxicity requirements,
- Total phosphorus reduction to achieve a maximum total phosphorus concentration of 1 mg-P/L; and
- Disinfection to meet non-detect fecal coliform water reuse indicator bacteria requirements; and

Although the number of indicator bacteria in Maple Lake Creek following passage through the wetlands system is comparable to that expected for UV or a chemical disinfection process, it is expected that disinfection of the water leaving the lagoon system would be the first incremental change to the treatment process. This would address concerns that the reduction in indicator bacteria due to natural processes may not necessarily reflect reductions in pathogens of concern. Ultraviolet transmissivity testing carried out during the summer concluded that UV disinfection is not a feasible option for disinfection due to extremely low UV transmissivity levels determine in filtered wastewater and water samples collected through the lagoon system and along Maple Lake Creek. As it is generally agreed that chlorination is undesirable due to the chlorinated hydrocarbon by-products produced and toxicity of chlorine to aquatic organisms, it is recommended that Peracetic Acid (PAA) disinfection be considered instead. This will be discussed further in a separate Technical Memo.

The second incremental change to meet the current Discharge Permit upgrade requirements is add phosphorus treatment to reduce effluent total phosphorus concentrations to less than 1 mg-P/L. This could be done in a number of ways, including the use of chemicals to precipitate phosphorus (e.g. lanthanum chloride, alum or ferric chloride), or by incorporating a reed-bed filtration system into the treatment process with media designed to adsorb toxic and complex organic and inorganic contaminants of concern – including emerging contaminants such as pharmaceuticals and endocrine disrupting chemicals, as well as phosphorus using zero valent iron.

8.0 TREATMENT OPTIONS

8.1 Background

The Village of Cumberland has over 50 years of lagoon effluent water quality and receiving environment water quality monitoring data that was collected and reported in compliance with the Discharge Permit requirements, but not analyzed as a means of assessing the treatment characteristics and performance of the lagoons. To better understand how the existing treatment lagoons are performing, a number of modifications were made to the monitoring programs, and the modified program was carried out this past summer as described in Section 7.0. The changes included collecting water quality samples between the two lagoons, additional stream water quality samples, in-stream flow measurements, and additional analytical parameters in order to better understand the treatment characteristics, capacity and performance of the existing lagoon system, and of the downstream natural wetlands along Maple Lake Creek. This work has enabled the project team to better understand the lagoon system treatment capacity, consider methods to enhance and upgrade the level of treatment achieved, and consider cost-effective means to benefit from the lagoon system as a wastewater treatment component for long-term community wastewater treatment planning.

The treatment options presented in this technical memo take into consideration:

- Discharge options described in Chapter 6.0,
- Raw water quality and quantity,
- Necessary improvements to achieve and maintain compliance with required water quality levels.

The three primary upgrading approaches discussed in this document are as follows:

- Option 1 – Lagoon based Treatment, with three phases;
    - Phase 1, upgrades for Permit Compliance Only
    - Phase 2A – further upgrades for MWR compliance to "MEP" water quality
    - Phase 2B – further upgrades from 2A to "GEP" water quality
- Option 2 Baseflow Mechanical Treatment, with excess flow handled by the lagoons
- Option 3 Full Flow mechanical treatment, with lagoons decommissioned

8.2 Option 1 - Lagoon-Based Treatment

8.2.1 Phased Approach or Single Phase

The lagoon improvements can be done in phases or as a single project. The gives the community flexibility to chart an affordable and fiscally responsible path to meet the ultimate goal of servicing a future population of 7000 people while meeting all applicable requirements of the provincial Municipal Wastewater Regulation.

The basic concept of the first phase is to optimize the treatment performance and capacity of the existing lagoons as the primary means of biological treatment with the focus on reduce the soluble biochemical oxygen demand (BOD) and meet the existing Discharge Permit water quality requirements. With that accomplished, a second phase can be carried out at some point in the future to expand treatment capacity and meet MWR requirements by adding mechanical equipment components.

The 2017 field monitoring program described in Chapter 7.0 provided information on the degree of treatment being achieved by each of the two lagoons and better insight on future performance under increased loading than is possible using generic lagoon system design equations.

The BOD analytical test provides information on how much oxygen will be consumed by bacteria in digesting the organic matter present in the water. Some of this organic matter is dissolved in the water, and some are solid particles that are slowly consumed by the bacteria during the 5-day test period. When there is an algae bloom, the proportion of the BOD associated with solid particles is very high. The 2017 monitoring program showed that if the algae and other total suspended solids (TSS) particles were removed using a mechanical solids/liquid separation component, the remaining soluble BOD and the TSS in the effluent would be less than 10 mg/L, under current population loading conditions; well below the current Discharge Permit BOD and TSS criteria.

8.2.2 Option 1 - Phase 1 Lagoon System Improvements – Meeting Discharge Permit Requirements

In order to maintain the effluent water quality as the contributing population increases, it is necessary to increase the treatment capacity. This can be achieved by optimizing the treatment performance of the existing lagoons and by adding mechanical equipment.

The lagoon BOD removal can be optimized by: 1) installing additional aerators to increase the amount of oxygen applied to the treatment process; 2) increasing the effective aerated volume of water by aerating the larger lagoon instead of the smaller lagoon; and 3) maximizing the retention time for biological treatment by installing floating baffles or curtains. The strategically placed floating baffles prevent water from entering one end of the lagoon and flowing immediately and directly to the exit by directing the flow pattern back-and-forth across the lagoon. Implemented as a single initial phase of work, Phase 1 focusses on achieving the necessary BOD, TSS, total phosphorus, and indicator bacteria water quality reductions to comply with the Village's current Discharge Permit requirements and allow the performance of the upgraded system to be evaluated and verified before further modifications are considered and implemented. In addition to modifying the lagoons to enhance biological treatment and add solids separation, disinfection capacity will be added to treat for both summer and winter flows.

8.2.3 Option 1 - Phase 2 Lagoon System Improvements – Meeting MWR Discharge Requirements

8.2.3.1 Triggering

It is expected that Cumberland will eventually need to bring the discharge into compliance with the MWR, which will require a second phase of upgrades.

While the Discharge Permit was grandfathered, significant changes to the discharge conditions could cause the Ministry to require the community to meet MWR conditions. Potential triggers include a request for a significant increase in the permitted average annual daily discharge, which is currently 910 m^3/d, or a desire to reuse reclaimed water.

8.2.3.2 Phase 2 Objectives

Phase 2 improvements will need to accommodate population growth while continuing to meet the water quality requirements of the existing Discharge Permit, the federal WSER and the provincial MWR Moderate Exposure Potential (MEP) water quality standards over the design flow range. As the existing lagoons have only a finite capacity to remove BOD, rather than increase the size of the lagoons to handle future BOD load increases, a more cost-effective method of BOD reduction in the form of primary solids separation is proposed. Further, with the addition of tertiary effluent filtration equipment, the upgraded lagoon system can also meet the more stringent provincial MWR Greater Exposure Potential reclaimed water quality standard.

Wastewater flows in excess of 3,600 m^3/d can also be treated through the upgraded lagoon system, but will be bypassed around the mechanical solids/liquid separation and filtration stages, with the excess flow being routed directly from the lagoons to disinfection prior to discharge.

In addition to meeting discharge water quality requirements, Cumberland will also need to meet the equipment redundancy and back-up power requirements under the MWR for both Phase 2 discharge alternatives. It is expected the upgrade design Average Dry Weather Flow (ADWF) will be 1,800 m^3/d, with the plant designed to meet provincial MWR requirements for wastewater flows up to 2xADWF (3,600 m^3/d) for both Phase 2A and 2B, as well as Options 2 and 3.

8.2.3.3 Two Discharge Locations and Associated Water Quality Alternatives

Once a requirement to Register the Discharge under the MWR is triggered, taking into consideration the near complete absence of dilution in dry weather in both MLC and the Trent, it is expected a continued discharge into MLC will need to meet the MWR Greater Exposure Potential (GEP) water quality criteria.

Cumberland was directed by the Ministry of Environment to consider alterative discharge locations. The wetlands located to the north of the lagoons (referred to as the north wetlands) is a possible alternative discharge location. A wetlands discharge without immediate or direct public access would require a water quality essentially the same as is currently required by the Discharge Permit, and is referred to as a Moderate Exposure Potential (MEP) reclaimed water quality.

8.2.3.4 Two Alternative Phase 2 Treatment Alternatives: 2A and 2B

The two discharge locations and associated water qualities are reflected in the following Phase 2 alternatives:

- Option 1 - Phase 2A to achieve a MEP water quality with a discharge to the north wetlands; and
- Option 1 - Phase 2B to achieve a GEP water quality with continued discharge to MLC.

8.3 Other Phase 2 Alternatives

The phased approach, beginning with a first phase lagoon upgrade, can be followed up by any of the mechanical equipment options in a second phase. Alternatively, if sufficient funding is available, the Phase 1 lagoon upgrade can be rolled into any of the Options to make a single upgrade project. All of Phase 1 scope is required for all options except the Full Flow Mechanical option.

8.3.1 Option 2: Baseflow Mechanical Treatment

This option provides mechanical treatment and disinfection capable of achieving a MWR GEP reclaimed water quality suitable for beneficial stream augmentation into MLC without the need for dilution, for a design ADWF of 1,800 m^3/d and wet weather flow of up to the 3,600 m^3/d. All excess wet-weather flows beyond 3,600 m^3/d would be directed through the lagoon treatment system. All flows, whether mechanically treated or directed through the existing lagoon system, are disinfected prior to discharge to MLC under this option.

8.3.2 Option 3: Full Flow Mechanical Treatment

This option also provides mechanical treatment and disinfection capable of achieving a MWR GEP reclaimed water quality suitable for beneficial stream augmentation into MLC without the need for dilution, for a design ADWF of

1,800 m^3/d and wet weather flow of up to the 3,600 m^3/d. It also provides mechanical treatment, and disinfection, to achieve a secondary water quality for excess flows up to 14,400 m^3/d. This option provides treatment for the high winter flows where there is major inflow and infiltration, and the lagoons could be decommissioned or re-purposed.

This approach is the proposed treatment process developed In November 2016, in response to a grant funding opportunity. This was deemed the preferred option at the time based on meeting the GEP potential in summer and current Discharge Permit water quality conditions in the winter, plus it could be constructed within the 1-year timeline limitation stipulated within the grant. The funding application was unsuccessful, and in 2017 all treatment options were re-considered.

8.3.3 Reed-bed

The 2016 "full flow mechanical" treatment concept also considered the construction of an engineered wetland, referred to as a "reed-bed", using a charcoal media (biochar) to remove emerging contaminants, including pharmaceuticals, from the treated wastewater effluent. This option is described briefly in the upgraded lagoon approach, and in more detail in Section 11.0 "Effluent Polishing by Reed-bed". It is not needed to meet any regulatory requirements, and can be considered an optional addition to any of the treatment options presented.

8.4 Option 1 – Lagoon-Based Treatment System

8.4.1 Lagoon-Based Treatment System Considerations

There is an old adage of "not throwing the baby out with the bathwater". In this case, the baby is the lagoons that have served and continue to serve the community well. For those who feel they need to acquire the latest electronic gadget, basing future community wastewater needs on a treatment technology that is over a century old must seem very antiquated. This is further underscored by the knowledge that the community's treated wastewater discharge has been out of compliance with the Discharge Permit from the date it was issued – giving the appearance that it must be the technology that is at fault.

However, for small communities, where there is sufficient land available, lagoon treatment is often the lowest cost method of BOD reduction, particularly when labour and power costs are taken into consideration. That is not to say a lagoon-based treatment would not require maintenance, but it would require significantly less daily operator attention than a mechanical treatment process. Further, lagoon systems, because of their characteristically long hydraulic retention times, can better handle wide variations in wastewater flows, resulting in a more stable effluent water quality, than higher rate mechanical processes. The long hydraulic retention time within the lagoons has served the community well with the high inflow and infiltration (I&I) that the community experiences. The ability to accept large variations in wastewater characteristics makes lagoon systems a particularly attractive treatment technology for Cumberland.

The Village of Cumberland also has considerable experience operating and maintaining the lagoon system and is fortunate to have access to a large body of land, including natural wetlands located adjacent to the lagoons and downstream along Maple Lake Creek. The Lagoon Upgrade approach builds upon the successes and strengths of the existing lagoon system.

Lagoon systems can also have a number of disadvantages that may affect their selection as a treatment technology, including:

- Design is typically based on a conservative interpretation of performance data obtained from a wide variety of lagoon systems;
- Lagoon systems are less efficient than mechanical processes in cold climates due to the large amount of heat loss that occurs as a result of the long hydraulic retention times and large surface area for heat loss;
- Lagoons can provide a breeding area for mosquitoes and other insects;
- Odour can become a nuisance as a result of turn-over in the spring;
- Lagoons typically have limited ammonia and phosphorus removal.
- Lagoons have trouble meeting regulatory effluent TSS requirements due to algae

8.4.2 2016 Federal Funding Grant Considerations

Continued and expanded use of the lagoon system was considered for the 2016 federal funding grant application; however, it was ruled out as an option due to a number of factors, including:

- Historical effluent water quality data indicated both BOD and TSS exceeded the Discharge Permit secondary effluent requirements;
- A capacity review using conventional lagoon design criteria concluded the lagoons had limited residual capacity to handle additional wastewater loading without considerable modification including enlargement and deepening;
- Based on the capacity review, expanding the lagoon treatment to serve a population of 7000 required extensive excavation, necessitating a geotechnical evaluation to assess feasibility that could not be completed within the limited amount of time available to prepare the grant-funding application.

8.4.3 Addressing Key Lagoon Effluent Quality Limitation – Solids Separation

The rejection of the federal grant funding for the Full Flow Mechanical concept in March 2017 allowed further exploration of options to upgrade treatment to meet future population demands, and resulted in a recommendation to analyse the lagoon performance in greater detail than had been previously done, as well as verify downstream environmental conditions. As noted previously, the enhanced monitoring program carried out in 2017 demonstrated the inability to meet the Discharge Permit BOD criteria was primarily due to the presence of algae and other suspended solids and that, by introducing a mechanical solids/liquid separation stage, both the BOD and TSS would be well below the Discharge Permit requirements. The data gathered this summer demonstrated the smaller aerated lagoon with a 14-day Average Dry Weather Flow (ADWF) hydraulic retention time is reducing the soluble BOD concentrations to less than 10 mg/L. This means that if solids separation were incorporated into the treatment process after lagoon treatment, both BOD and TSS would be less than 10 mg/L under current population loading conditions.

8.4.4 Phasing Lagoon-Based Treatment Improvements

Table 5-1 illustrates the Option 1 phasing alternatives with the objective of Phase 1 to meet the existing Discharge Permit requirements, and the objective of Phase 2 to meet the current MWR requirements when required at some point in the future. As previously noted, because there are two potential discharge locations that have been identified, each with different prospective effluent water quality requirements under the MWR. The lagoon-based Option 1 - Phase 2A and Option 1 – Phase 2B represent two different second phase upgrades that will meet the

MWR requirements for two different discharge scenarios while accommodating population growth projections for the next 20-years, as do the mechanical treatment systems Option 2 (baseflow) and Option 3 (full flow)

The Option 1 lagoon-based treatment system can be implemented to achieve full MWR compliance in a single phase or it can be upgraded in two phases if there are funding limitations. Both the Option 1 - Phase 2A and Option 1 – Phase 2B alternatives shown in Table 5-1 are based on Option 1 - Phase 1 being completed.

8.4.5 Option 1 - Phase 1 – Meet Current Discharge Permit Requirements and Conditions

Option 1, as previously noted, involves upgrading the performance and treatment capacity of the existing lagoons to serve as the primary means of BOD reduction in a two-phase process. The first phase involves optimizing the performance of the existing lagoons and adding solids removal and disinfection equipment for the purpose of meeting the current Discharge Permit requirements as shown in Table 8-1, The second phase involves additional mechanical equipment to further increase the treatment capacity as well as meet redundancy requirements under the MWR. There are two alternative second phases that have been developed for Option 1, each corresponding to a different discharge location and associated water quality requirement; however, either of the two other Options (i.e. 2 or 3) could also be implemented as a second phase following Option 1 Phase 1, if so desired.

Table 8-8-1 Option 1 - Phased Lagoon Upgrade Targets

	Option 1 – Lagoon-Based Treatment System		
	Phase 1	**Phase 2A**	**Phase 2B**
Purpose	Meet Current Permit	Meet MWR MEP	Meet MWR GEP
Discharge to:	MLC	North Wetland	MLC
Authorized ADWF (m^3/day)	910, may be increased to 1,000	1,800	1,800
Implied population capacity	5,000	7,000	7,000
Design peak flow for disinfection	14,400 (m^3/day)	14,400 (m^3/day)	14,400 (m^3/day)
Design peak flow for hydraulic components	2,000 (m^3/day)	3,600 (m^3/day)	3,600 (m^3/day)
BOD (mg/L)	≤ 25	≤ 25	≤ 10
TSS (mg/L)	≤ 25	≤ 25	≤ 10
Total Phosphorus (mg-P/L)	< 1	< 1	< 1
Orthophosphate (mg-P/L)	n/a	< 0.5	< 0.5
Fecal Coliform (CFU/100 mL)	< 200	< 100 (median) ≤ 400 (maximum)	< 1 (median) ≤ 14 (maximum)
Turbidity (NTU)	n/a	n/a	≤ 2 (average) ≤ 5 (maximum)
Un-ionised ammonia (mg/L)	< 1.25	< 1.25	< 1.25
Redundancy	Limited – Disinfection only	Multiple units for all processes	Multiple units for all processes

It is assumed that the Ministry of Environment will grant a request for a minor amendment to the Discharge Permit to increase the authorized average discharge, interpreted here as the Average Dry Weather Flow (ADWF) from the current 910 m^3/d to a flow of 1,000 m^3/d. The purpose of the request for the minor amendment to the Discharge Permit is to provide the community with additional time to plan and obtain funding for a second phase upgrade to bring the discharge into compliance with the MWR.

The process configuration for Option 1 – Phase 1, illustrated in Figure 8-1, involves modifying the existing lagoons to improve their BOD reduction performance and provide a more robust approach to meeting the existing Discharge Permit conditions.

This would involve the following changes:

- Minor improvements to the headworks area – storage, security, instrumentation and flow measurement
- Increased aeration and aerated hydraulic retention time to treat increased BOD loading from future populations. This includes increasing the aerated lagoon size by converting the existing larger facultative lagoon to an aerated lagoon, increasing the number of surface aerators, and adding baffles to reduce the potential for hydraulic short circuiting (i.e. optimizing lagoon treatment);
- Converting the existing smaller aerated lagoon into a facultative (stabilization) lagoon.
- Adding a chemically enhanced solids/liquid separation unit to remove algae and suspended solids to achieve an effluent total suspended solids concentration of less than 25 mg/L; This will also provide for phosphorus reduction through chemical addition (i.e. lanthanum chloride, alum, or ferric chloride) to the solids/liquid separation process.
- Supply and install permeable dewatering system for managing collected sludge from the solids/liquid separation system
- Add disinfection using Peracetic Acid (PAA) to reduce fecal coliform levels to < 200 CFU/100 mL.

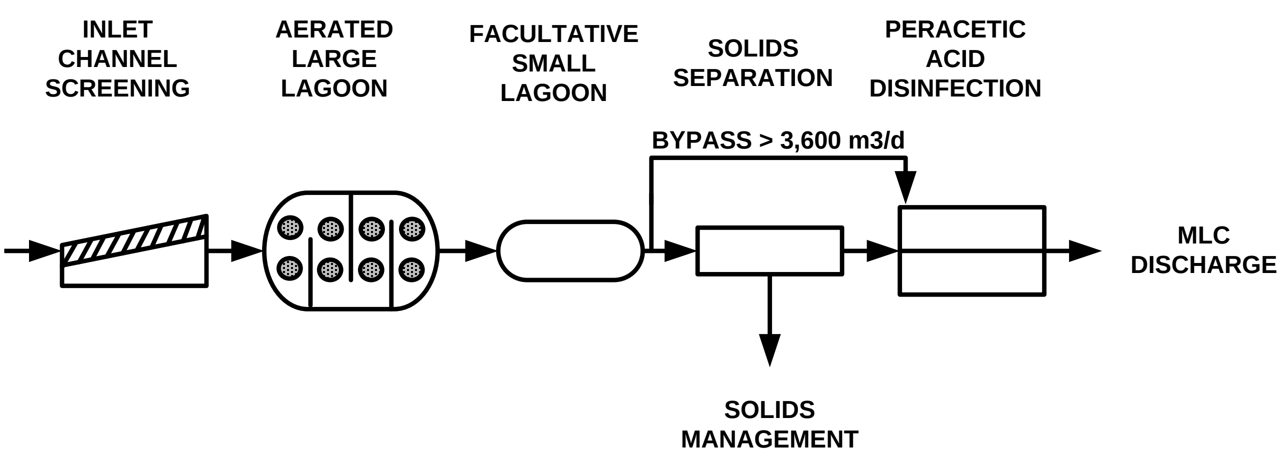

Figure 8-1 Option 1 – Phase 1 - Lagoon Upgrade to Meet Discharge Permit Requirements

Figure 8-2 illustrates a proposed reconfiguration of the existing lagoon system to achieve the above upgrades.

If needed, it is envisioned the work could be done on an incremental basis with the highest priority being the indicated modifications to the larger lagoon, adding disinfection, followed by the solids/liquid separation process.

Redundancy is not a requirement of the current Discharge Permit conditions and authorized works, but the disinfection system will be designed to meet the redundancy requirements under the MWR. The reason for not including redundancy in the solids separation component is that:

- some solids separation redundancy is provided by the smaller facultative lagoon;
- mechanical failure requiring the solids separation unit to be taken off-line for an extended period of time is considered to be unlikely;
- as a short-term priority cost control measure, solids separation following a large settling basin is the least most critical treatment component; and
- additional redundancy will be provided in conjunction with Phase 2 upgrades.

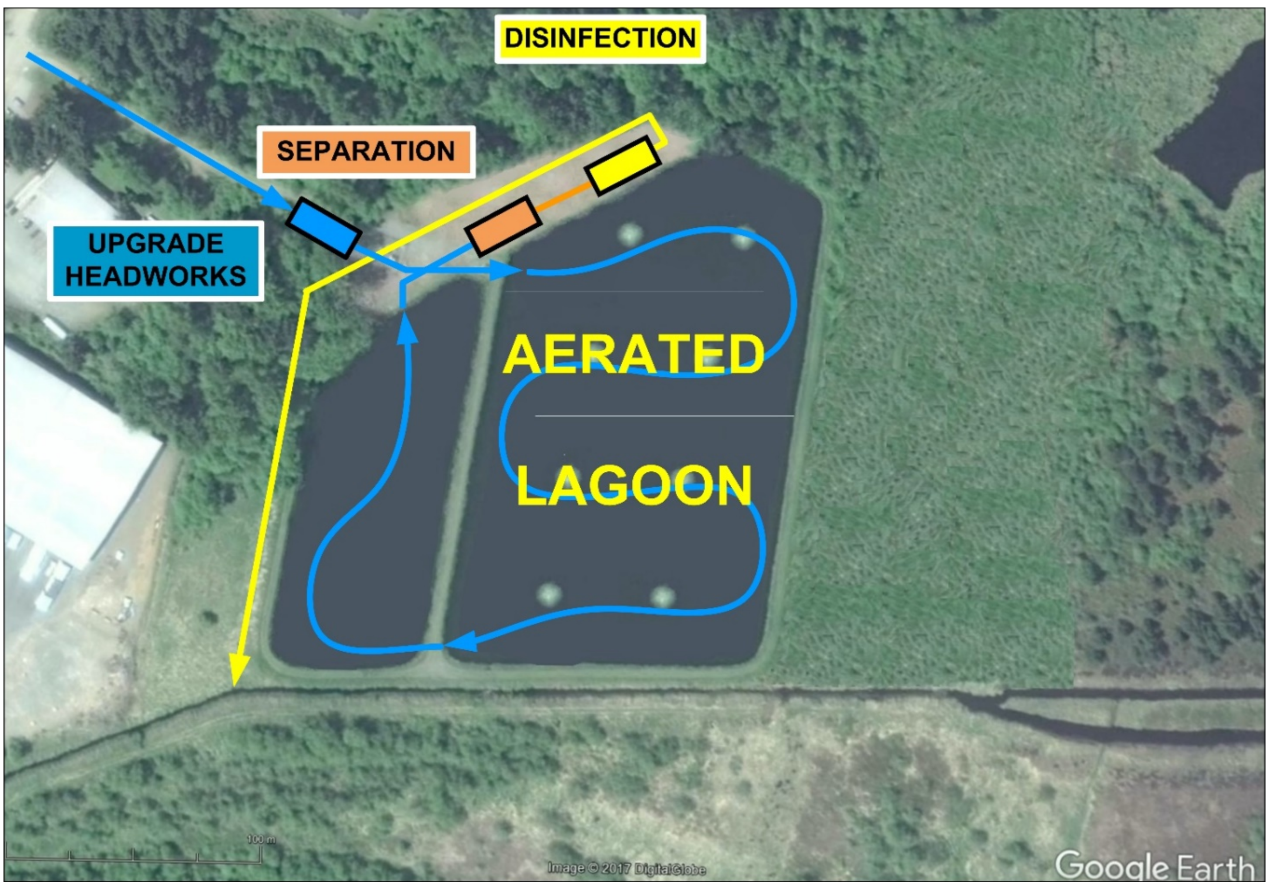

Figure 8-2 Lagoon Upgrade to Meet Discharge Permit Requirements

Option 1 Phase 1 has been designed such that either Option 1 Phase 2A or 2B, or Options 2 or 3 can be carried out as a second phase with little or no loss of benefit from the Phase1 works.

The Phase 1 upgrade is intended to optimize the performance of the existing lagoons and meet the existing Discharge Permit requirements by: 1) increasing the aerated volume of water and the hydraulic retention time; 2) providing mechanical secondary solids separation with chemical addition to remove suspended solids and phosphorus; and 3) providing for disinfection. By targeting an effluent quality with BOD & TSS less than 25 mg/L the upgrade will also enable the discharge to meet the new federal WSER requirements.

Option 1, Phase 1 is a meaningful upgrade that achieves regulatory compliance with the current Discharge Permit and represents the least cost to the community.

8.4.6 Option 1 - Phase 2 – Meet MWR Requirements and Conditions for 20-Year Projection

8.4.6.1 Option 1 - Phase 2A: Lagoon Upgrade to MWR MEP with Wetlands Augmentation

This second phase alternative for Option 1 is intended to meet the MWR registration requirements for MEP for discharge to the north wetlands. Illustrated in Figures 8-3 and 8-4, this alternative involves also increasing the baseflow (up to 3,600 m^3/d) for to augment flow through the wetlands. Excess flow over 3600 m^3/d (winter flows) would discharged direct to Maple Lake Creek, following disinfection.

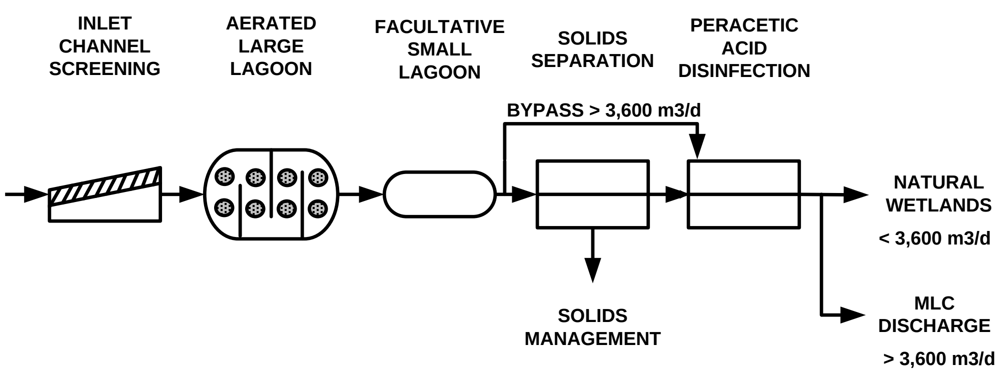

Figure 8-3 Option 1 – Phase 2A - Lagoon Upgrade to Meet MWR MEP Requirements

The MWR has an established reclaimed water quality criteria for wetlands flow augmentation under conditions whereby there is a low potential for public contact, referred to as a Moderate Exposure Potential reclaimed water quality - with a required BOD and TSS of less than or equal to 25 mg/L. This is the same water quality as achieved by Option 1 – Phase 1, but with a slightly higher quality disinfection standard. As the MEP water quality requirement does not require tertiary filtration to remove colloidal particles, it is less expensive to achieve than a GEP reclaimed water quality. An optional Reed-bed, if included, would also provide further treatment.

The release of reclaimed MEP water to the wetlands located to the north of the lagoons would augment the water flow through the natural wetlands and would result in an indirect discharge to Maple Lake Creek. This would enhance the habitat within the wetland area, and wetland plants would also benefit from the nutrients (phosphorus and nitrogen) in the effluent, resulting in reduced nutrient loading to Maple Lake Creek. The north wetlands are expected to provide a similar (duplicate) level of treatment to that being achieved currently through the wetland located downstream of the existing discharge into Maple Lake Creek and improves the water quality flowing in MLC upstream of the wetlands.

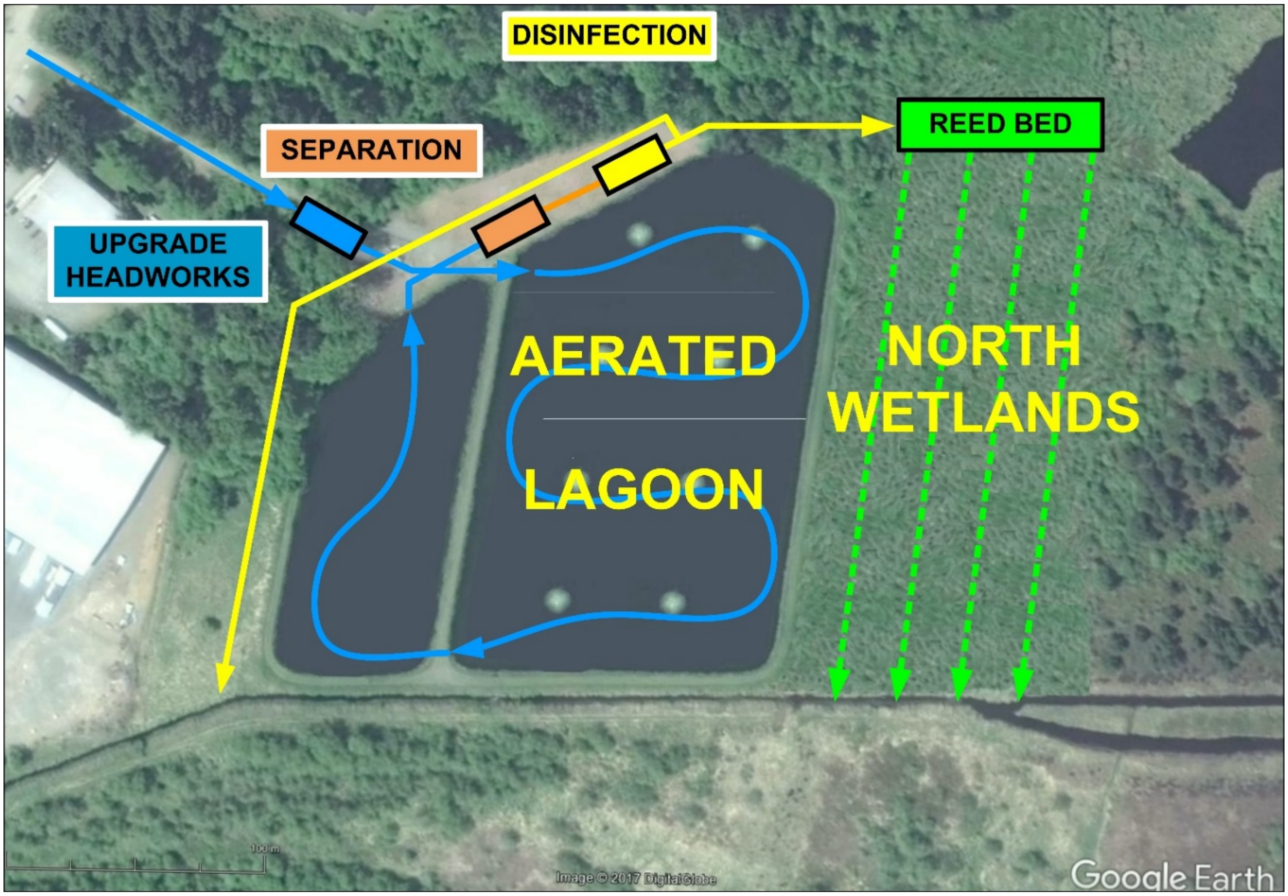

Figure 8-4 Option 1 – Phase 2A - Lagoon Upgrade to Meet MWR MEP Water Quality Requirements with Optional Reed-bed and Augmented (Flow) to the North Wetlands

The Ministry of Environment have established an ambient water quality objective for the Trent River of 0.005 mg/L. An advantage of the Phase 2A upgrade is that it is expected to significantly reduce the phosphorus concentration in the treated effluent to similar levels observed downstream of the wetlands in MLC. It is not possible to predict the degree of reduction or the long-term removal capacity within the north wetlands; however, if monitoring within MLC indicates a further reduction in phosphorus is required, chemical removal can be implemented at the solids separation stage. Given phosphorus concentrations in the Trent River, downstream of the confluence with MLC, as already close to the MoE phosphorus objective, there is a strong likelihood the 0.005 mg-P/L objective could be met by Phase 2A without chemical removal.

Lagoon Option 1 – Phase 2A could be constructed either as second phase to Option 1 – Phase 1, or as an initial construction project, if funding is available.

The following treatment is needed for Option 1 - Phase 2A, in addition to the works already done under Option 1 - Phase 1:

- Add a second influent screen, to meet the MWR redundancy requirements
- Add a second chemically enhanced separation unit, to meet the MWR redundancy requirements
- Add a pumping system for up to 3,600 m^3/day to transfer disinfected reclaimed water to the natural wetlands (and optional Reed-bed)
- Construct a subsurface distribution gallery or channel to disperse the reclaimed water to the north wetlands – with drainage and an indirect discharge to Maple Lake Creek.
- Optionally, construct the Reed-bed at the west end of the natural wetlands located along the north side of the new aerobic lagoon with discharge to a distribution channel into the natural wetlands. The Reed-bed is further discussed in section 11, but has been included here as it is a convenient fit to build it at the same time as the wetlands distribution.

The Reed-bed and natural wetlands flow augmentation process layout is illustrated in Figure 8-4. There are many possibilities for how and where reclaimed water could be dispersed for beneficial augmentation purposes to the natural wetland. The process of installing the reclaimed water distribution system to the wetlands could also be used to create paths, elevated boardwalks, or public walking trails through the wetlands, increasing the amenity value.

8.4.6.2 Option 1 – Phase 2B – Lagoon Upgrade to Meet MWR GEP Requirements

Illustrated in Figures 8-5 and 8-6, Option 1 - Phase 2B is an alternative extension to the Option 1 - Phase 1 Lagoon Upgrade, and involves installing additional process equipment to meet the MWR registration requirements for Greater Exposure Potential (GEP) reclaimed water, with all the water released to augment flows in Maple Lake Creek. The option could also direct baseflow to the north wetlands, and other reuse applications, if desired, and would enable Cumberland to continue to discharge to Maple Lake Creek. This Option considers that the current Discharge Permit would no longer be in effect and the discharge and treatment works would need to comply with the provincial MWR GEP water quality requirements. The process configuration for Option 1- Phase 2B is illustrated in Figure 8-5 and Figure 8-6.

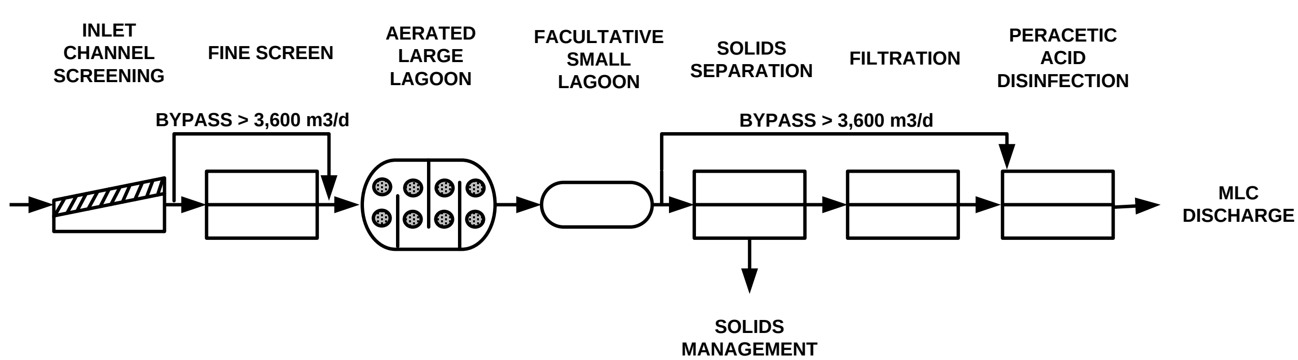

Figure 8-5 Option 1 - Phase 2B - Lagoon Upgrade to Meet MWR GEP Requirements

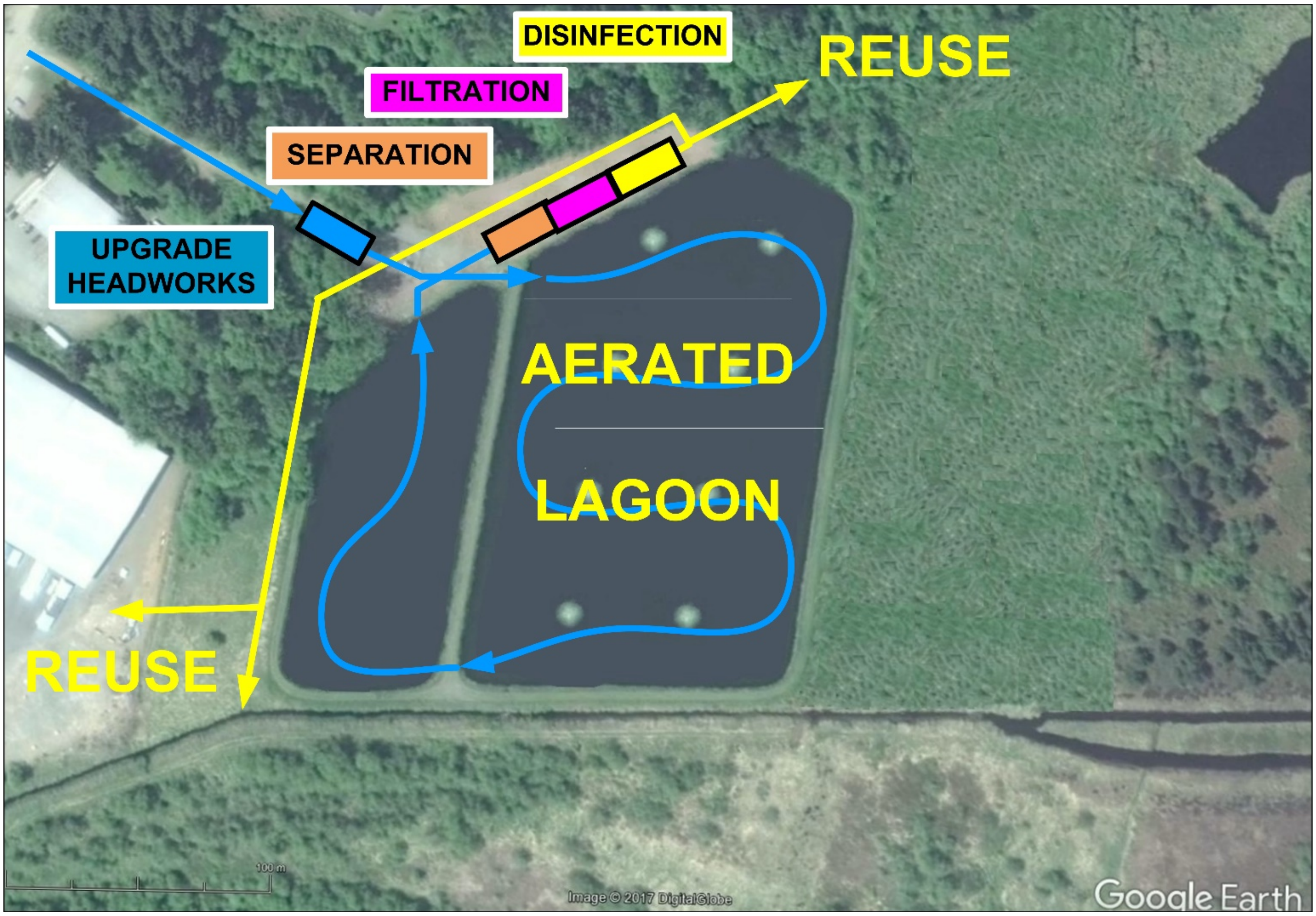

Figure 8-6 Option 1 – Phase 2B - Lagoon Upgrade to Meet MWR GEP Water Quality Requirements for Stream and Wetlands Augmentation to MLC and Potential Other Water Reuse Applications

Option 1 - Phase 2B includes full integration of all the scope defined the previous Option 1 – Phase 1 upgrade.

As noted earlier, an increase in the ADWF beyond 1,000 m3/d is expected to trigger a requirement for the Discharge Permit to be replaced with a Registered Discharge and compliance with the discharge requirements under current regulations, including additional requirements for effluent quality and equipment redundancy.

With the Phase 2B upgrade, the treated effluent quality will meet the reclaimed water standard for Greater Exposure Potential. The following additional treatment will be needed in addition to the Phase 1 and possibly 2A works, as illustrated in Figure 8-6:

- Add a primary solids removal process to reduce influent BOD loading to the lagoons, to achieve effluent BOD concentrations of less than 10 mg/L;
- Operate the installed chemically enhanced solids/liquid separation unit to reduce TSS concentrations to less than 10 mg/L.;
- Add filtration to reduce the average turbidity to less than 2 NTU, with a maximum limit of 5 NTU.

- Achieve disinfection performance to reduce fecal coliform levels to median of < 1 CFU/100 mL, and maximum of 14 CFU/100 mL, with the disinfection system designed and sized to achieve the fecal coliform standard for summer and winter flows.

It should be noted that some of these works may not be required if the Phase 1 upgrade consistently meets the GEP criteria. If the system reduces the BOD and TSS to less than 10 mg/L and the average turbidity to less than 2 NTU, without filtration, then the disk filters would not be required and may be omitted.

Until any water reuse projects are developed, the upgraded works would continue to release all water to Maple Lake Creek (MLC) and/or the north wetlands. In planning for reuse, the environmental flow needs of Maple Lake Creek and the Trent River, particularly in summer, is expected to require a minimum critical discharge flow to maintain the health of the streams. This limits the ability to divert stream discharges for external reuse purposes during the summer months. An environmental assessment will be needed to assess the impact of reductions and determine discharge policies. This assessment is also a need of the Registration process.

8.5 Option 2 – Baseflow Mechanical Treatment

8.5.1 Process Description

Option 2 involves constructing a mechanical biological treatment process to treat the “baseflow” of up to 3,600 m^3/d of wastewater to a MWR GEP water quality standard to allow continued discharge to Maple Lake Creek as a stream augmentation beneficial reuse application. Flows in excess of 3,600 m^3/d would be diverted through the existing lagoon treatment system in its current configuration, prior to merging with the baseflow for disinfection and discharge to MLC.

This Option provides an “all-new” Cumberland treatment plant would meet the current MWR standards for treated water quality and equipment redundancy. A continued discharge to Maple Lake Creek under the MWR would require a reclaimed water standard meeting Greater Exposure Potential (GEP) conditions due to low dilution in the receiving environment. Mechanical treatment is well suited to producing a high-standard reclaimed water quality with a tightly controlled treatment process.

Table 8-2 Baseflow Mechanical Effluent Targets

Item	Criteria
Flow Threshold (m^3/day)	< 3,600
Population capacity	7,000
BOD (mg/L)	$\leq$ 10
TSS (mg/L)	$\leq$ 10
Total Phosphorus (mg-P/L)	$\leq$ 1
Orthophosphate (mg-P/L)	< 0.5
Fecal Coliforms (CFU/100 mL)	< 1 (median) $\leq$ 14 (maximum)
Turbidity (NTU)	$\leq$2 (average) $\leq$ 5 (maximum)
Un-ionised ammonia (mg/L)	< 1.25

The selection of the baseflow threshold is based on the flow model developed in Section 5.0, "Historical and Projected Flows and Loads". It is intended that the treatment plant will provide baseflow treatment for the projected population at the 20-year design horizon of 2038. The design ADWF is 1,800 m³/day, and the MWR requires that treatment plants are sized to provide full treatment for flows up to 2 x ADWF, thus 3,600 m³/day is selected as the baseflow threshold. The process flow and site configuration for the baseflow mechanical options are as illustrated in Figures 8-7 and 8-8.

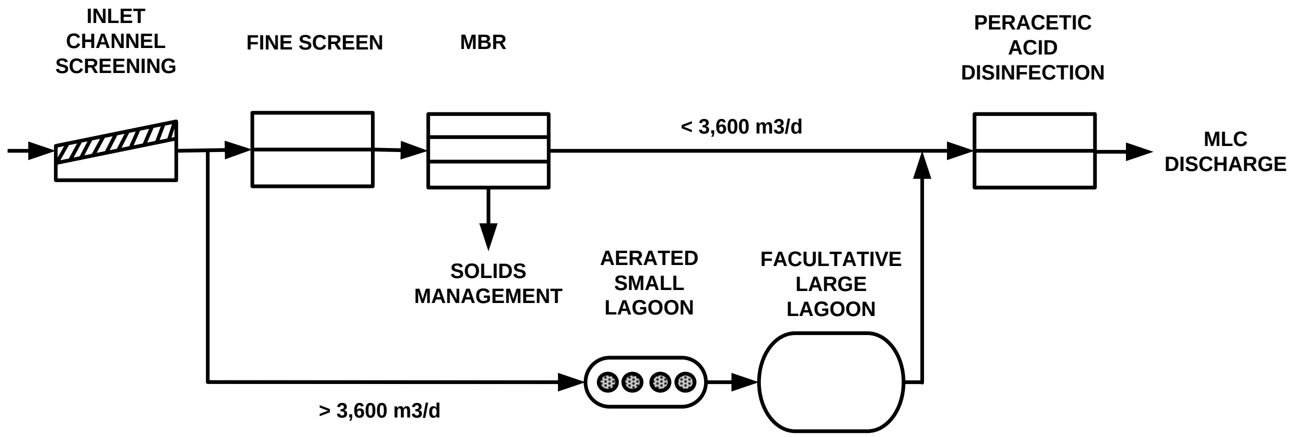

Figure 8-7 Option 2 – Baseflow Mechanical Treatment to Meet MWR GEP Requirements

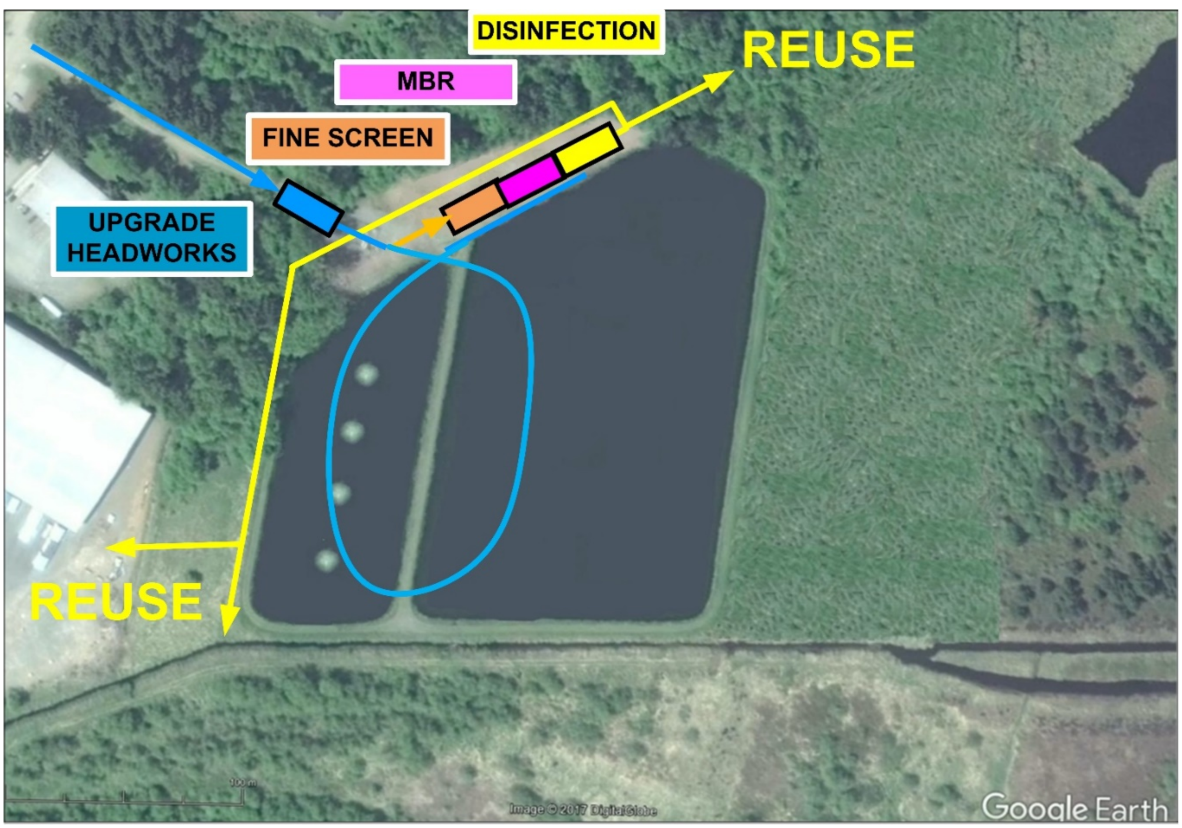

Figure -8-8 Option 2 – Baseflow Mechanical Treatment to Meet MWR GEP Water Quality Requirements for Stream and Wetlands Augmentation to MLC and Potential Other Water Reuse Applications

The historical flow records suggest that this flow threshold is exceeded from 40 to 60 days per year. However, during the dry summer period (May 1 to September 30), there has only been one exceedance in five years from 2013 to 2017, (which was September 30, 2013). Thus, a plant capacity of 3,600 m^3/d can be expected to provide full high-quality treatment of all the flows during the critical summer period.

The advantage of Option 2 is that the plant can be optimised for the smaller range of flows. Pumps, pipes, blowers and holding basins can be smaller, and the limited flow range simplifies the hydraulic engineering, allowing use of some standardised process designs.

The main disadvantage is that the existing lagoons must be retained in operation, and there is a decrease in effluent quality as flows increase above the baseflow level. As the storm sewer separation program proceeds, future peak wet weather flows are expected to decrease, moving closer to the baseflow level. Further, as illustrated in Figure -8-8 , the flow pattern through the lagoons for excess stormwater flows is expected to be sub-optimal, with a high degree of hydraulic short circuiting unless additional funds are allocated for an Option 1 improvement to the lagoons.

8.5.2 Mechanical Process Requirements

There are a wide range of mechanical treatment processes that could be used for the baseflow concept.

A “Membrane BioReactor” (MBR) treatment process has been selected as the design basis for this option. This process combines the BOD and TSS removal using an ultrafiltration membrane that allows water to filter through the membrane while retaining solids in the bioreactor. The accumulated solids in the bioreactor are removed (wasted) from the process, and then dewatered. The membranes are in large modular “cassettes” (as shown in Figure 7-9) that can be individually removed, cleaned and replaced as required. The membranes have a finite operating life, typically from 7-10 years, before they need replacement. The flow components for the proposed system are shown in Table 8-3.

Figure 8-9 Membrane Cassettes from in a MBR system

Table 8-8-3 Baseflow Mechanical system components

Unit Process	Flow range (m^3/day)
Fine Screen	14,400
Grit Removal	3,600
Equalisation Tank	3,600
MBR system	3,600
Existing lagoons	3,600-14,400
Peracetic Acid Disinfection System	14,400
Biosolids dewatering by Geotube	All biosolids produced

Like most mechanical treatment plants, the MBR would produce a continuous output of biosolids, which need to be dewatered on site, and the filtrate water returned to the start of the process. As with the lagoon system the proposed dewatering process is by permeable synthetic filter bag (Geotube), which is further discussed in the Biosolids section.

The MBR process combines the biological and separate separation (or filtration) stage in a single step. This provides a system that is very compact and can easily be enclosed for odour, noise control and aesthetic purposes. MBR's produce a high quality, filtered effluent and can be highly optimized when for designed for low variability flow. They are relatively complex systems, usually Class 4, and need an experienced operator. An MBR system has been in use at nearby Mt Washington Ski Resort for over 20 years, and at Ganges on Salt Spring Island for about 15 years.

8.6 Option 3 –"Full Flow" Mechanical Treatment

8.6.1 Option 3 – Full Flow Mechanical Treatment Design Criteria

The "Full Flow" mechanical treatment approach to meet the effluent water quality targets shown in Table 8-4, is illustrated in Figures 8-10 and 8-11, and involves constructing a mechanical wastewater treatment process to provide high quality treatment for the entire flow range up to the Peak Wet Weather Flow of 14,400 m^3/day. As with the "Baseflow" concept, this would be an all new treatment plant that must meet all the requirements of the MWR, for quality, capacity and redundancy.

Table 8-8-4 "Full Flow Mechanical" Effluent Targets

Item	Criteria
Tertiary Flow Threshold (m^3/day)	< 3,600
Secondary Flow Threshold (m^3/day)	14,400
Population capacity	7,000
BOD (mg/L)	$\leq$ 10
TSS (mg/L)	$\leq$ 10
Total Phosphorus (mg-P/L)	$\leq$ 1
Orthophosphate (mg-P/L)	< 0.5
Fecal Coliforms (CFU/100 mL)	< 1 (median) $\leq$ 14 (maximum)
Turbidity (NTU)	$\leq$2 (average) $\leq$ 5 (maximum
Un-ionised ammonia (mg/L)	< 1.25

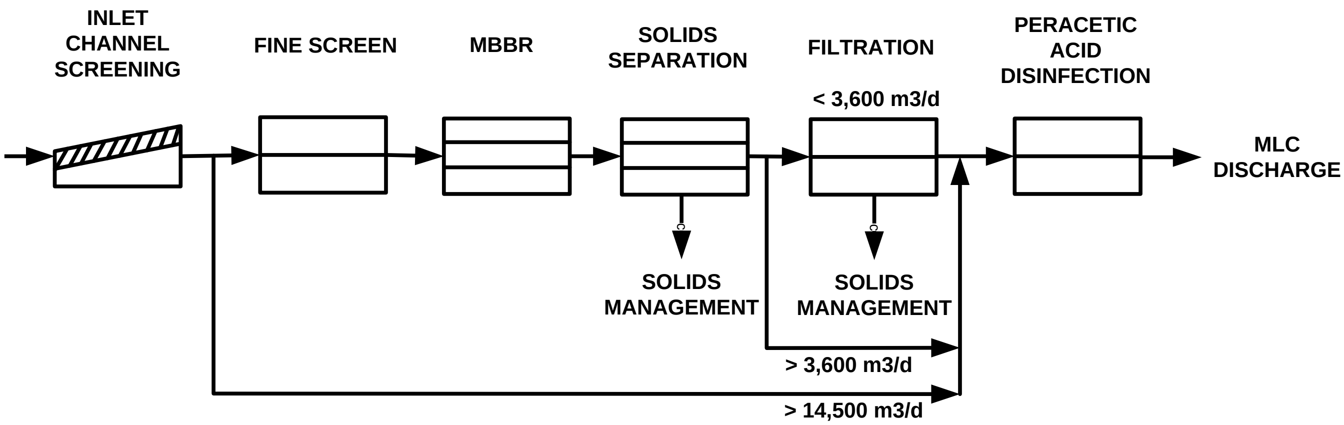

Figure -8-10 Option 3 – Full-Flow Mechanical Treatment to Meet MWR GEP Requirements

The treatment targets are based on the assumption that during the excess flow periods (> 2 x ADWF of 3,600 m^3/day), the turbidity target does not need to be met.

The Full Flow Mechanical treatment option was initially developed in conjunction with seeking grant funding in November 2016. The concept was to have the entire peak flow of 14,400 m^3/d treated to a secondary level, and tertiary (filtration) treatment up to the peak summer flow of 3,600 m^3/d. These are the same flow parameters developed in section 5.0 “Historical and Projected Flows and Loads”. Full description of this option can be found in the grant application documents as well as the RFP issued in 2016.

8.6.2 Mechanical Treatment Process Selection.

For the Full flow concept, the design flow range is from 1 to 8 x ADWF – an unusually high range to which some treatment processes are better suited than others. The Moving Bed Biofilm Reactor (MBBR) is a process that is particularly well suited to handling such large flow ranges.

Figure 8-10 illustrates a simplified representation of the mechanical treatment process, with the associates unit process components summarized in Table 8-5. Influent wastewater is treated in an aerated bioreactor containing polyethylene media. Aeration inside the tank keep the media in suspension as well as keep the tank in an aerobic state to maintain the health of the biofilm on the media. The media are kept in the tank by a screen inside the tank. The bacteria that are attached to the media eventually slough-off to be separated from the liquid through a clarifier.

Conventional clarifiers are not well suited to flow surges, such as the Cumberland design flow peaking factor of 8:1, or must be greatly oversized to accommodate them. For the “full flow” concept, the clarifier is replaced with a chemically enhanced solids separation system, as is proposed for the lagoon upgrade options. These systems use chemical conditioning to coagulate dissolve constituents and flocculate (clump) the fine suspended solids, including algae, and then separate them from the water. There are numerous engineered configurations for the separation process of these separation systems.

These units are specifically designed in providing consistent solids removal over a wide range of flows and offer superior performance over gravity settling for rapid changes in influent quality expected with the high inflow and infiltration.

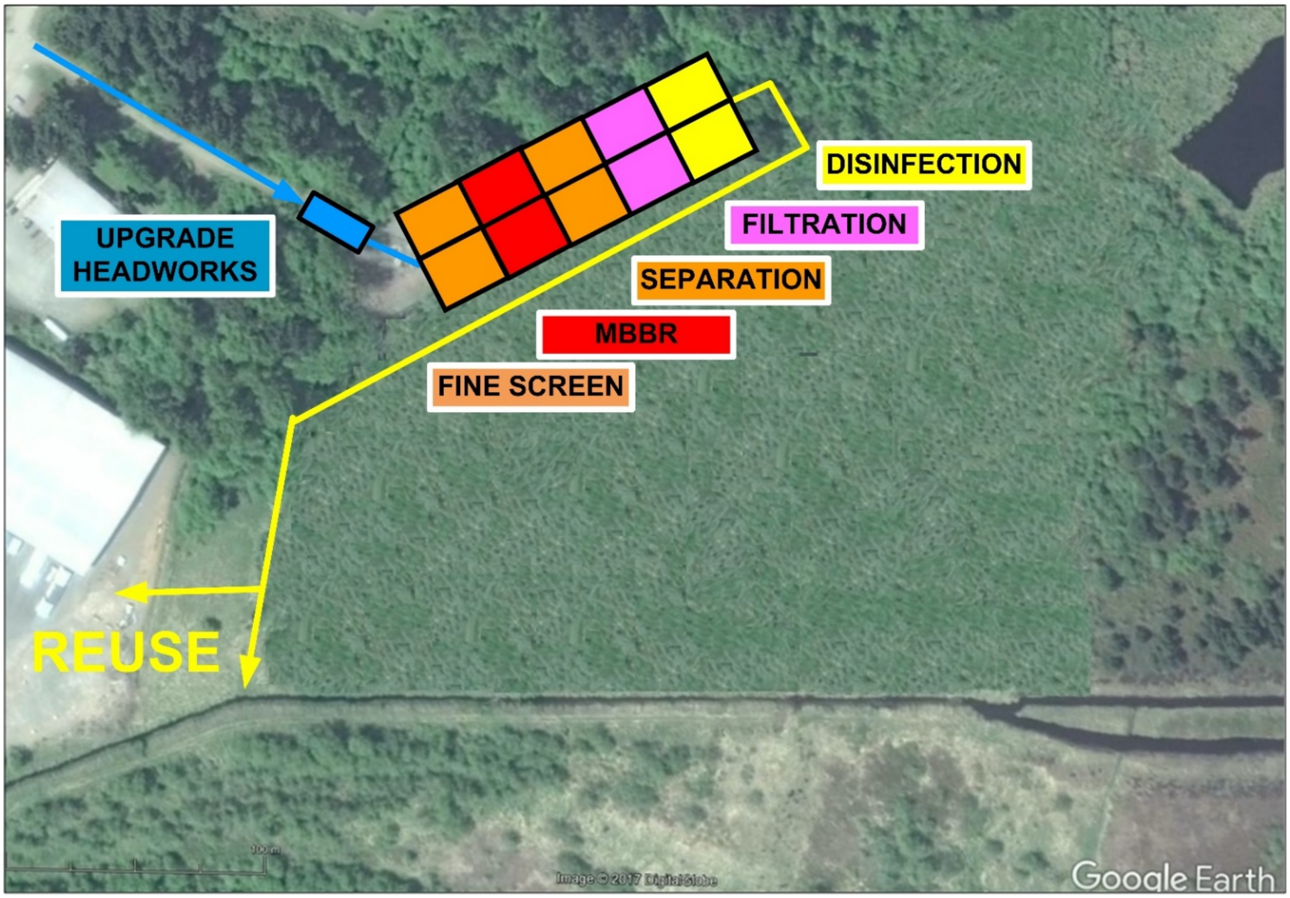

Figure -8-11 Option 3 – "Full Flow" Mechanical Treatment to Meet MWR GEP Water Quality Requirements for Stream and Wetlands Augmentation to MLC and Potential Other Water Reuse Applications

For assurance on meeting the low turbidity required for GEP reuse water, a final filtration process is required. A media "disc filter" is the recommended option. These are specifically designed for final filtration of wastewater, and are higher performance than sand filters and less complex than membranes.

Table 8-8-5 Full Flow Mechanical system components

Unit Process	Flow range (m^3/day)
Fine Screen	14,400
Grit Removal	14,400
MBBR system	14,400
Liquid/Solid Separation	14,400
Disk Filtration	3,600
Peracetic Acid Disinfection System	14,400
Biosolids dewatering by geotube	All biosolids produced

The treatment process is completed by Peracetic Acid disinfection prior to discharge to Maple Lake Creek.

Like most mechanical treatment plants, the MBBR would produce a continuous output of biosolids, which need to be dewatered on site, and the filtrate water returned to the start of the process. As with the lagoon system the proposed dewatering process is by "geotube", which is further discussed in the Biosolids section of this document.

The MBBR system is ideal for maintaining high effluent quality while handling the large flow variations that are characteristic of the Cumberland wastewater system. It will be a relatively complex system, being either Class 3 or 4, and will require an experienced operator.

With the Full Flow Mechanical system, the lagoons are decommissioned, and the entire 4ha land area can be repurposed for other community uses, e.g. parkland. Regaining the land is the main benefit of the Full Flow mechanical system over the Baseflow mechanical, where the lagoons must be retained and operated.

8.7 Phased Upgrade

A key consideration in the development of the treatment options was the ability to do a "phased implementation"- this is Option 1, Phase 1 - Lagoon Upgrade for Permit Compliance. It allows for a lower cost initial project to meet the immediate regulatory needs. But this is not an endpoint Option, as a second phase is required to;

- Increase population capacity from 5,000 to 7,000 people
- Meet MWR effluent quality requirements if Maple Lake Creek is the primary discharge
- Meet MWR requirements for process equipment redundancy

And the second phase would be to complete as one of Option 1 – Phase 2A, Option 1 – Phase 2B, Option 2 or Option 3.

As designed, each Option can be implemented as either a single, or two-phased implementation. While a two-phase approach allows deferring some works and cost to the future, it also increases the total cost over a one-phase execution, as two projects are being done, and there are additional costs incurred for:

- Construction with more sharing of trade resources
- Freight
- Storage
- Contractor Overhead, including second mobilization and demobilization
- Supervision and Safety
- Engineering
- Owners costs and project management
- Material Contingency

There is approximately 10% increase in the overall project cost because of these "indirect" costs for implementing a two-phase execution of the same scope of work.

An additional factor is that some of the Phase 1 works – the lagoon reconfiguration -become redundant for the mechanical treatment Options, when they are completed as a second phase

Option 1 Phase 1, Phase 2A or Phase 2B align well for a phased approach – there is no redundancy of any Option 1 - Phase 1 works.

Option 2 can also be completed after Option 1 - Phase 1. The upgrades to screening, disinfection and solids dewatering are all the same for Option 2. The solids separation unit of Option 1 - Phase 1 can be re-purposed to primary treatment before the mechanical process, or it could continue to be used for secondary solids separation of the treated excess wet weather flows from the lagoons. While the MBR process can be implemented after Phase 1, other mechanical treatment systems (such as MBBR) can also be considered when Option 2 is implemented as a second phase.

Option 3 can also be completed after Option 1 - Phase 1 (the initial upgraded lagoon for Permit compliance). The upgrades to screening, disinfection and solids dewatering are all the same for Option 3. The solids separation unit of Phase 1 becomes redundant, as it is replaced by two larger units, but can be retained as a standby or baseflow unit. The lagoon reconfiguration of Option 1 - Phase 1 is not required for Option 3, so this work also becomes redundant.

Overall, the phased approach provides flexibility and a more affordable first project, but at an increase in total capital cost. These costs are discussed in Section 9.

9.0 COSTS

9.1 Introduction

This document provides cost estimates and a comparison between the treatment options described in Section 10, taking into consideration the constructability and operational aspects of each option

The costs are partially based on cost estimates developed for the November 2016 funding application using internal Tetra Tech pricing and budgetary pricing obtained by vendors. This information has also been supplemented using estimates provided by two vendors prepared in response to a Request for Proposal issued in February 2017, representing a market pricing at that time. This information, combined with other up-to-date vendor pricing, construction estimates, and standard cost assumptions, was used to produce the operating costs contained within this Technical Memo. The comparative level estimates include a 25% contingency, and are intended and suitable for decision-making purposes in comparing options. Upon selection of a Preferred Option, more detailed cost estimate is recommended to develop a project budget.

9.2 Option 1 - Phase 1 – Lagoon Upgrade to Meet Existing Discharge Permit Requirements

As previously described, Option 1 - Phase 1 is for a lagoon upgrade intended to meet both the existing Discharge Permit and Federal WSER water quality requirements.

Specific construction works and cost considerations include:

9.2.1 Headworks

The existing headworks, including the inlet channels, grinder and screen, will be replaced with minor modification or upgrade to the existing channel to incorporate a new screen. Continued use of the existing single screen will continue to allow debris and solids to bypass the screen during peak wet weather flow conditions and accumulate in the lagoons, and increase the cost of removal.

The only other recommended headworks change is to add flow monitoring for measurement of influent flows to the treatment plant for process control purposes and to provide operations staff with information on instantaneous and historical flow events.

9.2.2 Lagoons

The following lagoon system modifications include the design and construction of increasing the existing wastewater treatment capacity to meet the Discharge Permit and Federal WSER and water quality requirements for average dry weather flows of up to 1,800 m^3/d, and peak wet weather flows of up to 3,600 m^3/d:

1. Dredging to remove accumulated solids to recover storage volume and treatment capacity. Estimates from previous dredging of lagoons provide the basis the allowance of $500,000. This includes transport and disposal of collected biosolids.
2. Supply and install three (3) 110-m-long floating curtain baffles with anchors to create four (4) cells with approximate dimensions of 50 m x 130 m to reduce the potential for hydraulic short circuiting and, thereby, maximizing the hydraulic retention time.
3. Relocation of the four (4) existing floating surface aerators from the smaller lagoon to the larger lagoon, and supply and install four (4) additional 5HP floating aerators.

4. Construction of a hydraulic structure at the east end of the large lagoon to allow water to flow through the berm separating the large and small lagoons.
5. Installation of pre-fabricated concrete lock blocks to the lagoon walls to prevent velocity and current direction changes from eroding the existing berm wall.

9.2.3 Chemically Enhanced Solids/Liquid Separation

Although the lagoon improvements will increase the biochemical oxygen demand reduction capacity, algae growing in the lagoon will contribute to the total suspended solids (TSS) and BOD. To meet the Discharge Permit and federal WSER BOD and TSS requirements of less than 25 mg/L, the chemically enhanced solids/liquid separation process will treat flows up to 2,000 m^3/d. This unit process will also reduce total phosphorus concentration to meet the Discharge Permit requirement of less than 1 mg-P/L through chemical addition. The solids/liquid separation system includes tankage, pumps, and piping integral to the separation process and includes a controlled feed system for polymer and lanthanum chloride, alum, or ferric chloride. The cost estimate includes allowance for either high-rate clarification ("ballasted floc") or Dissolved Aeration Floatation (DAF) solids separation processes.

Cost estimates for this unit process are based on previous estimates and quotations prepared for the two processes and vendor cost estimates for both 1,800 and 3,600 m^3/d capacity systems. Although the flow difference is 100% larger, the overall price difference is less than 20%. The reason is that design and control costs are similar for both capacities, and the treatment costs are not proportional to flow. These elements thus represent a more significant percentage of the total cost with lower flows.

9.2.4 Disinfection

The disinfection system consists of a contact tank or channel and a liquid Peracetic Acid (PAA) chemical injection dosing system to reduce fecal coliform levels to less than 200 CFU/100 mL, and includes inlet flow measurement and instrumentation/controls to monitor dosage levels and control the chemical metering pump.

9.2.5 Dewatering

The solids separation unit of Option 1 - Phase 1 will generate modest volumes of biosolids that require daily management. The estimate includes the supply and installation of permeable sludge dewatering bags. These will be located in disposal bins for ease of off-site transport. Polymer treatment, piping and pumps are included in this estimate and a channel to collect filtrate and return to front end of the plant.

Based on current operation and other plant experience, operational costs for desludging of the lagoons will occur on a five-year basis. Dredging lagoons is required to re-capture lost water treatment volume due to settled solids. A dewatering bag system will treat produced sludge for transport for offsite disposal.

9.2.6 Piping / Channels

Piping and channel work includes re-direct piping from headworks to south-west corner of the existing larger (39,000 m^3 facultative) lagoon.

1. making connections to the existing splitter box piping,
2. adding new valves and piping for raw water inflow into the larger lagoon,

3. Install cross-over channel through the berm at the south-east corner of the new aerobic lagoon to the north-east corner of the old aerobic lagoon (now facultative / stabilization lagoon), allowing water from the end of the aerated lagoon to enter the smaller 14,000 m^3 lagoon basin to the south;
4. Pipeline or channel construction from the disinfection system to a new discharge location into Maple Lake Creek.

9.3 Option 1 – Phase 2A – Lagoon Upgrade to meet MWR MEP Criteria

This provides the option for an indirect discharge to Maple Lake Creek involving augmenting flows to the natural wetlands bordering the north side of the lagoon meeting MEP reclaimed water quality. Option 1 - Phase 2A includes all scope defined in option 1 - Phase 1 Lagoon Upgrade with no lost investment from upgrade. The following is proposed to upgrade to meet the population and water quality needs.

9.3.1 Inlet Screen

A second inlet screening unit is required to meet the MWR equipment redundancy requirements. The existing concrete channel structure already includes a second channel that will require some modification to meet installation the second screen and access is required to allow movement of two disposal bins.

9.3.2 Chemically Enhanced Solids/Liquid Separation

A second solids separation unit is required to meet the MWR equipment redundancy requirements. Added controls for redundant control is included in this scope.

9.3.3 Disinfection.

An allowance has been included to increase contact time and add controls for control from the two liquid/solids processing units. This will include additional allowance for control to multiple feed points.

9.3.4 Dewatering

An allowance is included to provide additional interconnection to the bag dewatering system highlighted in Option 1.

9.3.5 Natural Wetlands Distribution

The estimate includes an allowance to add a pumping conveyance system to move treated water to wetland area to the north, and then a system of subsurface distribution. A low head transfer pump station and an infiltration trench are assumed, though there are other ways of doing the water distribution such as mulch beds and subsurface drip irrigation. It should be noted that an allowance to include operator access roads that will also include some allowance for walking trails and other public amenities, and habitat enhancement such as invasive plant removal and tree planting.

The wetland distribution is conceptual at this stage, and is not developed to the same level as the treatment system options. A feasibility study with site investigations and hydraulic testing and modelling are needed to complete the scope of this system.

The north wetland system can be added to any of Option 1 – Phases 2A or 2B, or Options 2 or 3, but it is required for Option 1 – Phase 2A.

9.4 Option 1 – Phase 2B – Lagoon Upgrade to Meet MWR GEP

This option considers that the current Discharge Permit would no longer be in effect and the discharge would need to comply with the provincial MWR GEP water quality requirements. Option 1 - Phase 2B includes all scope defined in Option 1 - Phases 1 and Option 1 – Phase 2A lagoon upgrades with full integration of previous upgrade.

9.4.1 Fine Screening

The MWR GEP BOD concentration requirements of less than 10 mg/L are considerably lower than the 25 mg/L requirement for the existing Discharge Permit or the MWR MEP. While the extra reduction in BOD could be achieved through extended additional biological treatment, a lower cost approach is to reduce the BOD loading to the plant.

Fine screens and chemically enhanced primary separation have been selected to reduce the BOD loading in the order of 30 percent or more, thereby reducing the BOD loading to the lagoons and reduce the effluent BOD concentrations following treatment. Two fine screens are included to meet the MWR equipment redundancy requirements.

The fine screens will be designed for a hydraulic flow of up to 3,600 m^3/d. As flows above the design capacity greatly degrade the performance of primary solids removal, flows in excess of 3,600 m^3/d will be bypassed around the fine screens into the lagoon.

9.4.2 Lagoon Upgrade

The plant will need additional treatment to achieve ammonia nitrification. The estimate includes and allowance to add suspended Ringlace media (or equivalent) to the facultative lagoon. If the north wetlands distribution is being implemented, it is possible that ammonia removal will occur in the wetland, as is currently occurring in the natural wetlands of Maple Lake Creek. This will need further investigation.

9.4.3 Filtration

The MWR also has an average turbidity water quality requirement of 2 NTU and a maximum of 5 NTU. High quality filtration in the form of, for example, chemically enhanced sand filtration, ultrafiltration membranes, or disk filters, are required to consistently achieve the required turbidity levels. Similar to the fine screens, the filtration system will be designed for a hydraulic flow of up to 3,600 m^3/d. As the filters inherently impede water flow and have hydraulic flux limitations, flows above the design capacity result in excessive head losses. Consequently, flows in excess of 3,600 m^3/d will be bypassed around the filtration system. Two filtration units are required to meet the MWR equipment redundancy requirements.

9.5 Option 2 - Baseflow Mechanical Treatment

Option 2 involves constructing a mechanical biological treatment process to treat up to 3,600 m3/d of wastewater to a MWR GEP water quality standard to allow continued discharge to Maple Lake Creek as a stream augmentation beneficial reuse application. Flows in excess of 3,600 m3/d would be diverted through the existing lagoon treatment system in its current configuration, with an allowance to remove accumulated sludge from the lagoons as part of the construction program. Specific elements include:

9.5.1 Headworks

In this phase, the headworks including the inlet channels will house two news screens for primary screening.

9.5.2 Fine Screens

As the membranes require finer removal, a fine filter screen will be installed after the coarse screen. The fine screen will not provide reliable service for the high inflow and infiltration solids typical with a combined collection system. Consequently, flows in excess of the design capacity of 3,600 m^3/d will be bypasses around the fine screens and diverted to the existing lagoon system. The two fine screen units will be provided to comply with the MWR redundancy requirements.

9.5.3 Membrane Bioreactor

The addition of a packaged MBR will be aligned with the original approach as verified by one of the vendor submissions from the Feb 2017 RFP. As noted, the MBR process incorporates ultrafiltration membranes for solids/liquid separation TSS removal, as well as colloidal particle (turbidity) removal.

9.5.4 Peracetic Acid Disinfection

The disinfection system consists of a contact tank and a liquid Peracetic Acid (PAA) chemical injection dosing system. The ultrafiltration membrane will reduce the number of fecal coliform levels to less than the detection limit. The membrane-based treatment will not have a similar effect in reducing any viruses that may be present. A Peracetic disinfection system will be added and disinfection efficacy will be based on concentration and time (CT) criteria using inlet flow measurement and instrumentation/controls to monitor dosage levels and control the chemical metering pump.

9.5.5 Dewatering

Option 2, with a higher level of treatment, will generate larger volumes of biosolids that will have to be managed on a daily basis. An allowance has been included for the supply and installation of permeable sludge dewatering bags. These will be located in disposal bins for ease of off-site transport. The dewatering performance is adversely affected but the ease of operation offsets the reduced performance. Piping and pumps are included in this estimate and a channel to collect filtrate and return to front end of the plant.

The original estimate allowed for a fully automated – batch dewatering system. The operational cost for the dewatering bags is higher but the capital cost aligns better for the phased approach. In subsequent stages, a business case could confirm the operational and cost advantages for upgrade. With treatment to these design flows and proximity to a landfill would likely prove bag dewatering as a good approach. Detailed analysis of the comparison is reserved for future study. Additionally, this cost-effective approach is part of the approach to create an affordable upgrade option

Option 2 can also be implemented after an Option 1 – Phase 1 lagoon upgrade. All of the Option 1 - Phase 1 works, except the lagoon aeration upgrade, are part of the baseflow mechanical scope. There are additional indirect costs incurred for executing a second project.

9.6 Option 3 – Full Flow Mechanical Treatment

The Full Flow Mechanical treatment option was developed when seeking grant funding in November 2016. The concept was to have the entire peak flow of 14,400 m^3/d treated to a secondary level, and tertiary (filtration) treatment up to the peak summer flow of 3,600 m^3/d. As previously described, these flow parameters were developed using historically based projected flows and loads.

A conservative capital cost estimate was developed for the funding application using internal Tetra Tech pricing and budgetary pricing obtained from vendors. An RFP for the process equipment was issued in February 2017, but cancelled when the grant funding was not received. However, in response to the tender call, two vendors progressed their estimate to completion based on the RFP, and provided those estimates to the Village of Cumberland, for future consideration. These proposals represent a market-based price to replace the original estimates used in November 2016.

The following provides a summary of the two received estimates using the same scope element as the initial estimate and a comparison to the phased approach as previously described.

Vendor A proposed a Membrane Bioreactor (MBR) system, and Vendor B a Moving Bed Biofilm Reactor (MBBR) system. Both estimates in response to the RFP appear to be close in price – within the accuracy of the estimate. The primary savings is found with the chemically enhanced separation component, where the indicative design assumed use of a ballasted flocculation process. This process accounted for 13% of the overall cost.

In the case of vendor A's MBR process, separation is integral with the membrane system. Vendor B with the MBBR used a less costly Dissolved Air Floatation (DAF) separation system supplied in a modular nature and installed on site by vendor staff.

The contingencies associated with multiple supplier alignment were also reduced. The original estimate included larger allowances for multiple suppliers providing process elements. The two bids provided supply with one organization thus providing more cost certainty.

Option 3 can also be implemented after an Option 1 – Phase 1 lagoon upgrade, but with some redundancy of phase 1works. The lagoon aeration upgrade and the Option 1 – Phase 1 solids separation unit are not part of the single-phase full-flow mechanical scope and represent additional costs. There are also additional indirect costs incurred for executing a second project.

9.7 Biochar Media Reed-bed

The Biochar Media Reed-bed is an optional component and is not needed to meet regulatory or capacity requirements. Capital costs for the various options do not include the Reed-bed, as it can be added to any option.

The reed-bed costs included here are based on data obtained from a study reporting on a similar lagoon and reed-bed system serving a community in Australia. The study found the reed-bed reduced BOD and TSS concentrations by an average of 22 mg/L and 8 mg/L, respectively, with an average loading rate of 70 mm/day, with similar reductions during wet weather overload conditions of 210 mm/day. The Cumberland reed-bed design estimate assumes a 210 mm/day loading rate for peak summer flow of 3,600 m^3/d, equating to 1.7 ha of reed-bed, or about 2/3 the size of the larger lagoon. The project cost reported for the Australian reed-beds was $2.5M for a 6 ha reed-bed in year 2000.

In January 2018, the Regional District of Okanagan- Similkameen issued an RFP for a constructed wetland – not including biochar - with a total project budget of $1M.

The estimate presented here assumes there are some cost savings from the nature of the site – easily accessible and one side wall already in place (the north side of the lagoons). A total cost placeholder of $1M has been used for the reed-bed, and the size of the reed-bed can be adjusted to meet this cost. An annual operating cost allowance is $25,000 for inspection and minor maintenance.

As the reed-bed is completely discretionary, and can be added to any treatment option at any time, its cost has not been included with any of the options. Strategically, the Reed-bed addition does present a phased option that would be better fit for grants focusing on innovative and energy efficient processes. The Reed-bed is broken out as the best potential for affordability is to add the Reed-bed subject to alternate grant programs thus reducing the tax burden.

9.8 Operating Costs

Operating cost estimates have been developed for all treatment options. They include;

- Operators (Labour)
- Electricity
- Process Chemicals
- Waste Biosolids Disposal
- Regular Maintenance
- Allowances for Membrane Replacement (where applicable)
- Operating the Wetland, for Option 1

Operating costs for the mechanical plants are based partially on operating costs from the Sechelt Water Resource Centre, with appropriate allowances for differences. Lagoon operating costs are based on current costs and standard estimates for cost of operating additional treatment elements like the chemically enhanced separation. It is important to note that the chemical cost for solids separation is an integral part of all Options, including Phase 1.

The operating costs for the lagoon options includes an allowance for dredging of biosolids every 5 years at a cost of $500,000. It may be possible to have longer periods between de-sludging, bit at a possible risk of reduced performance from reduced lagoon volume.

The operating costs are comparative estimates to provide an indication of the relative costs of adding chemical treatment and increasing power demands due to addition of mechanical equipment. The estimate includes an allowance for mid-life (15-year) capital replacement of process equipment but excluding tankage. The MBR option assumes membrane replacement every 7.5 years of operation.

Operating costs for the wetland distribution –estimated to be $25,000 per year - have been included in Option 1, Phase 2A only.

None of the options include a cost for operating the reed-bed, though this cost is expected to be similar to the wetlands distribution.

9.9 Option Cost Comparison

The capital costs for all Phases and Options are presented in Table 9-1 . The Option 1 series (Lagoon based Treatment) assumed a phased implementation, while the mechanical options 2 and three assume a single execution project.

In reality, the Option 1 series can be executed as a single project, and Options 2 and 3 can also be executed as a phased project. There is a $0.8M saving for combining Ph1 and 2A, and, if 2B is the endpoint, a $1.1M saving for combining Ph1, 2A and 2B. For the mechanical options 2 and 3, there is a $0.9 and $1.5M penalty respectively for a two-phased execution.

The wetland is shown as an addition to all Options, as it is possible that Ministry of Environment might require and accept it as an alternate discharge location to the direct discharge to Maple Lake Creek.

Table 9-1 Cost Components Summary for all Treatment Options

Item	Option 1, Ph 1	Option 1, Ph 2A	Option 1, Ph 2B	Option 2	Option 3
Construction Subtotal	$ 3.7 M	$ 2.4 M	$ 2.0 M	$ 5.4 M	$9.3
Engineering & Project Management	$ 0.4 M	$ 0.3 M	$ 0.3 M	$ 0.8 M	$0.9
Other Owners Costs	$ 0.2 M	$ 0.2 M	$ 0.2 M	$ 0.6 M	$1.0
Material Contingency	$ 0.3 M	$ 0.3 M	$ 0.1 M	$ 0.7 M	$0.6
Project Contingency (25%)	$ 1.0 M	$ 0.7 M	$ 0.6 M	$ 1.8 M	$3.0
Option Increment	$ 5.6 M	$ 3.9 M	$ 3.2 M		
Option Total	$ 5.6 M	$ 9.5 M	$ 12.7 M	$ 9.3 M	$14.8

Table 9-2 Cost Comparison for all Treatment Options

	Option 1			Option 2	Option 3
	Phase 1	Phase 2A	Phase 2B		
Capital Cost for 1-Phase execution	$5.6M	$8.7M*	$10.6M	$ 9.3 M	$14.8 M
Capital Cost for 1-Phase with Wetland	$6.6M	$8.7M*	$11.6M	$10.2M	$15.8M
Capital cost for 2-Phase execution	n/a	$9.5M*	$ 11.7M	$10.2M	$16.3M
Capital cost for 2-Phases with wetland	n/a	$9.5M*	$12.7M	$11.2M	$17.3M
Operating Cost	$350k	$375k	$425k	$450k	$500k

- Includes the wetland as this is integral to Option 1A

Table 9-3 provides a technical comparison of the options presented above.

Other comparisons (energy, complexity, carbon footprint) are made on a qualitative basis, to indicate the differences between the systems.

Table 9-3 Technical Comparison of Treatment Options

	Present System	Option 1			Option 2	Option 3
		Phase 1	Phase 2A	Phase 2B		
Description	Aerated and Facultative Lagoons	Upgraded Lagoon to Permit Compliance	Upgraded Lagoon to MEP	Upgraded Lagoon to GEP	Base flow mechanical to GEP	Full flow mechanical to GEP
Population capacity	<4,000	5,000	7,000	7,000	7,000	7,000
Discharge Location	Maple Lake Creek	Maple Lake Creek	North Wetlands	Maple Lake Creek	Maple Lake Creek	Maple Lake Creek
Effluent Quality (BOD-TSS, mg/L)	30-30	25-25	25-25	10-10	10-10	10-10
Suitable for reclaimed water use	No	No	Wetlands only	yes	yes	yes
Disinfection by PAA	None	< 200 CFU/100mL	< 100 CFU<100mL	<1 CFU/100mL	<1 CFU/100mL	<1 CFU/100mL
Biosolids Withdrawal	Periodic dredging (last done 2009)	Periodic dredging + low vol. continuous	Periodic dredging + low vol. continuous	Periodic dredging + low vol. continuous	Continuous biosolids wasting	Continuous biosolids wasting
Operational Class	1	2-3	2-3	3	4	3-4
Energy use	Low	Moderate	Moderate	Moderate	High	Highest
Carbon Footprint	Very Low	Low	Low	Low	High	Highest
Land Reclaimed	No	No	No	No	No	Yes – Lagoons 4Ha

10.0 EMERGING CONTAMINANTS

10.1 Introduction

Historically, the primary focus wastewater treatment plant designs was to reduce the concentration of readily biodegradable organic contaminants in the treated wastewater effluent so that the residual organic content could be consumed by aerobic bacteria in the environment without the risk of depleting dissolved oxygen to the extent of affecting fish and other aquatic species. Emerging Contaminants refers to a growing awareness that there are other contaminants, that are typically present at very low concentrations, that can have a chronic or long term detrimental impact on the environment, aquatic and wildlife species and humans. These include micro-plastics formed when plastic degrades and breaks down into microscopic particles that enter the food chain, contaminants from nano-technology such as carbon nano-fibres that can penetrate cell walls and immobilize bacteria in the environment, and a group of chemicals that have been found to affect the hormone and reproductive systems of aquatic organisms, wildlife and even humans referred to as Endocrine Disrupting Chemicals or EDCs.

10.2 Endocrine Disrupting Chemicals (EDCs)

Commonly used medications, birth control hormones, cleaning chemicals, fragrances, personal care products, anti-bacterial hand-wash lotions, and various other organic and inorganic pollutants are released to municipal sewers either as a result of direct disposal (e.g. poured down drains and flushed down toilets), application (e.g. shampoos contributing to shower and bath greywater drainage), or indirect release as part of urine and feces discharged to sewer through sanitary fixtures (e.g. toilets and urinals). Either individually, or in combination, over 800 chemicals have been found to exhibit or cause hormone and reproductive disruption and DNA damage in aquatic organisms, as well as being responsible for declines in wildlife populations and loss of species, and are referred to as “endocrine disrupting chemicals” or EDC’s. Some metals and organometallic compounds, for example cadmium, lead, mercury and tributyl tin (TBT), have also been identified as EDCs EDC’s include well known persistent organic pollutants such as PCBs and DDT, and brominated flame retardants used in electronics, phthalates used in plastics and personal care products, and perflouorinated compounds. Some EDCs are persistent and can bioaccumulate to toxic levels within the food chain long after the chemical has ceased to be actively used (e.g. PCBs). Consequently, EDC’s not only affect aquatic species and wildlife, they have also been shown to affect humans.

The ways in which EDC’s interfere with hormone function is varied. The chemical can either affect hormone receptors or it can modify the production, transport, metabolism or secretion of hormones. EDCs can also interfere with other endocrine systems, including the immune system and fat development, and most EDCs interfere with several physiological systems simultaneously (Bergman et al, 2013).

Bergman, A.,, J. J. Heindel, S. Jobling, K. A. Kidd, R. T. Zoeller. (2013). State of the Science of Endocrine Disrupting Chemicals - 2012. WHO (World Health Organization)/UNEP (United Nations Environment Programme).

As a consequence of the increasing awareness of the ecological damage that EDC’s are causing, there is a greater awareness that wastewater effluent discharges to the environment are a significant source of these chemicals. These contaminants enter the environment largely through human or personal activity and use, rather than contamination caused by industry. Unfortunately, wastewater treatment technologies have been primarily focussed on reducing the concentration of readily biodegradable organic matter in wastewater, and the technologies employed have limited effect on reducing the amount of EDC’s in wastewater. While EDCs have been labeled as an “Emerging Substance of Concern” by the Canadian Council of Ministers of the Environment (CCME), the lack of technologies to remove these chemicals, and the fact they have a detrimental impact even at very low concentrations, make them difficult to target from a treatment perspective. What reduction that does occur is primarily through adsorption ("sticking") to biosolids – bacterial growing in the treatment process. When the bacteria are wasted from the treatment process, depending on how the biosolids are managed, the EDC's associated with the biosolids can be released to the environment.

There are presently no Canadian standards for the treatment/removal of EDC's from wastewater, or acceptable levels in receiving environments. The CCME is looking at this and have recently released the first draft of a standard for the pharmaceutical Carbamazepine in aquatic environments, but other countries such as Australia have already developed guidelines on EDC's in receiving waters.

10.3 Treatment to Remove EDC's

10.3.1 EDC Treatment

The wide range of EDC's that can be present in wastewater, their low concentrations, and their different chemical and physical characteristics makes them difficult to treat and remove. Treatment approaches that have been researched include:

- Biological treatment over long periods of time enable bacteria to slowly and gradually break down the typically complex and long-chain organic structures. Attached growth or fixed film wastewater treatment processes have characteristically extremely long biosolids retention times and are expected to be better suited to adsorbing and breaking-down complex organic compounds. However, many of the EDCs are toxic or are inorganic and not suited to biological treatment, and can take extended periods of time to biodegrade.
- Advanced oxidation using ozone and/or generated hydroxyl radicals to chemically oxidize and break down complex organic molecules. However, advanced oxidation technologies are typically very expensive and imprecise in terms of being able to target EDCs – and a great deal of the treatment capacity is spent reducing or removing non-EDC contaminants at considerable cost. Finally, some of the oxidation products may harmful in themselves, and effort must be taken to remove them, typically by an adsorption type process.
- Adsorption to chemicals and organic compounds for subsequent removal and targeted treatment/destruction. Activated carbon is a well known and effective contaminant adsorption substance that can remove both organic and inorganic contaminants. While adsorption can be highly effective at removing EDCs from water, the contaminants have not been treated or destroyed, but merely partitioned from the liquid to a solid particle, or biosolids, and requires further treatment.

10.4 Attached-growth Fixed-Film Processes

Attached growth or fixed film processes are generally considered to be superior to suspended growth processes in the ability to adsorb and break-down complex organic molecules. This adsorption and long-term retention characteristics is expected to allow such systems to achieve significant reductions in EDC contaminant levels in wastewater. An example of a fixed film process is a Reed-bed which consists of support media with reeds growing on the surface of the media and the plant roots providing additional attached growth surface area for bacteria.

While some of the biodegradable organic EDC contaminants that become adsorbed to the bacterial biofilm can be gradually broken down and digested, other EDC contaminants may be more difficult or impossible (e.g. inorganic contaminants) to treat and can buildup in the biosolids that eventually have to be removed and disposed of.

Consequently, the attached growth process has an indefinite ability to degrade some EDC's, and a finite ability to adsorb and treat certain others.

10.5 Use of Biochar

The filtering of water through charcoal is an ancient method of water purification, and carbon adsorption using activated carbon filters is a common method of treating drinking water to remove inorganic contaminants (metals), and organic contaminants that can affect taste and odour. and is still used today in many water and food applications. Some of this work has focused specifically for advanced wastewater treatment for organic micropollutant removal by biological activated carbon filtration. Although activated carbon has displaced charcoal for many specialized purposes, it is much more expensive to manufacture than charcoal, and is impractical to manufacture on a small scale. Consequently, over the last five years, there has been extensive research focused on using biochar as a sorbent for contaminant management in soil and water.

Biochar is a specialized form of charcoal, made primarily for use as a soil amendment, or filter media. It has an advantage over activated carbon in that it is relatively easy to make, especially at small scale, and can be made from a wide variety of carbonaceous materials, including wastewater biosolids. There have been many studies on making biochar from various feedstocks, including from wastewater biosolids. Biochar can be made easily at small scale, and there are a few emerging systems for small scale continuous production.

In summary, biochar offers the potential to;

- Effectively remove EDC's from reclaimed water
- Removes EDCs at least well as activated carbon
- Can be made locally from available waste-carbon feedstocks
- Is a cheaper alternative to commercial Activated Carbon

As noted, many of the organic contaminants and EDCs removed during the water treatment process end up in the biosolids. Making biochar from the biosolids represents an alternative method of treatment compared to conventional methods such as composting, heat drying or lime stabilization. Biochar, made form wood waste, has also been found to be a beneficial aid to the composting of biosolids, leading to numerous improvements in the process and product.

There are currently no biosolids treatment processes that specifically target trace organics, including EDC's. Some charring processes can be operated in a way to destroy the organic contaminants, thus the biochar process has the potential to destroy all the organic contaminants in the biosolids.

Biochar, when applied to as a soil amendment, is also carbon negative – it is actually sequestering solid carbon into the ground. Various studies have shown charcoal can be stable in the soil, for hundreds to thousands of years. Protocols have been developed in other countries to quantify the use of biochar as a carbon sequestration methodology, though there is not one yet for BC or Canada. This is an area for future study with biochar, but the proposed project can quantify the fixed carbon contents of produced biochar.

The ability of biochar to remove EDC's was evaluated at the District of Sechelt Water Resource Centre in 2015. Table 11-1 illustrates the variation in concentration of various pharmaceutical compounds present in tertiary effluent from the Sechelt wastewater treatment facility after one hour of contact with wood-pellet biochar – with 1 gram of wood pellet biochar mixed with 1 L of tertiary treated wastewater effluent. While the tertiary treatment process was able to decrease the concentration of about half of the targeted analytes to less than the analysis detection limits, contact with the biochar resulted in adsorption and further significant reductions.

Table 10-1 Pharmaceutical reductions after 1 hr contact with biochar (1gm wood pellet biochar with 1L Tertiary Effluent)

Analyte	Use	Detection limit (ug/L, or parts per billion)	Influent	Tertiary Effluent (reclaimed water)	Biochar Treated Tertiary Effluent	Tertiary Treatment Removal %	Tertiary + Biochar Removal %
Carbamazepine	anti-epileptic	0.001	0.334	0.347	0.083	0%	75%
Trimethoprim	antibiotic	0.005	0.138	0.213	0.017	0%	88%
Warfarin	blood anti-coagulant	0.001	0.009	0.007	0.004	22%	56%
Diclofenac	anti-inflammatory	0.01	2.82	0.899	0.427	68%	85%
Sulfamethoxazole	antibiotic	0.005	0.733	0.146	0.086	80%	88%
Triclosan	anti bacterial agent	0.05	0.637	0.064	<0.05	90%	100%
Naproxen	anti-inflammatory	0.025	10	0.388	0.104	96%	99%
Acetominophen	pain killer	0.005	62.9	0.075	<0.005	100%	100%
Caffeine	coffee	0.02	73	<0.02	<0.02	100%	100%
Fuoxetine (Prozac)	anti-depressant	0.02	0.038	<0.02	<0.02	100%	100%
Sildenafil (Viagra)	erectile dysfunction	0.025	0.246	<0.025	<0.025	100%	100%
Triclocarban	anti bacterial agent	0.05	0.214	<0.05	<0.05	100%	100%
Bisphenol A	plasticiser	0.01	0.22	<0.01	0.012	100%	95%
17a-Ethynylestradiol (synthetic estrogen)	birth control	0.01	<0.01	<0.01	<0.01	n/a	n/a
Gemfibrozil	cholesterol control	0.005	<0.005	<0.005	<0.005	n/a	n/a

10.6 Systems in Full-Scale Use

There are a few examples worldwide of wastewater treatment system that have components specifically intended to remove EDC's. Most of these are plants that are producing high quality reclaimed water, or are discharging into a river that is subsequently used as a source for drinking water.

A well-researched example is a study on three advanced wastewater treatment plants in Australia using ozonation and "Biological Activated Carbon (BAC) filtration to produce high quality reclaimed water.

"Biofiltration for Advanced Treatment of Wastewater" Reungoat et al, Urban Water Security Research Alliance Technical Report No. 73 , 2012

From the executive summary, with emphasis added:

> *BAC filtration without prior ozonation is capable of significantly improving the quality of the WWTP effluent. BAC filtration proved more effective than sand filtration and ozonation before BAC filtration did not significantly improve the performance.* ***BAC filtration is therefore suggested as a simple and cheap option for the upgrade of WWTPs with advanced treatment in order to improve effluent quality before discharge.*** *Further research is required to better understand the parameters influencing the performance of BAC filters and to provide information for the design of full scale units.*

Several other research and field studies have shown that activated carbon and charcoal produce good performance in degradation long after their adsorptive capacity has been exhausted. It is interpreted that it is the biofilms that are responsible for this performance.

Since the carbon and biofilms are reducing the dissolved organic carbon content, the clarity of the water is increased, which can be measured by the Ultra Violet transmissivity, and more simply, it is often commented that the water is “sparkling”. This represents getting closer to the state of “fresh” water.

While the long term “fixed bed” systems perform well, the systems that have the media replaced more often perform slightly better due to the adsorption characteristic

That said, where the highest performance is not critical, the simplicity and cost efficiency of a single charge of media in long term service is operationally a better choice.

10.7 Combined Fixed-Film and Biochar Process

The concept of a treatment by a Reed-bed (an engineered constructed wetland) was proposed in 2016 as polishing step for the Cumberland wastewater treatment system. Reed-beds are normally built with inert gravel media simply because it is cheap and free draining. By adding biochar to the media within a reed-bed, the adsorptive capacity of the reed-bed to remove EDCs from the treated wastewater effluent can be significantly increased, and the carbon from the biochar can also be used to support bacterial growth within the reed-bed. Charcoal is well known as a successful plant growing media in horticulture and hydroponic operations.

The media within the reed-bed could also be further enhanced to remove phosphorus from the effluent by incorporating zero-valent iron (e.g. iron filings or shavings) into the media, as well as removing ammonia through nitrification by ensuring the support media is aerated and aerobic conditions are maintained.

This system would have adsorption, biofilm and plant based biological process happening, and is a promising, and potentially simple, means of providing treatment for emerging contaminants. The concept of combining the features of adsorption and fixed film biological treatment process into a reed-bed will be discussed further in Section 11.0 “Effluent Polishing by Biochar Reed-bed”.

11.0 EFFLUENT POLISHING BY BIOCHAR REED-BED

11.1 Background

The concept of "effluent polishing" generally refers to passive or natural means of treatment occurring after conventional wastewater treatment, and is typically intended to further remove remaining dissolved organics (BOD) and nutrients (phosphorus and nitrogen). Cumberland's large facultative stabilization pond is an example of effluent polishing as there is no mechanical components that require maintenance or methods to control or influence the degree of additional treatment received.

Because of the lack of controls or adjustments, effluent polishing is generally applied as a secondary measure to improve effluent quality and serve as an additional barrier to the release of contaminants to the environment in the event of incidental water quality exceedances. Incorporated into the design of a wastewater treatment process these polishing stages serve as a means to better ensure the required water quality will be met.

However, planned effluent polishing can also occur after a regulated discharge, and may not be needed to meet regulatory requirements. The natural wetlands located downstream of the lagoons are a good example, as the water quality of the lagoon discharge to Maple Lake Creek continues to improve and achieve an extremely high quality as a result of uncontrolled natural processes within the wetlands – "polishing" the lagoon effluent.

A constructed wetland is not, strictly speaking, applied as an effluent polishing component. Constructed wetlands are engineered processes designed to replicate and optimize biological, physical, and chemical treatment that is achieved when water passes through a natural wetland. There are well established design guidelines and criteria for constructed wetlands to provide secondary and tertiary wastewater treatment, and levels of treatment comparable to mechanical treatment processes, and are highly engineered systems designed to achieve specific treatment objectives. The concept of constructing wetlands to provide wastewater treatment for Cumberland is not new – this was the preferred treatment option developed in the Stage 2 LWMP in 2006 – and consisted of large areas of emergent system of open water ponds with various floating and fixed vegetation thatches, and was designed for secondary treatment and stormwater handling.

The proposed reed-bed concept is a constructed engineered wetland consisting of plants growing in porous media, where water flows through the media and plant root zone below the surface, and there is no free water surface. To differentiate this constructed wetland from the natural wetlands surrounding, and downstream of, the lagoons, the more descriptive term of "reed-bed" has been adopted.

The concept of effluent polishing by the reed-bed, incorporating charcoal media, was developed as part of the November 2016 funding application, with the intention of incorporating the reed-bed within the overall conventional treatment process with specific treatment functions in terms of BOD, suspended solids, and emerging contaminants removal, and with secondary objectives of carbon credits and aesthetics.

With the re-examination of all treatment options, the reed-bed stands as a discretionary treatment element that can be added on to any of the main treatment options, as and when desired. Although it can be incorporated into the overall lagoon-based or mechanical treatment process, it can also be incorporated as an "add-on" polishing stage following a regulated discharge.

11.2 Types of Treatment Wetlands

A constructed wetland is an engineered bacteria-mediated ecosystem that is specifically designed for water treatment purpose.

They typically have a shallow containment basin (0.5 to 1m deep) that is filled with support media (typically gravel) and planted with a variety of wetland plants. As the water moves through the system, the biological activity of the plants, and biofilms on their roots and the support media, extract nutrients and organic compounds from the water, thus "polishing" it as it moves through the system. The design and the flow regimes of wetlands can be engineered or controlled to achieve a number of treatment objectives.

Treatment wetlands can be grouped into three main designs, in increasing order of complexity.

1. "Surface Flow" where the water level is above the ground surface, and moves horizontally amongst the plant stems, with negligible flow beneath the surface. This is analogous to flow through shallow natural swamps.
2. Subsurface flow, where the water flow path is through the root zone of the porous media. There are two types of subsurface flow wetlands;
    a. Horizontal flow, where the water flows horizontally from one side of the wetland to another. This is analogous to water entering a stream by filtering through the root zone of the bankside vegetation.
    b. Vertical flow, where the water is dispersed at the top of the wetland and flows downwards through the root zone to a drainage layer. This is essentially the same as watering a potted plant.

Figures 12-1, 12-2 and 12-3 have been sourced from Tilley et.al. (2014) (source: Tilley, E., Ulrich, L., Lüthi, C., Reymond, Ph., Zurbrügg, C. - Compendium of Sanitation Systems and Technologies - (2nd Revised Edition). 2014 Swiss Federal Institute of Aquatic Science and Technology (Eawag), Duebendorf, Switzerland.) illustrating the basic features of three of the most common wetland configurations, also summarized in Table 10-1.

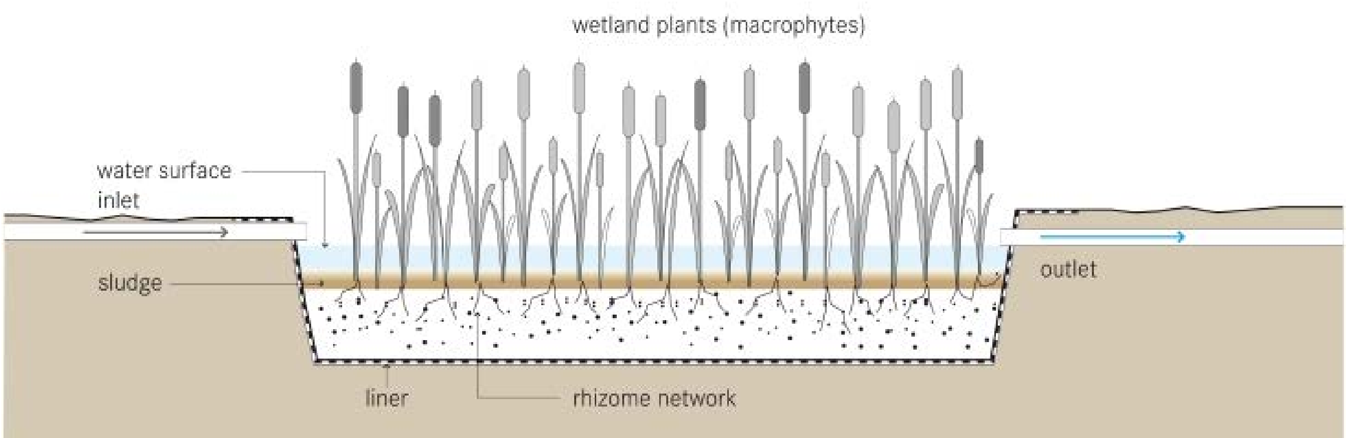

Figure 11-1 Surface Flow Wetland

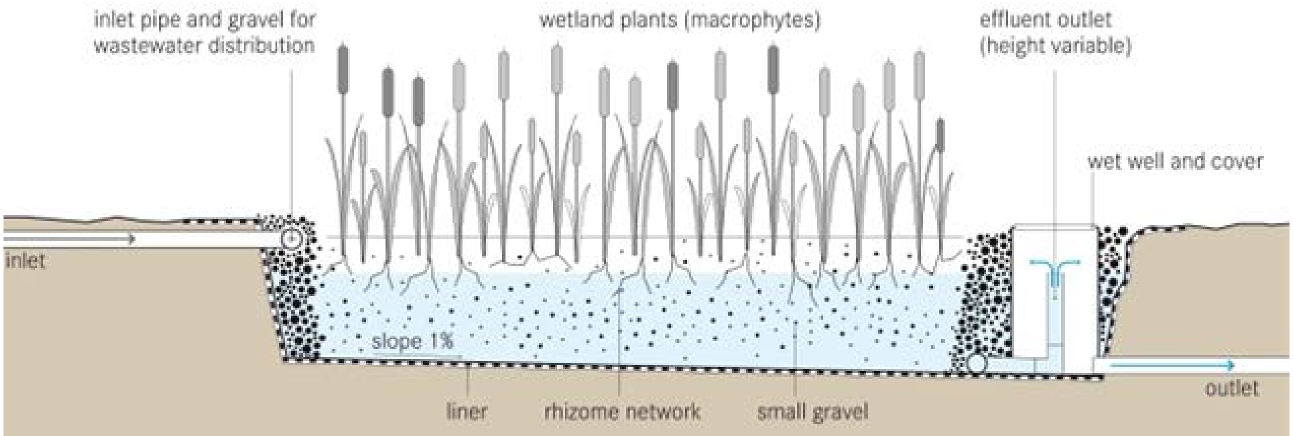

Figure 11-2 Horizontal Flow, Sub-Surface Wetland

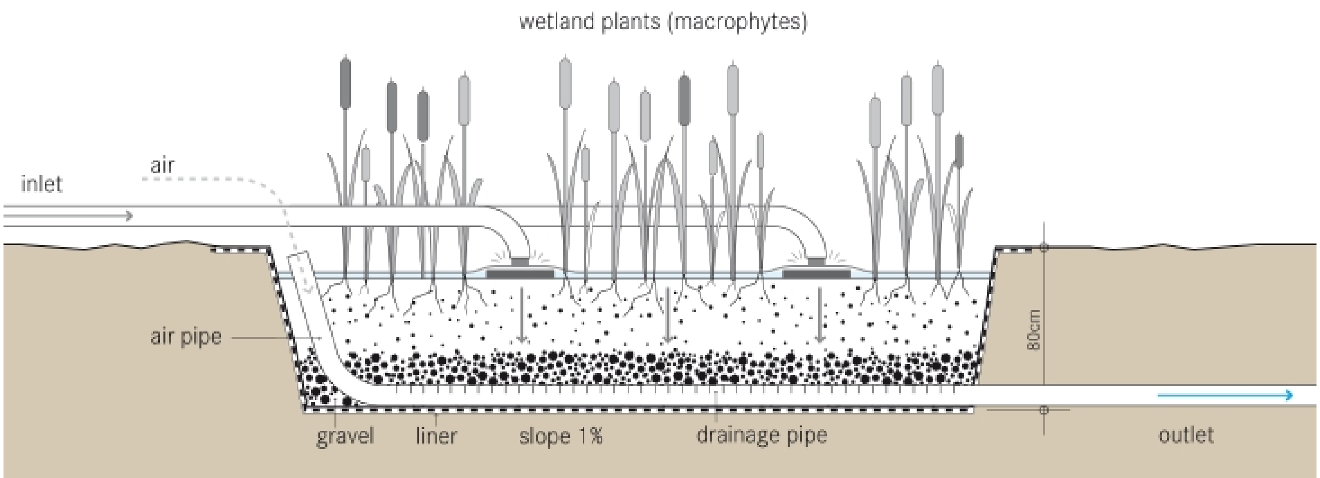

Figure 11-3 Vertical Flow, Sub-Surface Wetland

Table 11-1 Comparison of wetland types

Wetland Type	Surface Flow	Horizontal flow, sub surface	Vertical flow, sub surface
Treatment quality	good	better	best
Cold weather performance	fair	best	good
Potential for insects	moderate	low	low
Ease of installation	easy	moderate	intricate
Relative flow capacity	moderate	low	high
Media type	Can be natural ground	porous	porous
Maintenance	low	low	low
Ability to add aeration	no	yes	yes
Land area requirement	large	moderate	small
Relative cost (excl. land)	low	moderate	high

11.3 Cumberland Wastewater Treatment Sustainability Goals

In June 2016, The Cumberland Wastewater Advisory committee developed a series of goals for the wastewater treatment system. There were mandatory goals, set by regulation, and “aspirational goals” representing desirable, but not necessary outcomes. An ideal solution achieves all the mandatory goals and as many of the aspirational goals as possible.

The aspirational goals largely reflected the goals contained within major planning documents, such as the Village of Cumberland Official Community plan, and the Comox Valley Sustainability Strategy. Several of the goals are only partially achieved by conventional wastewater treatment:

- Reduce Energy Use and GHG's
- Innovation/Environmental leadership
- Support health of waterways with robust treatment
- Use of existing ecosystems to control cost including low tech solution and or bio solutions plus beneficial use of produced biosolids
- Sustainability, Climate Change resilience/adaptation/robustness
- Reduce manmade toxins

These goals combined are worth 18 of the 20 points for Environmental goals, an 18% of the overall evaluation. There was a strong desire from the committee to have a system that would action some or all of these goals.

There is an additional benefit in that most of these goals are also provincial and federal government objectives, and are evaluation criteria for infrastructure funding programs.

In pursuing innovative and aspirational goals, the challenge is to not compromise the mandatory goals. An ideal solution in this case would be some element that could be added on to any wastewater treatment system, and action these goals without compromising performance or reliability, and at reasonable cost.

The concept of the biochar media reed-bed was developed specifically to meet this challenge and address all these aspirational goals.

In all cases engineered treatment wetlands have a high density of plants and minimal or no open water areas. It should be noted that these wetlands are a highly engineered system designed to perform a specific function. They are not to be confused with “habitat wetlands” that have deeper water and large open areas, and are for encouraging aquatic life and waterfowl.

The type of wetland that is proposed to be used for the Cumberland reed-bed is the vertical flow type. This will give the highest flow throughput for the lowest area, and likely the lowest construction cost. The following sections are based on the vertical flow, sub surface configuration.

11.4 Wetlands for Wastewater Treatment

Constructed wetlands can be used to perform a variety of wastewater treatment functions, including primary, secondary, tertiary and polishing treatment and for sludge drying and composting. Small scale wetlands are also used as an alternative to conventional drainfields for domestic septic systems. The higher the biological load on the wetland, the larger it needs to be, and the more often that accumulated solids need to be removed.

For these reasons, wetlands are most commonly found on small systems and in tertiary or polishing functions, where the biological load is small. That said, there are some very large treatment wetlands. The world's largest is 700ha and treats 115,000 m3/day of oilfield wastewater in Oman.

The treatment wetlands can be designed to performs some very specific wastewater functions. If the objective is removal of BOD and TSS then forced aeration and/or very large areas are required, as is a means of removing accumulated solids. For this reason, wetlands are rarely used for doing the "heavy lifting" of primary and secondary treatment.

For tertiary treatment and polishing, the organic loads are much lower and other functions can be optimized with the design and operation of the reed-bed. Specifically;

- Nitrification is the bacterial process of converting ammonia to nitrate. The surface area of the plant roots and media all provide space for growth of nitrifying biofilms within the wetlands. If aerated water is supplied to the reed-bed, or if it is aerated by subsurface aeration, then it can be very effective at nitrifying.
- Denitrification is the bacterial process of converting nitrate to atmospheric nitrogen. This is done in anaerobic conditions, and with a carbon source. The bacteria feed on the carbon and get their oxygen from the nitrate. Reed-beds can be designed to have an anaerobic zone, or be operated in batch fill and drain mode, or have intermittent aeration, or be operated in series aerobic and anaerobic to achieve this function. One study for the US Army Corps of Engineers found that simply replacing gravel media with woodchip media dramatically improved denitrification performance. (link at http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1148&context=usarmyceomaha)
- Phosphorous removal can be accomplished in sub surface flow wetlands by augmenting the media with phosphorous adsorbents such as zero valent iron, dolomite, lanthanum and others. Surface flow wetlands are generally not suited to phosphorus removal as it is absorbed in the biofilm on plant stems and the plants themselves, and eventually reaches a steady state where no more is adsorbed. Some free surface wetlands exhibit seasonal uptake and release of phosphorus as plants grow and die back. The Maple Lake Creek natural wetlands exhibit this seasonal summer uptake and winter release of phosphorus, which is why they can still absorb 97% of the phosphorus load in the summer
- Pathogen reduction occurs naturally within the soil, and the plant roots encourage competing biota, which further reduces pathogens
- Removal of colloidal and some dissolved constituents by bacterial and plant activity
- Aesthetic functions – a well-designed wetland looks good!

Wetlands have the additional features of being low maintenance, low operational complexity and zero energy, or low energy in the case of aerated wetlands. When used for effluent polishing after tertiary treatment, the wetland has an almost indefinite life without getting clogged from solids accumulation, as the plants gradually absorbed the captured biological load.

11.5 Removal of Emerging Contaminants

Treatment or emerging contaminants was discussed in Section 10.0, with two of the mechanisms being adsorption and biodegradation. There have been numerous studies showing biochar can achieve meaningful reductions, through both adsorption and biodegradation.

Engineered wetlands are less known for removing emerging contaminants, but there have also been several studies showing they can achieve meaningful treatment, with biodegradation being the prominent mechanism. There are more variables with wetland systems – the flow regime (vertical, horizontal or surface), flow rate/residence time, plant types, temperature etc. A field study on pharmaceutical removal from a seasonal release, wastewater polishing wetland at Grand Marais in Manitoba studied removal of some common pharmaceuticals and showed that it achieved good removal of some, such as Carbemazapine (anti- epileptic drug), and not others, like sulfamethxazole (an antibiotic) and gemfribrozil (cholestorol drug) (link at https://ccj.springeropen.com/articles/10.1186/1752-153X-7-54). Other studies have confirmed that wetlands do not remove sulfamethoxazole – however – it is well removed by activated carbon and biochar. A side note is that the Grand Marias wetland also removed phosphorus from an influent concentration of 0.4mg/L to an outlet concentration of 0.007mg/L or <0.005mg/L – thus meeting the same level as the in-stream objective for the Trent River.

Some further studies have looked at improving the performance of wetlands by using adsorptive media such as peat, woodchips, activated carbon and biochar. These studies have found improved performance for removal of EDC's, other organics and heavy metals, though the performance varies with the media type. Adsorptive performance can be further enhanced by adding specific adsorbents such as zero valent iron, dolomite and others.

11.6 Full Scale Example – Port of Tacoma

While most studies on biochar media wetlands are laboratory or pilot scale, a full scale implementation was done in 2013 by the Port of Tacoma. (link at http://aapa.files.cms-plus.com/AwardsCompetitionMaterials/Tacoma 2014 Comprehensive Environmental Management.pdf).

The project was for filtration of contaminated runoff from a log yard. After doing technology comparisons and field trials, it was determined that a multi stage, vertical flow wetland, with a biochar media stage, was the most economical and sustainable way to treat the contaminated water. The project was constructed and commissioned in 2013, and has been very successful, winning an industry award in 2014.

From the project report (link at https://www.portoftacoma.com/news-releases/2014-11-19/innovative-treatment-system-exceeds-water-quality-rules

The system measures 600 feet long by 45 feet wide and was completed in 2013, it moves stormwater through four cells. Each targets a particular pollutant:

- In stage one, pea gravel removes solid pollutants.
- In stage two, sand amended with biochar removes fine solids, metals and organic contaminants.
- In stages three and four, the bioretention mix of sand and compost is planted with bamboo and other vegetation to remove the remaining pollutants through biological uptake in the plants.

To date, the system has yielded impressive results, removing more than 92 percent of pollutants, as illustrated in Table 12-2.

The cost of the system was relatively high at US$2.4m. Much of this is due to the design of the system, which involved a series of concrete tanks, and each one requiring a pump station to lift the water to the next. The cost of the actual wetland within – media, drainage and plants, was a relatively minor part of the total.

Table 11-2 Port of Tacoma Reed-bed Treatment Performance

Parameter	Influent (mg/L)	Effluent (mg/L)	Permit (mg/L)
Turbidity	58.4	9.4	25
Total suspended solids	42	3.5	100
Copper	33.9	12.5	14
Zinc	57.4	8.8	117
Chemical oxygen demand	290	85	120

Even though this system is not intended to remove pharmaceutical type compounds, it is likely that it would if they were in the incoming water. The system is clearly working well, and is a good example to draw from.

11.7 Carbon Sequestration

There is a general desire for reduction in carbon emissions and greenhouse gas (GHG) emissions, to lower the “carbon footrprint”. BC municipalities are required to annually quantify and report their emissions, and achieve carbon neutrality, through the Climate Action Revenue Incentive Program (CARIP). This is done by carbon reduction actions, and buying carbon credits to make up for remaining emissions. Part of the evaluation of wastewater treatment options will be the carbon footprint of each one.

Wastewater treatment is typically energy intensive, and it is always desired to reduce energy use and GHG emissions in new wastewater projects. But even the most efficient system is still “carbon positive”. And it was expected that any new system for Cumberland will use more energy than the existing one, thus raising overall GHG emissions. In order for a wastewater treatment system to reduce Cumberland’s overall emissions, the system itself would have to be carbon negative, and there no known examples of such a system.

Biochar is mostly carbon, and is made from natural carbonaceous sources, typically wood waste but also from other organic waste including animal manures and, most recently, *wastewater biosolids*. The production of biochar in itself releases carbon, but since all the feedstocks are natural carbon sources (not fossil fuels) they are considered carbon neutral to start with, and so are any carbon emissions. This is the same principal that applies to use of biofuels.

Thus, biochar is a carbon neutral product, but what is needed is a carbon negative product, or process. When biochar is applied to the ground, as a soil amendment, it remains in the soil permanently. A large portion of it, called the “fixed carbon”, is effectively non-biodegradable. Various studies, such as the the Eurochar study have shown the life of charcoal in the ground is hard to determine, and the half-life estimates ranged from 70 to 145 years, and a mean residence time of over 600 years, though other studies have suggested indefinite soil life. On a human timescale, over 100 years is considered *permanently sequestered*.

If the fixed carbon was 100% of the mass of the biochar, and all the biochar stayed in the soil indefinitely, then the CO2 credit would be that of carbon itself, i.e. 3.67tCO2/t biochar. The Eurochar study found 1.59 ton CO2 per ton of biochar (sourced from forest residue), equivalent to a fixed carbon content in biochar of 43.3%. During the actual production of the charcoal, the fixed carbon can be explicitly measured and quantified, and a common design assumption is 50%, leading to a carbon credit of 1.83 tons of CO2 per ton of biochar sequestered.

To be considered sequestered, the biochar must remain in the ground. If it is used as a reed-bed media, it will be there for 10 to 20 years, or longer. If the media needs to be replaced, the biochar can then be applied elsewhere as a soil amendment, and is still considered sequestered. If the biochar is considered "contaminated", and disposed of into a landfill, it would most certainly have been permanently sequestered.

In BC, there have not been any projects, or even a methodology developed, for officially verifying carbon negative (sequestration) projects. This would need to be done before any official carbon credits could be given to the project.

For this planning stage, the reed-bed has been modelled as follows;

- Area to be 17,000 sq.m and 1m deep
- Bed volume = 17,000 m3, normally filed with coarse gravel
- Substitute charcoal for 20% of bed volume, 3400 m3 of charcoal
- Bulk density of charcoal is 250 kg/m3, gross weight = 850tons
- Fixed carbon content of biochar at 50% by weight.
- CO2 sequestration 3.66 tons CO2 per ton of fixed carbon.
- Total CO2 sequestration 1,555 tons

For calendar year 2015, the net CO2 emissions for the Village of Cumberland were 52 tons of CO2. If they were to remain at that level, the biochar would offset the emissions for the next 30 years.

There is clearly great potential for carbon sequestration by the production and use of biochar.

11.8 Implementation at Cumberland

Cumberland is a good opportunity for a polishing reed-bed, as the final water from the treatment process will be of sufficient quality to discharge to either the creek or the natural wetlands, so it is also good enough for a polishing reed-bed before going to the natural wetlands and the creek.

The proposed approach is to integrate two treatment processes (wetland and biochar) by putting biochar into the plant support media, thus maximising the treatment performance. Table 12-3 compares the treatment functions of a treatment wetland and biochar filtration.

It is apparent that the two processes complement each other very well, each providing something that the other does not.

An interesting possibility that arises with the use of a vertical flow wetland is the concept of a combined vertical and surface flow wetland in high flow or stormwater conditions. If engineered correctly, the normal vertical flow pattern can continue, while excess flow is introduced at the surface, to flow across the surface through the plant stems. This surface flow acts in the same ways as "rain gardens" for municipal stormwater, slowing the flow of water and trapping and settling fine suspended solids. In the case of Cumberland, the vertical flow portion would be designed for the "base flow" and excess (winter) wet weather flows, after disinfection, could surface flow across the wetland prior and then "overflow" to Maple Lake Creek. This will be studied further as the wetland concept is developed.

For an implementation at Cumberland, the concept is to;

- Build the reed-bed to the north of the lagoons, with earthen-bermed walls
- Potential area of up to 17,000 sq.m (to be determined)
- Use a vertical flow configuration

- Use biochar for a portion of the media (actual % to be determined)
- Plant with a variety of wetland plants, preferably native
- Send the treated water to the reed-bed only after it has been disinfected and met all the regulatory water quality requirements for environmental discharge
- Send the polished water from the reed-bed to the natural wetlands to the north, from where it will naturally migrate into Maple Lake Creek

Table 11-3 Treatment Comparison of Wetlands and Biochar Filtration

Treatment Function	Engineered Wetland	Biochar Media Filtration	Combined Performance
Suspended Solids	***	*	***
Nitrification	***	*	***
Denitrification	***	*	***
Phosphorus	**	*	**
Endocrine Disruptors	*	***	***
Dissolved organics	*	***	***
Colour	*	***	***
Odour	*	***	***
Heavy metals	*	***	***
Aesthetic	***	*	***
Carbon sequestration	neutral	**negative**	**negative**

The land area to north and east of the lagoons was extensively studied from 2002 to 2008, with the original intent being to have the wetlands as part of the secondary treatment process. The land was given to the Village of Cumberland under the Federal "Eco-Gift" program in 2002, and use of these lands for a treatment wetland has already been approved by Environment Canada, in 2003.

The proposed layout of the system is illustrated in Figure 11-4, with the Reed-bed and Wetland Areas 1 and 2 corresponding to the area approved by Environment Canada for treatment wetland purposes.

11.9 Costs

At this concept stage, there are still several unknowns to be resolved before a project can proceed, or even be meaningfully budgeted. These include:

- The source and cost of the biochar and gravel media
- The practical size of the reed-bed
- Construction considerations – excavation, berms, piping etc.

Budgeting of a project is difficult when there are so many unknowns. For the 2016 project funding application, a budget of $1.9M was used ($1.5M +25% contingency), with the theory being that the reed-bed would be as large as possible within that budget. After identifying some real-world examples of constructed wetlands being built for $0.5 to $2M, a "placeholder" budget of $1M has been adopted as at January 2018.

There clearly needs to be more detailed study and a meaningful budget estimate before a decision can be confirmed to proceed with the biochar reed-bed.

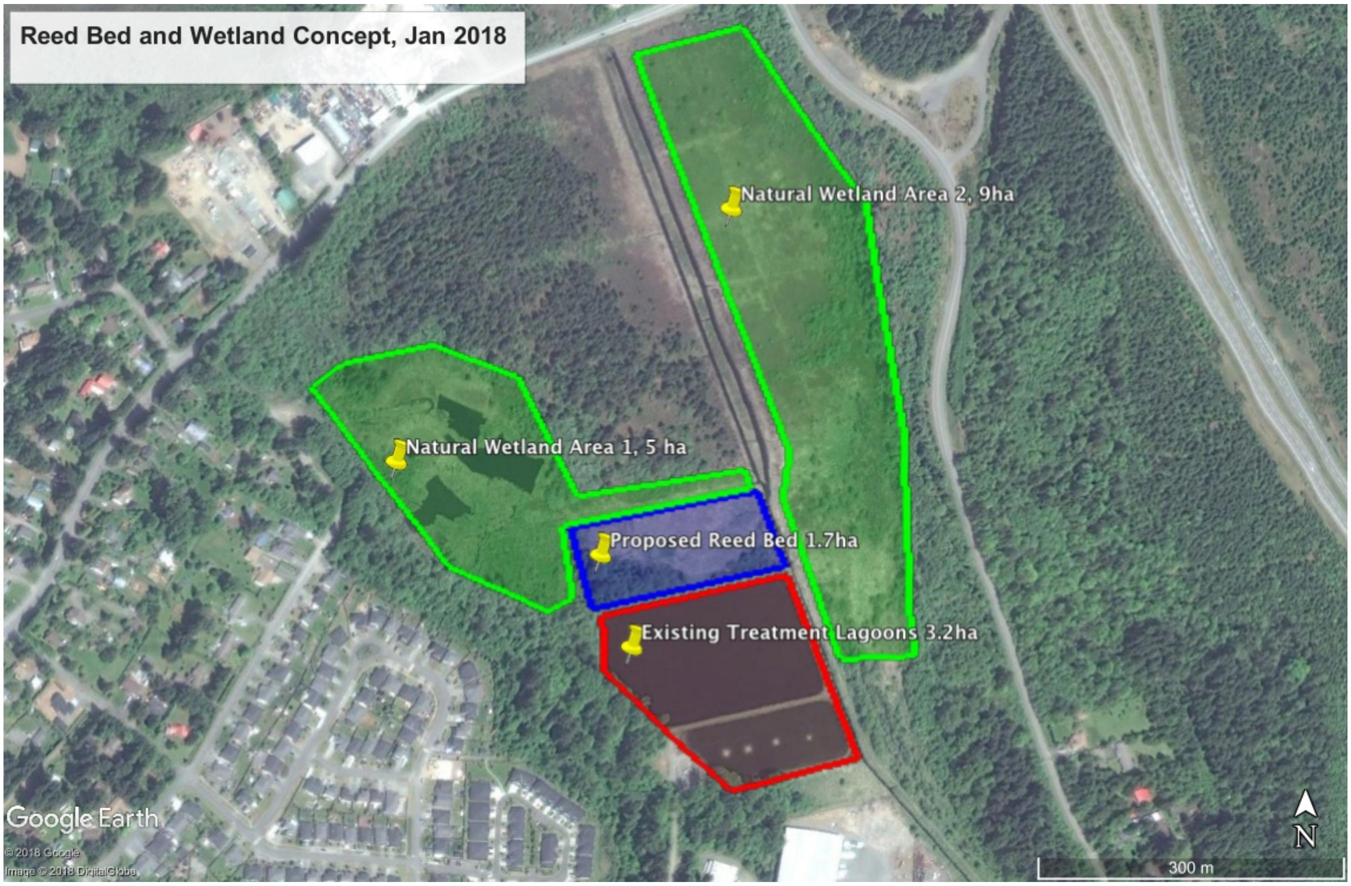

Figure 11-4 Potential Areas for Locating a Reed-bed and Augmented Wetlands

11.10 Summary

The biochar media reed-bed represents an innovative combination of natural (wetland) and engineered (biochar) processes.

Both these systems have been proven in separate situations, and there are some field trials in and one full scale use of this combination. The result is a high performance, low maintenance system that removes a variety of contaminants that the conventional wastewater treatment system does not.

The biochar component results in substantial carbon sequestration that, if validated and accepted by the authorities, would make the entire wastewater facility carbon negative for its operational life. This would be the first documented carbon negative wastewater facility in the world.

The biochar media reed-bed has the potential to address almost all the Wastewater Advisory Committee's Environmental Goals, and is the only one that is carbon negative. It also makes for a good prospect for funding under federal and provincial infrastructure funds, and environmental leadership funds.

Since the reed-bed is not needed for meeting regulatory requirements, its use at Cumberland is therefore entirely discretionary, and it can be added to any treatment system, at any time.

It is recommended that;

- this option remain on the table,
- be studied further to develop an implementation concept, and
- be considered on its own merits for addition to the preferred Treatment Option.

12.0 BIOSOLIDS

12.1 Background

As part of the LWMP, direction for collecting and disposing of the solid waste – or the residuals -generated from the treatment plant must be addressed as part of the overall solution. The recovered solids are not subject to any specific criteria in compliance to the current permit. In general, the solids produced as part of screening and biological digestion must be collected and safely disposed to a suitable location. The primary concern is the reduction/elimination of pathogen transfer.

The majority of small communities capture and transport the wastewater treatment solids to landfill. Larger plants and areas that have specific plans for beneficial re-use have systems added to the treatment plant that will produce biosolids that can be used for recovery of the nutrient inherent within the biosolids.

Solids are currently generated from two sources within the Cumberland plant:

12.2 Screenings

All flow into the plant currently pass through a 6 mm screen. This reduces the volume of non-digestible solids entering the system. They are recovered in a garbage container and transported to landfill for safe disposal. The solids are compressed prior to recovery. This reduces the water volume and reduces the recovery of digestible material.

This represents the typical method of management and all upgrade options would use an equivalent management of the screened solids. There are no considerations for a viable economic recovery / re-use of captured solids.

12.3 Biosolids

Nutrient-rich organic materials are currently settling in the aerated and settling lagoons. Current management practice is to contract out service for specialty dredging and dewatering equipment to periodically remove the settled solids from the two lagoons. The recovered material is then shipped offsite for disposal. The specialty contractor will typically survey the lagoon to determine the depth of the settled sludge. This is done from a boat and the results are used to provide an estimate and plan for removing sludge. In the last survey done in 2016, the there was an estimated 1308 cubic meters. The cost to remove and dispose of the solids was estimated to be $50,000 to 100,000 depending on how well the contractor could dewater the solids and thus reduce hauling and disposal costs.

The removal of solids is a necessary part of operations of the lagoon system as accumulation of solids reduces the effective treatment volume of the lagoons - thus reducing the effective capacity of the plant.

12.4 Upgrade Options

Municipalities have three primary options for biosolids management:

- recycle biosolids as fertilizer or other beneficial re-use,
- incinerate
- bury in a landfill.

These residuals can be recycled and applied as fertilizer to improve and maintain productive soils and stimulate plant growth. The controlled land application of biosolids completes a natural cycle in the environment. By treating sewage sludge, the biosolids can be used as valuable fertilizer, instead of taking up space in a landfill or other disposal facility. The organic nitrogen and phosphorous found in biosolids provide plant nutrients that are released slowly throughout the growing season. This enables the crop to absorb these nutrients as the crop grows. This efficiency lessens the likelihood of groundwater pollution of nitrogen and phosphorous.

The local example of this is the SkyRocket biosolids compost produced by the Comox Valley Regional District at their landfill to the north of Cumberland By combining the biosolids and wood chips for a defined time and temperature, the pathogens are reduced to allow for the safe recovery and use of the nutrients. OgoGrow is produced from Kelowna's sewage treatment plant and has been marketed to the community for decades. They combine the treatment plant dewatered biosolids with hog fuel - a by-product of the local lumber mills - and wood ash.

Incineration is an approach that provides effective reduction of volume and elimination of pathogens. This approach is more aligned with larger communities and is often used in combination of thermal recovery. The process does however generate higher greenhouse gas which is not favoured by the community.

Landfill is the current management practice.

12.5 Regulations

Biosolids directed to landfill are typically regulated by the management practices of the landfill. Typically, the solids must pass a paint filter test that provides an indication of water content. Typically, mechanical dewatering is completed at the treatment site using mechanical processes to provide a solid product meeting acceptance criterion at the landfill. Dewatering typically includes mechanical processes such as centrifuges, recessed plate presses, belt press and rotary drum presses. Other options include use of drying beds where sludge is in very shallow retention ponds that dry over time. A somewhat similar approach is to direct sludge to a permeable bag that allows water to escape and solids to accumulate within the bag. The dewatering solids remain in the bag and given time, the free water drains to allow collected solids to be sent to landfill or other intended Class B uses.

Given that the treatment plant site is not currently secured, any addition of biosolids treatment must restrict public access to the selected process area.

If biosolids are intended for beneficial use, elimination of pathogens is required to allow safe handling. Canada generally follows American federal biosolids rule 40 CFR Part 503. Biosolids that are to be land applied must meet these strict regulations and quality standards. The Part 503 rule governing the use and disposal of biosolids contain numerical limits for:

- metals in biosolids,
- pathogen reduction standards,
- site restriction,
- crop harvesting restrictions and
- monitoring, record keeping and reporting requirements for land applied biosolids

Most recently, standards have been proposed to include requirements in the Part 503 Rule that limit the concentration of dioxin and dioxin like compounds in biosolids to ensure safe land application.

12.6 Beneficial Re-use of Biosolids

Class A is typically the standard required for beneficial re-use. Class A biosolids contain no detectible levels of pathogens and low levels metals contents. Class B biosolids are treated but still contain detectible levels of pathogens. There are buffer requirements, public access, and crop harvesting restrictions for virtually all forms of Class B biosolids.

For re-use, the solids must have a process in place to control pathogens (disease-causing organisms, such as certain bacteria, viruses and parasites) and other organisms capable of transporting disease. The treatment of biosolids can be done completely at the treatment plant or can be combined with compost materials where time and temperature will control the pathogens for production of beneficial compost materials intended for marketing such as the Skyrocket in the CVRD and OgoGrow program in Kelowna.

An option for pathogen control of biosolids includes chemical addition (most typically lime) to the captured solids that are treated by raising the pH level and elevating the temperature. These systems tend to also eliminate objectionable odours. These systems are used in much larger facilities than Cumberland. Small plants have not included these systems and the high initial capital cost and high operating costs make operation less viable to more conventional approaches. As communities produce more sludge, the cost per cubic meter decreases making these systems more economically viable.

Biosolids treated to a lesser level (Class B) have also been used in the Province for industrial uses such as composting, mine reclamation, controlled silviculture for rapid timber growth in areas outside of a watershed. These uses appear a good fit for Cumberland and may provide an effective management of the water resource.

If beneficial re-use is planned, practices are required to the control odour, traffic, noise, and dust as well as the management of nutrients.

Processing of dewatered biosolids is presumed to be by composting at the nearby CVRD landfill facility. It is believed that CVRD are already directing the sludge to their organic composting. Thus, there is an indirect beneficial reuse already in place. The proximity of the landfill and available volume within the landfill plus operating cost make the current management practice the optimal short-term approach. In addition, the periodic nature of collecting biosolids from the lagoons does not align well with providing dedicated biosolids management equipment.

This may change depending on upgrade option selected.

12.7 Medium Term Plan

Options under consideration for upgrade would likely include processes for continual removal of biosolids. The process such as clarification, Dissolved Air Floatation and filtration would produce a continual biosolids stream of between 0.5 and 3% solids. This stream could not be sent to landfill as this would fail the paint filter test. Dewatering would be required. The intent of the plan would be to continue with disposal to the landfill and use of low cost permeable bags for dewatering. The anticipated approach included a secure area for the dewatering process, site preparation and a small control building to house the required chemical conditioning.

In the medium term, once biosolids are recovered from the new process, the volume and composition of the solids can be determined. Given the large hydraulic storage of the lagoons, the majority of solids will remain in the lagoons, thus falling under the current practice of periodic dredging. The community will monitor costs of dewatering and adherence to landfill criteria to confirm needs. The nature of the biosolids will represent an interesting opportunity. In theory, a large portion of the recovered solids will be algae and thus provide a high quality nutrient.

The community will gather data on the solids both from lagoon and from the secondary process(es) to study potential upgrades.

12.8 Long Term Plan

The community has aspirations to provide sustainable solutions and integrate innovative options meeting both the Village of Cumberland Social Procurement Policy and to provide a treatment system representing the "Cumberland attitude". In the long term the community will also have data from the optimized upgrade to the current two lagoon process.

Options for utilizing the valuable nutrient inherent in municipal sludge is a directive well supported by the Wastewater Advisory Committee. A phased approach is suggested whereby investment into the liquid portion of the plant must remain the focus. Once funding and detailing of the upgrade is complete, the community retains the advantage of having the landfill to manage the recovered solids. With the upgrade in place, the community can then review options for biosolids use. This may take advantage of the Cumberland owned forested areas for Silviculture projects. These projects are often challenged by seasonal restrictions, so this may be an approach of both landfill and silviculture. In public consultation sessions, expansion of agricultural activities – especially on the eco land had considerable support. Given the nature of the solids, the value of the biosolids may make the agricultural use a viable approach meeting sustainability directives and social values within the community.

The community will upgrade the plant then investigate the options of continuing landfill disposal or providing options for community use.

13.0 INTEGRATED RESOURCE MANAGEMENT (IRM)

13.1 Background

Integrated Resource Management (IRM) of municipal wastewater and water systems addresses the provision of water and wastewater services in the following manner:

- Focus on resource recovery within a business case model incorporating a structured analysis of options and a broad range of environmental considerations (GHGs, carbon taxes and credits, energy, etc.) evaluated to determine the net highest and best use, and maximizing value;
- Considers overall net impact to taxpayers taking into consideration a broad set of impacts on a range of stakeholders;
- In order to maximize energy recovery value and utilization, IRM requires integrated consideration of both liquid and solid waste streams (the latter is outside the scope of this document);
- Incorporates water management taking into consideration the reclamation and reuse of wastewater to reduce potable domestic and commercial/industrial water demands while benefiting watershed environmental resources;
- Considers ecological impacts and reuse opportunities to establish more resilient infrastructure solutions that are better able to adapt and accommodate future challenges, including climate change and population growth;
- Incorporates adaptive strategies, scales of application, and dynamic optimization of value realization; and,
- Maximizes sustainability in terms of maximizing environmental, social and financial values from waste with an overarching objective of zero waste.

Rather than focussing on cost, IRM is focussed on revenue potential and the costs to generate revenues, it takes into consideration both primary and secondary environmental benefits, optimizes the use of natural resources, and looks for synergies and opportunities for reclamation and recycling. Rather than adopting a conventional long-term strategy, IRM typically establishes an adaptive phased approach, recognizing factors that impact design, approach and capacity will change with time.

IRM also recognizes that although the cost of producing a specific resource is the same for various uses, the economic, environmental and social values are often significantly different. For example, under conditions of dwindling water supplies, the cost per cubic meter of water typically remains the same for supply, whereas the economic, environmental and social costs of the loss of water availability not only increases exponentially, but the net cost from a sustainability perspective can vary widely between water users. Under conditions of drought, those who can relocate to areas with greater water resources are less affected than those who are not as mobile. The greatest challenging in carrying out an IRM assessment is determining and quantifying the true costs and benefits of a particular resource under conditions of variable availability and demand.

One of the key potential benefits of IRM is the reduction in GHGs and the province`s carbon neutral objectives. With respect to water management, the greatest potential to maximize value is initiating measures for resource recovery, in particular water reclamation and reuse, at source, due to the significant benefits that can be attained with respect to reduced impact on infrastructure. Water conservation in the form of water reuse and recycling at the source reduces demands and environmental impacts of water resource extraction, and the costs and capacity impacts on water treatment and distribution, as well as wastewater collection, treatment and disposal.

Reclamation and reuse can also have significant environmental benefits. For example, recharging and augmenting water flows in wetlands and water courses can result in localized carbon sequestration and carbon credits as well as increased ecological resiliency for wetlands to adapt to climate change – taking into consideration their value in adsorbing and sequestering toxic organic and inorganic contaminants from stormwater runoff and downstream land use activities. While full life cycle valuation, including both social and environmental factors, costs and benefits, is challenging, it must be the focus of option comparisons to maximize IRM values including maximizing resources, revenues and broad sustainable benefits, with the highest and best use values, while meeting environmental standards. Social benefits can include the production of educational materials to inform the public and for use in the school education program (information and educational programs are integral to IRM success), and includes potential employment opportunities through the establishment of support businesses and industries in response to the recovered resources. This, in turn, leads to economic benefits with respect to new sources of revenue, reduced infrastructure life-cycle costs, and integrated labour efforts in recovering multiple resources with common infrastructure. It changes the financial paradigm from one of protecting the public and the environment at the lowest reasonable cost in managing the disposal of waste, to one of maximizing and optimizing economic benefits through resource recovery and establishing synergies between the social, environmental and economic objectives.

The BC government commissioned a task force study team review on the subject of Integrated Resource Management (2008) describes IRM as having the following attributes:

1. Smaller localized facilities incorporating off-the-shelf technology (higher competition resulting in lower capital cost), inherent redundancy, and ability to upgrade as technology improves;
2. Recovery and reuse of solid and sewage-based organic waste to recover energy and nutrients;
3. Wastewater reclamation, reuse and recycling to reduce potable water demands and environmental resource extraction; reduced water and wastewater infrastructure upgrade costs to serve increasing populations; enhanced recharged creeks, wetlands and groundwater; and decentralized discharge to reduce environmental and ecological impacts associated with centralized discharge location;
4. Minor modifications to existing infrastructure (maximize the use of existing infrastructure rather than replacement); and
5. Energy capture taking into consideration smaller localized applications with higher grade heat in the wastewater.

Taking an IRM approach involves re-examining conventional approaches to wastewater management that are oriented towards minimizing the impact on the environment, by considering ways to enhance the environment and generate revenues. It also involves considering and addressing liquid and solid waste streams together, as well as potable and non-potable water opportunities, and the relationship between water and wastewater management and energy. From a planning perspective, this could involve considering wastewater as a water resource and integrating planning for potable and non-potable (reclaimed water) distribution systems, or adopting a decentralized wastewater reclamation strategy to minimize the need for and costs for non-potable water distribution. Or it could involve a comprehensive energy assessment pertaining to the relationship between the treatment and distribution of water, the collection and treatment of wastewater and the energy involved in pumping, treatment, and gravitational & thermal energy.

13.2 WASTEWATER AS A RESOURCE

Water is a universal polar solvent that characteristically erodes, dissolves and solubilises solid material that it comes into contact with in its use resulting in a gradual increase in suspended and dissolved organic and inorganic solids;

from the point it condenses as a water droplet in the atmosphere through its passage over and under the surface of the earth, to its eventual cyclic return to the ocean. Some of this water is collected and used as a source of freshwater for domestic and industrial purposes and, in the process of being used, the water entrains organic and inorganic dissolved and suspended solids such that the water is referred to as a wastewater and requires treatment to reduce the concentration of the contaminants present to prevent the water from having a detrimental impact on the environment or public health when released to the environment. The contaminants fall into the following categories:

- Total Dissolved Solids (TDS) consisting of about dissolved (mostly biodegradable) organic matter and (non-biodegradable) inorganic metals and salts. Dissolved organic contaminants can typically be treated by biological oxidation. Dissolved inorganic contaminants typically require chemical removal, and are characteristically more difficult and costly to remove. While phosphorus is often removed chemically, both nitrogen and phosphorus can also be removed biologically.
- Total Suspended Solids (TSS) consisting of about 80 percent organic (volatile) solids and 20 percent inorganic (non-volatile) solids.

While domestic wastewater contains trace levels of many metals, the concentration is typically too low and the cost of extraction and separation are too high to make recovery as a resource a consideration. While the dissolved salts also have little economic value to recover, under certain circumstances nitrogen and phosphorus can be recovered and recycled for agronomic use as fertilizer.

Water also has physical properties that make it useful for suspending and transporting solids and energy. With adequate velocity within a pipe or channel, it can be used to transport solids either in suspension or as a high-density slurry. It is also an effective medium for absorbing and transporting thermal energy for cooling or heating purposes.

Water supports and is essential to life. Without water there can be no industry, and life cannot be sustained. It is a precious resource and one that is subject to being taken for granted when there is excess.

The sections in this Technical Memo further discuss three key resource aspects of water including: 1) the ability to recycle, reclaim and reuse water to reduce demands of this resource from the environment; 2) the ability to concentrate, collect, and use nutrients contained within wastewater for agronomic purposes; and 3) the ability to recover and distribute thermal energy.

13.3 Recovering Water - Recycling, Reclamation and Reuse

The world's supply of fresh water is finite and the availability of this precious resource to satisfy urban needs is threatened by pollution and climate change, resulting in higher temperatures, changes in precipitation, rising sea levels, and increases in the severity and frequency of severe weather events. Increasing use of limited water supplies to meet agricultural, industrial, and municipal demands is creating competitive pressure around limited fresh water resources and a growing need to manage water resources in a sustainable manner.

As communities look for ways of making more efficient use of existing potable water supplies, there is growing interest in putting highly-treated wastewater to beneficial use, making reclaimed wastewater an important water resource, rather than a liability, and a means of reducing anthropogenic impacts.

Water reclamation and reuse involves treating wastewater for beneficial non-potable applications, including agricultural and landscape irrigation, toilet and urinal flushing, replenishing ground water (ground water recharge), cooling water, fire suppression, and a wide range of industrial applications. Unplanned indirect potable reuse (IPR) commonly occurs along freshwater rivers and lakes systems where upstream municipal treated wastewater discharges contribute to downstream municipal potable water intakes. Planned IPR has been implemented for over 40 years in North America, where reclaimed wastewater is used to replenish depleted groundwater or surface water sources for the intentional purpose of augmenting drinking water supplies.

There has been a long history of wastewater reclamation for non-potable reuse in the U.S. and Canada, with growing public and industry interest regarding the use of reclaimed water for appropriate domestic, commercial, or industrial non-potable water applications. Both US and Canadian jurisdictions have adopted legislation to facilitate water reuse, with British Columbia being the first province to establish a comprehensive wastewater reclamation regulation under the Municipal Sewage Regulation (1999), which was recently revised as the Municipal Wastewater Regulation (2012).

The Canadian federal government has also recognized the importance of using reclaimed wastewater for non-potable reuse applications to conserve potable water supplies. In 2010, Health Canada published the Canadian Guidelines for Domestic Reclaimed Water for Use in Toilet and Urinal Flushing, a document prepared with the financial support of the Canada Mortgage and Housing Corporation and a committee comprised of provincial health representatives from across Canada, for the purpose of reducing domestic potable water consumption. Established to ensure that the operation of water reclamation systems protect of public health, the document provides guidelines for domestic reclaimed water quality for use by regulatory authorities, public health professionals, engineering consultants, and others with a technical understanding of the subject area.

Whether the purpose of treatment is to remove and recover valued resources or otherwise remove constituents that could have a detrimental impact on the environment and/or public health, the water quality is improved either for the purpose of releasing the water to the environment or reusing it for beneficial purposes.

The BC Municipal Wastewater Regulation (MWR) provides for four (4) reclaimed wastewater water quality standards:

1. Indirect Potable Reuse – reclaimed water used to replenish a potential potable water source;
2. Greater Exposure Potential – reclaimed water used where public contact is likely;
3. Moderate Exposure Potential – reclaimed water used with moderate risk to the environment and either pubic is educated regarding the risks or has restricted to the reuse application; and
4. Lower Exposure Potential - reclaimed water used with low risk to the environment, restricted public access, the public is unlikely to come into contact with the reclaimed water, or an industrial or commercial reclaimed water application.

The MWR applies to all uses of reclaimed water unless the reclaimed water is from a sewerage system that serves only a single family residence or duplex. Consequently, a single family residence or duplex cannot register a discharge for the purpose of reclaiming and reusing the wastewater. The only other legislation that addresses wastewater generated by a single family residence or duplex is the Health Act Sewerage System Regulation, in which the discharge to a surface body of water or land, regardless of the intent to reuse the water, is prescribed as being a health hazard unless authorized under another enactment (i.e. MWR).

It is not clear from the wording of the regulations whether the reclamation of wastewater for a reuse application, that does not involve a discharge to the surface body of water or land, constitutes a health hazard – the use of reclaimed wastewater for toilet flushing purposes, for example. Considering a single family residence or duplex is exempt from having to meet the water quality and other reuse requirements of the MWR, and the MWR would otherwise require a letter of authorization from Health for the reuse application, it would appear that Health would likely be concerned about such a reuse application – it's just not clear whether they have jurisdiction or whether toilet use could be considered to be a land application under the Health Act. Previous legislation through the Municipal Sewage Regulation contained a description of the regulated reclaimed wastewater reuse applications that included toilet flushing. A request for clarification to the Attorney General's office at the time the MSR was in place determined that it would apply to all applications of reclaimed wastewater for toilet flushing, regardless of whether or not there was an environmental release; however, that legislation is no longer valid.

While the application of reclaimed wastewater to land or surface body of water for beneficial purposes is the sole jurisdiction of the Ministry of Environment under the Environmental Management Act - Municipal Wastewater Regulation, the Plumbing Code and municipal bylaws can also be a factor in the application of reclaimed water, and Health could determine such applications constitute a health hazard. The BC Plumbing Code was modified in 2012 to accommodate dual plumbing systems (i.e. potable and non-potable water supplies), enabling non-potable water to be distributed legally to users, and allowing non-potable water to be discharged to a plumbing fixture. Prior to the change, it would have been contrary to the plumbing code to use reclaimed water to fill a toilet tank for flushing – unless the code had been modified accordingly through a municipal bylaw.

The implementation of wastewater reclamation and reuse requires plumbing codes and performance standards to assist municipalities in permitting and regulating these systems. In Canada, the plumbing requirements for non-potable water systems are addressed by the Canadian Standards Association (CSA) Standard B128.1-06/B128.2-06, Design and installation of non-potable water systems / Maintenance and field testing of non-potable water systems (CSA, 2006) as well as B128.3, Performance of non-potable water treatment systems (CSA, 2010), which establishes performance verification and testing criteria for onsite (in-building) wastewater reclamation package treatment technologies.

The economic rationale for municipalities to consider water reclamation opportunities, by-laws and plumbing codes is significant. Flushing with reclaimed wastewater can reduce water demands within the home by about 30 percent, equivalent to approximately 126 m^3 per year per household, and resulting in a savings of about $200 per year per household. Beyond the bulk value of the water saved, however, the benefits are numerous, including:

- a more balanced, practical approach to water management, providing consistent, reliable water supply as communities face climate change challenges;
- reduced demands on water supply, treatment, and distribution infrastructure;
- reduced demands on wastewater collection, transport, and treatment infrastructure;
- reduced discharge of treated wastewater into receiving environments and reduced water pollution;
- protecting and preserving environmental resources by providing more water and increased environmental benefits to many watersheds, rivers, and streams for fish habitat;
- overall ability to provide water and wastewater services to a greater population density than would otherwise be possible without water reuse, using existing water and wastewater infrastructure; and
- eliminating, downsizing, or postponing the need for capital projects for upgrading water and wastewater infrastructure capacity.

The most ecologically important use of reclaimed water is that it reduces the amount of potable water required and allows more water to remain in streams, rivers and lakes, and enables communities to meet the demands of increasing populations with decreased demands on environmental resources.

Although most of the urban water reuse applications to date have involved large-scale centralized treatment facilities serving entire municipalities, there is a growing trend towards constructing building-scale decentralized systems, where the wastewater generated within a residential or commercial building is treated and reused to satisfy the non-potable water needs of that structure. While centralized systems are perceived to offer economies of scale, once the pumping and pipeline costs of transferring reuse water back into the community is taken into consideration, decentralized systems can be a more cost-effective alternative – plus, they can adapt more readily to improvements in technology than centralized facilities. Decentralized and parcel-level wastewater treatment presents more opportunities for water reuse and lower cost of application, as treatment systems can be located closer to the reuse application. Additionally, the level of treatment provided can be matched to the water quality requirements of specific reuse applications, reducing or minimizing the overall costs of treatment. As an integrated system, decentralized applications can also facilitate more cost-effective recovery and use of thermal energy and potentially biosolids (organic solids tend to break-up and be more difficult to extract from wastewater as they pass through the sewage collection system).

Recent examples of buildings with internal wastewater reclamation and non-potable water reuse systems in North America include: the Missouri Department of Conservation Discovery Center (Kansas City, MO); Dockside Green (Victoria, BC); the Vancouver Convention Centre (VCC) West building (Vancouver, BC); and the recently completed (2011) University of British Columbia Centre for Interactive Research in Sustainability (CIRS) building (Vancouver, BC). All four buildings reclaim wastewater for non-potable reuse applications including toilet flushing, and satisfying irrigation demands. Toilet flushing and irrigation are typically responsible for 80 percent or more of a commercial building's water demands. The UBC CIRS building also incorporates sewer mining, in order to generate sufficient reuse water to meet the building's irrigation demands during the summer, a period with fewest building occupants.

The VCC and CIRS buildings' water reclamation facilities offer an interesting comparison, the former using a state-of-the-art activated-sludge membrane bioreactor process incorporating hollow-fiber ultrafiltration membranes, and the latter consisting of a conventional activated-sludge process that uses a secondary clarified for bacteria retention, but which also has floating plants over the bioreactors and polishes the treated effluent through constructed wetlands.

The VCC treatment plant operates very much behind the scenes and, aside from signage in the building advising that reclaimed water is used to flush the toilets and urinals, most visitors to the building are relatively unaware of the water reclamation process. On the other hand, the CIRS system is very much evident to visitors entering the building, appearing to be a large in-building greenhouse located right in front of the main entrance. While the plants functionally do very little to treat the wastewater, they do serve as a highly visible reminder to the occupants and visitors that what is flushed down sinks and urinals will directly affect the plants in the treatment process, inherently making the occupants of the building part of the overall treatment process – helping to prevent contaminants from being released to the environment through source control.

13.4 RECOVERING NUTRIENTS

The opportunity to recover phosphorus and nitrogen from wastewater arises from biological treatment involving growing bacteria on the soluble biodegradable organic matter present in the wastewater. The bacteria also require nitrogen and phosphorus to grow, and if biological nutrient removal (BNR) processes are implemented the amount of phosphorus stored by the bacteria can be many times that required for growth. Because of the high cost of disposing waste bacteria, wastewater treatment plants typically include some means of digesting excess bacteria (biosolids), and then dewatering the digested sludge to reduce transport and disposal costs. In the process of dewatering the digested sludge, a high concentration of phosphorus and ammonia nitrogen is released with the removed water, that is normally returned to the plant for treatment. However, technologies have been developed to, instead, precipitate the phosphorus and nitrogen in the form of magnesium ammonium phosphate (MAP or struvite) from the removed water (e.g. Ostara), or as calcium phosphate, and under certain circumstances as ammonium calcium phosphate, through a side-stream stripping process (e.g. Phostrip).

The PHOSTRIP process involves creating environmental conditions under which Acinetobacter release excess stored phosphorus, and then precipitating the phosphorus out as calcium phosphate using lime. Acinetobacter species are capable of storing phosphorus in excess of growth requirements in the form of poly-phosphate granules as an energy storage mechanism, and when subjected to anaerobic conditions they release phosphorus and use the energy generated to store short-chain organic acids (acetate, propionate, etc.) in carbon deposits for growth.

Cumberland wastewater contains phosphorus in both solid (organic/volatile suspended solids) and dissolved (ortho-phosphorus) forms. The total amount of phosphorus present in Cumberland wastewater consists of:

- Dissolved: 5 mg/L x 1,000 m^3/d = 5 kg-P/d
- Organic Solids: 300 mg-solids/L x 30 gm-P/1,000gm-solids x 1000 m^3/d x 0.8 volatile = 7.2 kg-P/d

Excessive phosphorus loading of the soil can be an environmental concern. At soil levels lower than about 150 ppm, phosphorus will adsorb to soil particles and not move through the soil; however, once the saturation level is reached, phosphorus can move down into the soil profile. Each soil layer can only retain a fixed amount of phosphorus, and once that is exhausted additional phosphorus contributions will move further through the soil. This type of movement has been demonstrated in long-term (40 year) manure application studies in sandy soils located below feedlots even when the 150 ppm P-saturation capacity of the soil had not been reached. However, this vertical movement is very slow and can be readily monitored with sufficient time to take corrective action should there be evidence of phosphorus movement.

Cumberland wastewater also contains nitrogen in both solid (organic/volatile suspended solids) and dissolved (ammonia) forms. The total amount of phosphorus present in wastewater consists of:

- Dissolved: 50 mg/L x 1,000 m^3/d = 50 kg-N/d
- Organic Solids: 300 mg-solids/L x ?0 gm-P/1,000gm-solids x 1000 m^3/d x 0.8 volatile = ?.?kg-N/d

A site specific opportunity for nutrient recovery at Cumberland is that of phosphorus recovery from the DAF (dissolved air flotation) unit which will be used to separate suspended solid particles. These particles include suspended sediments and algae, and chemical precipitates containing phosphorus. The DAF injects a stream of extremely fine gas bubbles that become attached to solids, and float them to the surface of the DAF tank where they can be skimmed off. The skimmed solids, or sludge, is then placed into geotextile bags (Geotubes) that allow retained water to seep through the fabric, while retaining the solids within the bag – dewatering the sludge. The dewatered solids from the DAF unit will have a very high phosphorus content, which presents a potential resource recovery opportunity. This possibility will be further studied once the system is in operation and the sludge characteristics are confirmed.

13.5 Energy Recovery

There are many ways to recover energy from wastewater including the extraction of organic solids from the raw wastewater and biosolids generated during treatment, and the conversion of that organic material through pyrolysis to oil, anaerobic digestion to generate methane gas and other fuels for combustion purposes (i.e. vehicle fuel or heat/electricity generation), or the extraction of heat from the wastewater or digestate using heat pumps.

Wastewater discharged from residences to sewer has a temperature of about 25 ºC, and typically drops to an annual average of about 15 ºC due to thermal losses to the soil surrounding the sewer line and the influence of stormwater entering the sewer. Cumberland wastewater temperatures entering the treatment lagoons range from a low of about 5ºC during the winter to a high of about 19ºC during the summer. The cooler winter temperatures are largely caused by the cold stormwater content and heavy precipitation events can drop the liquid temperatures by as much as 6ºC over a couple of days, with day-to-day temperatures typically varying by as much as 3ºC. While these temperatures may not appear to be attractive from a heat recovery perspective, taking into consideration the mass of wastewater they represent a significant flux of heat that can be recovered. Using modern heat pumps, these sewer temperatures can be used to generate usable product water temperatures of about 65-70 ºC, which is sufficient for heating buildings.

To rationally consider a wastewater heat recovery scheme, several key questions need to be addressed:

1. How much energy is represented in the thermal mass of wastewater entering the treatment facility?
2. Where can the heat be most cost-effectively extracted without having a detrimental impact on biological wastewater treatment (as wastewater temperatures cool, the length of time and capital cost to achieve the required level of treatment increases)?
3. Taking into consideration existing and potential future infrastructure, what methods are available to recover heat and how can they be best applied?
4. What kind of systems and infrastructure are required to transfer the recovered thermal energy to a location for beneficial use?
5. What are the capital, operating and maintenance costs for the required heat recovery and energy transfer systems?
6. What are the capital, operating and maintenance costs for the energy system being off-set by the heat recovery system?
7. How will the project be financed?

Often only the value of the commodity being recovered is taken into consideration in assessing resource recovery options. However, a more sustainable assessment approach takes into consideration other critical factors including:

- Life cycle costs for the heat/energy recovery system, and for the energy system and resources that are being conserved, noting that a heat pump's working lifetime is expected to be significantly greater than for a boiler due to the low working temperatures and reduced corrosion/scaling potential.
- Consideration for limitations in non-renewable energy systems, and future changes in energy cost.
- Increased capacity of existing energy infrastructure to serve a greater population and business development density, including delaying the need for upgrading those systems to meet increasing demand.
- Educational and social leadership values, increasing the awareness among the public and industry of the value and importance of energy resource recovery and conservation, and the cumulative importance of individual efforts to save and recover energy.
- Increased industry investment in research to improve energy resource recovery technologies and resulting improvements in recovery efficiencies and decreased system costs as a result of increased public awareness and value for energy recovery systems.
- Potential reductions in GHG emissions.

In considering a wastewater heat recovery system it is important to take into consideration the number and location of potential users of the recovered thermal energy as well as the number and location of other potential sources of waste or otherwise available heat.

The distance between heat recovery and energy utilization needs to be minimized to avoid excess heat loss that can adversely affect economics. In addition, the higher the wastewater temperature, the greater the potential energy recovery efficiency. Consequently, thermal energy recovery is generally most efficient if carried out immediately following use, such as extracting heat from the drain lines of dishwashing equipment, laundry, and bath/showers (i.e. greywater sources).

If the users of the extracted thermal energy are located closely together, there may be an opportunity to consider a district energy sharing system. Heat recovered from wastewater could be distributed through a high-volume low-velocity circulating storage-loop pipeline to public buildings, commercial buildings, residences, institutional buildings and industry, as well as integrated with geothermal heat RECOVERY (e.g. mine water), as illustrated in Figure 14-1.

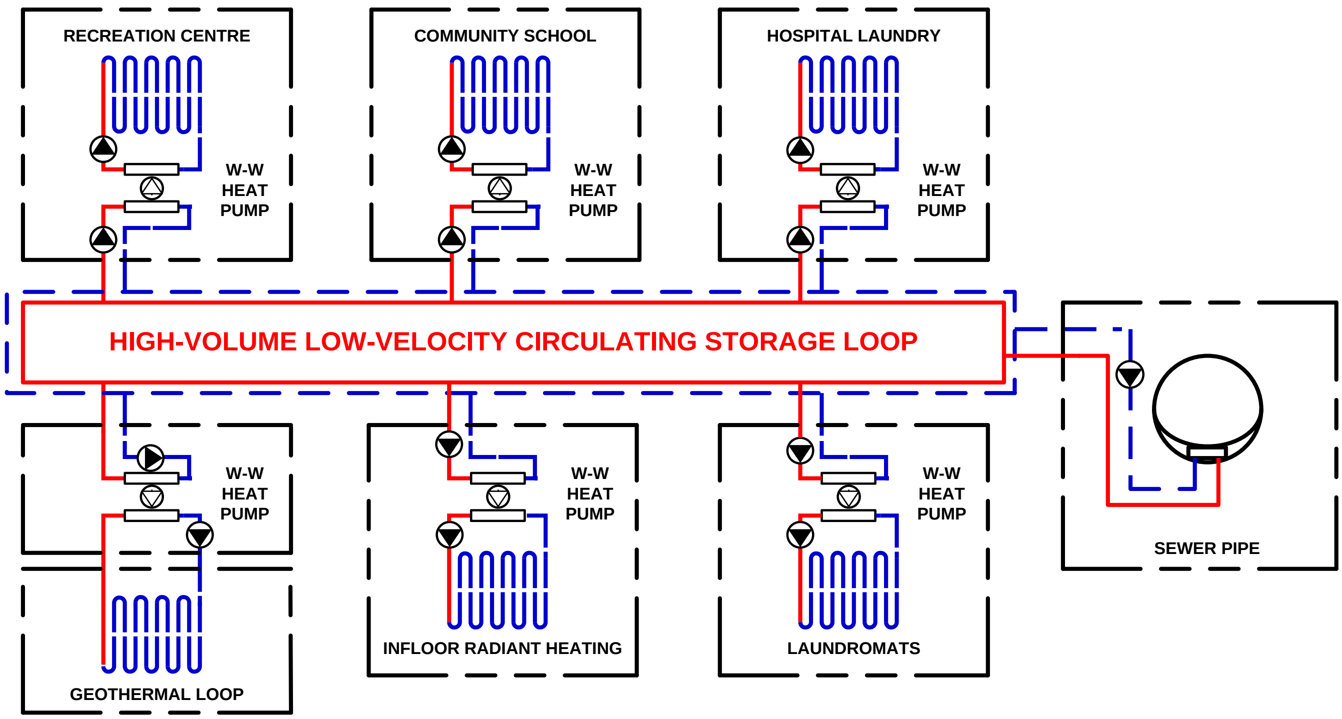

Figure 13-1 District Energy Sharing System Concept

It is also important to take into consideration other potential energy sources as a means of maximizing energy benefits while minimizing overall costs. For Cumberland, this could involve extracting and distributing waste thermal energy in the wastewater from the Regional Hospital laundry facility and/or providing the laundry facility with thermal energy obtained from the treated effluent. Although not within the scope of the LWMP, it may even be possible to collect geothermal energy through mine water sources for distribution.

Another factor favouring a DESS-type process is that the availability of wastewater thermal energy may not coincide with the variability in energy demands. For example, building heating requirements in the morning typically precede increases in wastewater temperature and flow as a result of morning baths, showers and laundry. Consequently, the distribution of recovered thermal energy must also have capacity to store and equalize thermal energy while minimizing energy losses.

Heat pumps are used to move or transfer excess thermal energy from wastewater to a closed-loop system containing a carrier fluid (water or refrigerant) within a District Energy System (DES), which is used to convey the thermal energy to buildings for use in space or hot water heating. The amount of heat that can be recovered depends on a number of physical parameters (i.e. wastewater temperature & flow, heat transfer efficiency, and specific heat capacity) as well as consideration for the impact of reduced liquid temperatures on biological treatment efficiencies. Because of the latter consideration, thermal recovery is often done using residual effluent temperatures following biological treatment. Liquid temperatures below 15 ^{o}C can significantly impact biological treatment, reducing growth rates by as much as 50% with a 3 ^{o}C drop to temperatures below 12 ^{o}C.

Transferring the energy from wastewater does have some energy cost, with the ratio of the heat output to the electrical power required referred to as the Coefficient of Performance, with is typically about 3-4 for geothermal heat pumps, meaning 1 Joule of electrical energy is required to extract and transfer about 3.5 Joules of heat energy. The COP is not a constant and is affected by the temperature difference between the source temperature and the output, as illustrated in Figure 14-2, making the determination of overall energy efficiency more complex than simply selecting a typical COP value.

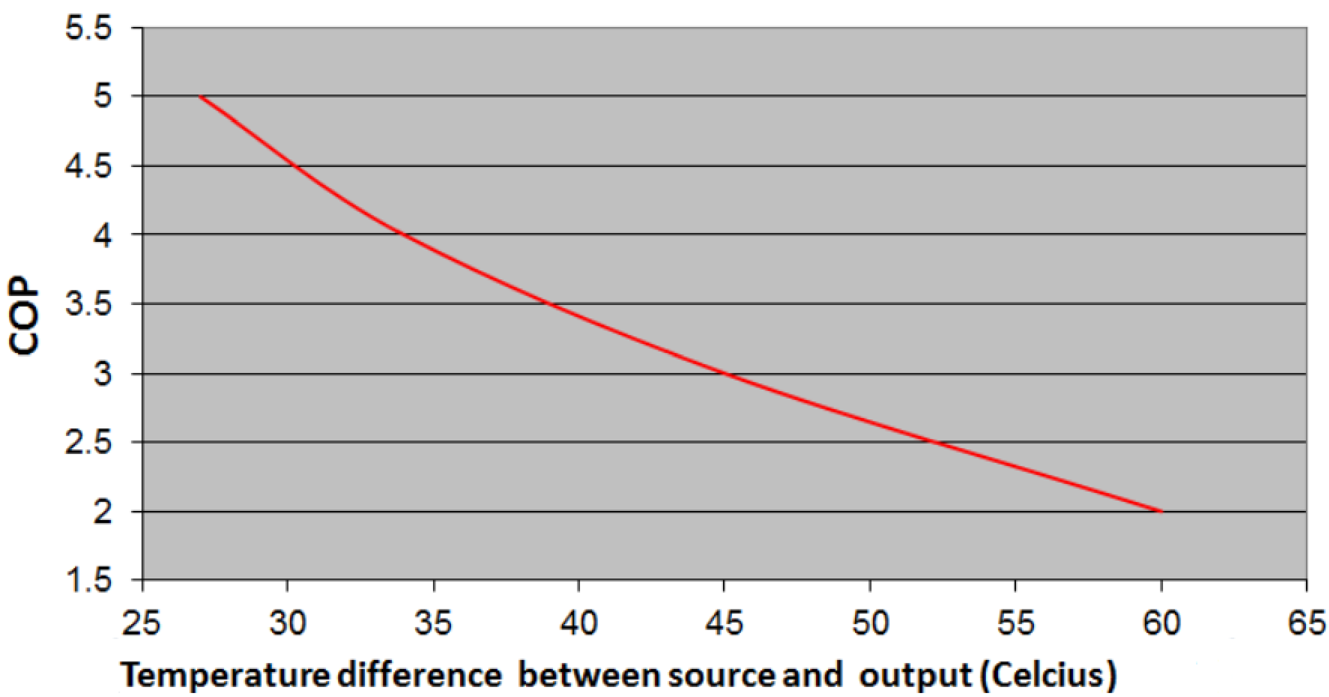

Figure 13-2 Relationship between Coefficient of Performance and Temperature Difference for a Heat Pump

To illustrate the amount of energy potentially recoverable, the energy required to increase the temperature of 1,000 m^3 of water by 1 ^{o}C is 4,185 kJ, or 3,967 BTU.

Potential wastewater related thermal extraction methods include:

- Geoexchange loops installed on the bottom of the lagoons (similar to that implemented by Metro Vancouver at the Seymour-Capilano filtration plant to heat and cool space and heat domestic hot water);

- Wastewater (similar to Southeast False Creek neighbourhood energy system for space heating & cooling and domestic hot water).
- Regional Hospital Laundry Facility waste heat captured from laundry greywater. Other opportunities to capture waste heat from refrigerant facilities within the community could be explored.
- Treated wastewater effluent (similar to the Okanagan District Heating system (first in Canada and in operation since 2003) and CRD Saanich Peninsula Thermal Energy Recovery System (in operation since 2012, that recover heat from treated effluent and uses it to supply hot water)

Like water reclamation and reuse, energy in sewage may be more cost effectively collected and distributed for heating a cooling purposes in nearby buildings using heat pump technology in decentralized applications. Locating the heat extraction immediately adjacent to the point of use in a decentralized application also reduces the heat or energy lost associated with transmission either from the source to the point of extraction or from the point of extract to use. Further, it is more energy efficient to extract heat from high-temperature streams (e.g. drain-line from a commercial dishwasher or laundry machine) than from cooler temperature streams once the hot water has mixed with cooler wastewater in the sewer.

There are a number of companies who manufacture systems designed to extract thermal heat from wastewater.

13.5.1 RABTHERM Energy Systems

Rabtherm designed and installed their first sewer heat recovery system over 20 years ago. Their system is based on an integrated heat exchanger that is embedded in the bottom of a section of sewer pipe, or within a sewer, as illustrated in Figure 14-3 and Figure 14-4. The company has developed an anti-fouling system to prevent the formation of slime that can interfere with thermal transfer efficiencies. The system can produce approximately 2-3 kWh per cubic metre of water. Key criteria include the following:

- Minimum sewer diameter 800 mm
- Minimum average wastewater flow of 1,000 m^3/d
- Heat exchanger lengths 9 m (min.) – 200 m (max.)
- Maximum distance from sewer to consumer: 200 m
- Primary product temperature: 70 ^{o}C

Figure 13-3 RABTHERM Heat Recovery

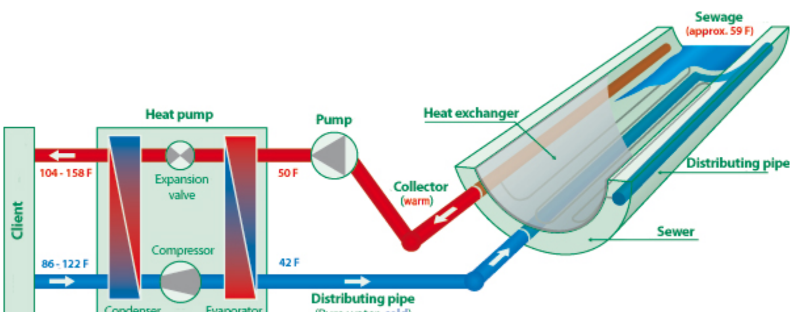

Figure 13-4 RABTHERM Schematic

13.5.2 SHARC Energy Systems

Figure 13-5 SHARC System

Illustrated in Figure 14-5 and 14-6, the SHARC is a skid mounted unit that is designed to extract heat from raw wastewater, removing solids larger than 3/32 inch that would otherwise interfere with the operation of a heat exchanger. Heat recovery claims are about 1,500,000 BTU/hr for a wastewater flow of 350 gpm based on a COP of about 5.3. Separated solids are discharged through an outlet located on the bottom of the SHARC.

The heated process fluid is then pumped to a water-to-water Carnot cycle heat pump which transfers the heat to a domestic hot water storage tank. The sewage from the heat exchanger is combined with the solids from the SHARC and returned to the primary sump.

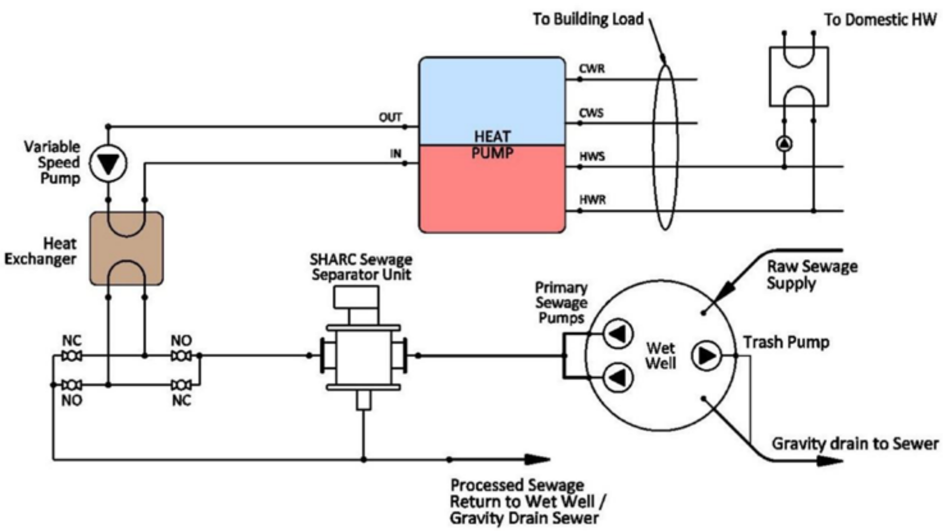

Figure 13-6 SHARC System Schematic

13.5.3 Heat Recovery by the Cumberland Regional Hospital Laundry

An unusual and very site-specific opportunity exists for an off-site heat recovery project at the adjacent commercial laundry operation – the Cumberland Regional Hospital Laundry. This laundry facility takes the hospital linens form the Comox and Strathcona area hospitals. It is the largest potable water use in the Village of Cumberland, using about 100 cu.m/day of water, or 12% of the average dry weather flow seen at the lagoons.

Like any commercial laundry, it uses a significant amount of energy for hot water. Having a large commercial user of low grade heat (i.e. not steam) right next to the wastewater lagoons is an unusual opportunity for a “close coupled” heat recovery system.

A simple configuration would be for the final, disinfected lagoon effluent to be piped over to the laundry, where are SHARC system would then extract the heat for use by the laundry, with the heat depleted water being returned to the lagoon facility for discharge to Maple Lake Creek or the reed-bed and wetlands.

District heating systems using wastewater heat suffer from the fact that when the heat is needed most – in the idle of winter – is when the wastewater temperatures are the lowest, and the least heat is available. When the most heat is available – midsummer – there is little heat demand on the district system. The laundry is a different case, as it is a year round heat user, so the summertime heat content of the effluent water could be used.

Island health provided heat consumption (natural gas) data for the laundry, which uses 40GJ/day in summer and 60 GJ/day in winter.

A simplified heat recovery model has been prepared based on the “average minimum flow” at the lagoons. The model assumes that the Sharc system can withdraw heat down to 5 degrees C – although Sharc have said that lower temperatures are achievable, but the Coefficient of Performance gets lower as the exit temperature gets lower. The data are presented in Table 13-1 and graphically in Figure 13-7.

Table 13-1 Preliminary Heat Recovery Model for Cumberland Hospital Laundry.

Month	Modelled flow for heat recovery	Influent Temp	Effluent Temp	Min water temp	Available Heat	Available Heat	Laundry Heat Demand
	m3/day	C	C	C	kW	GJ/day	GJ/day
Jan	1500	10.4	3.5	5	(109)	(9)	60
Feb	1500	8.9	5	5	0	0	60
Mar	1500	8.5	7	5	145	13	55
Apr	1000	10.7	8	5	145	13	45
May	1000	13	16.8	5	572	50	40
Jun	800	15.5	19	5	543	47	40
Jul	800	18	20.5	5	601	52	40
Aug	800	19	19	5	543	47	40
Sep	800	18	15	5	388	34	40
Oct	1500	16	10	5	364	32	45
Nov	1500	12.9	5.5	5	36	3	50
Dec	1500	11.4	4	5	(73)	(6)	55

The results show that there is more than enough heat available for four months of the year, and that in winter there is a minimal heat resource.

The comparison of lagoon influent and effluent temperatures, presented in Figure 13-8 also shows that the lagoons “gain” heat in summer – they are effectively acting as large, low temperature solar collectors. Extracting this excess heat would not only benefit the laundry, but also the receiving waters of Maple Lake Creek as they would receive cooler water in summer, instead of “heated’ water. This would help to further restore natural inflow conditions into Maple Lake Creek.

Supplying recovered heat to the laundry would also be a great example of “carbon neutral” energy, and would achieve a net carbon reduction by displacing natural gas.

Island Health has expressed interest in this possibility and are conducting their own preliminary feasibility study of the concept. The proposed operating model is for Cumberland to "give" the treated effluent to the laundry to extract as much heat as practical, and then return the water to Cumberland.

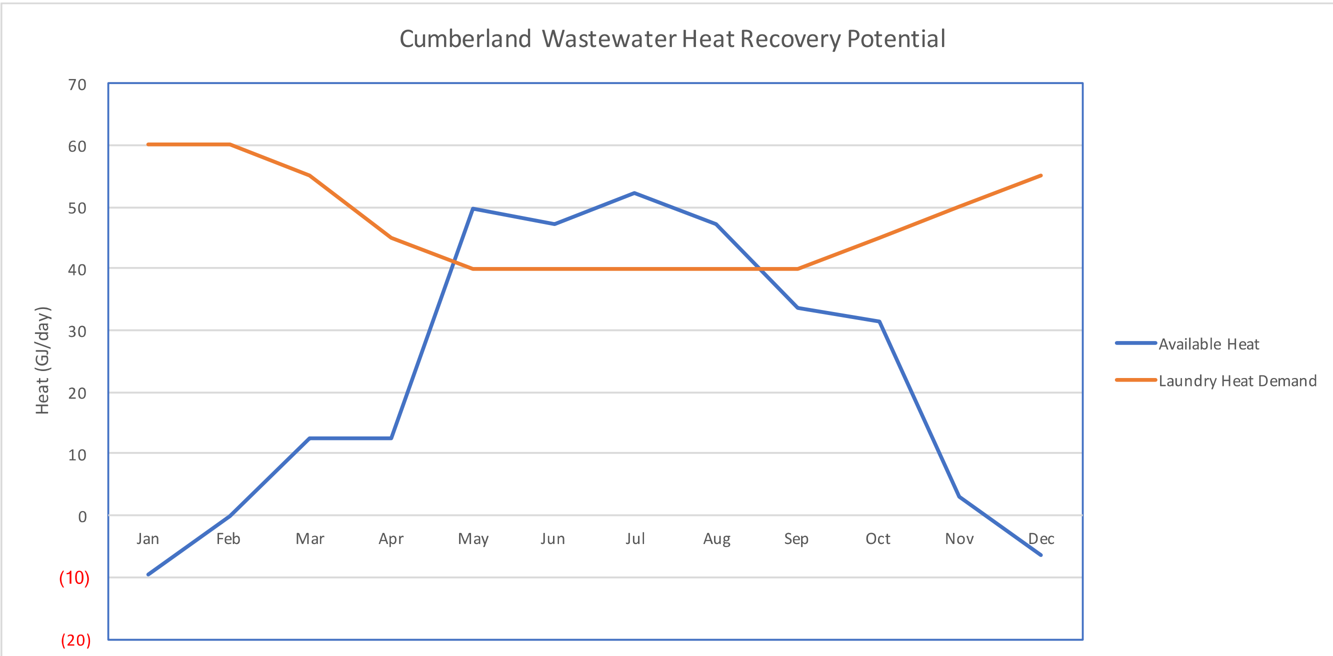

Figure 13-7 Monthly Heat Availability and Demand

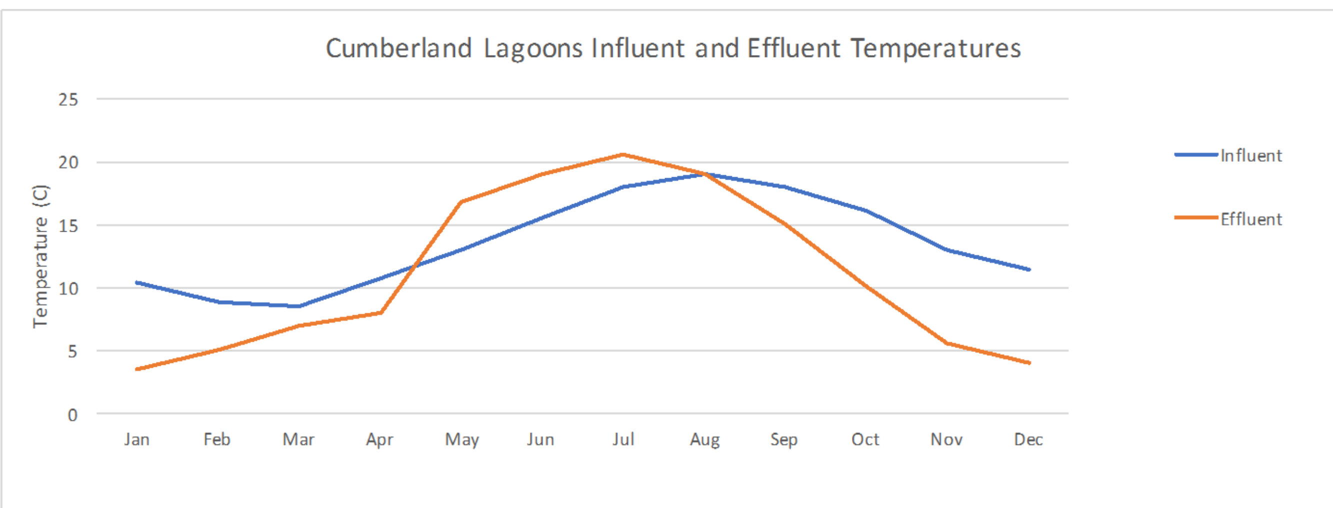

Figure 13-8. Monthly Influent and Effluent Temperatures.

13.5.4 Biogas Generation

Raw wastewater contains about 300 mg/L of primary solids, of which about 80% is organic and biodegradable. The wastewater also contains soluble biodegradable organic matter (about 300 mg/L) which is consumed by bacteria in the secondary treatment process and converted into bacterial or secondary biosolids. Most conventional mechanical treatment processes are designed to remove a high percentage of the primary solids to reduce the organic loading on the treatment plant and, thereby, reduce the amount of energy and oxygen required to digest the organics as well as reduce the amount of bacteria grown in the process. Further, to prevent excess biosolids buildup in the process, a proportion of the secondary biomass is routinely removed and wasted from the process and sent to a mechanical thickener. The thickened secondary biomass is then combined with the mechanically thickened primary biomass, and the combined sludge is then sent to an Anaerobic Digester for the purpose of reducing the amount of waste sludge and to convert the digested biomass into biogas. The biogas typically consists of 50 to 60 percent methane gas, which is collected, combusted and used to produce heat and electricity. If a thermophilic digestion process is used, the elevated temperatures (in excess of 55 oC) also reduces the number of disease causing microorganisms (pathogens) that may be present. The digested sludge is then sent to a centrifuge for dewatering to about 30% solids, and the dewatered solids are then often transported to a composting facility or they may be pelletized and directly land applied.

The cost effectiveness for an anaerobic digester generally improves with facility size and the availability of primary solids with a high volatile content. Option 1 is not well suited to biogas generation as the majority of the primary and secondary solids are trapped within the lagoons where they are subject to biological degradation and stabilization. The amount of biosolids gradually accumulates to a point where the lagoons require desludging, and the dewatered sludge is typically sent to a composting facility for further stabilization and thermal treatment. Even if the dredged biosolids retained a significant volatile content, the dredged sludge would not be suited to anaerobic digestion as it is removed very infrequently.

Option 1A and 1B, and Options 2 and 3, incorporate both primary solids separation and generate secondary biosolids. Consequently, anaerobic digestion is a potentially technically viable option. The key concern regarding viability is whether the quantity of biogas that can be generated is sufficient to justify the higher capital cost for stabilization in comparison to alternative aerobic stabilization processes. From an IRM perspective, the economic viability could be significantly improved if combined with an organic solid waste stream from the community.

Other key factors that improve economic viability and sustainability include the market value of the energy generated, efficiencies in transferring the energy to where it is needed, and GHG and carbon credit considerations. There are several options to secure revenue from the generated methane including transport by pipeline or to burn it and generate electricity or distribute the heat. Combustion to convert the gas to electricity will result in energy loss and is unlikely to yield the highest and best value, nor would it maximize carbon reduction. Other options include using the methane to displace gasoline or diesel vehicle operation as a biofuel. Transportation, again is a key issue, but it may be possible to clean the gas and pipe it through existing natural gas lines, or establish a municipal works fueling station.

14.0 COMOX LAKE AREA SERVICING

14.1 Description

The Comox Valley Regional District (CVRD) uses the Comox Lake as its main potable water source, and has responsibility for watershed protection. Watershed protection planning for Comox Lake is a multi-phased process similar to the LWMP that began in 2006 with a Phase I risk identification and assessment for Comox Lake. The first part of Phase II, Analysis and Development of Options, was completed in 2011, producing the initial Watershed Protection Plan. From 2014 to 2016 the second part of Phase II was completed, as was Phase III -development of recommendations for implementation of watershed protection, culminating in the 2016 Watershed Protection Plan (link at https://www.comoxvalleyrd.ca/sites/default/files/docs/Projects-Initiatives/2-20160603_cvrd_wpp_final.pdf)

There are two intake points from the lake for water supply for: 1) the primary intake from the BC Hydro penstock; and 2) a pump station drawing water directly from the Puntledge River near the generating station.

The public has open access to large portions of the Comox Lake watershed. There are over 50 seasonally occupied cabins located along the southern portion of the lake, an additional 26 cabins on the eastern shore of the lake, including seven with year-round use, and two campgrounds: 1) Cumberland Campground located in the southeastern part of the lake; and 2) the Courtenay and District Fish & Game Club located near the Comox Lake Dam. Both campgrounds have day-use beach areas and provide washroom facilities for users as well as boat launches.

The portion of the Comox Lake shoreline that lies within the boundary of the Village of Cumberland is shown in Figure 1.

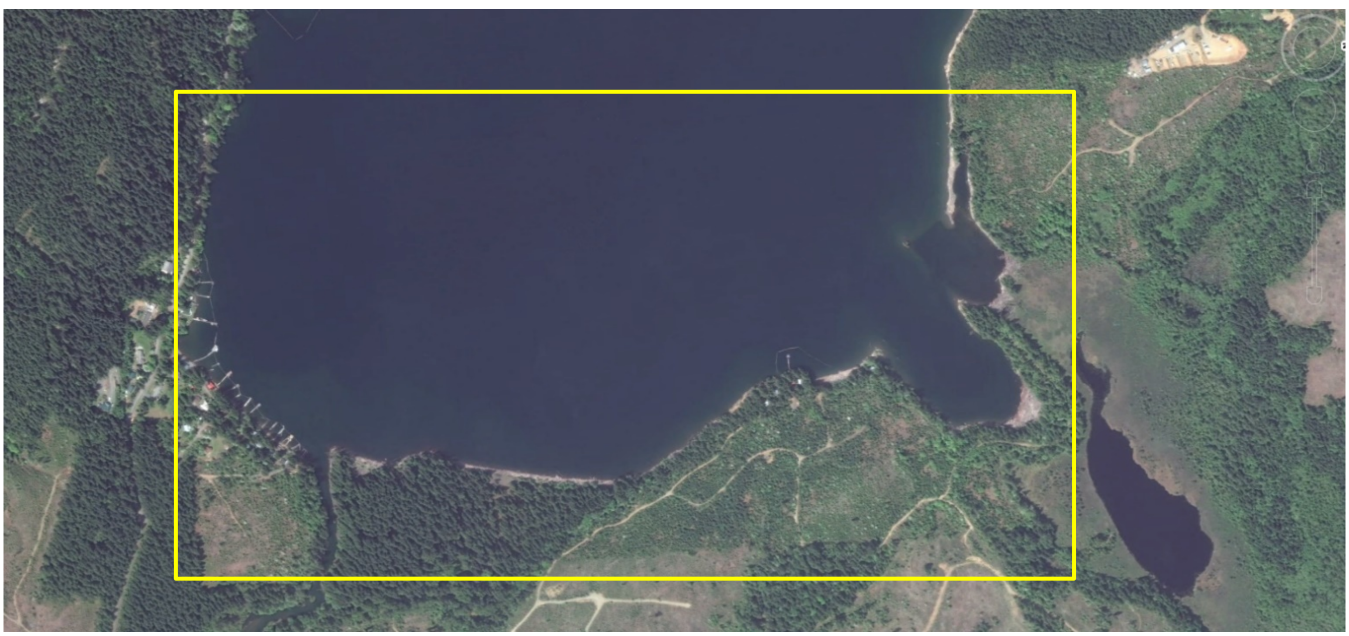

Figure 14-1 Comox Lake RE-1 Zoned Area (land areas within the yellow rectangle)

14.2 Current Servicing

The 51 cabins along the south shore of the lake are characteristically old (from 60 to 85 years). Most are reported to be owned by Cumberland residents, and are occupied an average of about 45 days per year. Wastewater management is reported to include grey and black separation, with pit privy toilets and seepage pits for grey water. There are also composting toilets, chemical toilets and a few septic field disposal systems.

The 26 cabins along the east end of the lake include about 7 that are occupied year-round, with the remainder seasonally occupied. Although the area with the 26 cabins on the CLLC property are within the Village of Cumberland boundary, the Village does not provide community water and wastewater services to this area. Typical wastewater management practices are reported to include combined grey and black water systems, with ten cabins using wastewater holding tanks, nine cabins using septic tank systems, and the remaining cabins have pit privy toilets and seepage pits for grey water disposal.

14.3 Problems

Vancouver Island Health Authority (VIHA) indicate that seepage from these ground disposal systems, spills of chemicals and hydrocarbons, and potential flooding are considered to be hazards of concern for lake water quality. VIHA also noted the age of the buildings along the lake is such there are no permits or registrations on record for these dwellings.

The Cumberland campground on the south shore is also considered to be a potential lake contamination source, although it has a regulated wastewater disposal system. Beach use adds to the potential sanitary waste concerns.

Areas of notable concern as sources of contamination to the lake include recreational boating on the lake, camping in non-designated areas near the lakeshore, and the cabins in the eastern part of Comox Lake. Other identified contaminant sources of concern included roads and transportation, housing (including permanent and part-time residences) and recreational activities. However, the lake has a wide variety of other potential contamination sources including: forestry, mining, and agriculture.

Although bacterial counts in raw water samples taken from Comox Lake have historically been at satisfactory levels, there has been an increase in fecal coliform bacteria levels over the past decade. (Comox Strathcona Regional District. 2006. Summary Report – Comox Lake Watershed Assessment).

14.4 Alternatives

14.4.1 Introduction

The following three sections describe alternative methods of providing wastewater service to the Comox Lake area. This information is presented here to illustrate the range of options that could be considered, from the current onsite wastewater practices that could be gradually brought up to standard in conjunction with dwelling upgrades and replacements, through to a centralized serving model that would collect wastewater and transfer it to the central village lagoon treatment facility.

14.4.2 Status Quo – Continued Onsite Systems

Although the old-time buildings that exist in this area have aged sanitary disposal systems of a questionable nature due to their age and lack of documentation and low septic regulatory standards at the time they were constructed. Despite this status, discussions with Vancouver Island Health indicate there are no known failed septic systems or incidents of surfacing sewage that have occurred. While pit privies are not an ideal sanitary service system, bacteria in the soil surrounding the pit privy biologically treat the wastewater as it enters the soil, and the soil also acts to filter particulates, such that a secondary effluent water quality is typically achieved within a couple of feet of soil. As dwellings require renovation and upgrading, their wastewater systems can be brought up to current standards, relying on Registered Onsite Wastewater Practitioners and Qualified Professionals to ensure each new system is brought up to current standards. Cabins served by pit privies typically have extremely low levels of water servicing and occupancy, so onsite systems could continue to be an effective means of managing wastewater in the lake area.

14.4.3 Cluster Servicing

Cluster serving would involve constructing a limited sewage collection system and transfer it to a small wastewater treatment plant designed to serve just the dwellings in the lake area. This could be done using a conventional gravity and pumped sewage collection system, or by continuing to use individual septic tanks connected to each dwelling and then pumping the primary treated wastewater to a common treatment and disposal system through a small diameter forcemain. The provision of septic tank treatment at each dwelling has the following advantages:

- use of small diameter sewage pipe resulting in lower sewage collection system capital costs;
- reduced treatment capital and operating cost, as the individual septic tanks provide primary treatment before the wastewater reaches the common treatment plant; and
- poor wastewater generation practices, such as discharging grease and oil to sewer, affect only the dwelling with the poor practices and not the overall community sewer system.

A key advantage of a cluster service model is that a common wastewater treatment plant is expected to be better operated and maintained, and result in a higher water quality, than would be expected to be achieved by an onsite wastewater package plant maintained by a property owner, and the overall costs for wastewater treatment are expected to be lower than the collective cost of onsite wastewater treatment. Further, the treated effluent can be disposed of to a common ground dispersal system located in an area with ideal soil conditions, whereas onsite systems must disperse wastewater within each property.

14.4.4 Centralized Sewer – Collect and Transfer to Central Treatment System

While the Comox Valley Regional District and VIHA are concerned about the integrity and appropriateness of the existing onsite wastewater management systems serving the cabins and campgrounds along the lake shore, and regarding the potential for wastewater seepage to enter the lake, there is no direct evidence this is occurring. Before an alternative management strategy can be proposed, it is necessary to carry out a detailed assessment of current wastewater management conditions, environmental water quality monitoring, and a review of onsite, decentralized and centralized alternatives for the area. The distance from the lake to the closest connection point to the Village of Cumberland sewer system precludes consideration for a pipeline connection to the central treatment facility due to the high cost, and the few number of existing potential connections in the Comox Lake within the Village boundary that could financially support the expenditure. Further, constructing a sewer connection would almost certainly result in increased interest development along the lake, which would exacerbate VIHA's concerns regarding development and the increased potential for non-wastewater associated chemical spills and contaminated surface runoff into the lake from increased development. As imposing changes to existing onsite wastewater management systems is not possible without evidence the systems are failing. Thus, a study for this area is needed. The findings of this study may support a decentralized or cluster approach as a possible solution. This would provide improved wastewater management and reduce the likelihood of lake pollution without creating an over-capacity centralized solution.

14.5 Need for Information

All of the problems and concerns with regard to the impact of the existing development around Comox Lake and, in particular, whether the existing onsite systems and continued practice of onsite wastewater servicing can protect lake water quality, are speculative. There is no direct evidence that the increased incidence of higher than normal bacteria levels in Comox lake are attributable to the onsite wastewater systems within the Village boundary along the lake shore. Considerations for servicing the area with a centralized sewage collection system will undoubtedly encourage more development and redevelopment of existing structures, potentially exacerbating concerns regarding potential effects of development on lake water quality.

In order to determine whether the status quo is satisfactory (subject to brining individual onsite systems up to current standards), or whether a cluster or centralized wastewater management system would provide a more sustainable level of servicing for the area, further study is required. It is recommended that the Liquid Waste Management Plan include a comprehensive study of the Comox Lake area within the Village boundaries to determine which of the three alternatives described in this Section are best suited to the area.

15.0 WATER CONSERVATION

15.1 Background

This section summarizes water conservation measures for consideration as part of the Liquid Waste Management Plan development process.

The primary reference is the May 11, 2017, report prepared by Welder Engineering LLP titled "Water Conservation and Reuse Program", supplemented with comments, suggestions and recommendations from the LWMP Stage 2 Project team members.

15.2 Wedler Water Conservation & Reuse Program Report

The Wedler Engineering Water Conservation and Reuse Program report describes three tasks that were carried out:

1. discussion paper on water reuse regarding the various technologies available, and the corresponding regulatory framework for reusing water from various sources, including conducting research into comparable municipal ticketing information bylaws;
2. review and analysis of overall use, consideration for communications and rebate strategies to encourage water conservation; and
3. development of materials for public outreach, including a mail out design, a PowerPoint template, and a social media / web template for communicating water conservation messages.

15.3 Water Consumption Reductions

Figure 1 illustrates the Village of Cumberland has an unusual community water consumption characteristic in that while it exhibits a typical seasonal summer water consumption peak, for other BC communities that peak is usually in either August or September. Further, in 2015 the water demands in October, November, and December successively increased over the September water consumption. The Wedler report notes that while single home consumption rates average between 50 and 80 m^3 per quarter, there are several commercial properties in the Village with high rates of water consumption between 500 and 6,500 m^3 per quarter. The report notes that since universal metering was introduced by the Village, gross annual water consumption has dropped from a high of 1.4M m^3/yr to below 850,000 m^3, a reduction of about 40 percent, and the maximum monthly water consumption has dropped from a high of 132,377 m^3/month to 56,577 m^3/month, a reduction of about 60 percent.

15.4 Proposed Measures to Reduce Water Consumption

The Wedler study recommended the Village of Cumberland should focus its public outreach, rebates, ticketing and other water conservation efforts on the high water-users in the Village. In addition to mail-outs, rebates and social media and web communications, the recommended water consumption reduction program should include the following activities:

- April (1st Quarter)
    - Discuss benefits of the metering program,
    - Provide leak detection methodology
    - Provide basic information on overall Village water use

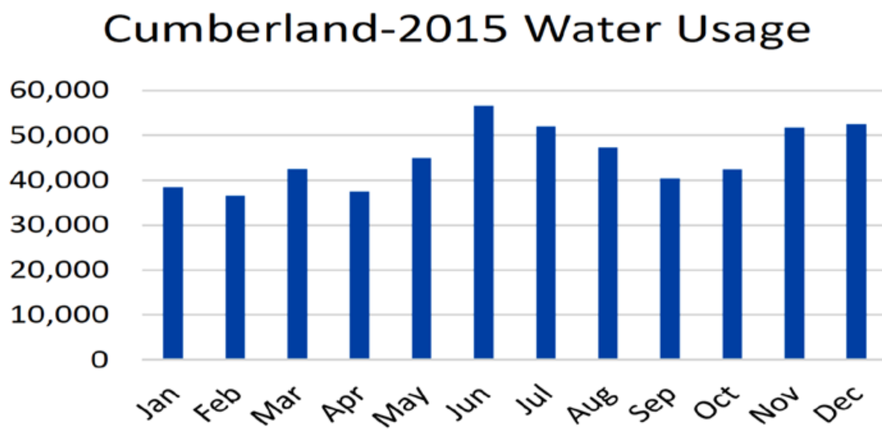

Figure 15-1 Annual Village of Cumberland Water Consumption Pattern

- July (2nd Quarter)
  - Announce shower head rebate
  - Report out on irrigation use by the Village
  - Village water use stats report
- October (3rd Quarter)
  - Report on shower head rebate program
  - Provide basic information about household water consumption
  - Report on efforts to work with the Hospital Laundry Society (TBC)
- Jan 2018 (4th Quarter)
  - Review of 2017 water consumption data
  - Final shower head rebate report
  - Village plans for 2018 water conservation

Recommendations were also made for the Village to: 1) audit its facilities and demonstrate leadership by making low-flow plumbing fixture retrofits; 2) partner with the hospital laundry society to purchase new water-efficient washers; 3) carry out measures for more efficient public park irrigation; and 4) review water main flushing operational procedures.

15.5 Example of Commercial Water conservation – the Cumberland Regional Hospital Laundry

The Cumberland Regional hospital laundry is the largest potable water user in Cumberland, using 100 m3/day, and representing 7.5% of the potable water use and 12.5 of the average dry weather wastewater flow.

It is unusual to have a single water user that is such a large proportion of the flow, but what is even more interesting is that the water use at this site was once much larger.

In 2008, the average monthly water use at the laundry was 5600 m3/ month.

In September 2009, a new, highly efficient washing system with an internal water recycle was installed, to bring the laundry up to industry best practice for water efficiency.

The result was a spectacular decrease in water use to 2200-2500 m3/month, a 57% decrease. The amount of water saved is equal to that used by 120 houses.

It is a great example of a targeted water conservation measure in a commercial environment, where there is a real payback in savings when the customer is on a metered water rate.

Had the laundry been on a metered sewer arte, the savings would have been even greater, as would the incentive to do such project in the first place.

15.6 Rainwater Harvesting

The Wedler assessment study also considered measures for rainwater harvesting and wastewater reclamation and reuse.

Canada and the US recently completed the development of a joint CSA and ICC rainwater harvesting and stormwater recycling standard for potable and non-potable applications.

Rainwater harvesting is typically defined as water collected from external surfaces of buildings or other hard-surfaced areas not exposed to vehicular or pedestrian traffic. A key aspect of rainwater harvesting is that the practice, while conserving potable water sources, does not reduce wastewater generation.

While rainwater harvested from roof surfaces may not require treatment prior to distribution for non-potable water applications, such as toilet flushing, filtration and disinfection is commonly required for rainwater that is used for non-potable applications where there is a potential for ingestion or aspiration of aerosols. Bacteria, like Legionella, can proliferate in collected rainwater distribution systems that are subject to elevated temperatures, and pose a potential health hazard. Accordingly, the simplest application of harvested rainwater is typically landscape or garden irrigation, where there is minimal risk of elevated water temperature.

Although the Welder report states that harvested rainwater must be treated to a potable water standard prior to being applied to any domestic water application, including toilet flushing, as of 2005 the Drinking Water Protection Regulation allows for small system distribution of non-potable water provided the water is not intended for human consumption and/or food preparation, or connected to a water supply system that is intended for human consumption and/or food preparation, or where each recipient of water from the system has a point of entry or point of use treatment system that makes the water potable. The BC Plumbing Code was also modified in 2012 to include non-potable water systems within buildings.

Treatment (typically sediment and activated carbon filtration) and disinfection is required for applications for potable water use. Generally, two forms of disinfection are recommended for a rainwater-supplied potable water system, providing a dual barrier and different modes of disinfection. For example, ultraviolet light followed by chlorination, where both are designed for 99.99% (4-log) virus removal. The use of chlorination is important in order to meet chlorine residual requirements at the point of use within the distribution system.

The materials that come into contact with the harvested rainfall, before, during and after treatment, are also important. NSF/ANSI Standard 61 certifies materials and products as being safe for use in potable water applications. As there are no similar Canadian potable water system material standards, NSF/ANSI Standard 61 is commonly referenced by Canadian health jurisdictions, including the Ministry of Health in BC. As there are very few roofing products that contemplate being used in a rainwater harvesting application, there are few products available that are certified for use. Consequently, municipalities and health often require a professional engineer to certify the suitability of the materials being used for potable water application through letters of assurance.

The use of rainwater harvesting to meet both non-potable and potable domestic and commercial water demands is not uncommon in BC, particularly in the Gulf Islands and other areas of the province with limited surface and groundwater sources.

15.7 Wastewater Reclamation & Reuse

While Cumberland enjoys having a good water supply, climate change has already significantly reduced stream flows in the area during the summer months, including the Trent River, and it is possible the Village could face water shortages in the future or have to change supplies. Climate change results in higher temperatures, changes in precipitation patterns, rising sea levels, and increases in the severity and frequency of severe weather events. Increasing use of water supplies to meet agricultural, intended industrial growth, and municipal demands could create competitive pressure around limited fresh water resources and a growing need to manage water resources in a sustainable manner.

Despite declining per-capita potable water demands as a result of water conservation efforts and building codes incorporating higher efficiency water fixtures and appliances. In 2008 at least 36 U.S. states – in particular California, Arizona, and New Mexico – were having to address severe and chronic water shortages. As communities explore ways of making more efficient use of existing potable water supplies, there is growing interest in putting highly-treated wastewater to beneficial use. Increasingly, wastewater is being recognized as an important water resource, rather than a liability. A recent survey study of European, Israeli, and Australian medium- and large-scale water reclamation utilities identified over 3,300 international water reclamation projects (mostly in Japan, Australia, and the U.S.), concluding that technological risks no longer represent a major concern for the development of water reclamation projects. Instead, issues such as the financing, failure management, and social acceptance have become the key critical issues for implementation.

Water reclamation and reuse involves treating wastewater for beneficial non-potable applications, including, for example, agricultural and landscape irrigation, toilet and urinal flushing, replenishing ground water (ground water recharge), vehicle and grounds washing, cooling water, fire suppression, and a wide range of commercial and industrial applications. Unplanned indirect potable reuse (IPR) commonly occurs along freshwater rivers and lakes systems where upstream municipal treated wastewater discharges contribute to downstream municipal potable water intakes. Water flowing through the Colorado River and Mississippi River, for example, has been extracted, used, treated, and piped back into the river to be extracted as part of a public water supply many times over between the headwaters and the mouth of the rivers. Planned IPR has been implemented for over 40 years in North America, including California, and Washington State, where reclaimed wastewater is used to replenish depleted groundwater or surface water sources for the intentional purpose of augmenting drinking water supplies. An example of a well-documented planned IPR project is the Water Factory 21 Direct Injection Project, located in Orange County, California, which has been injecting highly treated wastewater into a groundwater aquifer since 1975 to prevent salt water intrusion. Examples of cities practicing significant IPR using surface fresh water supplies includes Singapore, Las Vegas (NV, USA) and San Diego (CA, USA), where reclaimed municipal wastewater is treated using a multi-barrier process to a potable water standard, and is then blended with the raw water supply and treated again for drinking water use. Despite an inherent public reluctance to consider direct potable reuse, this has been successfully practiced in Windhoek, Namibia, since 1968, currently producing over 21,000 m^3/d of wastewater for drinking water use.

The U.S. and Canada have a long history of wastewater reclamation for non-potable reuse, with growing public and industry interest regarding the use of reclaimed water for appropriate domestic, commercial, or industrial non-potable water applications. California is a recognized leader in developing standards for treating wastewater to generate a reuse product that is safe for a wide range of non-potable uses, and these standards have been adopted by many other states, with support and guidance from the Environmental Protection Agency through its publication *Guidelines for Water Reuse* (EPA/625/R-04/108, 2004). Canadian jurisdictions have also been adopting or considering legislation to facilitate water reuse, with British Columbia being the first province to establish a comprehensive wastewater reclamation regulation under the Municipal Sewage Regulation (1999), which was revised as the *Environmental Management Act - Municipal Wastewater Regulation* (2012).

The Canadian federal government also recognizes the importance of using reclaimed wastewater for non-potable reuse applications to conserve potable water supplies and, in 2010, Health Canada published the *Canadian Guidelines for Domestic Reclaimed Water for Use in Toilet and Urinal Flushing* in consultation with provincial health representatives from across Canada.

Plumbing requirements for non-potable water systems are addressed by the Canadian Standards Association (CSA) Standard B128.1-06/B128.2-06, *Design and installation of non-potable water systems / Maintenance and field testing of non-potable water systems* (CSA, 2006) as well as B128.3, *Performance of non-potable water treatment systems* (CSA, 2010), which establishes performance verification and testing criteria for onsite (in-building) wastewater reclamation package treatment technologies. Similar U.S. standards include the National Sanitation Foundation Standard 350 *Onsite Residential and Commercial Water Reuse Treatment Systems*.

Water reclamation policies and practices also have a high economic value for municipalities to consider by-laws and plumbing codes. Flushing with reclaimed wastewater can reduce water demands within a single family residence by about 30 percent, equivalent to approximately 126 m^3 per year per household, and resulting in a savings in the cost of water of about $200 per year per household. Beyond the bulk value of the water saved, however, the benefits are numerous and include:

- a more balanced, practical approach to water management, providing consistent, reliable water supply as communities face climate change challenges;
- reduced demands on water supply, treatment, and distribution infrastructure;
- reduced demands on wastewater collection, transport, and treatment infrastructure;
- reduced discharge of treated wastewater into receiving environments and reduced water pollution;
- protecting and preserving environmental resources by providing more water and increased environmental benefits to many watersheds, rivers, and streams for fish habitat and salmon recovery;
- overall ability to provide water and wastewater services to a greater population density than would otherwise be possible without water reuse, using existing water and wastewater infrastructure; and
- eliminating, downsizing, or postponing the need for capital projects for upgrading water and wastewater infrastructure capacity.

Most of the urban water reuse applications to date involved large-scale centralized treatment facilities that serve entire municipalities. However, there is a growing trend towards constructing wastewater reclamation facilities within buildings. While centralized systems offer economies of scale, once the pumping and pipeline costs of transferring reuse water back into the community is taken into consideration, decentralized systems can be a more cost-effective alternative – plus, they can adapt more readily to improvements in technology.

Recent examples of buildings with internal wastewater reclamation and non-potable water reuse systems in North America include: the Missouri Department of Conservation Discovery Center (Kansas City, MO); Dockside Green (Victoria, BC); the Vancouver Convention Centre (VCC) West building (Vancouver, BC); and the recently completed (2011) University of British Columbia Centre for Interactive Research in Sustainability (CIRS) building (Vancouver, BC). All four buildings reclaim wastewater for non-potable reuse applications including toilet flushing, and satisfying irrigation demands. Toilet flushing and irrigation are typically responsible for 80 percent or more of a commercial building's water demands. The CIRS building also incorporates sewer mining, in order to generate sufficient reuse water to meet the building's irrigation demands during the summer, a period with fewest building occupants.

Considering wastewater from both a blackwater (sanitary and kitchen-sink/dishwasher drainage) and greywater (bath/shower, lavatory, and laundry) perspective, opportunities for reclamation and reuse for the Village of Cumberland include the following:

- **Blackwater:** Treat to Municipal Wastewater Regulation (MWR) Greater Exposure Potential (GEP) or Indirect Potable Reuse (IPR) water quality standards and reuse the reclaimed water for landscape irrigation, toilet/urinal flushing, and general exterior cleaning and water applications (e.g. street washing, vehicle washing, building cooling, etc.).
- **Greywater:** The BC MWR requires all wastewater, regardless of whether it is blackwater or greywater, to be treated to a reclaimed water quality standard under the MWR before it can be reused or recycled for non-potable water applications. The City of Nanaimo and City of Kelowna are the only two municipalities in BC to have modified their plumbing code bylaws to allow untreated greywater to be recycled without treatment to the MWR standards. Members of the Stage 2 LWMP project team have previously engaged the Ministry of Environment and the Attorney General's office to consider whether the act of recycling wastewater falls under the Environmental Management Act, and received an informal advisory that the MWR would apply to all wastewater reclamation and reuse applications – regardless of the scale, or whether the practice involved a discharge to the environment. The Health Act – Sewerage System Regulation – has provisions for greywater collection and shallow distribution into landscape areas; however, this is intended for properties that require onsite wastewater disposal. Should Cumberland wish to explore greywater subsurface irrigation applications, it is expected that a regulatory legal assessment will be required.

15.8 Implementing Reuse and Rainwater Harvesting systems

One of the key difficulties experienced in both wastewater reclamation/reuse, and rainwater harvesting considerations is the need for municipal plumbing code provisions for dual plumbing (potable and non-potable) and routine verification of cross-connection and back-flow prevention provisions, pipe labeling/coloring to identify the water as being non-potable, testing and verification of cross-connection control devices, as well as the associated training and education of local plumbers in working with dual-plumbing systems. The Village of Cumberland would need to work with the Vancouver Island Health Authority to establish educational materials, signage, trades training, and inspection protocols to ensure public health is protected. For applications under the jurisdiction of the Municipal Wastewater Regulation, the Village is also required to inform Health of the intended water reuse applications and seek their approval and authorization. However, as health officers are not bound by the MWR, only notification and a request for authorization is required – not approval.

15.9 Potential for Water Reuse at the Wastewater Lagoons

There is the potential for doing a simple water reuse project at the wastewater lagoons themselves, to displace an existing potable water use.

The influent trash screens require a periodic water spray to wash the collected trash off the perforated screen. Presently, this spray is potable water, and averages about 10m3/day, and higher in winter when there is more trash in the flow. This represents 1.25% of the average dry weather flow.

This water use is known as a "process" water use, where it is used in the workings of the wastewater treatment plant. It is an increasingly common practice to use the final disinfected water for such process water use, where potable water quality is not required, and the water instantly becomes "dirty".

The reuse of the final effluent water will be studied in the detail design stage of the wastewater improvements.

The Cumberland Regional Hospital Laundry is also a potential candidate for the use of reclaimed water, however it will need to be of the highest grade – "Greater Exposure Potential" standard. The laundry is considering the possibility of the use of reclaimed water and if it was to be implemented, a small, dedicated filtration and chlorination system would be need to achieve the required water quality. With the laundry using 100 m3/day of potable water, they may be a good business case for this reuse project in the future.

15.10 Australia Building Sustainability Index (BASIX)

New South Wales (NSW) in Australia introduced the Building Sustainability Index (BASIX) as a means of delivering equitable, effective water and greenhouse gas reductions across the state. Since being introduced in 2004, BASIX has become an integrated part of the NSW planning system and has reduced potable water consumption and greenhouse gas emissions for new homes built in NSW while winning numerous awards.

BASIX is a web-based permitting tool that was developed to help the NSW government minimize the impact of new development on water supplies and on greenhouse gas emissions (as related to energy consumption). It applies to all residential dwelling types and is part of the development application process in NSW.

Individuals seeking a building permit are required to enter the information about their property or development into the online system, which estimates the theoretical water and energy consumption based on established benchmarks, or norms, and the characteristics entered and compares the proposed design against sustainability targets. The applicant is then presented with information on a wide range of water conservation measures, and makes an informed decision on selecting the type of options that collectively must achieve a minimum 40 percent reduction in water consumption and 50 percent reduction in energy consumption. The water options include various low water use fixtures and appliances, rainwater harvesting, wastewater reclamation and reuse, and greywater recycling. The online system also provides information on where to purchase the various components and the costs. The resulting collection of water conservation measures then become part of the building permit and are subject to verification by an inspector.

The BASIX initiative, although implemented at a municipal level with respect to permitting, is administered state-wide through the web site, and provisions to enable the operation of BASIX are contained in the Environmental Planning and Assessment (EP&A) Regulation and State Environmental Planning Policy. The EP&A Regulation specifies the types of development BASIX applies to, the purpose and content of BASIX certificates, the circumstances under which a BASIX certificate is required, how those certificates are issued, who must check compliance with commitments made in BASIX certificates and when, fees for BASIX certificates and requirement for an eventual BASIX completion certificate.

This type of system could enable the Village of Cumberland to both communicate measure to improve water consumption and, thereby reduce wastewater generation, as well as implement a tool that would enable the municipality to set and achieve specific water conservation targets.

16.0 COMBINED SEWER SEPARATION

16.1 Sewer Separation Status

Efforts to separate the combined sewer system into sanitary and storm sewers have gradually been carried out since Permit 197 was first issued in 1967. Due to the long time-frame, documentation of these changes is limited. However, staff review of drawing records indicate the following progress has been made, as illustrated in Figure 16-1:

- Sewer Area #1 – basically most of the area south of Dunsmuir Ave up to the Colliery
- Sewer Area #2 – Beaufort to First Street and on the north side of Dunsmuir up to Maryport from First Street to Second Street and a small section down to Third Street.
- Sewer Area #3 – A small area at the top end of Third Street between Ulverston and Windermere
- Some of the area north of Dunsmuir and east of Fourth Street.
- Dunsmuir Avenue Second to Seventh including the lane north of Dunsmuir
- Some minor work on Third Street from Penrith to Dunsmuir
- Some minor work on Maryport between Fourth and Fifth Street

Figure 16-1 Separated Sewer Service Areas

16.2 Sewer Separation Work Planned for 2018

For 2018, the Village of Cumberland plans to extend the storm sewer in conjunction with planned road work on Egremont Road up to Ulverston Avenue to establish a new storm sewer pipeline that has sufficient capacity for future storm separation efforts in the area west of Egremont Road between Dunsmuir Avenue and Ulverston Avenue. The Village is also planning to complete a block of separation in the lane south of Maryport Avenue between Egremont Road and Silecroft Road later this year.

16.3 Activities for I&I Reduction

In addition to continued efforts to construct separate sanitary and storm sewers to replace combined sewers, the Village of Cumberland carries out an ongoing program every year to reduce inflow and infiltration (I&I) into sanitary and combined sewer systems. This work includes smoke testing, dye testing, and CCTV investigations. Village operations are hoping to start a formal process of cataloguing all the sewer camera work and testing that's been done to date. A visual inspection of the Hope Road sewer trunk-main manholes is planned to help narrow down where inflow is entering the sewer along that section.

16.4 Other Sewer Maintenance Activities

Although the Village of Cumberland does not currently have a sewer flushing program in place, operations are hoping to begin implementing a formal flushing program in 2018 once the Village is able to acquire a used single-axle vactor truck. Crews were able to carry out some work in 2017, including the Hope Road Sewer Trunk main and a short section of the sewer main that runs through the Second Street townhouse complex below Derwent Avenue. In both cases, the mains were half full of rocks, and grease had accumulated along the top of the sewer pipe. Along with sewer flushing, the Village is hoping to do some camera work in some of the older areas to provide a better idea on pipe condition and use the information for planning pipe replacement.

16.5 Achievements to Date in I&I Reduction

Table 16-1 presents the total annual wastewater flows generated within the Village of Cumberland. Despite the investment and efforts in separating the combined sewer system, at first glance, there does not appear to have been a significant reduction in wastewater flows as a result of this effort and cost. Taking into consideration the population has not significantly increased in the time period shown, the data seems to indicate the wastewater flows have increased despite the Villages efforts.

Table 16-1 Annual Wastewater Flows

Year	2013	2014	2015	2016
Total Flow (m3/y)	657,729	912,056	795,251	1,179,234

However, Table 16-1 does not take into account the effects of climate change on the total annual precipitation. Figure 16-2 illustrates the highly correlated relationship between annual I&I flows and rainfall, and an analysis of the wastewater flows taking into consider this relationship, population sanitary contributions, rainfall indicates the Village's efforts in sewer separation has reduced the amount of I&I flow per unit of rainfall (m3/day per mm of rainfall), as shown in Figure 16-3. Despite a local peak in 2015 of around 450 cubic metres per day per mm of rainfall, there has been a progressive reduction from about 425 cubic metres per day per mm rainfall in 2013 to just over 350 cubic metres. per day per mm rainfall in 2017 (i.e. a net reduction in I&I contributions of almost 20 percent over that period.

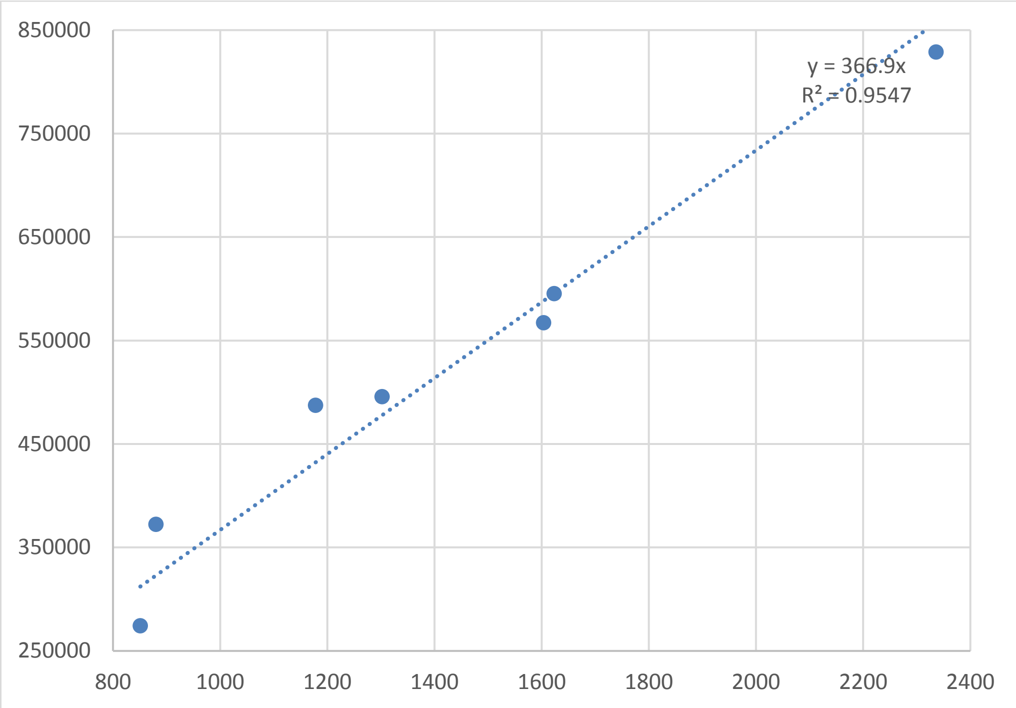

Figure 16-2 Relationship between I & I Contributions and Annual Total Rainfall

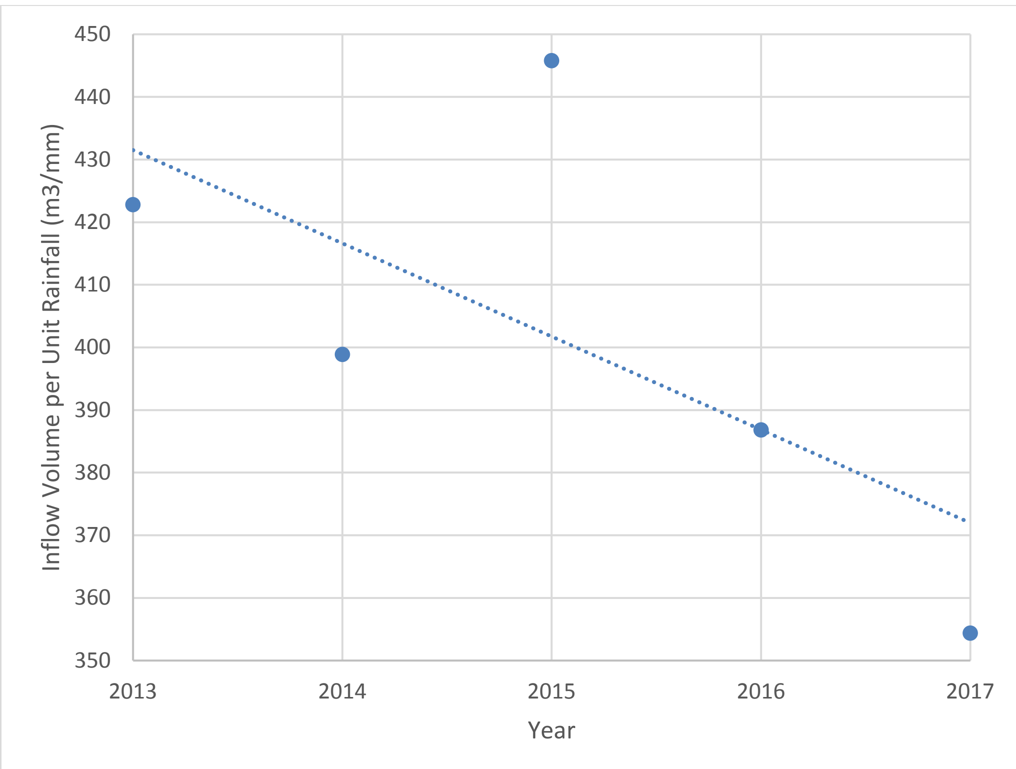

Figure 16-3 Reduction in I&I

17.0 GRANT FUNDING ANALYSIS

17.1 Background

A key hurdle in Cumberland's ability to implement any wastewater treatment project is funding. Projects that exceed Cumberland's combined reserves and borrowing capacity can only proceed with the assistance of external grant funding.

This Technical Memo summarizes the opportunities, and constraints, for pursuing the major external grant funding avenues. The analysis is based on the recent history of grant programs available in 2015-2017, and discussions with various program administrators in December 2017. It should be noted while the general principles remain the same, specific details of grant program purposes and eligibility can, and do, change, so the most up-to-date information should be sought before any decisions are confirmed.

17.2 Purpose of Grant Funding programs

Generally, there are four primary reasons for carrying out wastewater projects.

1. **Replacement** – Replacing or rebuilding existing infrastructure that is nearing the end of its service life.
2. **Improvement** - Upgrading the quality and service levels for existing facilities to meet new standards, particularly for environmental performance.
3. **Expansion** - Increasing supply or treatment capacity, to service population and/or economic growth.
4. **Greenfield construction** – Adding treatment and collection to a new area previously not serviced.

From the point of view of the Provincial and Federal governments, it is generally expected that municipalities should fund **replacement** of their own infrastructure through appropriate taxes and user fees. Similarly, it is also generally expected that **expansion** and **greenfield construction** will be funded by those who need the expansion – typically property developers or new commercial and industrial users, through mechanisms such as Development Cost Charges (DCC's).

The major focus for most of the infrastructure grant programs is on **Improvement.** The grants are intended to help municipalities meet new requirements that have been imposed upon them by the senior governments.

Grant funding often encourages communities to demonstrate **Leadership and Innovation**, enabling projects to go above and beyond current standards, and demonstrating new approaches or technologies. This is often a secondary focus for funding, although some funding programs have this as their primary purpose or even a pre-requisite.

Almost all grant funds are awarded on a competitive basis – evaluating specific projects on a set of pre-determined criteria for the relevant fund. The programs are always over-subscribed as all communities have needs that exceeds their available funding.

The contribution amount is usually a percentage of the estimated capital cost of a project, typically 50 or 67 percent. Some grants will fund up to 100 percent of the costs, but they generally have a maximum amount that can be applied for.

There is often a pronounced preference for "shovel-ready" projects, where the scope and design are set, and costs and execution time are well-estimated. The more a community can define their project, and show it can be completed within the stated time and budget, the better the chance of receiving funding. Project applications that are general or vague in scope, with details to be worked out later, are rarely successful. Applications are typically not accepted for a project that has already started construction or had tenders awarded, though there are exceptions.

For most funding programs, the time frame for completion is typically three years, but there are also some exceptions and variances to this.

There are usually restrictions on the "stacking" of Federal funds, where several funding sources are applied to the same project. The limit is usually to a total of 50% of a project, although there are also exceptions. Notably, money from the Federation of Canadian Municipalities does not count as "Federal" funding.

17.3 Joint provincial-Federal Infrastructure Funding

Since the 1990's there has usually been some form of a joint infrastructure program between the provincial and federal governments. The most well-known example is the Building Canada Fund, which provided a 1/3 contribution from each of the federal and provincial governments, to be matched by a 1/3 contribution from the municipality. The percentages can change, and the most recent example was the 2016 Clean Water and Wastewater Fund, where the contributions were 50% Federal, 33% Provincial, and 17% Municipal. Some earlier funding programs required a 50 % municipal contribution.

These funds are typically focused on **improvements**, but also have a secondary purpose for **leadership and innovation**. **Expansion** and **replacement** are usually minor priorities and – in some cases – are specifically excluded from funding eligibility.

In the case of wastewater treatment facilities, a specific requirement is that the project will improve treatment to meet the municipality's current regulatory obligations. For Cumberland, this means that the treatment must be improved to meet the current Provincial Discharge Permit and the Federal Wastewater System Effluent Regulation. Unless specifically stated in the funding program, upgrading to meet the provincial Municipal Wastewater Regulation (which a greenfield project would have to meet) would not be required, although it may be assumed this would be desirable.

There are often secondary objectives – though not requirements – for things like energy efficiency, green building practices, greenhouse gas reductions and water conservation programs.

While most of these programs will fund a broad range of infrastructure, including roads, water, energy and municipal facilities, some of the programs focus on just one category, like the 2016 Clean Water and Wastewater Fund.

There is no indication what the focus of upcoming programs will be.

There are no joint funding opportunities open as of December 2017. It is expected that new funding programs will be announced in the Provincial Budget in February 2018 and in the Federal Budget in April 2018. It takes several months for the implementation details to be worked out between the governments.

Thus, a call for funding applications is expected in the second half of 2018, but not before.

17.4 Federal Gas Tax fund

The Federal Gas Tax Fund is a special category of federal funding that shares the revenue from fuel tax to the Provinces for the specific purpose of municipal projects. In BC, the Union of BC Municipalities administers the fund. There are two components to the Gas Tax Fund and the one of interest for a wastewater project is called the Strategic Priorities Fund. It is a competitive application based fund that is intended to fund major infrastructure projects, including wastewater treatment plants. The most recent call for projects was in April 2017 and it allowed for 100% funding of a project to a maximum SPF contribution of $6 million. Project applications over $6 million remain eligible provided that additional costs are confirmed through other funding sources.

This fund is mainly focused on **improvements** and economic development (**expansion**), with a secondary objective of **leadership and innovation.** The technical criteria for the Strategic Priorities Fund for wastewater are the same as the joint Federal-Provincial infrastructure funds.

Historically, the Strategic Priorities Fund puts out a call for applications every two years, so the next funding call is not expected until 2019.

17.5 Provincial Specific Funds

The BC government has implemented targeted funding programs in the past, such as the “Towns for Tomorrow” or the “Innovative Clean Energy” program. These programs are usually for one type of infrastructure only (e.g. roads, water or energy), and are not recurring. They reflect the specific priorities of the Government of the Day.

There are currently no Provincial specific funding programs available, though it is possible something may be announced in the upcoming budget in February 2018.

17.6 Federal Specific Funds

Federal governments come out with many specific funding programs according to the priorities of the Government of the Day. There is a trend to make these into joint federal-provincial programs by requiring matching funding, or other commitments from the provinces.

Some funds are relatively independent of the provinces and are administered through agencies such as Western Economic Diversification or the Sustainable Development Technology Fund. As the names imply, these funds are heavily geared towards economic development (**expansion)** and **leadership and innovation.** It is rare, but not impossible, for traditional infrastructure projects to qualify for these funds. Examples would be the use of reclaimed water to create an agriculture related opportunity or support other industry. In addition, grants can be focused on the development or piloting of new treatment technologies.

A new specific Federal fund announced in 2017 is the Low Carbon Economy Fund, which supports projects that reduce greenhouse gas emissions. A treatment project that sets a new benchmark for low energy use might qualify for this fund, as might the concept of processing biosolids (and wood) into biochar for carbon sequestration in a reed-bed, or as a general soil amendment. Details are yet to be announced on this fund.

Eligibility for any of the purpose specific funds should be considered a bonus, and should not be driving factor in decision making on a project, though it may assist with funding specific or additional components of a project.

17.7 Green Municipal Fund

The Federation of Canadian Municipalities administers the Green Municipal Fund. This is a fund that is focused on infrastructure **improvements** that demonstrate environmental **leadership and innovation**. The main purpose is to provide additional funding to cover the additional costs for projects that show new or better ways of doing things, and have a high replication potential.

GMF has five different focus areas. The one relevant to wastewater is “water quality and conservation”.

GMF provided 50% funding to Cumberland for the Stage 1 and 2 LWMP as a Feasibility Project, to investigate innovative ways of improving the wastewater treatment and resource recovery.

For capital projects, GMF provides low interest loans of up to $5 million, and a grant for 15% of the loan amount. For example, a $5M loan is accompanied by a $750k grant. These loans are an alternative (and less expensive) source to borrowing through the Municipal Finance Authority, but still use up the municipality's borrowing capacity.

Applying for funding is a two-stage process. The first stage is an Initial Review that determines whether the project is red-flagged and deemed ineligible for funding. For those applications that are deemed eligible, the second stage is a formal application followed by peer review and evaluation, with funding awarded on a competitive basis. The evaluation criteria are laid out in the water- specific Project Scorecard.

A specific interest of GMF and FCM is in the affordable and effective improvement of lagoon treatment systems. There are many small towns across Canada that have lagoons, and can't afford to replace them with mechanical treatment plants. A project that demonstrates practical upgrades to achieve high quality water and other environmental and societal benefits from a lagoon-based system has high innovation and replication potential.

Replacing lagoons with a mechanical treatment plant, even a high quality one, has already been done for numerous towns across the country. So, while it has high replication potential, it has little or no innovation or leadership value, and GMF indicated such a project would not likely be funded.

GMF have also indicated that the proposed scope of work for Option 1, Phase 1 – adding the separation and disinfection processes would likely not qualify for GMF funding as these upgrades have already been successfully demonstrated with lagoons.

If an application is to be made to GMF for a Phase 1 project, the application will be eligible, and a good candidate for success, if it includes innovative treatment elements like the wetland and biochar reed-bed. The Cumberland situation is ideal for demonstrating innovative treatment methods where the extra performance is *desired,* but not *required*. Thus, if applying for a Phase 1 project, it is recommended to include the wetland and the biochar reed-bed in the project application.

Funding intakes occur twice a year, with the Initial Review being March 1 and second stage Applications due April 15. The second intake begins in August. The decision process takes about four months from the application date.

17.8 Municipalities for Climate Innovation Fund

The Federation of Canadian Municipalities delivers a second program specifically aimed at combating climate change, called the Municipalities for Climate Innovation Program (MCIP). The Program funding, training and resources and is organized into two streams- climate *adaptation*, and climate *mitigation*.

Climate Adaptation – to prepare for and minimize the impacts of climate change. Eligible capital projects are designed to enable the adoption of a technology or solution that has the potential to help municipalities improve the resilience of municipal infrastructure to a climate risk.

Relevant example projects include;

- Increasing the capacity of the municipality to deliver services such as water, recreation, etc. in the event of temperature extremes (*e.g. by using reclaimed water*)

- Developing enhancements to sewer, stormwater and storage infrastructure to reduce the impact of untreated combined sewage entering waterways.
- Managing or revitalizing natural assets such as urban tree canopy to support temperature management

Climate Mitigation –targeted at projects that reduce greenhouse gas emissions (or equivalents). These projects are designed to enable the adoption of a technology or solution that has the potential to reduce GHG emissions.

Relevant examples of projects include;

- Making energy-efficiency and renewable upgrades to a drinking water or wastewater treatment plant
- Creating an energy recovery loop to channel waste energy to heat
- Using digested solids from a wastewater treatment plant to generate gas for electricity or heat

The evaluation is focused on the mitigation/adaptation benefits, and the ability to deliver the project and quantify the benefits.

Table 17-1 Climate Innovation Fund Evaluation Criteria

Evaluation Criteria		Points
Potential to reduce vulnerability to climate change impacts (**Adaptation** projects)	Potential to reduce GHG emissions (**Mitigation** projects)	30
Measurement systems		20
Alignment with municipal priorities and local context		20
Project management		30
TOTAL		**100**

Further details are in the Climate Adaptation Project Scorecard and the Climate Mitigation Project Scorecard.

Funding is in the form of grants, of up to 80% of the project costs, to maximum of $1 million. Applications are accepted any time, and the program runs until January 2020.

For Cumberland, the wastewater treatment project as a whole, (including the wetland) might be eligible if it is achieving significant adaption or mitigation benefits. However, this program seems to be most applicable to the wetland or reed-bed, or resource recovery projects, as stand-alone projects, as they are more tightly defined, measurable and replicable.

17.9 Non – Infrastructure Funds

There are several sources of funding that are not specifically related to infrastructure, that might be applicable to specific parts of the Cumberland project. The best examples of these are

- Islands Coastal Economic Trust (ICET)- Aimed at encouraging economic development on Vancouver Island and Coastal BC. Project is funded 33% to a $400k maximum. A project that makes economic use of reclaimed water (e.g. developing agriculture or industry) might be eligible for this. Establishing the wetland area as an eco-tourism destination would also be a possibility

- BC Habitat Conservation Trust Fund (HCTF) – Aimed at restoring and improving natural habitat. Project funding is 50% to a maximum of $100k. The wetland augmentation and enhancement would be the only part of the project eligible for funding.
- Environment Canada Habitat Stewardship Program (HSP) Aimed at restoring and improving natural habitat. Project funding is 50% to a likely maximum of $100k. The wetland augmentation and enhancement work would be the only part of the project eligible for funding. It is worth noting that Environment Canada previously approved the use of the Eco-Gift lands for a constructed treatment wetland, noting the benefits to Maple Lake Creek and the Trent environments were concluded by Environment Canada to offset the habitat changes as a result of the wetlands loss and conversion to retention ponds. A project that uses the existing wetlands to deliver downstream environmental benefits while enhancing the wetland habitat might be very appealing for this program.
- Environment Canada National Wetland Conservation Fund (NWCF) - Aimed at supporting on-the-ground activities to restore and enhance wetlands in Canada. The objectives of the fund are to:
  - Restore degraded or lost wetlands on working and settled landscapes to achieve a net gain in wetland habitat area;
  - Enhance the ecological functions of existing degraded wetlands;
  - Scientifically assess and monitor wetland functions and ecological goods and services in order to further the above objectives to restore and/or enhance wetlands; and
  - Encourage the stewardship of Canada's wetlands by industry and the stewardship and enjoyment of wetlands by the Canadian public.

  The wetland component of the project is a good candidate for the NWCF fund. Details are not presently available as to what the NWCF funding contribution and arrangements are.

These non-infrastructure funds are very focused and are not relevant to the major infrastructure of wastewater treatment. But the wetland component of the treatment project clearly has some potential for the habitat focused funds.

There are also some smaller, third party funds and groups that are more focused on community involvement in habitat and community improvement projects, such as Ducks Unlimited. These could be pursued for community or special group involvement in planning and volunteer help for executing a wetland enhancement program.

17.10 Risk Assessment for Funding Applications

When the funding programs evaluate project applications, the evaluators are not just looking at the technical and economic criteria- they are also looking at the risks related to the project. There is a very strong desire to have the funded projects be successfully completed on time and budget, and not become white elephants. Thus, a major part of the evaluation is the assessment of risk to successful completion. The most prominent risks include;

- going over time;
- going over budget;
- not being completed at all;
- failing to achieve the desired results (especially for innovative projects);
- scope is too large for the community to manage project team;

- technical ability of the project team;
- scope (and cost) is too large to have a net benefit;
- not receiving regulatory approvals; and
- not receiving borrowing approval from electors (referendums or Alternate Approval Processes).

The risks that most frequently arise are related to funding and regulatory approvals.

17.10.1 Funding Risk.

Generally, infrastructure programs only fund part of a project, and the evaluators like to see that the evidence that the balance of funding required for project completion is already in place. Where the municipality is relying on borrowing for its share of the funding, the ideal situation would be for elector approval to already be received before the funding application is made. There have been projects such as the CVRD South Sewer Project - that have been halted and cancelled because approval was not received. The strongest application is one where the municipality's portion is already approved – either in reserve funds or elector approved borrowing.

For Cumberland, the preferred strategy would be to seek borrowing approval as soon as the decision has been made on the treatment Option and the preferred phasing/implementation.

17.10.2 Regulatory Approvals Risk

Wastewater projects require authorization from the Ministry of Environment before construction can proceed. These authorizations can take up to a year or more to obtain. This creates a significant schedule risk if the community applies for project funding before receiving authorization. For Cumberland, the Ministry of Environment has already authorized the proposed works within the existing Discharge Permit and so there is no regulatory risk.

17.10.3 LWMP Considerations

The LWMP is a unique process in that upon approval of the Stage 3 LWMP, a municipality gains both regulatory and borrowing authorizations, allowing the community to confidently apply for grants without funding or regulatory risks. It must be emphasized that only a completed, and Minister approved Stage 3 LWMP achieves these authorizations, and a Stage 1 or 2 LWMP achieves neither.

17.11 Summary of Major Funding Opportunities

The characteristics of both the major programs, and the treatment Options, are summarized in Tables 17-1 and 17-2. Table 17-3 combines this information to give an initial assessment of suitability of the different options for the various funding programs. It should be noted that these assessments are qualitative based on previous experience and the evaluation information available from the funds themselves. Not all funds give out their detailed evaluation criteria, so assessments of likelihood of success are subjective at best, and should be reviewed against the most up to date information possible.

The assessments have been done on a scale of zero to five, where five is the best, no ranking meaning not applicable and "N" meaning not eligible.

Table 17-2 Summary of Grant Funds and Criteria

Fund	Joint Prov/Fed	Gas Tax	GMF	MCIP	ICET	HCF	HSP	NWCF
Contribution	67% typical	100% to $6M	Loan to $5m +15% grant	80% to $1M	33% to $400k	50% to $100k	50% to $100k	TBD
Replacement (only)	N	*	N	N	N	N	N	N
Improvement (environmental performance)	3	3	4					
Leadership and Innovation	2	2	3	4				
Expansion/ Economic Development	1	2			4			
Habitat Enhancement/ Restoration			1	1		5	5	5
Community Enhancement	1	1	1		1			
GHG Reductions	1	1	1	5				

Table 17-3 Summary of Options and Assessment of Grant Fund Criteria

	Option 1			Option 2	Option 3	Add-ons Additional points to be added to the Options score	
	Phase 1	Phase 2A	Phase 2B				
Criteria	Lagoon to Permit Compliance	Lagoon to MEP (incl. wetland score)	Lagoon to GEP	Base Flow Mechanical to GEP	Full Flow Mechanical to GEP	Wetland	Biochar Reed-bed
Replacement	1	1	1	1	1	0	0
Improvement (Quality)	1	2	3	4	3	1	1
Leadership/ innovation/demonstration	0	2	1	1	2	2	2
Capacity expansion	1	3	3	3	4	0	0
Habitat enhancement	1	3	2	2	2	2	1
Community enhancement	0	1	0	0	1	1	0
GHG Reductions (compared to "standard" treatment of same quality)	1	2	2	0	0	1	4
Value for Money	2	3	2	3	1	0.5	0.5

Notes:

1. Only Option1, Phase 2A includes the wetland augmentation as this is integral to this option. For all other Options it is a discretionary add-on.
2. The points from the wetland and reed-bed can be added to any Option, but cannot take the total score over 5.

Table 17-4 Summary of Grant Funding Probabilities

		Option 1			**Option 2**	**Option 3**	**Add-ons**	
		Phase 1	**Phase 2A (incl wetland score)**	**Phase 2B**			**Additional points to be added to the Options score**	
Fund	Monetary Contribution	Lagoon to Permit Compliance	Lagoon to MEP	Lagoon to GEP	Base Flow Mechanical to GEP	Full Flow Mechanical to GEP	Wetland	Biochar Reed-bed
Joint Prov/Fed	67% typical	2	3	2	3	1	0.5	0.5
Gas Tax	100% to $6M max	2	3	2.5	3	2	0.5	0.5
GMF	Loan to $5M +15% grant	N	2	1	N	1	1	2
MCIP	80% to $1M max	N	1	1	1	1	0.5	1
ICET	33% to $400k max	N	N	N	N	N	1	N
HCTF	50% to $100k max	N	3	N	N	N	3	1
HSP	50% to $100k	N	3	N	N	N	3	1
NWCF	TBD	N	3	N	N	N	3	1
Overall Ranking		1.5	**3.1**	2	2.5	1	0.5	1

18.0 FINANCING FRAMEWORK

18.1 Background

Any improvements or expansions to the wastewater treatment system need to be paid for at the time of construction. The ability to pay for public works is a major influence on what can be done, and when. Regardless of the technical, environmental and other merits of any proposed option, if it can't be paid for, it can't be done.

In the Cumberland context, financing of a wastewater project can come from three major sources;

1. Village of Cumberland funds
2. Borrowing by the Village of Cumberland
3. Grants from outside sources, typically Provincial and Federal governments

While development of a sewer financing plan is a Stage 3 LWMP activity, the ability of Cumberland to pay for a project is a major factor in the decision making about preferred options, so it is given some consideration here.

This memorandum examines the status of these funding sources, and how they relate to potential LWMP wastewater projects.

18.2 Village of Cumberland Wastewater Reserves

Wastewater reserve funds are accumulated by the Village for the purposes of maintaining, replacing and improving wastewater infrastructure. There are four sources of funds;

1. User fees, from existing connected or serviced wastewater users,
2. Property taxes
3. Sewer parcel taxes, and
4. Development Cost Charges, or DCC's,

User fees are normally intended to cover operation and maintenance of the system, and are not intended to be a major contributor to reserves, though surplus amounts in any given year can be put into reserves. Equally, in years when there are extraordinary operating or maintenance costs, these can be covered from wastewater reserves. The wastewater user fee for a single-family house is currently set at $366.60 per year. *For LWMP planning purposes, the net contribution from user fees for capital projects is considered to be zero.*

Sewer "frontage" taxes (parcel taxes levied based on frontage measurements) are intended to cover infrastructure replacement costs. They can be accumulated to offset future costs, and used to pay off borrowing for previous projects. Since there is a defined number of properties, and a defined tax rate, frontage taxes provide a predictable rate of reserve accumulation. They are the primary means for building-up reserves. In the case of wastewater, frontage taxes can only be levied on properties that are serviced by (capable of connecting to) the wastewater system. The property itself does not need to be connected, so a vacant lot will pay the frontage tax even though it is not paying user fees. This is in recognition of the fact that the infrastructure - both collection and treatment - to service the lot is aging and needs replacement regardless of whether the lot is actually connected. Cumberland has a Sewer Frontage Tax of $1.57 per foot of frontage, with a minimum deemed frontage of 50 feet, and maximum of 100 feet, for a range of $78.50 to $157 per lot per year. For financial year 2017, the sewer frontage tax revenue that has been levied is $155,290. Where a major project, such as a new treatment plant, creates large additional costs, parcel taxes can be raised to cover all or part of this. However, while levying a high frontage tax may seem to be an easy way to accumulate reserves, they must be considered in the context of the overall tax burden on the community.

DCC's are usually collected from developers at the time of subdivision approval or at the time a building permit is issued. The purpose of DCC's is to offset the portion of sewer, water drainage, roads and park services infrastructure that are required to accommodate the new development. They consider the projected growth, and expected future costs of infrastructure, to establish a charge for each new dwelling unit or equivalent. They are subject to Provincial government review, established by bylaw and typically updated every five years, with the next update for the Village of Cumberland set to take place in 2018.

Since DCC's are dependent on the rate of growth, their annual revenue is unpredictable. For a growth of 1500 houses – a doubling of the current Cumberland population – this would bring in sewer DCC revenues of $14.5M. However, this growth is projected to occur over a 20 year horizon, so none of this money is available for a current project, though it can be used to pay off borrowing for a current project.

The Cumberland DCC's are set by Bylaw #934, last updated in 2015, and for wastewater, the current DCC is set at $9,664 per house, with equivalent rates for multi family housing and commercial properties.

As of March 2018, Cumberland has the funds shown in Table 18-1 in wastewater reserves;

Table 18-1 Status of Cumberland Reserve Funds as at January 2017

Fund	2018 status
Developer Amenity Fund (Trilogy)	200,000
Wastewater Reserve Fund	$485,000
Wastewater DCC Fund	$548,330
Total	**$1,233,000**

The wastewater reserves are not only intended to be used for treatment works, but also for replacement of works in the collection system, and the on-going storm-sewer separation program. The reserves have been used for matching funds on major projects that have taken place in Cumberland over the past number of years, including the storm and sewer separation work on Dunsmuir Avenue in 2016.

Key Points about reserves;

- *They accumulate slowly over time*
- *They are partially dependent on growth rates*

- *They are needed for the whole wastewater system, not just the treatment plant*
- *Cumberland presently has minimal reserves*

18.3 Borrowing

Many municipalities borrow money to pay for infrastructure projects. There are two main reasons for considering borrowing;

1. Where a project is to be built now, or built larger, to service future growth needs. Water and wastewater treatment plants are the best examples of this.
2. Where the municipality has insufficient funds in reserves to cover the cost of the project.

Borrowing has the advantage of allowing infrastructure to be built sooner and paid off over time, and partially paid for by future growth. The disadvantages are that there are interest costs, and it imposes a burden on future residents; so, a heavy debt load may inhibit the ability to do other projects in the future.

Municipal borrowing is typically over terms of 10, 20 or 30 years, and at relatively low interest rates compared to commercial borrowing. Any long-term borrowing – for terms of greater than five years – must have elector approval. This is normally done by either a referendum or an Alternate Approval Process, as was done in January 2017 for the potable water project. A third means of elector approval is the LWMP process itself. The LWMP process includes extensive public consultation, and where a completed, and Ministry of Environment approved Stage 3 LWMP has borrowing as part of the long term financing plan, elector approval is deemed to have occurred.

Municipalities have a limited borrowing capacity, which is determined by the tax revenues of the municipality and its current financial position. As at January 2017, Cumberland's borrowing capacity is about $8.5 million. However, $1.4M of this is committed to the 2017 potable water treatment project, leaving a net borrowing capacity of about $7.1M.

Cumberland Council may desire to keep some of this borrowing capacity for projects other than wastewater thus reducing the capacity for wastewater borrowing – the Wastewater Advisory Committee cannot make this decision.

Key points about borrowing;

- *It allows projects that create long term benefits*
- *It imposes a long term financial burden*
- *Cumberland's borrowing capacity is limited to maximum of $7.1M*

18.4 Grants and Outside Funding Sources

The use of outside funding sources is common for municipal infrastructure projects, and most municipalities try to obtain grants wherever and whenever possible.

As described in Section 15, the major sources are the joint provincial and federal infrastructure funds such as;

- Building Canada Fund
- Gas Tax fund

– Clean Water and Wastewater Fund (CWWF)

These fund sources award grants for specific projects based on a competitive application process. The funds are intended to help improve standards of infrastructure, especially to help meet new regulatory standards. They are not intended to be just for growth related expansion, which should be funded by DCC's.

These funds typically do intakes every two years. Cumberland applied to the CWWF in November 2016 for both potable and wastewater projects, and secured funding of $5m for the potable water project, and was rejected for the $21M wastewater project. There is never any guarantee that any projects will get funded.

An additional, smaller, source of grant funding is through the Federation of Canadian Municipalities Green Municipal Fund "GMF" which provides loans and small grants for infrastructure projects that demonstrate environmental leadership. Cumberland has received a $175,000 grant from GMF for the 2016 and 2017 LWMP work as a Feasibility Study, and can apply to GMF for a loan and grant for a Capital Project.

Table 18-2 Major Infrastructure Grant Funds*

Fund	Funding %	Maximum Amount	Next Expected Intake
Building Canada Fund	66%	None	Unknown
Gas Tax Fund	Up to 100%	$6M	2019
Clean Water and Wastewater Fund	83%	None	2018
Green Municipal Fund	15% of loan amount	$750k	Continuous

*As of 2017. Future funding amounts to be confirmed.

There are also numerous small funding grants available that have very specific criteria, such as environmental enhancement, economic development and community group involvement. These are not a meaningful source of funding for a wastewater treatment project, but may be suitable for some specific aspects of it, such as a habitat reclamation or creation of community recreation or education component.

Another potential source of outside grants is "amenity" contributions from developers, where large projects being planned. These contributions are by negotiation between the developer and the municipality. Because of their nature it is difficult to predict when they will happen or how much they might be.

Key Points about grants

- *Outside grants from varying sources can be pursued*
- *It is not possible to predict how much money can be obtained*
- *It is not possible to predict when they might be obtained.*

18.5 Financing Strategy

The financing position that Cumberland is in, for a wastewater project, can be summarised as follows;

1. There are negligible reserves available, and they will increase too slowly to fund a near term project.
2. The maximum possible borrowing capacity is $7.1M

3. While all available grant opportunities will be pursued, it could take years before any funding is obtained

Thus, if a project is going to be less (or significantly less) than $7M, then Cumberland can decide to borrow and proceed without waiting for outside funding.

If a project is going to be more than $7M, Cumberland will need to wait for securing of outside grants before it can be completed, thus making timing unpredictable.

The regulatory framework sets the necessity for action to be taken as soon as practical, to meet current Permit and incoming federal regulations, and also triggered by the need to meet current regulatory standards as a result of population growth and increased wastewater flows since the latest Discharge Permit was issued in 1997. Thus the timing *must* be predictable.

This financing framework, specifically the borrowing capacity, sets a limit on how much can be done immediately, thus necessitating a phased approach, where a first phase would;

1. Improve treatment quality to meet the current Permit and new Federal requirements;
2. Cost less than $7M, thus allowing Cumberland to decide to proceed; and
3. Be operational by 2020.

The second phase would;

1. Deliver any further improvements in treatment quality that are needed, or desired (e.g. for reclaimed water);
2. Create any additional capacity for future growth not delivered in the first phase, and
3. Proceed when outside grants are obtained and/or reserve funds have built up sufficiently,

Preferably, the project type is such that both phases could be done at the same time, if grants are obtained before or shortly after a decision to proceed with the first phase.

An “ideal” solution is one where a planned project meets all current and future needs and costs less than $7M, and thus does not need to be phased. It should be noted that over the past 19 years of the LWMP, an “ideal” solution of low cost and high quality and capacity has never been identified.

18.6 Summary

External grant funding has become a major part of how municipal infrastructure projects are funded. There are numerous funds available to Cumberland, with separate and sometimes overlapping purposes.

The funds are all evaluated and awarded on a competitive basis, and consideration of risk factors that can delay or halt a project are equally as important a consideration of the technical and environmental benefits.

Some types of projects are more likely to secure grant funding than others, and this is a valid consideration in decision making.

Grant programs can also assist with funding of specific or additional components of a project that would not otherwise be pursued.

Once a project has started, or gone out to tender, it is not eligible for most funding programs (with the notable exception of the Green Municipal Fund) so it is ideal to pursue and secure grants before commencing the project. If grant funding is not obtained, and the project has not started, the scope can be changed and/or reduced to reduce the overall cost.

19.0 WASTEWATER ADVISORY COMMITTEE, PUBLIC CONSULTATION AND WASTEWATER STEERING COMMITTEE PROCESS

19.1 Wastewater Advisory Committee

A public advisory committee is a standard part of the LWMP process, usually in parallel with a Technical Advisory Committee. In the case of Cumberland, as with many small communities, it is much more efficient to combine the committees into a single advisory committee, which was called the Wastewater Advisory Committee.

19.1.1 WAC Composition

A call for members was put out in April 2016, and six members of the public were appointed by Cumberland Council.

Other members of the committee included, as per the LWMP guidelines, representatives from;

- Komox First Nation
- Vancouver Island Health Authority
- Cumberland staff – Chief Administrative Officer and Manager of Operations
- Cumberland Council – one representative and an alternate
- Consultants – Project Coordinator and Technical consultants
- Ministry of Environment (ex-officio)
- Federal Dept of fisheries and Oceans

All delegates were sent agendas and minutes before all meetings, but not all delegates attended all meetings;

- Village staff and the Project Coordinator attended all meetings
- Most of the public members attended the meetings most of the time.
- The two Technical Consultants attended the most of meetings, and some by teleconference
- Komoks First Nation attended one meeting.
- The Island health representative attended about 50% of meetings
- Ministry of Environment and Dept of Fisheries and Oceans did not attend meetings.

The WAC selected a member of the public as the Chair.

Voting was restricted to the public and external committee members –the council delegate does not get to vote, as they get a vote at Council. Staff and consultants are advisors to the committee.

Documentation was maintained by the Project Coordinator, who prepared the agendas, kept the minutes, and facilitated the technical part of the meetings.

19.1.2 WAC Meetings & Review

WAC meetings were normally held Thursday from 1 to 4pm, with three full day meetings when extensive "workshop" style interaction was required.

A total of fifteen meetings have been held from May 2016 to January 2018, with the main topics and recommendations as follows:

Mtg #	Date	Main Topics and Recommendations
1	May 28, 2016	Introductory, LWMP objectives
2	June 16, 2016 (all day)	Goal Setting session
3	June 30, 2016	Review of goal setting
4	July 28, 2016	Review of Open House #1 feedback, ***Recommendation to Council on Goals and Evaluation System***
5	August 25, 2016 (all day)	Discharge Options – develop Long List
6	Sep 8, 2016	Evaluate Long List to select Short List
7	October 6, 2016	Review Open House #2 feedback, Evaluate discharge options – summer "effluent storage" options preferred, but Maple Lake Creek must remain on table. ***Recommendation to Council to pursue Federal CWWF 83% funding opportunity.***
8	Oct 27, 2016	Initial Review of Long List of Treatment Options, evaluated down to the Short List
9	1 Nov 2016	Evaluate Short List of Treatment Options - "Full Flow Mechanical" selected as preferred Option.
10	17 Nov 2016	Review Open House #3 feedback, ***Recommendation to Council -Full Flow Mechanical is preferred treatment option.***
11	April 25, 2017	Post mortem of CWWF funding rejection, 2017 workplan – field data gathering on lagoons and Maple Lake Creek.
12	Sep 7, 2017	Initial Review of summer environmental and lagoon monitoring. Minimal dilution in Maple Lake Creek but wetlands doing an outstanding job of polishing effluent. Lagoon based treatment options appear viable.
13	Nov 2, 2017 (all day)	Review results of 2017 Technical Studies, initial evaluation of treatment options. Lagoons look preferred, but MBR is cost competitive.
14	Nov 30, 2017	Review feedback from Open House #4, evaluate treatment options and ***Recommendations to Council;*** ***1. Discharge to Maple Lake Creek is only viable discharge location, with preference for indirect discharge to MLC via the north wetlands.*** ***2. Lagoon based treatment to "moderate Exposure Potential" reuse quality (Option 1, Ph1 +2A) as preferred option.***
15	Jan 25, 2018	Review funding and phasing strategy. ***Recommendations to Council;***

		1. Adopt the Biochar Reed-bed as part of the project, subject to further study and pilot testing. ***2. Pursuing a complete project rather than a phased one for all funding applications, and implement a phased approach only if funding is unsuccessful.*** ***3. Move to implementation of a project under the regulatory authorization of the existing permit, and seek elector approval for borrowing.***

19.2 Public Consultation

Public consultation is one of the two foundational elements of developing a BC Liquid Waste Management Plan, with the other being the protection of the environment.

This section presents a summary of the public consultation activities carried out during the course of the Stage 2 LWMP from March 2016 to May 2018

19.2.1 Public Open Houses

Public open houses have been the primary means of taking information to the public and getting feed back. Five public events have been held in developing the Stage 2 LWMP;

Table 19-1 LWMP Stage 2 Public Events

Title	Date
Wastewater Lagoon Tour (in the rain!)	May 28, 2016
Open House 1 - Goals and Evaluation System	July 14, 2016
Open House 2 - Discharge Options	Sep 22, 2016
O.H. 3 - Federal CWWF Funding Opportunity and Treatment Options	Nov 1, 2016
O.H. 4 - Treatment and Phasing Options	Nov 23, 2016

The format for these open houses has been;

- 6-9pm at council chambers
- Posterboard viewing 6-6:30pm
- Presentation by consultants and Committee chair 6:30-7:30
- Q&A 7:30-9
- Survey form filled out by attendees

The attendance at the open houses has varied from 10 to 16 members of the public, not including staff, Councillors, Advisory committee members or consultants.

The public has generally, but not always unanimously, agreed with the recommendations and preferred direction of the WAC.

19.2.2 Public Newsletters

Public newsletters have been periodically mailed out to all residents of Cumberland during the LWMP, most frequently to announce upcoming public events.

Table 19-2 Public Newsletters Regarding the LWMP Process

Title	Date
Newsletter #1 – Invitation to Lagoon Tour	May 2016
Newsletter #2 – Invitation to Open House 1	July 2016
Newsletter #3 – Invitation to Open House 2	September 2016
Newsletter #4 – Invitation to Open House 3	October 2016
Newsletter #5 – Summer 2017 LWMP Update	July 2017
Newsletter #6 – Invitation to Open House 4	November 2017

The newsletters also contained information about the Advisory Committee, the LWMP process and some relevant Q&A's

19.2.3 Public Access to WAC Meetings

All Wastewater Advisory Committee meetings are open to the public. The public can view the meetings, but not interact with the proceedings. All meetings have concluded with a public Q&A session after the adjournment. Attendance has varied from 2 to 10 people.

19.3 Council Decisions

The Village of Cumberland Council acts as the official "Wastewater Steering Committee" as defined by the LWMP guidelines. Council considers the recommendations of the Wastewater Advisory Committee (WAC), the advice of Village staff and makes the final decisions.

In all cases, Council has unanimously accepted the recommendations of the WAC.

20.0 DECISIONS ON PREFERRED DISCHARGE AND TREATMENT OPTIONS.

20.1 Results of the Goal-Based Evaluation System

The purpose of all the Stage 2 LWMP information is to select the preferred long-term Discharge and Treatment Options, for detailed evaluation study in Stage 3. To do this, the Wastewater Advisory Committee used the goal based Evaluation System, that was developed at the start of the process in June-August 2016, to evaluate and rank the short listed treatment options developed in the Stage 2 study.

The evaluation was carried out at WAC meetings #14 (Nov 30, 2017) and #15 (Jan 25, 2018).

20.1.1 Preferred Discharge Location

The first decision was to confirm the Discharge Location. The environmental studies showed that;

- The large winter stormwater flows mean that Maple Lake Creek is the only practical discharge location in winter.
- The need to maintain summertime flows in Maple Lake Creek mean that this is the only environmentally acceptable discharge location in summer.
- If there is to be future reclaimed water use, the flow needs of Maple Lake Creek must be met first.
- The discharge to Maple Lake Creek could also made indirectly via the north wetlands, restoring natural summertime “wet” conditions there.

The Committee confirmed that Maple Lake Creek is the Preferred Discharge Location, and the preferred conveyance is indirectly to the creek via distribution to the North Wetlands.

20.1.2 Preferred Treatment Option

For the Treatment Options, the four long-term treatment options were evaluated (Option 1, Phase 1 was not evaluated as it is an interim option only). The results of the evaluation are summarized in Table 20-1.

Table 20-1 WAC Options Evaluation Results

		Option 1 Upgraded Lagoon		Option 2	Option 3
	Category Score	**Phase 1 + Phase 2A**	**Phase 1+ Phase 2B**	**Baseflow Mechanical**	**Full Flow Mechanical**
Water Quality		MEP	GEP	GEP	GEP
Discharge Location		N. Wetland	MLC	MLC	MLC
Capital Cost		$8.7M	$10.6M	$9.3M	$14.8M
Annual Operating Cost		$375k	$425k	$450k	$500k
Affordability	40	36.6	27.5	26.7	11.4
Economic Benefits	20	12.9	11.5	8.8	9.3
Environmental Benefits	20	16.5	14.1	12.9	14.5
Social Benefits	20	13.9	12.4	10.4	10.4
Total Score	**100**	**79.8**	**65.6**	**58.8**	**45.7**

20.2 Decision Process

The first decision was to adopt the Goals and Evaluation System, which was done on August 8, 2016. The other major decisions came before Council on 9 April 2018, and were;

1. Adoption of the Discharge Location being Maple Lake Creek, with the preferred means being Indirect via the North Wetlands
2. Adoption of the preferred long term Treatment Option as being Option 1, Phases 1+ 2A – the Upgraded Lagoon to MEP Quality
3. That, subject to successful field trials, the Biochar Media Reed-bed be added to the Treatment Option
4. That funding be sought for implementing a combined project of Option 1, Phases 1 and 2A, rather than just Phase 1, and
5. That implementation of treatment upgrades proceed using the regulatory authorization of the existing Discharge Permit, and seeking elector approval for any borrowing, rather than waiting for authorizations by completion of Stage 3 of the LWMP.

The last decision is driven by the need to come into regulatory compliance as soon as possible.

20.3 Stage 3 LWMP Considerations

Once the mandatory Treatment Upgrades are in place, Stage 3 of this Liquid Waste Management plan can then consider the major regulatory item of obtaining regulatory authorization for increasing the wastewater flows beyond the limit of the current Permit. This could be by completing Stage 3 with ministerial authorization, or registering directly under the Municipal Wastewater Regulation.

Stage 3 of the LWMP can also further consider the remaining liquid waste issues outlined in this Stage 2 report including;

- Reviewing the performance of the treatment upgrade works

- Updating long term growth planning
- Management options for the Comox Lake area
- Further storm-sewer separation and infiltration reductions
- Management of stormwater discharge
- Long term biosolids options
- Potential reclaimed water use