Attachment 3(a)

Capital Regional District

Core Area Liquid Waste Management Plan

Wastewater Treatment System Feasibility and Costing Analysis

Technical Memorandum #1

Background and Technical Foundation

Engineers...Working Wonders With Water™

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1.0 Introduction and Methodology

1.1 Project Background

Phase 2 analysis is an important chapter in an ongoing decision making process. Phase 1 included a constructive engagement process to characterize sites and option sets and collect public input on their values for wastewater treatment. Future phases, Phase 3 and beyond, allow the Core Area Committee and the Regional Board to confirm detailed performance criteria that ultimately becomes an owners' statement of requirements, or similar, for responses by the treatment and resource recovery market(s) to price, build and commission and potentially operate a core area wastewater solution. It is critical that the Phase 2 methodology respect the multi-phase sequence of this project and deliver on specified milestones, such as to assess systems and technologies, however not to select ultimate products and or technologies but rather to help the Core Area Committee define the required characteristics of the future system and provide a characterization of the option sets. All option sets may proceed to Phase 3 or it may become apparent that a subset of the option sets achieve the desired objectives and move forward to subsequent phases. Overall, the three phase analysis is summarized below.

Process Summary	
Phase 1:	Identify Sites and Option Sets and Collect Public Input on Values
Phase 2:	Confirm Performance Criteria and Characterize Financial/Environmental/Social Aspects of Option Sets
Phase 3+:	Finalize/Narrow Options, Determine Preferred Method to Engage with Private Sector, Confirm Funding Approach, Amend LWMP, Select Partners, Deliver Project(s), Operate Systems

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In effect, Phase 2 technical and costing analysis includes assessments and calculations that enable preliminary performance criteria to be tested and refined. The results of the process and analysis will enable the Committee to decide and direct on future performance criteria and infrastructure siting locations based in part on industry best practice, regional context and long-term service delivery excellence. Phase 2 significantly advances the Committee to confirming its requirements for a Core Area wastewater solution and serves to screen the options based on project criteria.

A process for establishing performance criteria typically involves key ingredients as outlined below.

- **Preliminary Design Criteria:** A project charter frames the project and provides guidance for analysis and outcomes. Preliminary criteria should be derived from the charter goals and commitments and later, the criteria can instruct the engineering and costing analysis.
- **Representative Design:** Employing the preliminary design criteria against technical options and technologies begins to frame up the market possibilities (e.g. technologies, resource recovery pathways, pipe alignments, etc.) for a Core Area system. Representative design includes provisionally selecting technologies and system configurations to characterize the relative value of available options and encourage deeper dialogue on the particulars of any commissioned facilities. While analysis and reporting will refer to specific solutions these are

not recommended outcomes; instead, the results of the representative design allow the criteria to come to life for a deeper understanding including life-cycle costing.

- **Life-Cycle Costing:** Potential ratepayer impacts based on proposed levels of service are crucial to performance criteria. Each option set will be assessed using capital, operating and revenue characteristics which will uncover the trade-offs in Core Area alternatives and likely lead to further iterations in future phases. For Phase 2, these costs are Class D only for the purpose of comparing options with significant contingencies due to the nature of the unknowns.
- **Presentation of Alternatives:** Option sets analysis will convey the ability of multiple solutions to meet the criteria and aspirations of the Core Area. While no single alternative will be able to fully address the criteria, it is the presentation of the alternatives and the ensuing debate that will help to clarify the refined set of technical criteria.
- **Refined Criteria:** Final reporting will center on the evolution and rationale for the stated, refined technical criteria. Future phases will test these criteria further so as to confirm the Committee's final statement of requirements (for one or more contracts) for responses by the wastewater treatment and resource recovery market.

Our work plan and methodology follow these ingredients explicitly. We endeavour to translate the project charter into preliminary design criteria, undertake technical analysis and present alternatives so as to provide information for direction by the Committee on their refined performance criteria. Technology and option set evaluations are provisional for deeper understanding of the criteria.

1.2 Preliminary Criteria

There is a need to focus the broad range of treatment and engineering solutions to arrive at a representative design that can be used to develop Class D life-cycle financial scenarios. While private sector submissions will help to finalize the ultimate system design based on prescribed owner's requirements, establishing criteria based on the Project Charter will guide representative design parameters. These parameters will become a key step in setting performance criteria for the project and ultimately guide the technical analysis through Fall 2015 to support Committee direction on preferred system configurations and outcomes.

These criteria are preliminary but suitable for carrying out Phase 2 and stem from the Committee's Charter. Input from the Technical Oversight Panel and direction by the Committee will enhance these criteria and ensure that design parameters align with Core Area expectations and public input to date. Criteria are used to assess alternatives and arrive at potential options that suit the multiple needs and goals of the project. The Charter's Goals and Commitments (left column) frame the criteria.

Charter Goal/Commitment	Preliminary Charter Criteria
1. Meet or exceed federal regulations for secondary treatment by December 31, 2020.	a. Refer to Section 2.5.4. b. Extent of liquids or solids produced in excess of regulations.
2. Minimize costs to residents and businesses (life cycle cost) and provide value for money.	a. Extent of leveraging of existing infrastructure assets; b. Reduction of consumable and operations costs; c. Extent of revenues from resource recovery;
3. Produce an innovative project that brings in costs at less than original estimates.	a. Extent of alternative to bring in costs less than original estimate.
4. Optimize opportunities for resource recovery to accomplish substantial net environmental benefit and reduce operating costs.	a. Certainty of long-term demand and revenue; b. Extent of support for community building; c. Extent of new infrastructure/services to support resource recovery; d. Extent of integration of other regional waste streams
5. Optimize greenhouse gas reduction through the development, construction and operation phases and ensure best practice for climate change mitigation.	a. Reduction of carbon footprint (buildings, treatment, transportation); b. Ability to produce high-quality air emissions; c. Ability to balance energy needs;
6. Develop and implement the project in a transparent manner and engage the public throughout the process.	a. Ability of an alternative to meet the preliminary criteria
7. Develop innovative solutions that account for and respond to future challenges, demands and opportunities, including being open to investigation integration of other parts of the waste stream if doing so offers the opportunities to optimize other goals and commitments in the future.	a. Ability to phase capacity/expansion with growth; b. Ability to improve effluent quality over life of facility; c. Extent of integration of other regional waste streams (above)
8. Optimize opportunities for climate change mitigation	a. Reduction of carbon footprint (buildings, treatment, transportation); b. Ability to produce high-quality air emissions; c. Ability to balance energy needs;
9. Deliver a solution that adds value to the surrounding community and enhances the livability of neighborhoods.	a. Extent to provide for positive public interaction; b. Reduction of risk to neighborhoods from facility failure; c. Reduction of interruption to neighborhood during normal operation;
10. Deliver solutions that are safe and resilient to earthquakes, tsunamis, sea level rise and storm surges.	a. Site/design resiliency for seismic and sea level rise;

The preliminary criteria outlined in this Technical Memo provide the basis for detailed technical criteria to develop a representative design and also allow for a comprehensive presentation of the option sets toward the end of Phase 2. Direction from the Committee in December 2015 will allow the CRD to take further steps to refine the performance criteria for a market response to a Core Area solution.

Technical Memorandum #2 will apply the initial steps of our methodology and the preliminary criteria against the defined option sets for further analysis. Additional feedback from the Technical Oversight Panel and ultimately, direction by the Committee, will finalize the option set analysis through Fall 2015.

1.3 Proposed Option Sets Evaluation: Considerations for Decision Making

Phase 2 feasibility and technical analysis provides for an evaluation of 4 option sets across the Core Area. Each option set includes different extents of infrastructure, facilities, services, risks and operations. Life-cycle costing is a core element of the option set evaluation.

Committee direction from June 2015 centers on life-cycle costing analysis which includes design and construction contingencies, administration costs, escalation, inflation, environmental costs as well as capital, operating and maintenance costs. This type of analysis is consistent with comparisons of major capital projects to screen options and further, supports staff and consultants in determining potential allocations per municipality.

In addition to financial analysis, each option set will be further assessed based on its performance against the preliminary criteria stemming from the Charter and from public values from previous phases. While the assessment will be primarily qualitative in nature, the characterization of social benefits, environmental values, risks and service governance will be supportive for Committee direction. Neither the financial analysis nor the qualitative assessment are enough on their own to confirm direction, but instead, it’s the balance of needs and aspirations reflected across the entire suite of criteria from which reasonable direction can be made.

1.4 Option Set Evaluation Methodology

Evaluating option sets is led by the Project Goals and Commitments and the established technical criteria. Whether centralized or distributed, it is the ability of any one option set to best meet the goals of the project that warrants even further optimization by the Committee in future phases. Designing the option sets must consider the evaluation method, hence why both methods are included.

Option Set Design Consideration

- Confirm flows by catchment area and site node.
- Inventory supply and demand projections for water and heat recovery reuse across site nodes in the Core Area. Locate potential customers and define their product needs including barriers and pricing considerations.
- Locate treatment facilities (liquids and or solids) among available sites with consideration to existing infrastructure, land uses, road access and synergies with neighboring site nodes.

- Apply regulatory requirements and overlay with existing infrastructure to meet reliability needs without excess infrastructure.
- Develop conceptual resource recovery infrastructure systems to convey resources to their demands. Look for synergies with neighboring site nodes to reduce unnecessary infrastructure.
- Incorporate various processes and technologies to meet the resource recovery, regulatory and neighborhood considerations. Each option set should look to address a different level of service (in line with the criteria) to allow for lateral comparison of all option sets.
- Optimize resource recovery infrastructure to suit the supply demand balance e.g. focus toward the size of treatment facility to suit actual reuse needs and look for phasing to support growth.
- Confirm regulatory and risk-management needs including ultimate disposal of water as required. Confirm limitations and service governance considerations for implementation and operation.
- Iterate design considerations for 2030 and 2045 scenarios.

Evaluation

- Summarize the technical and engineering elements and characterize their relative levels of service.
- Create aggregate resource recovery summary (qualitative and quantitative) for comparative and communication purposes including overall benefits to community, climate change considerations, others.
- Inventory life-cycle costing elements including construction, operation, maintenance and revenues.
- Present life-cycle costing results including sensitivity analysis for various risk, revenue and contingency factors.
- Characterize operations and service governance needs, risk considerations, preliminary economic factors (e.g. supply and demand, pricing), qualitative elements such as social-benefits stemming from the ability to deliver on community aspirations such as water reuse, advanced treatment and other returns on investment that aren't readily quantifiable.
- Assess distributed option sets against technical criteria (Section 1.2).
- Discuss option sets against all project goals of the Charter.
- Reflect on criteria, project goals, and financial results and develop balanced scorecard approach to presenting the option sets.
- Consider recommendations for Committee consideration which may include further refinements of the option sets to best suit the needs of the Core Area.

Technical Memorandum #2 will provide extensive inventories of the option set designs whereas Technical Memorandum #3 will present the evaluation of each option set.

2.0 Design Criteria

2.1 Design Horizon

Most of the work undertaken to date targets meeting the population/flow requirements to the year 2030, with preliminary consideration to flows in 2045 and 2065. These design horizons are consistent with funding applications and businesses cases and therefore could be adopted for Phase 2. Phase 2 feasibility and technical analysis will address infrastructure and life cycle costing for both the 2030 and 2045 design years.

2.2 Design Populations

Previous phases of analysis researched and collated residential populations in each of the seven (7) municipalities and two (2) First Nations, as well as developed equivalent populations for the industrial, commercial and institutional sectors within each area. Population and flow projections are a considerable resource for Phase 2 and we propose to utilize available information following a preliminary screening on their suitability at this time.

Growth rates have been estimated a low rate (at 1.3%/year) and a high rate (at 2.1%/year). Aggregate populations provide a scale of growth for the Core Area however Phase 2 design and analysis will consider municipal by municipal growth to account for locally-specific design capacities. Overall, growth rates to 2030 and 2045 are tabulated below and include population equivalent contributions from industrial, commercial, and institutional sources

	@ 1.3%/year growth	@ 2.1%/year growth
Core Area Population (eq.) 2030	436,000	494,000
Core Area Population (eq.) 2045	570,000 (1)	669,000

(1) Derived from Discussion Paper 033-DP-1

Actual flow projections are based on municipal expectations as communicated to the CRD which are outlined in the following section.

2.3 Flows

Table 2.3.1 summarizes the design flows for 2030 and 2045. While there are nuances and potential discrepancies for flow estimates, Table 2.3.1 appears to reflect the most current CRD estimates with general agreement by the municipalities. We intend to move forward for Phase 2 relying upon the flow estimates in column 1, which we note are different than the flow estimates as provided by the Westside Technical Committee.

The flows noted are based on average dry weather flows (ADWF which aligns directly with the regulatory requirements of the Municipal Wastewater Regulation, as outlined in Section 2.5.1.

Recent direction from the Westside Select Committee is that engineering analysis for Westside Option Sets should account for the flows from west Saanich and west Victoria currently destined for the Macaulay outfall. Flows from the Eastside that travel to the Macaulay outfall are represented in Table 2.3.1.

To account for ongoing water conservation programs and demand management initiatives, the projected per capita flow rates decrease around the Core area from 225 to 250 litres per capita per day now to 195 in 2030 and 2045. Flows are presented in megaliters per day (MLD) which is a summation of the population equivalents per catchment area based on the per capita estimates.

Table 2.3.1 - Core Area 2030 and 2045 Design Flow Allocations

Location		ADWF (MLD)		
		2030 (1)	**2030 (2)**	**2045 (3)**
A.	**Clover Outfall**			
	- Oak Bay	6.6	-	6.6
	- East Saanich	9.2	-	12.8
	- East Victoria	31.9	-	34.0
	Sub-Total	**47.7**	**-**	**53.4**
B.	**Macaulay Outfall**			
	- Langford	14.1	14.1	23.1
	- Colwood	4.7	4.7	13.1
	- View Royal	3.5	3.5	7.9
	- Esquimalt First Nation	0.3	0.7	0.4
	- Songhees First Nation	0.4	0.7	0.5
	- Esquimalt	7.1	6.2	7.9
	- West Victoria	6.4	1.0	6.8
	- West Saanich	23.7	16.5	32.9
	Sub-Total	**60.2**	**47.4**	**92.6**
	Totals	**107.9**		**146.0**

(1) Core Area LWMP Committee Orientation Presentation, January 7, 2015

(2) Flows assumed by Westside

(3) Derived from CRD 2030 projections (first column). Refer to Appendix A for derivations

2.4 Influent Wastewater Quality and Loads

The CRD collects 24 hour composite samples and tests the influent effluent for numerous parameters. A summary of the 2014 data is included in Appendix B. The most relevant influent sewage concentration data from 2014 are summarized in Table 2.4.1. This data is consistent with historical reports prepared for the Core Area LWMP, the latest being the January 23, 2013 Technical Memo "Indicative/Detailed Design/Wastewater Characterization and Design Loads". Table 2.4.1 also includes a summary of the 2030 maximum month loads, which are used to size the biological components of the plants. To account for flow and load variability, design factors account for the maximum load that the facility will experience in any 30 consecutive days which typically represents the 92 percentile of the data set analyzed for 2014. The proposed flow-load variability factor is set at 1.25 times the average loading.

Table 2.4.1 – Average Influent Quality Concentrations and Maximum Month Loads for 2030 Flows [(1)]

Parameter	Macaulay		Clover	
	Average (mg/L)	Max Month (kg/d)	Average (mg/L)	Max Month (kg/d)
Carbonaceous BOD_5	226	17,010	192	11,450
Total BOD_5	275	20,700	238	14,190
Total Suspended Solids	270	20,320	238	14,190
Chemical Oxygen Demand (COD)	632	47,560	530	31,600
Ammonia	42	3,160	27	1,610
Alkalinity	217	16,330	168	10,020
Total Kjeldal Nitrogen	54	4,060	40	2,385

(1) Note influent pH ranges from 7.3 to 7.7 typically

2.5 Liquid Effluent Criteria

2.5.1 Introduction

Two regulations currently govern effluent discharges in BC – The Federal Wastewater Systems Effluent Regulation (WSER) and the BC Municipal Wastewater Regulation (MWR). The WSER deals only with discharges to surface waters and has marginally different criteria than the MWR. The MWR addresses discharges to surface water, ground, wet weather flows and for reclaimed water. Both provincial and federal governments intend to harmonize the regulations which will affect the effluent criteria.

There is a strong sentiment within the Core Area to reuse reclaimed water as much as possible. To facilitate this sentiment, it is proposed that effluent destined for reuse meet the *Greater Exposure Potential Category* for reclaimed water as defined in the BC Municipal Wastewater Regulation. This level of quality is similar to the requirements of the Canadian Guidelines for Domestic Reclaimed Water for Use in Toilet and Urinal Flushing and the California Title 22 Regulation and would permit all reclaimed uses except indirect and direct potable reuse applications. It is our understanding that this would also be acceptable for aquifer recharge based on work currently being undertaken by the City of Colwood. If the CRD was to limit the reuse to irrigation on restricted public access sites only, then the standard of effluent quality could be reduced to *Moderate Exposure Potential Category* which is basically equivalent to secondary treatment as defined in Section 2.5.4. Also, secondary treatment is suitable for discharge to most marine environments but the outfall depth must be positioned at 30 m or more which effectively rules out any discharge to the inner harbour.

Stream augmentation is cited in the regulations whereby treatment must be greater than secondary (tertiary) with effluent criteria to suit the receiving environment. However, MWR requires an alternate disposal or storage for reclaimed water (stream augmentation or reuse) as follows:

"Alternate Disposal or Storage

114 (1) A person must not provide or use reclaimed water unless all of the following requirements are met:

(a) There is an alternate method of disposing of the reclaimed water that meets the requirements of this regulation or is authorized by a director.

(b) Treatment processes are built with the minimum number of components specified in the applicable reliability category for the alternate method of disposal, as described in section 35 *[general component and reliability requirements]*;

(c) If there is no immediate means of conveyance of the municipal effluent or reclaimed water to the alternate disposal method, the wastewater facility has 48 hours' emergency storage outside the treatment system.

(2) Despite subsection (1) (a), a director may waive the requirement for an alternate method of disposal for reclaimed water that is not generated from residential development or institutional settings if an alternate method is not required to protect public health or the receiving environment and the wastewater facility has

(a) 48 hours' emergency storage outside the treatment system and the ability to shut down generation of municipal wastewater within 24 hours, or

(b) A dedicated storage system that is designed to accommodate:

i. At least 20 days of design average daily municipal effluent flow at any time,

ii. The maximum anticipated volume of surplus reclaimed water, and

iii. Storm or snowmelt events with a less than 5-year return period.

(3) Despite subsections (1) (a) and (2), if reclaimed water is discharged from a wastewater facility directly into a wetland, a director may waive the requirement for an alternate method of disposal if an alternate method of disposal is not required to protect public health or the receiving environment.

Failure to meet municipal effluent quality requirements

115 (1) If municipal effluent does not meet municipal effluent quality requirements, a provider of reclaimed water must ensure that the municipal effluent is diverted immediately to

(a) An alternate method of disposal, as provided for in section 114 (1) (a) *[alternate disposal or storage]*, or

(b) Emergency storage or a dedicated storage system, as described in section 115 (1) (c) or (2),

Until municipal effluent quality requirements are met and reclaimed water uses may continue.**"**

These regulatory requirements strongly suggest that an alternate ocean outfall is required if stream augmentation is pursued.

A discharge to a wetland may be possible without requiring an alternate method of disposal, but this would require a specific environmental impact study and a waiver from the Director of the Ministry of Environment. A discharge to a wetland has not been considered in our analyses at this time however may be considered at the direction of the Committee.

The MWR and previous liquid waste management plan amendments further regulate the quality of effluent with respect to wet weather flows, as tabulated below:

Effluent Criteria	Macaulay Outfall	Clover Outfall
Secondary	0 – 2 x ADWF	0 – 2 x ADWF
Primary	2 – 4 x ADWF	2 – 3 x ADWF
Screening (6 mm Ø)	> 4 x ADWF	> 3 x ADWF

ADWF = Average Dry Weather Flow

2.5.2 Ammonia and Toxicity

Ammonia and toxicity in wastewater effluent is a complicated topic which is discussed in detail in Appendix C. In summary, the Federal and BC governments have criteria that regulate the amount of ammonia in the effluent, in particular to the un-ionized ammonia concentrations. Our research and analysis concludes (Appendix C) that it is not necessary to reduce ammonia in the wastewater treatment plants to comply with both the federal and provincial regulations before discharging out the Clover and Macaulay outfalls. Enhanced treatment would be required however for any option that contemplates stream augmentation and/or wetland discharges.

2.5.3 Primary Liquid Effluent

The MWR requires primary effluent to meet:

$CBOD_5 \leq 130$ mg/L

TSS ≤ 130 mg/L

2.5.4 Secondary Liquid Effluent plus Disinfection

Ocean outfall effluent criteria should best address both the federal and provincial regulations, as proposed in the table below, and based on the requirement of outfall diffusers at a minimum depth of 30 m below the surface.

Parameter	Units	Average Concentration	Maximum Concentration
$CBOD_5$	mg/L	≤ 25	≤ 45
TSS	mg/L	≤ 25	≤ 45
Un-ionized Ammonia in Effluent	mg/L	NA	≤ 1.25 (1)
Un-Ionized Ammonia at End of Dilution Zone	mg/L	NA	≤ 0.016 (1)
Total Residual Chlorine	mg/L	NA	≤ 0.02
Faecal Coliforms	cfu/100 mL	NA	≤ 200 (2)

(1) Only one of these parameters need to be met.

(2) It is our understanding that disinfection will be required. This is the standard concentration for discharge to recreational waters.

The frequency of testing and the averaging period is dependent on flow rates as shown below for continuous flow systems.

Flow Range	Testing Frequency	Averaging Period
$\leq 2,500$ m^3/d	Monthly	Quarterly
> 2,500 but $\leq 17,500$ m^3/d	Every 2 Weeks	Quarterly
> 17,500 but $\leq 50,000$ m^3/d	Weekly	Monthly
> 50,000 m^3/d	3 Days/Week	Monthly

2.5.5 Enhanced Tertiary Liquid Effluent

Secondary Liquid Effluent Treatment with added disinfection achieves tertiary treatment levels. However, in order to provide the ability for reuse we have identified enhanced tertiary treatment targets.

The proposed enhanced tertiary level of treatment is designed to satisfy most reclaimed water applications in the *Greater Exposure Potential* category as defined in the Municipal Wastewater Regulation including aquifer recharge in Colwood, as noted below:

Parameter	Greater Exposure Potential	Monitoring Requirements
pH	6.5 to 9	Weekly
$CBOD_5$	$\leq$ 10 mg/L	Weekly
TSS	$\leq$ 10 mg/L	Weekly
Turbidity	Average 2 NTU Maximum 5 NTU	Continuous Monitoring
Faecal Coliform (1)	Median 1 cfu/100 mL Maximum 14 cfu/100 mL	Daily

(1) Median is based on the last 5 results.

2.5.6 Emerging Contaminants

In the terms of reference for Phase 2 the base case treatment standard is secondary treatment with advanced oxidation. Unfortunately, we have not been able to determine what parameters and effluent criteria this system was intended to meet. There are in the order of 1,700 pharmaceuticals and personal care products (PPCPs) alone. At the present time, there are no published standards in Canada for the discharge of emerging contaminants to marine waters. The CRD has prepared a fact sheet on emerging contaminants which can be found in Appendix D. From this fact sheet it is interesting to note the data collected by the CRD on their Ganges MBR plant and Saanich Peninsula secondary plant (conventional activated sludge) for removal efficiencies. Approximately 80% of the contaminants (211 of 266) had removal efficiencies > 90% for the MBR plant. Approximately 45% of the monitored contaminants (145 of 324) had removal efficiencies > 90% for the activated sludge plant.

Urban Systems and Carollo Engineers are of the opinion that treatment targets for emerging contaminants be approached in the following manner:

- That treatment processes and technologies for emerging contaminants be assessed in the future once effluent criteria for emerging contaminants of concern have been identified by the regulators; thorough analysis of options can be conducted for the addition of further treatment works at that time;
- That further monitoring and research be conducted in the early years of operation of the new Core Area system to assess the level of reduction of emerging contaminants already occurring in the effluent; and
- That future proposals by market proponents indicate the level of reduction of emerging contaminants in their proposed system and that proposals are evaluated, in part, by the level of reduction achieved.

Space could be left in the plant(s) if it was desired for emerging contaminant treatment in the future once the specific effluent criteria are known.

2.5.7 Liquid Treatment Summary

In summary it has been assumed for the remainder of Phase 2 that secondary treatment plus disinfection will be provided for all ocean discharges up to 2x ADWF with primary treatment to 3 x at the Clover Outfall and 4 x ADWF at the Macaulay Outfall and any other new outfalls. Water for reclaimed purposes will be treated to Greater Exposure Potential Tertiary Standards given the water quality requirements for anticipated uses. No specific treatment will be added at this time for additional treatment of emerging contaminants of concern beyond what the secondary or tertiary process will achieve.

2.6 Solids Criteria

Solids management is an integral component of wastewater treatment and the processing and disposal of the solids generated during the treatment of the wastewater must be addressed. Unlike the water, the solids management has additional requirements both from a public perception and the acceptability of the materials produced. As such, defining the goals and metrics that the solids management must achieve is critical for the technology evaluation.

Sludge is defined as untreated residual solids, whereas biosolids are treated to an extent defined in the BC Organic Matter Recycling Regulation.

Solids criteria are dependent on end uses, some of the typical criteria and end uses are summarized below:

Table 2.6.1 - Solids Criteria

Criteria	End Use	Comments
Class B Biosolids	Land Application	Stringent regulatory constraints
Class A Biosolids	Land Application	Option to donate or sell to public
Dewatered Sludge (12 – 20% dry solids)	Landfill	Could be quite odourous; occupies large volume
Dried Sludge (60 – 85% dry solids)	Landfill	Less concern with odours, occupies much less volume
Dried Sludge (60 – 85% dry solids)	Biofuel for Incinerators	Minor quantities of ash to dispose
Dried Sludge (60 – 85% dry solids)	Biofuel for Gasification	Biochar and ash to be disposed

In terms of the application of these criteria the following aspects will be considered:

- CRD has a current policy that does not allow the land application of biosolids, within its boundaries.
- CRD strongly discourages solids being discharged to their landfill e.g. residual solids disposal should be minimized.

2.7 Resource Recovery Markets: Design and Evaluation Methodology

Wastewater provides for multiple resources that can be recovered for a variety of beneficial uses. Previous studies served to narrow the broad list of possibilities toward a reasonable list of potential applications, including: water reclamation, heat recovery, solids recovery including potential energy conversion, and fertilizer supplements (i.e. struvite). While each application requires its own unique infrastructure and service-operation requirements, there are common attributes that apply universally to suit the charter and preliminary criteria. Throughout Phase 2, possibilities for resource recovery will be initially examined through a lens for:

- Long-term revenues and demands
- Minimized processing-technology footprint
- Cost of service
- Energy balance
- Complexity of customer agreements or partnerships
- Ability to support other community amenities
- Synergy with public utility services
- Regulatory feasibility

This list of attributes will frame the scan for market opportunities for resource recovery and help to identify target markets where there is greatest potential for applications to meet the project goals. Further, distributed option sets are designed to situate multiple plants throughout the Core Area to capitalize on resource recovery demands. Heat recovery and water reuse demands are distributed in particular and instruct the proposed methodology for identifying target markets, including:

- Review the broad inventory of water reuse and heat recovery possibilities including existing customers and future development.
- Inventory supply and demand projections for water and heat recovery reuse across site nodes in the Core Area. Locate potential customers and define their product needs including barriers and pricing considerations.
- Scan the broad list of recovery possibilities against the list of criteria above:
- Narrow the recovery options based on the results of the scan.
- Develop conceptual resource recovery infrastructure systems to convey resources to their demands. Look for synergies with neighboring site nodes to reduce unnecessary infrastructure.
- Optimize resource recovery infrastructure to suit the supply demand balance e.g. focus toward the size of treatment facility to suit actual reuse needs and look for phasing to support growth.
- Confirm regulatory and risk-management considerations. Confirm limitations and service governance considerations for risks and opportunities related to implementation and operation.

- Confirm cost and revenue projections for life cycle costing analysis.

Table 2.7.1 outlines the preliminary considerations for resource recovery target markets.

Table 2.7.1 Preliminary Resource Recovery Opportunities

Reclaimed Water	• Large parcels, clustered in areas within a few kilometres of site nodes, for irrigation supply at parks and local green spaces • Potable substitution for toilet flushing (only) in new (future flows) town center developments including commercial uses • Aquifer recharge
Heat Recovery	• Opportunities to support local development and sustainability goals by providing hydronic heat opportunities (e.g. low grade heat recovery systems) from pump stations or treatment facilities at various institutional and commercial buildings • Opportunities to integrate with any imminent district energy systems • Heat capture at major treatment facilities to offset heating costs and other fuel costs
Solids Recovery	• Market possibilities whereby treated biosolids are mixed into a beneficial topsoil product and sold for land application elsewhere • Market possibilities for biochar or dried solids which remain after energy recovery processes
Energy Recovery	• Recovery of methane gas from decomposed organic materials to produce electricity, natural gas, bioplastics, diesel fuels, others. • Thermal conversion opportunities of carbon via gasification, incineration or pyrolysis.
Struvite	• Recovery of ammonia and phosphorous as nutrients for use in fertilizers • Confirmation that market possibilities previously identified remain and that they are congruent with solids recovery processes

Each of these applications presents opportunities to recover resources from wastewater. Further consideration to service governance, responsibilities, risks, investment needs and long-term operation will be presented to the Committee and the public as part of the analysis results.

3.0 Facility Characterization Criteria

Technical criteria from Section 2 inform the facility design, or *facility characterization criteria*, which is a significant step toward establishing a representative design for each site (Section 4.0).

The following tables summarize the proposed Facility Characterization Criteria and how they align with the Preliminary Charter Criteria outlined in Section 1.0.

Table 3.1 - Liquid Discharge Requirements

Facility Characterization Criteria	Preliminary Charter Criteria	Comments
Flow Requirements	Meet Regulations (1a)	System must work as a whole but each site in a solution set may play a different part (i.e. Where we treat the flows over 2x average dry weather flow)
Receiving Environment – Regulatory Limits	Meet Regulations (1a)	Tied to discharge location
Receiving Environment – Emerging Contaminants	Improve Effluent Quality (4c)	As outlined earlier this one requires further dialogue and definition if it is to be included
Reuse Requirements	Support Resource Recovery (2c, 3c)	Highly tied to market demand

Table 3.2 - Solids Discharge Requirements

Facility Characterization Criteria	Preliminary Charter Criteria	Comments
Disposal/Reuse Requirements	Support Resource Recovery (2c, 3c)	Consider scale, synergies with energy and solids resource recovery and integration with other regional waste streams.

Table 3.3 - Site Constraints

Facility Characterization Criteria	Preliminary Charter Criteria	Comments
Adjacent Land Use	Safe Solutions (6b, 6c) Community Support (3b)	Certain technologies and solutions integrate better into residential settings than others.
Livability of Neighbourhood	Positive Public Interaction (6b) Community Support (3b) Reduction of Carbon Footprint (5a) Balance Energy Needs (5c)	Certain technologies and solutions integrate better into residential settings than others

Table 3.4 - Risks

Facility Characterization Criteria	Preliminary Charter Criteria	Comments
Certainty for Demand/Revenue	Certainty of Long-Term Demand and Revenue (3a) Ability to Phase with Growth (4a)	Certain technologies and solutions are more resilient to variations in demand/revenues.
Climate Variability Impacts	Site/Design Resiliency (4b)	Location specific
Seismic	Site/Design Resiliency (4b)	Location specific
Neighborhood Impacts	Reduction to Risks to Neighbourhoods from Facility Failure (6b) Reduction of Normal Interruption to Neighbourhood (6c) Ability to Produce High-Quality Air Emissions (5b)	Acceptable levels of risk beyond regulation vary by land use.
Process Risks – Liquids	Safe Solutions (6b, 6c) Reduction to Risks to Neighbourhoods from Facility Failure (6b)	Acceptable levels of risk beyond regulatory requirements vary by land use.
Process Risks – Solids	Safe Solutions (6b, 6c) Reduction to Risks to Neighbourhoods from Facility Failure (6b) Ability to Produce High-Quality Air Emissions (5b)	Acceptable levels of risk beyond regulatory requirements vary by land use.
Process Risks – Energy Recovery	Safe Solutions (6b, 6c) Reduction to Risks to Neighbourhoods from Facility Failure (6b) Ability to Produce High-Quality Air Emissions (5b)	Acceptable levels of risk beyond regulatory requirements vary by land use.

4.0 Methodology to Select Representative WWTP Technology

As outlined in Section 1, the criteria outlined in Section 2 and 3 will be used to arrive at representative designs for the various facility locations within the option sets. We have proposed that four sample site characterizations be used in order to inform the representative design process. These site characterizations will be used to consider facility design requirements, siting considerations and to review indicative technologies. Once the site locations and option sets are confirmed they can be refined prior to costing analysis. The proposed site characterizations are summarized in the table below:

Table 4.1 - Site Characterization Summary

Site Characterization	Neighbouring Land Use	Flow Range (Average Dry Weather Flow)	Anticipated Plant Purpose – Liquid Train
Small Distributed	Residential	< 5 ML/day	Tertiary treatment for local reuse
Medium Distributed	Residential	6-15 ML/day	Tertiary treatment for local reuse
Large Distributed	Residential	16 – 25 ML/day	Tertiary treatment for local reuse
Extra Large Distributed or Central	Non-Residential	26 + ML/day	Primary & Secondary treatment for outfall and tertiary treatment for local reuse

Representative design and analysis for solids treatment and recovery will adhere to the criteria outlined in section 3.0 and be considered in synergy with the liquid treatment and energy recovery needs/opportunities for the site.

5.0 Costing Factors

5.1 Introduction

Costs will be presented in 2015 Canadian dollars. It is important to recognize that since 2010, and from 2015 until the systems are constructed, prices of all cost elements can be significantly affected by time and typically, cost escalations. For example, the Engineering News Record (ENR) is an industry guide to the construction industry. The ENR states that the construction cost index for Toronto (BC is currently not represented in the ENR) has increased from 9,434 (2010) to 10,515 (2015). This is equivalent to a construction cost increase of 11.5% over the 5 year period. A review of data available from Stats Canada for the Victoria area indicates that their construction price index has risen from 111.5 (2010) to 122.8 (2014; no 2015 data yet available), using a base index of 100 (2007). This is equivalent to a 10.1 % increase over this 4 year period. This would appear to correlate fairly closely with the 11.5 % increase over 5 years for the ENR index. We have used the Stats Canada index for the purposes of calculating all cost escalations.

The impact of the exchange rate between the Euro, the US and Canadian dollars is also relevant, since a portion of the equipment may be manufactured in the USA or Europe.

Some costing considerations are difficult to predict, like the supply and demand and productivity of skilled labour in the Greater Victoria area, especially if other large scale projects in the province were to occur, such as liquefied natural gas and the Metro Vancouver Lion's Gate WWTP. It is also widely known that construction on Vancouver Island carries a premium compared to the mainland.

We will be using all of the recent construction related projects that Urban Systems and Carollo have completed to inform the estimates we provide, including local estimate considerations provided by municipal staff. Previous cost estimating from other consultants on this project have also been reviewed and have been considered in our evaluations.

5.2 Capital Cost Breakdown

Capital cost estimates include multiple factors and contingencies. For Class D cost estimates we have included *general requirements*, *contractor profit and overhead*, *construction and project contingencies, engineering, administration, interim financing and escalation.* Table 5.1 illustrates these cost factors for an example project with a base construction cost estimate of $1,000,000. For comparative purposes the percentages used in this study are the same as those used in previous studies. We have assumed the mid-point of construction is four years or 2019.

Table 5.1 - Capital Cost Breakdown

Description	Total
Construction Cost	$ 1,000,000
General Requirements (Mobilization, Demobilization, Bonds, Insurance, etc.) – 10%	$ 100,000
Contractor Profit/Overhead – 10%	$ 100,000
Construction/Project Contingency – 35%	$ 350,000
Subtotal of Direct Costs	**$ 1,550,000**
Engineering – 15%	$ 233,000
CRD Administration and Project Management and Miscellaneous – 8%	$ 124,000
Interim Financing– 4%	$ 62,000
Escalation to Mid-Point of Construction – 2%/year (4 years)	$ 124,000
Total Capital Project Cost	**$ 2,093,000**

5.3 Pump Stations

The pump stations that will be used to pump effluent from the existing CRD collection system to the proposed treatment plants are typically designed to be low-lift, high-volume facilities. Because of the unique nature of each pump station (siting, access, pump capacity, proximity to major utilities and sensitive areas, geotechnical considerations, etc.), costs for such facilities can vary widely.

Class D cost estimates are commonly derived from cost curves which are based on extensive cost data gathered from the combination of a wide range of pump stations throughout the industry. These curves typically plot station costs against the size of the stations in L/s. Typical curves are shown in Appendix E.

These particular curves were developed by an extensive study undertaken 11 years ago for the Ministry of Public Infrastructure Renewal in Ontario. In conducting our estimates we assessed the application of estimates from Ontario against our experience in the BC market. The unit rates have been multiplied by 1.6 with consideration of the following:

a. 20% - for temporary and permanent site work.

b. 20% - for standby power and SCADA

c. 20% - inflation from 2004 to 2015.

Where possible, the unit rates have been compared to cost data available from recently designed and constructed projects, to confirm general data conformance. These facilities typically comprise a concrete below grade wet well, in which the sewage is collected and from which the sewage is pumped using submersible pumps. An at-grade superstructure (usually concrete block or similar durable material) is located on top of the wet well (typically poured in place concrete), to house mechanical and electrical equipment, including MCCs, PLCs and standby power.

Where pump stations will be included in the design and construction of a wastewater treatment plant, i.e., are not stand alone facilities, experience informs that a 30% cost deduct should be applied to the unit costs rates to account for common infrastructure and other facility synergies.

Below is a summary of a few examples of anticipated pump station costs, based upon the curves in Appendix E and including the 1.6 multiplier. All rates are in 2015 dollars and pertain only to the Construction Cost portion as outlined in Section 5.2, which would be factored up as per Table 5.1.

Pump Station Size	Construction Cost (CDN$)
350 L/s	$ 3,400,000
750 L/s	$ 6,400,000
925 L/s	$ 8,000,000

Estimates and market pricing (historic) for the Craigflower Pump Station upgrade will be examined further in an effort to further refine these estimates, once the tender information is made available.

5.4 Piping

The piping systems that will be used to service the Core Area option sets will comprise PVC pipe installed in existing rights-of-ways, typically existing road allowances. As such, the unit cost rates allow for pavement and any existing surface improvement restoration. In addition, an allowance has been included for temporary site works, traffic control and associated above ground work.

In general, these pipes will provide the connectivity between the existing CRD sewer trunk mains, proposed pump stations, proposed wastewater treatment plants and proposed outfalls. Typically sanitary collection systems are designed for minimum flow velocities of 0.8 m/sec to ensure that material does not build up within the piping systems. From a capital cost and energy perspective, ideally flows should be near 2.5 m/sec. Given the wide range in flows within the CRD system (0 to 4 x ADWF), detailed analysis is required for any pumped and piped system to ensure that the optimum life cycle range of costs are achieved.

For the purposes of this costing exercise, we have sized our pipes such that the resultant velocities are in the 1.5 to 2.5 m/sec range, based upon 2 x ADWF.

The unit cost rates developed are based upon meeting or exceeding accepted industry design standards, such as those detailed by AWWA.

The following is a summary of the unit cost rates developed by Urban Systems as part of the ongoing work with the CRD. All rates are in 2015 CDN dollars and pertain only to the Construction Cost portion outlined in Section 5.2.

Pipe Diameter (mm)	Construction Unit Cost $/m
300	$ 700
350	$ 740
400	$ 780
450	$ 820
500	$ 870
600	$ 950
750	$ 1,130
900	$ 1,350
1050	$ 1,620
1200	$ 1,850
1350	$ 2,100
1575	$ 2,450

5.5 Outfalls

Developing unit cost rates for outfalls into a marine environment proved to be the most challenging task, given the wide range of unknowns and variabilities. Not too dissimilar from pump stations and their unique features, the unit cost rates for outfalls also vary widely. In particular, geotechnical considerations and seabed profiles will have significant impacts on these costs. However, unlike, pump stations, there is not a large data base on which to draw upon and develop cost curves.

Outfalls are anticipated using steel pipes, installed with concrete collars anchored to the sea floor. Based upon the data available, 2015 costs for these sizes were developed as summarized below and pertain only to the Construction Cost portion outlined in Section 5.2.

Pipe Diameter (mm)	Construction Unit Cost $/m
600	$ 6,150
750	$ 7,000
900	$ 7,800
1050	$ 8,600
1200	$ 9,600
1350	$ 10,800

5.6 Methodology to Provide WWTP Cost Estimates

For Wastewater Treatment Plants the costing methodology is more complicated since each plant includes both liquids and solids treatment processes and costs are largely dependent on the technology selected. For this project we will use the experience database developed by Carollo and Urban Systems in order to determine appropriate costs for the representative facilities. Only the representative technology will be costed in order to arrive at comparative cost estimates between the option sets.

5.7 Revenue Sources

Revenue sources will cover the range of incomes based on exchange of goods or services and also monies that offset costs including potential development contributions or potential partnerships which minimize the extent and impact of new works. Examples of revenues include:

- Utility billings, requisitions, transfers and interest gains
- Retail rates for resource recovery systems including water rates, gas/fuel rates (solids recovery) and incomes collected for any sales related to solids residuals
- Development cost charges and other potential private sector development contributions available to local governments
- Municipal cost-shares for example where infrastructure upgrades are needed for both local and regional benefit
- Grants in terms of secured monies available to CRD
- Other offsetting costs for example, homeowner cost savings that may arise through waste diversion as part of integrated solids recovery

This list of preliminary revenue resources will be refined through high-level feasibility analysis in collaboration with CRD and municipal staff.

5.8 Life Cycle Costing

Life-cycle costs will be prepared for each of the option sets, which will be detailed in Technical Memo #2. Life cycle costing includes capital, as well as operating costs and later, consideration to revenues as part of the aggregate financial scenarios. Operating costs will consider typical cost elements as well as revenue (outlined in Section 5.7) which can reasonably be assumed to accrue given the resource recovery opportunities available. The operating and life cycle costing will be completed in Technical Memo #3.

Below is a summary of the inputs into our life cycle costing model. As this is a constant dollar analysis, all costs will be in \$2015. The only escalation that will be included will be 2% per year for initial capital projects for the time from today until midway through construction which is assumed to be 2019.

We propose to conduct sensitivity analysis on the discount rate, escalation factors and revenue projections to monetize the risks inherent in long-term capital financing and service delivery. As a base case, our life cycle analysis will be guided by previous analysis and in particular, will suit treasury board guidelines to suit the funding partners.

Life Cycle: 30 years (2015-2045)

Interest Rate: to be confirmed with funding partners (as needed) e.g. 4%

Inflation Rate: to confirmed with funding partners (as needed) e.g. 2%

Discount Rate: to be confirmed with funding partners (as needed) e.g. 3%

Water Cost: Distribution cost from distribution supplier (i.e., CRD for Westshore & Sooke) is \$1.81/m^3

Electricity Cost: Average rate \$0.08/kwh

Chemical Costs; Current market prices

Labour Rates:

Labour Type	2015 Annual Salary [(1)]
Plant Manager	\$ 158,000
Chief Plant Operators	\$ 135,000
Chief Area Operator	\$ 113,000
Plant Operator	\$ 90,000
Labourer	\$ 56,000

(1) Refer to Appendix F for derivation

Vehicle Rates: \$40,000/yr./vehicle

Trucking Rates: Current market prices

Disposal Rates: Current tipping charges to CRD Landfill (i.e. \$157 per tonne for screenings and pumpings from Sewage Treatment Plants)

Maintenance/Repairs Pump Stations: 1% of Capital/yr.

Equipment Replacement Reserve: 1% of Capital

Operation & Maintenance Contingency: 10%

While there are multiple financial scenarios to consider, it is important that Phase 2 results remain consistent with previous analysis but also reflect a shift in project outcomes and criteria. Further, qualitative evaluation of various social and environmental factors will support the financial analysis and allow the Committee to review the merits of option sets across a balanced scorecard. Phase 2 evaluations should support the committee in screening away option sets that don't effectively meet the goals and commitments of the project in order to refine the project criteria for ultimate design parameters for a Core Area solution. Additional public investment analysis beyond Phase 2 may be needed (e.g. value for money) to suit the needs of the funding partners.

Appendix A

2045 ADWF Calculation

2045 ADWF Calculation

Area	2015 - 2045 Residential Growth Rates (%) [1]	2045 Residential & ICI Total Population Equivalents [1]	2045 Residential & ICI Flows (MLD) [2]	2045 Base Groundwater Infiltration (MLD) [5]	2045 ADWF (MLD)	
Saanich	0.5	184,424	36.0	9.7	45.7	West = 32.9 / East = 12.8
Victoria	0.5	151,589	[3]	[3]	40.8 [3]	West = 6.8 / East = 34.0
Esquimalt	0.5	30,140	[4]	[4]	7.9 [4]	
Langford	2.9	93,189	18.2	4.9	23.1	
Colwood	1.5	52,697	10.3	2.8	13.1	
View Royal	1.5	31,867	6.2	1.7	7.9	
Oak Bay	0.1	26,670	5.2	1.4	6.6	
Subtotal		**570,576**			**145.1**	
Esquimalt First Nation	-	-	-	-	0.4 [6]	
Songhees First Nation	-	-	-	-	0.5 [6]	
				Total	**146**	

(1) 033-DP-1

(2) Assume 195 Lcd, from CALWMP Amendment #8

(3) Equilavent Population increase estimate from 2030 is 10,000 people - increase 2030 flow by 10,000 x 195 Lcd x 1.27 = 2.5 MLD or 38.3 + 2.5 = 40.8

(4) Population increase estiamte from 2030 is 3274 - increae 2030 flow by 3274 x 195 Lcd x 1.27 = 0.8 MLD or 7.1 + 0.8 = 7.9

(5) LWMP Amendment 8 - 2030 ADWF = 108 MLD for Core Area

Equivalent Population in 2030 is 436,032 x $195 \frac{L}{\text{person}\cdot\text{day}} = 85$ MLD

Base GWI = 108 - 85 = 23

BGWI is $\frac{23}{85}$ = 27% of the Residential + ICI Flows

(6) Increase 2030 EFN and SFN flows by 145.1/108 = 1.33

Appendix B

Influent Wastewater Quality for 2014

Macaulay **Screened Raw Sewage 2014**

Parameter	State	Unit	requency of Detectio	Average Concentration	n	Max Concentration	Min concentration	1:175 Dilution	BC WQG	CCME WQG
alkalinity - total - pH 4.5	TOT	mg/L	75%	217.7	9	273.0	188.0	1.1		
biochemical oxygen demand	TOT	mg/L	100%	275.8	12	376.7	180.0	1.5		
chemical oxygen demand	TOT	mg/L	100%	632.5	12	816.0	433.3	3.3		
carbonaceous biochemical ox	TOT	mg/L	100%	226.4	12	291.0	162.0	1.2		
cyanide-SAD	TOT	mg/L	100%	0.00256	9	0.00334	0.00173	0.00001		
cyanide-WAD	TOT	mg/L	100%	0.00148	10	0.00263	0.00083	0.00001	0.001b	
hardness (as CaCO3)	DISS	mg/L	100%	76.8	12	112.7	55.1	0.5		
hardness (as CaCO3)	TOT	mg/L	100%	88.6	12	127.7	63.6	0.5		
oil & grease, total	TOT	mg/L	100%	8.8	10	17.3	4.9	0.1		
oil & grease, mineral	TOT	mg/L	25%	ND	3	3.30	2.00	0.01		
pH	TOT	pH	100%	7.34	12	7.71	7.10	0.03		
pH @ 15° C	TOT	pH	100%	6.99	12	7.19	6.77	0.03		
specific conductivity - 25°C.	TOT	µS/cm	100%	794.4	12	971.0	649.3	4.0		
sulphate	TOT	mg/L	100%	29.3	2	39.6	18.9	0.2		
sulfide	TOT	mg/L	100%	0.353	11	0.632	0.125	0.003	0.002cf	
temperature	TOT	°C	100%	17.2	12	20.5	13.3	0.1		
enterococci	TOT	CFU/100 mL	100%	2,584,848	12	4,266,667	1,633,333	17,000	20j	35/70n
fecal coliforms	TOT	CFU/100 mL	100%	8,563,636	12	29,000,000	4,200,000	118,000	200j	
N - TKN (as N)	TOT	mg/L	100%	54.4	12	70.3	40.5	0.3		
N - NH3 (as N)	TOT	mg/L	100%	42.4	8	49.0	35.3	0.2		
N - NH3 (as N)- unionized	TOT	mg/L	100%	0.115	12	0.190	0.058	0.001	19.7e	
N - NO2 (as N)	TOT	mg/L	75%	0.041	9	0.253	0.005	0.001		
N - NO3 (as N)	TOT	mg/L	25%	ND	3	0.020	0.005	---		
N - NO3 + NO2 (as N)	TOT	mg/L	0%	ND	0	0.0200	0.0200	---		
P - PO4 - total (as P)	DISS	mg/L	100%	4.3	10	5.75	2.63	0.02		
P - PO4 - total (as P)	TOT	mg/L	100%	5.5	12	6.81	3.89	0.03		
P - PO4 - ortho (as P)	TOT	mg/L	100%	3.8	12	4.96	2.02	0.02		
total organic carbon	TOT	mg/L	100%	82	11	144.0	42.6	0.6		
total suspended solids	TOT	mg/L	100%	270	12	332	168	1.4		
aluminum	TOT	mg/L	100%	0.3	12	0.365	0.203	0.001		
antimony	TOT	mg/L	100%	0.0003	12	0.000399	0.000243	0.000002		
arsenic	TOT	mg/L	100%	0.0006	12	0.00084	0.00044	0.000003	0.0125cg	0.0125
barium	TOT	mg/L	100%	0.02	12	0.0387	0.0137	0.0002	0.5ac	
beryllium	TOT	mg/L	0%	ND	0	0.0000100	0.0000100	---		
cadmium	TOT	mg/L	100%	0.0002	12	0.000275	0.000139	0.000001	0.00012c	0.000120
calcium	TOT	mg/L	100%	21.7	12	29.3	16.8	0.1		
chloride	TOT	mg/L	100%	89.1	8	140.3	75.0	0.6		
chromium	TOT	mg/L	100%	0.002	12	0.00298	0.00116	0.00001		
chromium VI	TOT	mg/L	25%	ND	3	0.00120	0.00100	---		
cobalt	TOT	mg/L	100%	0.0009	12	0.001310	0.000504	0.000005	0.000004	
copper	TOT	mg/L	100%	0.12	12	0.169	0.081	0.001	0.001	0.003bh

Clover **Screened Raw Sewage 2014**

Parameter	State	Unit	Frequency of Detection	Average Concentration	n	Max Concentration	Min concentration	1:175 Dilution	BC WQG	CCME WQG
alkalinity - total - pH 4.5	TOT	mg/L	75%	168	9	179.3	154.3	1.0		
biochemical oxygen demand	TOT	mg/L	100%	238	12	305.0	184.0	1.7		
chemical oxygen demand	TOT	mg/L	100%	530	12	686.0	301.3	3.9		
carbonaceous biochemical oxygen	TOT	mg/L	100%	192	12	248.3	118.3	1.4		
cyanide-SAD	TOT	mg/L	100%	0.002	9	0.00257	0.00158	0.00001		
cyanide-WAD	TOT	mg/L	100%	0.0013	10	0.00216	0.00071	0.00001	0.001b	
hardness (as CaCO3)	DISS	mg/L	100%	63.9	12	90.4	49.0	0.5		
hardness (as CaCO3)	TOT	mg/L	100%	73.2	12	97.9	60.1	0.6		
oil & grease, total	TOT	mg/L	100%	9.7	10	24.3	3.5	0.1		
oil & grease, mineral	TOT	mg/L	42%	ND	5	4.00	2.00	0.02		
pH	TOT	pH	100%	7.33	12	7.71	7.10	0.04		
pH @ 15° C	TOT	pH	100%	6.89	12	7.15	6.24	0.04		
specific conductivity - 25°C.	TOT	µS/cm	100%	528.1	12	568.0	481.0	3.2		
sulphate	TOT	mg/L	100%	20.6	2	24.1	17.0	0.1		
sulfide	TOT	mg/L	100%	0.246	11	0.424	0.092	0.002	0.002cf	
temperature	TOT	°C	100%	18.4	12	21.2	14.9	0.1		
enterococci	TOT	CFU/100 mL	100%	2,255,556	12	4,500,000	766,667	25,714	20j	35/70n
fecal coliforms	TOT	CFU/100 mL	100%	6,433,333	12	14,333,333	3,033,333	81,886	200j	
N - TKN (as N)	TOT	mg/L	100%	40.8	12	51.7	28.9	0.3		
N - NH3 (as N)	TOT	mg/L	100%	27.1	8	34.0	13.3	0.2		
N - NH3 (as N)- unionized	TOT	mg/L	100%	0.058	12	0.120	0.012	0.001	19.7e	
N - NO2 (as N)	TOT	mg/L	92%	0.063	11	0.187	0.005	0.001		
N - NO3 (as N)	TOT	mg/L	50%	ND	6	0.489	0.006	0.003		
N - NO3 + NO2 (as N)	TOT	mg/L	0%	ND	0	0.0200	0.0200	0.0001		
N - Total (as N)	TOT	mg/L	100%	40.3	1	40.3	40.3	0.2		
P - PO4 - total (as P)	DISS	mg/L	100%	3.40	10	4.30	1.88	0.02		
P - PO4 - total (as P)	TOT	mg/L	100%	4.36	12	5.74	2.76	0.03		
P - PO4 - ortho (as P)	TOT	mg/L	100%	2.91	12	4.04	1.75	0.02		
total organic carbon	TOT	mg/L	100%	61.9	11	118.0	30.8	0.7		
total suspended solids	TOT	mg/L	100%	238.4	12	292.0	166.0	1.7		
aluminum	TOT	mg/L	100%	0.310	12	0.435	0.217	0.002		
antimony	TOT	mg/L	100%	0.000258	12	0.000380	0.000186	0.000002		
arsenic	TOT	mg/L	100%	0.00066	12	0.00111	0.00050	0.00001	0.0125cg	0.0125
barium	TOT	mg/L	100%	0.0214	12	0.0253	0.0120	0.0001	0.5ac	
beryllium	TOT	mg/L	8%	ND	1	0.0000103	0.0000100	0.0000001		
cadmium	TOT	mg/L	100%	0.000157	12	0.000260	0.000100	0.000001	0.00012c	0.00012
calcium	TOT	mg/L	100%	18.8	12	25.4	16.3	0.1		
chloride	TOT	mg/L	100%	42.8	8	45.7	39.0	0.3		
chromium	TOT	mg/L	100%	0.00100	12	0.00155	0.00069	0.00001		
chromium VI	TOT	mg/L	0%	ND	0	0.00133	0.00100	0.00001		
cobalt	TOT	mg/L	100%	0.000360	12	0.000506	0.000289	0.000003	0.000004	

Appendix C

Ammonia Toxicity

MEMORANDUM

Date:	September 23, 2015
To:	Chris Town, P.Eng.
cc:	Ehren Lee, P.Eng., Steve Brubacher, P.Eng.
From:	Dr. Joanne Harkness, R.P.Bio.
File:	1692.0037.01
Subject:	Requirements for Ammonia Treatment

1. INTRODUCTION

The CRD is currently assessing options for the management of the sanitary sewage which is produced by the area. The purpose of this memorandum is to provide a summary of the assessment which was completed to determine if treatment for ammonia will be required in order to meet Federal and Provincial regulatory requirements.

2. BACKGROUND TO AMMONIA IN MUNICIPAL WASTEWATER

Ammonia is the predominant form of nitrogen in untreated municipal wastewater and in municipal wastewater effluents where there is no nitrification (biological reduction of ammonia). Ammonia is one of the key parameters of concern with respect to sewage effluents and aquatic toxicity. Both acute and chronic toxicity need to be considered.

Acute toxicity refers to a rapid and extreme response to environmental conditions – i.e. death normally occurs within a short period of time. The standard test for determining acute toxicity in an aquatic environment is the LC50 96 hour rainbow trout bioassay. In this test, 10 young rainbow trout are used per test. If 6 fish die within 96 hours, the test solution is determined to be acutely toxic and has failed the toxicity test. Acute toxicity is the focus for effluent prior to release to the environment.

Chronic toxicity is less easy to define than acute toxicity as this type of toxicity refers to effects which may be observed over a long time period and which may be subtle in nature. Chronic toxicity could equate to impacts on off-spring of exposed individuals, metabolic differences or subtle changes in the ability to survive or reproduce. Due to the complexity of chronic toxicity, acute toxicity has historically been the primary focus for legislation and the regulatory government agencies. Chronic toxicity is the focus for environmental conditions, once the effluent has been released.

Ammonia is present in two forms: ionised and un-ionised, the proportion of which is dependent on pH and temperature. It is the un-ionised form of ammonia which is of particular interest, as this is the form which is toxic to fish. The un-ionised form of ammonia becomes the predominant form of ammonia as the pH increases. As a result, under alkaline conditions, it is possible for very low concentrations of ammonia to cause aquatic toxicity. Total ammonia is the sum of the ionised and un-ionised forms of ammonia.

3. REGULATORY BACKGROUND

3.1 Provincial Legislation and Guidelines

The Municipal Wastewater Regulation (MWR) is the regulatory framework for management of sewage in British Columbia. The MWR was published in April 2012, and replaced the Municipal Sewage Regulation, which was promulgated in 1999. The MWR outlines the effluent quality standards and discharge requirements for municipal wastewater treatment plants in British Columbia. For discharge to surface waters, the MWR indicates the expectations for effluent quality, dilution and defines the concept of an initial dilution zone (IDZ). The IDZ is an area immediately around the point of discharge where it is acceptable for degradation in water quality to occur. With respect to ammonia, the MWR focuses on meeting chronic ammonia concentrations at the edge of the IDZ. The concentration of ammonia in the effluent is to be back calculated based on the need to meet site-specific chronic conditions at the edge of the IDZ.

The Capital Regional District (CRD) has an approved Liquid Waste Management Plan (LWMP). A LWMP is a powerful document which is based on the current legislation. The completion of a LWMP results in a document which takes precedence over any existing permit or the MWR. Although a LWMP can provide an avenue for flexibility, the general intent of a LWMP is to develop a plan which will be implemented over time in order to meet the intent and conditions of the MWR.

The BC Water Quality Guidelines provide guidance as to suitable water quality for a range of different uses including drinking water, aquatic life, recreation and agriculture. The guidelines do not have any direct legal standing but are intended to be used as a tool to provide policy direction for decisions relating to water quality. These guidelines can be used to evaluate appropriate effluent criteria for release from a municipal wastewater treatment plant. For ammonia, there are acute and chronic guidelines for the protection of aquatic life for both marine and freshwater surface waters. The guideline value varies, depending on the temperature and pH. For marine waters, the salinity also needs to be taken into consideration. The BC Water Quality Guidelines define chronic as a 30 day average, based on 5 weekly samples taken over a 30 day period. This definition allows for an increased likelihood that a particular condition may both exist and persist in an environment.

3.2 Federal Legislation and Guidelines

The Federal wastewater regulation (the Wastewater Systems Effluent Regulations) was published in July, 2012 and applies to any surface water discharge in Canada where the average annual incoming flow to the sewage treatment plant is ≥ 100 m^3/d, with the focus being to protect surface waters which are regarded as fisheries resources. The regulation contains National Performance Standards, with the standard for ammonia being a maximum concentration of un-ionised ammonia of 1.25 mg/L, prior to release. The Federal regulation also recognises ammonia conditions after dilution in the receiving environment. In the event that the un-ionised ammonia concentration of 1.25 mg/L cannot be met before effluent release, then there is no need to upgrade for ammonia treatment as long as an un-ionised ammonia concentration of 0.016 mg/L is met in the receiving environment, 100 m away from the point of release. The discharger would need to apply for a temporary authorisation which is valid for 3 years. Re-application for the temporary authorisation would be required every 3 years, if the effluent is still acutely toxic.

3.3 Summary of Legislation

There are three regulatory criteria for ammonia, all of which have direct relevance to each other.

1. The Federal wastewater regulation stipulates a maximum un-ionised ammonia concentration of 1.25 mg/L, before release. This focuses on acute toxicity to fish.
2. The Federal wastewater regulation stipulates that in the event that the effluent un-ionised ammonia concentration is above 1.25 mg/L, treatment for ammonia is not required as long as the concentration of un-ionised ammonia in the receiving environment is ≤ 0.016 mg/L, at a distance 100 m from the point of effluent release. This focuses on chronic toxicity to fish.
3. The MWR stipulates that the concentration of ammonia at the edge of the IDZ is to meet fisheries chronic concentrations, based on conditions in the receiving environment for temperature and pH. There is no requirement in the MWR for acute ammonia toxicity.

4. EFFLUENT AMMONIA EVALUATIONS

4.1 MWR Evaluations

In order to estimate the chronic total ammonia concentration at the edge of the IDZ, historical data for temperature, pH and salinity were taken from the CRD monitoring program database for locations at the edge of the IDZ. The data indicated little variability in the pH (range pH 7.50 to 7.96). The 90th percentile of the whole dataset (pH 7.83) was used for the evaluation. There was also consistency in the temperature throughout the year, ranging from a low of 7.07 ^{o}C in January to a high of 12.44 ^{o}C in July. The 90th percentile of the July dataset (11.10 ^{o}C) was used for the evaluation. The data indicated that the salinity was in the order of 30 g/kg, which is the highest threshold indicated in the BC Water Quality Guidelines. Based on these data the total ammonia concentration at the edge of the IDZ should be less than or equal to 3.4 mg/L.

The evaluations focused on 90th percentile data rather than the maximum data. Maximum data represent the worst case scenario and the intent was to evaluate the potential for a chronic effect to occur, which requires conditions which have a likelihood of occurring on a regular basis for an extended period of time. Maximum data represent extreme events which occur for short periods of time. This is not the intent of the definitions in the BC Water Quality Guidelines, where chronic conditions are evaluated using 5 data points taken on a weekly basis over 5 consecutive weeks.

Table 4.1 summarises the chronic total ammonia concentration at the edge of the IDZ and the corresponding effluent total ammonia concentration for both the Macauley Point and Clover Point outfalls. The dilution ratio was taken from CRD customized oceanographic/plume modelling of the effluent dilution and dispersion at both outfall locations. The estimations do not take into account the background total ammonia concentration. However, this is a low concern given that the background total ammonia concentration is expected to be close to the analytical detection limit (e.g. in the order of 0.005 mg/L) and the estimated effluent concentrations which would be required to cause chronic ammonia conditions at the edge of the IDZ are significantly higher than what would be expected for untreated municipal wastewater. From this evaluation, since untreated municipal wastewater would have a maximum total ammonia concentration of 45 mg/L, there are no requirements to treat for ammonia to meet chronic ammonia conditions at the edge of the IDZ.

Table 4.1: Summary of End of IDZ Chronic Ammonia Concentration and the Corresponding Effluent Total Ammonia Concentration

Outfall Location	Edge of IDZ Chronic Total Ammonia Concentration to Meet MWR (mg/L)	Edge of IDZ Dilution Ratio	Corresponding Effluent Total Ammonia Concentration (mg/L)
Macaulay Point	≤ 3.4	245:1	≤ 833
Clover Point	≤ 3.4	175:1	≤ 595

4.2 Federal Wastewater Regulation Evaluations

The Federal wastewater regulation recognises both acute toxicity before effluent release and chronic toxicity at a point 100 m away from the point of release. For the effluent prior to release, the standard is a maximum un-ionised ammonia concentration of 1.25 mg/L. Table 4.2 summarises the pH range expected for a typical municipal wastewater effluent and the corresponding total ammonia concentration which would equate to an un-ionised ammonia concentration of 1.25 mg/L. The standard total ammonia concentration for untreated municipal wastewater is 25 mg/L. However, it is reasonable to expect that there will be periodic increases in the wastewater total ammonia concentration, with the concentration potentially being in the order of 45 mg/L. For a wastewater treatment plant that is not designed to nitrify, it is reasonable to expect that the effluent total ammonia concentration will typically be in the 25 mg/L range, but could periodically be as high as 45 mg/L. From this, although there would be no concerns with the acute un-ionised ammonia threshold of 1.25 mg/L being exceeded if the effluent pH is 7.5 or less, this may not be the case if the pH is in the order of 8.0, as the maximum effluent total ammonia concentration is very close to the acutely toxic threshold under these conditions.

Table 4.2: Effluent Total Ammonia Concentration to be Non-acutely Toxic

Effluent pH	Total Ammonia Concentration (mg/L)
7.0	≤ 455
7.5	≤ 148
8.0	≤ 47

In the event that the effluent is acutely toxic before release, there will be the need to consider the ability to meet chronically toxic concentrations after the release. Table 4.3 summarises the effluent un-ionised and total ammonia concentration required in order to meet an un-ionised ammonia concentration of 0.016 mg/L at the edge of the IDZ, which is approximately 100 m away from the point of effluent release, for both the Macaulay Point and Clover Point outfalls. Using the worst case effluent pH of 8.0, the information presented in Table 4.3 indicates that, in the event it is not possible to meet the pre-discharge un-ionised ammonia concentration of 1.25 mg/L, it will be possible to meet the receiving environment concentration of 0.016 mg/L. The calculated corresponding total ammonia concentration for both the Macaulay Point and Clover Point outfalls is significantly higher than what would be expected for ammonia to be present in untreated municipal wastewater. As a point of reference, the effluent pH would need to be in the order of 8.4 before there would be concerns regarding the ability to meet an un-ionised ammonia concentration of 0.016 mg/L in the receiving environment.

Table 4.3: Summary Effluent Total and Un-ionised Ammonia Concentration to Meet Chronic Conditions 100 m Away from the Outfall

Outfall Location	Effluent Un-ionised Ammonia Concentration (mg/L)	Edge of IDZ Dilution Ratio	Effluent Total Ammonia Concentration (mg/L)
Macaulay Point	≤ 3.9	245:1	≤ 146
Clover Point	≤ 2.8	175:1	≤ 104

From the above information, there are no requirements to treat for ammonia to meet the requirements of the Federal wastewater regulation. In the event that the effluent ammonia concentration is deemed to be acutely toxic, the chronic concentrations in the receiving environment can be met and, therefore, this site would be eligible to apply for a temporary authorisation, which is renewable every 3 years, if required.

5. ADDITIONAL INFORMATION – REGULATORY CHANGES

This document considers both the Federal wastewater regulation and the MWR. However, discussion is currently underway to harmonize the BC regulation with the Federal wastewater regulation, which will mean that the Federal wastewater regulation will no longer apply in BC, and the default regulation for an effluent release to a surface water will be the MWR. Preliminary discussions with the BC Ministry of Environment have indicated that, with respect to ammonia, the approach will be to focus on meeting chronic concentrations in the receiving environment, which is consistent with the current conditions in the MWR. However, this approach will need to be confirmed once the harmonization process is complete.

The timing of the harmonization agreement has not been set, but prior to the end of 2015 is considered to be reasonable.

6. SUMMARY

At this point in time, both the Federal and Provincial wastewater regulations need to be considered with respect to effluent ammonia standards. This may not be the case in the future, if the harmonization process is finalised. The default regulation will be the MWR.

The information presented above indicates that there is no requirement to reduce ammonia in order to meet the MWR. Chronic conditions at the edge of the IDZ can be met without ammonia treatment. There is also no requirement to treat for ammonia to meet the Federal wastewater regulation. There could be a slight risk that the effluent could be periodically acutely toxic for ammonia, depending on the operational

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pH. However, there is no risk that the chronic concentration would not be met in the receiving environment. Therefore, in the event that there is an issue with acute effluent toxicity, this site would be eligible to apply for a temporary authorisation, which is renewable every 3 years, if required.

Sincerely,

URBAN SYSTEMS LTD.

COLLEGE OF APPLIED BIOLOGY
Harkness
R.P.Bio
#1345

Dr. Joanne Harkness, R.P.Bio.
Water and Wastewater Specialist

/jh

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Appendix D

CRD Fact Sheet on Emerging Contaminants

Fact Sheet

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DIVISION: Wastewater & Marine Environment Program

DATE: March 17, 2015
LAST EDIT: August 6, 2015

SUBJECT: Emerging Contaminants in Wastewater

- Municipal wastewater treatment has two primary streams within the process:
  - Liquid stream
  - Solids stream

- Municipal wastewater treatment effectively reduces many contaminants from the liquid stream of the treatment process.
  - There is no solid stream or liquid stream treatment technology capable of rendering all contaminants completely inert.
  - Removal efficiency depends upon treatment technology, the optimization of the plant, and the chemical characteristics of each individual contaminant
  - Generally, the higher the level of treatment or the more technologies/steps employed, the greater reduction of contaminants in the liquid stream (i.e., influent to effluent)

- Wastewater treatment processes can:
  - Reduce or destroy contaminants making them less toxic
  - Reactivate contaminants making them more toxic
  - Create byproducts that can be more or less toxic than the original contaminant
  - Transfer contaminants to the sludge/biosolids fraction
  - Have no impact on some contaminants (i.e., what goes in the plant comes out of the plant).

- Sewage potentially contain any element or chemical in use by humans.
  - Hydrophilic (water soluble) contaminants predominate in the liquid stream.
  - Hydrophobic contaminants predominate in sludge/biosolids. .

- Contaminants found in wastewater include:
  - ***Polybrominated diphenyl ethers (PBDEs) and other brominated flame retardants***
  - ***Perfluoroalkyl substances (PFOS, PFOA, etc.)****
  - ***Bisphenol A****
  - ***Metals***
  - ***Triclosan****
  - ***Chlorinated alkanes***
  - ***Metals and organometals***
  - ***Parabens***
  - ***Nonylphenol and ethoxylates****
  - ***Siloxanes****
  - ***Pharmaceuticals and personal care products (PPCPs)****[1]

[1] The Scientist Magazine – Drugging the Environment by Megan Scudellari - http://www.the-

- ***Polycyclic aromatic hydrocarbons (PAHs)***
- Phthalates
- Pesticides
- Surfactants
- Polychlorinated biphenyls (PCBs)
- Dioxins and furans
- Pathogens
- Microplastics*
- Nanoparticles*
- Many others

- Some of the above contaminants are considered emerging (identified with an *), while others are considered current use or legacy

- Just because you can detect the above contaminants in wastewaters does not automatically mean there is an environmental or health risk associated with them.
  - Analytical capabilities are rapidly improving and our ability to detect contaminants at much lower concentrations (often below known risk levels) is increasing
  - The relative risk of the above classes of contaminants depends upon their propensity to persist, bioaccumulate or have known toxicity effects.
    - Risk assessments for emerging substances are relatively limited, but are ongoing

- Environment Canada's Chemicals Management Plan[2] and the United States Environmental Protection Agency[3] are two of the organizations around the world that are characterizing contaminants in wastewaters.

- Environment Canada has currently prioritized the contaminants in ***bold italics*** above for wastewater (and biosolids) characterization[1].
  - Their findings to date indicate that contaminant removal efficiencies varied by:
    - treatment technology
    - contaminant
    - season (summer versus winter)
  - To reiterate a previous bullet:
    - The majority of contaminants were reduced by treatment (either through destruction or by transfer to the solids stream of the process) rendering them less toxic in the effluent.
    - Some contaminants were increased by treatment (either through reactivation or conversion to more harmful byproducts) rendering them more toxic in effluent.
    - A few contaminants were not impacted by treatment at all, thereby retaining their toxicity in effluent.
  - Their findings will be used to inform environmental and human health risk assessments for wastewater receiving environments and reuse.
  - Their findings can be found in various scientific journal articles[1]
    - MetroVancouver's Annacis Island treatment facility participated in Environment Canada's study and can be identified in their results as the only facility that employs trickling filter/solids contact as a treatment process
      - We have not yet received results from MetroVancouver staff, but they have committed to sending them to us

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scientist.com/?articles.view/articleNo/43615/title/Drugging-the-Environment/ - accessed online August 6, 2015

[2] Environment Canada's Chemicals Management Plan summary presentation - http://www.cwwa.ca/pdf_files/ISO-10_Smyth.pdf

Smyth – 2015 – Monitoring Chemical Substances in Canadian Municipal Wastewater: 5 Years Later. A report prepared for the WEAO 2015 Technical Conference, Toronto, ON by Environment Canada. 14 pp. – PDF available upon request

Many of Environment Canada's results are also contained in scientific journal articles. CRD Marine Programs staff have some of these articles and would be happy to discuss their contents. Licensing restrictions prevent us providing copies.

[3] United States Environmental Protection Agency wastewater assessment - http://water.epa.gov/scitech/wastetech/guide/index.cfm

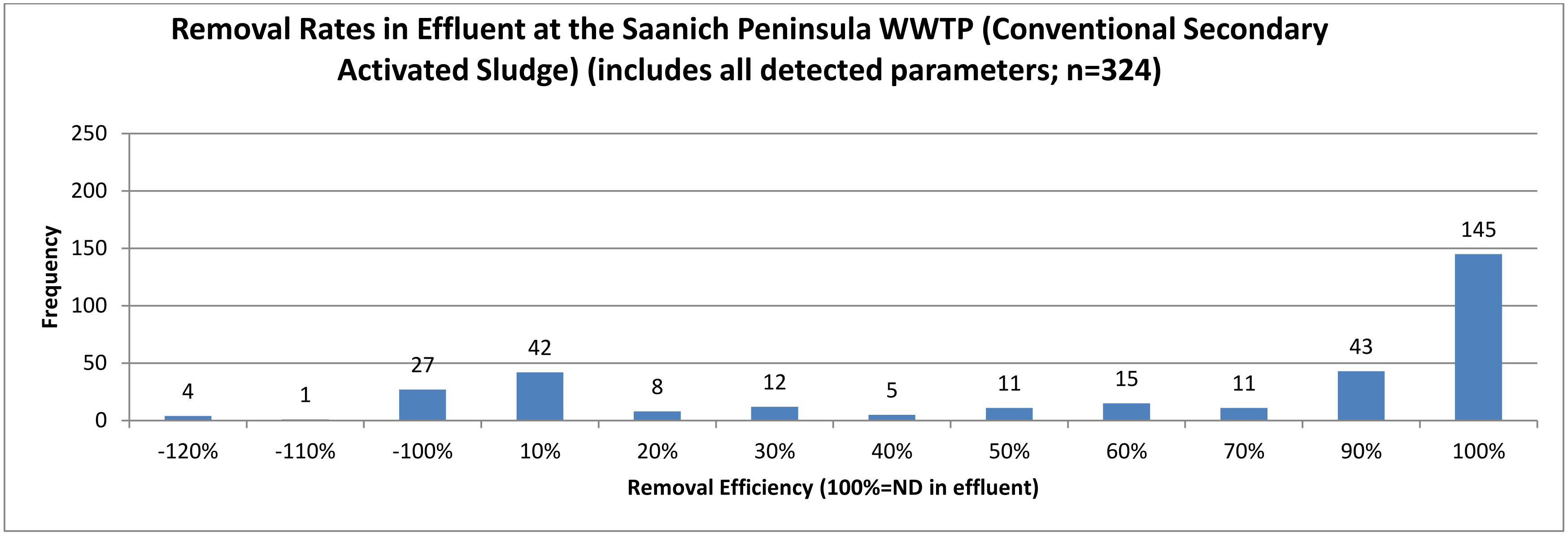
- The CRD also undertakes contaminant monitoring, including some emerging substances, in regional wastewaters and has determined removal efficiencies at two of our facilities:
  - The Saanich Peninsula Wastewater Treatment Plant (WWTP) which employs conventional activated sludge processes to create secondary non-disinfected effluent
  - The Ganges Harbour WWTP which employs membrane bioreactor technology and UV disinfection to create advanced secondary disinfected effluent

- CRD results are summarized in the attached figures and tables
  - The Ganges Harbour WWTP was more effective at reducing/removing contaminants than the Saanich Peninsula WWTP
    - Ganges – approximately 80% of the contaminants (211 of 266) had removal efficiencies >90% while only 2% of the monitored contaminants (5 of 266) had effluent concentrations higher than influent concentrations (i.e., contaminant reactivation during treatment)
    - Saanich Peninsula – approximately 45% of the monitored contaminants (145 of 324) had removal efficiencies >90% while approximately 10% of the monitored contaminants (32 of 324) had effluent concentrations higher than influent concentrations (i.e., contaminant reactivation during treatment)
  - Results confirm Environment Canada's findings that many contaminants are removed/reduced by treatment, some are increased by treatment, and some are not impacted by treatment

- Environmental and human health risk assessments associated with emerging contaminants in wastewaters are ongoing as different contaminants are identified/prioritized. So far, relatively few risks have been identified and these risks have been addressed through the application of water quality guidelines (WQG) or contaminant bans.
  - Currently, very few emerging substances WQG exist. Examples in Canada include:
    - The Province of BC has a WQG for the synthetic birth control chemical 17alpha-ethinylestradiol, but only for aquatic life in freshwater systems.
    - The Canadian Council for Ministers of the Environment is currently considering a Canadian WQG for the antiepileptic drug carbamazepine, but also only for aquatic life in freshwater systems.
    - Additional emerging substance WQG have yet to be developed in Canada as risk assessment is ongoing or wastewater contaminant levels have been well below known risk thresholds.
  - Other legacy and emerging substances have required higher level regulation or bans to protect the environment. Examples include:
    - The legacy PCB compounds, along with several chlorinated pesticides, were banned in Canada in 1970 after it was determined they were persistent, bioaccumulative and toxic
    - PBDEs were banned in Canada in 2010 for the same reasons.
    - Environment Canada is also currently undertaking an assessment of the material preservative and antimicrobial agent triclosan. Preliminary findings indicate it is being discharge to the environment at levels of concern. A regulatory decision in anticipated sometime Spring 2015.
  - Source control is also very important for removing some emerging contaminant concentrations in wastewaters.
    - For example, the CRD's Regional Source Control Program helps promote the Medications Return Program which promotes the proper disposal of unused and expired medications, thereby reducing their release to the environment.

- Additional technologies can be used to supplement primary and secondary treatment thereby enhancing effluent quality.
  - These technologies are typically termed tertiary treatment and are usually installed to address site-specific receiving environment needs

- These technologies are highly variable in design and include everything from wetlands to highly mechanised systems.
- Tertiary treatment processes typically improve effluent quality by:
  - Improving clarity to protect receiving environments and/or improve disinfection
  - Reducing nutrients to prevent eutrophication (i.e., over-fertilization) of receiving environments
  - Removing pathogens to protect human and aquatic life
  - Targeting specific contaminants of concern to protect aquatic life
- Some tertiary treatment technologies are showing promise for the reduction of emerging contaminants, but no single technology can eliminate all contaminants[1]


Removal Rates in Effluent at the Saanich Peninsula WWTP (Conventional Secondary Activated Sludge) (includes all detected parameters; n=324)
Frequency
250
200
150
100
50
0
4
1
27
42
8
12
5
11
15
11
43
145
-120%
-110%
-100%
10%
20%
30%
40%
50%
60%
70%
90%
100%
Removal Efficiency (100%=ND in effluent)

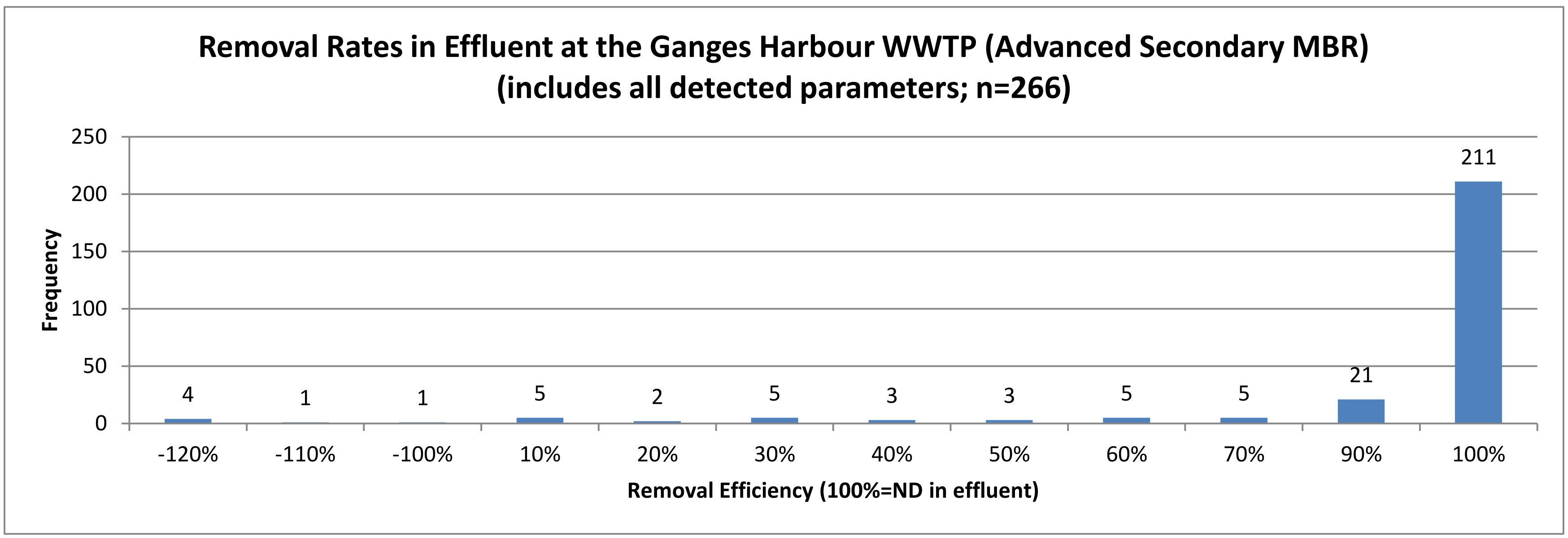

Removal Rates in Effluent at the Ganges Harbour WWTP (Advanced Secondary MBR) (includes all detected parameters; n=266)
Frequency
250
200
150
100
50
0
4
1
1
5
2
5
3
3
5
5
21
211
-120%
-110%
-100%
10%
20%
30%
40%
50%
60%
70%
90%
100%
Removal Efficiency (100%=ND in effluent)

Table 1 - Removal estimates for contaminants monitored in Saanich Peninsula wastewater. Pharmaceutical data represents samples collected approximately bi-weekly from 2011 to 2012. Conventional detection limit results represent the averages from samples collected quarterly in 2013. High resolution chemistry represents samples collected in January 2014 only.

Sample Parameter	Influent Concentration mg/l	Effluent Concentration mg/l	% reduction
1,7-Dimethylxanthine	13.9	1.31	91%
Acetaminophen	64.1	1.11	98%
Albuterol	0.0260	0.0245	6%
Caffeine	48.6	1.51	97%
Carbamazepine	0.293	0.362	-24%
Chlortetracycline	0.0191	0.0177	7%
Cimetidine	0.633	0.297	53%
Clarithromycin	0.430	0.446	-4%
Codeine	1.93	0.851	56%
Cotinine	0.820	0.399	51%
Diltiazem	0.731	0.453	38%
Doxycycline	0.655	0.152	77%
Erythromycin	3.28	1.57	52%
Fluoxetine	0.0588	0.0684	-16%
Gemfibrozil	0.349	0.127	64%
Ibuprofen	14.1	0.443	97%
Lincomycin	0.0222	0.0213	4%
Metformin	43.7	10.3	76%
Oxytetracycline	0.0347	0.0331	5%
Ranitidine	1.61	0.641	60%
Roxithromycin	0.00206	0.000305	85%
Sulfamethazine	0.0130	0.0117	10%
Sulfamethizole	0.0157	0.00838	47%
Sulfamethoxazole	1.04	0.429	59%
Sulfathiazole	0.0351	0.0303	14%
Tetracycline	0.900	0.361	60%
Triclosan	4.84	1.30	73%
Trimethoprim	0.213	0.242	-14%
Tylosin	0.000111	ND	100%
Warfarin	0.0257	0.0248	4%
SAD cyanide	0.0061	0.0122	-100%
WAD cyanide	0.0015	0.0014	6%
Oil & grease, mineral	3.4333	2.0000	42%
Oil & grease, total	19.2500	1.2000	94%
sulphate	23.9500	26.9500	-13%

Sample Parameter	Influent Concentration mg/l	Effluent Concentration mg/l	% reduction
sulfide	1.0968	0.0799	93%
temperature	14.3800	15.8800	-10%
TOC	71.9250	14.8100	79%
TSS	245.0000	8.8667	96%
Enterococci	8208333	22825	up to 100%
Fecal Coliforms	14691666	108133	99%
N - TKN (as N)	52.5500	4.1025	92%
N - NH3 (as N)	34.3364	1.3800	96%
N - NO2 (as N)	0.2276	1.4228	-525%
N - NO3 (as N)	0.2670	12.2825	-4500%
P - PO4 - ortho (as P)	4.6833	4.7400	-1%
P - PO4 - total (as P)	4.0517	3.5317	13%
P - PO4 - total (as P)	5.3058	3.8100	28%
aluminum	0.2096	0.0349	83%
antimony	0.0001	0.0002	-38%
arsenic	0.0003	0.0002	29%
barium	0.0135	0.0064	52%
cadmium	0.00014	0.00007	49%
calcium	17.6000	17.0000	3%
chloride	72.6667	62.6667	14%
chromium	0.0018	0.0006	66%
chromium VI	0.0024	0.0021	13%
cobalt	0.0003	0.0002	30%
copper	0.0712	0.0296	58%
iron	0.4162	0.0859	79%
lead	0.0023	0.0007	70%
magnesium	7.0450	6.7875	4%
manganese	0.0410	0.0319	22%
mercury	0.000010	0.000008	21%
molybdenum	0.0008	0.0008	3%
nickel	0.0039	0.0030	21%
potassium	15.6667	15.1250	3%
selenium	0.0003	0.0002	29%
silver	0.0002	0.0001	79%
thallium	0.0000043	0.0000040	8%
tin	0.0011	0.0053	-364%
zinc	0.0739	0.0404	45%
aluminum	0.0284	0.0168	41%

Sample Parameter	Influent Concentration mg/l	Effluent Concentration mg/l	% reduction
antimony	0.0002	0.0002	-22%
arsenic	0.0003	0.0002	19%
barium	0.0059	0.0055	6%
beryllium	0.00002	0.00002	0%
cadmium	0.00002	0.00005	-118%
calcium	15.1750	16.8667	-11%
chloride	72.0000	76.0000	-6%
chromium	0.0009	0.0005	41%
cobalt	0.0002	0.0002	3%
copper	0.0527	0.0219	58%
iron	0.2413	0.0612	75%
lead	0.0009	0.0005	43%
magnesium	6.5258	6.5692	-1%
manganese	0.0294	0.0271	8%
mercury	0.00001	0.00001	0%
molybdenum	0.0009	0.0008	11%
nickel	0.0031	0.0026	17%
potassium	14.9333	14.6500	2%
selenium	0.00020	0.00016	23%
silver	0.00023	0.00004	82%
thallium	0.0000054	0.0000040	26%
tin	0.0011	0.0007	37%
zinc	0.0188	0.0359	-91%
Methyl Mercury	0.0001	0.0001	0%
Monobutyltin	0.000006	0.000007	-22%
Monobutyltin Trichloride	0.000010	0.000012	-21%
total phenols	0.0689	0.0091	87%
phenol	0.0293	0.0031	89%
fluoranthene	0.00007	0.00001	85%
fluorene	0.00050	0.00002	97%
phenanthrene	0.00015	0.00003	80%
pyrene	0.00006	0.00001	78%
Total HMW-PAH's	0.00017	0.00002	86%
Total LMW-PAH's	0.00121	0.00024	80%
total PAHs	0.00122	0.00025	80%
bis(2-ethylhexyl)phthalate	0.0117	0.0050	57%
diethyl phthalate	0.0014	0.0003	82%
dichloromethane	0.0240	0.0021	91%

Sample Parameter	Influent Concentration mg/l	Effluent Concentration mg/l	% reduction
trichloromethane	0.0051	0.0016	69%
dimethyl ketone	0.0520	0.0150	71%
alpha-terpineol	0.0186	0.0050	73%
PCB-1	24.7000	12.4000	50%
PCB-2	12.7000	10.3000	19%
PCB-3	26.3000	10.2000	61%
PCB-4	23.1000	ND	up to 100%
PCB-6	25.3000	ND	up to 100%
PCB-7	6.7800	ND	up to 100%
PCB-8	76.8000	10.0000	87%
PCB-9	5.3100	ND	up to 100%
PCB-11	416.0000	89.7000	78%
PCB-12	14.8000	ND	up to 100%
PCB-15	39.7000	7.6700	81%
PCB-16	48.7000	7.3300	85%
PCB-17	45.9000	8.3000	82%
PCB-18	90.9000	13.9000	85%
PCB-19	13.3000	22.8000	-71%
PCB-20	188.0000	10.7000	94%
PCB-21	107.0000	9.4300	91%
PCB-22	68.3000	ND	up to 100%
PCB-24	ND	2.1100	-100%
PCB-25	11.5000	5.1400	55%
PCB-26	27.3000	ND	up to 100%
PCB-27	6.4000	ND	up to 100%
PCB-30	ND	21.0000	-100%
PCB-31	159.0000	5.9300	96%
PCB-32	31.6000	ND	up to 100%
PCB-34	ND	3.1400	-100%
PCB-35	17.3000	ND	up to 100%
PCB-36	3.9100	ND	up to 100%
PCB-37	38.0000	ND	up to 100%
PCB-38	ND	9.2100	-100%
PCB-40	88.5000	4.4400	95%
PCB-42	39.1000	25.4000	35%
PCB-43	4.9200	5.0300	-2%
PCB-44	234.0000	ND	up to 100%

Sample Parameter	Influent Concentration mg/l	Effluent Concentration mg/l	% reduction
PCB-45	35.7000	ND	up to 100%
PCB-46	9.6500	4.7000	51%
PCB-47	ND	10.4000	-100%
PCB-48	39.6000	2.6300	93%
PCB-49	100.0000	ND	up to 100%
PCB-50	20.5000	28.8000	-40%
PCB-52	281.0000	ND	up to 100%
PCB-54	ND	6.5200	-100%
PCB-55	2.9400	ND	up to 100%
PCB-56	68.3000	ND	up to 100%
PCB-57	ND	1.3800	-100%
PCB-58	ND	3.6000	-100%
PCB-59	13.3000	32.8000	-147%
PCB-60	45.1000	ND	up to 100%
PCB-61	378.0000	ND	up to 100%
PCB-62	ND	8.7100	-100%
PCB-63	7.2300	ND	up to 100%
PCB-64	72.7000	14.7000	80%
PCB-66	136.0000	ND	up to 100%
PCB-67	4.8600	ND	up to 100%
PCB-68	10.7000	ND	up to 100%
PCB-77	9.9000	ND	up to 100%
PCB-79	3.5600	ND	up to 100%
PCB-80	3.1500	ND	up to 100%
PCB-81	ND	18.8000	-100%
PCB-82	22.6000	5.4400	76%
PCB-83	165.0000	6.3200	96%
PCB-84	73.9000	21.2000	71%
PCB-85	43.6000	ND	up to 100%
PCB-86	181.0000	4.3400	98%
PCB-88	37.4000	29.5000	21%
PCB-90	300.0000	5.0300	98%
PCB-91	ND	25.6000	-100%
PCB-92	52.1000	ND	up to 100%
PCB-93	254.0000	ND	up to 100%
PCB-103	3.6900	7.1700	-94%
PCB-104	1.8600	ND	up to 100%
PCB-106	7.0400	ND	up to 100%

Sample Parameter	Influent Concentration mg/l	Effluent Concentration mg/l	% reduction
PCB-107	9.2400	ND	up to 100%
PCB-108	ND	24.7000	-100%
PCB-109	14.2000	ND	up to 100%
PCB-110	256.0000	ND	up to 100%
PCB-112	ND	1.1900	-100%
PCB-114	7.0300	ND	up to 100%
PCB-116	ND	15.7000	-100%
PCB-118	174.0000	ND	up to 100%
PCB-121	2.0300	ND	up to 100%
PCB-123	2.7300	ND	up to 100%
PCB-126	ND	3.8000	-100%
PCB-127	ND	22.1000	-100%
PCB-128	29.0000	ND	up to 100%
PCB-129	281.0000	ND	up to 100%
PCB-130	13.5000	5.1700	62%
PCB-131	3.4300	ND	up to 100%
PCB-132	65.9000	1.9500	97%
PCB-133	4.9200	6.7800	-38%
PCB-134	11.8000	3.3100	72%
PCB-135	79.4000	1.8800	98%
PCB-136	29.3000	ND	up to 100%
PCB-137	16.3000	ND	up to 100%
PCB-139	6.4000	3.6500	43%
PCB-141	38.9000	ND	up to 100%
PCB-144	10.9000	3.3200	70%
PCB-145	ND	13.2000	-100%
PCB-146	40.1000	ND	up to 100%
PCB-147	178.0000	ND	up to 100%
PCB-148	1.4700	ND	up to 100%
PCB-150	2.0900	ND	up to 100%
PCB-151	ND	24.3000	-100%
PCB-153	288.0000	1.6400	99%
PCB-154	ND	3.8400	-100%
PCB-155	18.3000	ND	up to 100%
PCB-156	40.2000	1.8500	95%
PCB-158	21.5000	ND	up to 100%
PCB-164	11.3000	ND	up to 100%
PCB-167	9.6000	ND	up to 100%

Sample Parameter	Influent Concentration mg/l	Effluent Concentration mg/l	% reduction
PCB-168	ND	2.7700	-100%
PCB-170	63.8000	ND	up to 100%
PCB-171	13.9000	ND	up to 100%
PCB-172	10.9000	4.1900	62%
PCB-174	35.1000	ND	up to 100%
PCB-175	3.1800	ND	up to 100%
PCB-176	7.6500	ND	up to 100%
PCB-177	24.3000	1.6900	93%
PCB-178	21.4000	13.3000	38%
PCB-179	21.6000	ND	up to 100%
PCB-180	185.0000	ND	up to 100%
PCB-181	ND	4.6500	-100%
PCB-182	ND	3.0400	-100%
PCB-183	39.3000	ND	up to 100%
PCB-184	34.5000	ND	up to 100%
PCB-185	ND	5.5100	-100%
PCB-187	89.2000	ND	up to 100%
PCB-189	2.8100	ND	up to 100%
PCB-190	11.3000	ND	up to 100%
PCB-191	1.8100	ND	up to 100%
PCB-194	35.7000	ND	up to 100%
PCB-195	11.4000	ND	up to 100%
PCB-196	14.4000	3.8700	73%
PCB-197	5.2000	ND	up to 100%
PCB-198	49.0000	ND	up to 100%
PCB-201	4.3100	ND	up to 100%
PCB-202	13.4000	ND	up to 100%
PCB-203	26.7000	ND	up to 100%
PCB-206	25.9000	ND	up to 100%
PCB-207	3.5400	2.7400	23%
PCB-208	9.1800	ND	up to 100%
PCB-209	13.7000	ND	up to 100%
4-Nonylphenols	1940.0000	206.0000	89%
4-Nonylphenol monoethoxylates	ND	98.2000	-100%
4-Nonylphenol diethoxylates	ND	27.6000	-100%
PBDE-8	8.9600	ND	up to 100%
PBDE-12	6.2800	ND	up to 100%
PBDE-15	71.8000	ND	up to 100%

Sample Parameter	Influent Concentration mg/l	Effluent Concentration mg/l	% reduction
PBDE-17	269.0000	39.5000	85%
PBDE-28	734.0000	56.2000	92%
PBDE-35	15.6000	ND	up to 100%
PBDE-37	11.7000	ND	up to 100%
PBDE-47	38000.0000	3200.0000	92%
PBDE-49	1020.0000	99.3000	90%
PBDE-51	122.0000	14.9000	88%
PBDE-66	668.0000	38.4000	94%
PBDE-71	139.0000	19.2000	86%
PBDE-75	61.0000	11.5000	81%
PBDE-79	65.2000	25.9000	60%
PBDE-85	1370.0000	119.0000	91%
PBDE-99	34900.0000	2920.0000	92%
PBDE-100	6930.0000	550.0000	92%
PBDE-119	125.0000	ND	up to 100%
PBDE-138	281.0000	ND	up to 100%
PBDE-140	99.1000	ND	up to 100%
PBDE-153	2790.0000	212.0000	92%
PBDE-154	2300.0000	197.0000	91%
PBDE-155	204.0000	ND	up to 100%
PBDE-183	471.0000	44.1000	91%
PBDE-203	1020.0000	ND	up to 100%
PBDE-206	8690.0000	ND	up to 100%
PBDE-207	18100.0000	550.0000	97%
PBDE-208	13800.0000	372.0000	97%
PBDE-209	131000.0000	2480.0000	98%
1,4-Dichlorobenzene	248.0000	34.2000	86%
1,2-Dichlorobenzene	3.9000	0.6120	84%
1,2,4-Trichlorobenzene	0.2680	ND	up to 100%
Pentachlorobenzene	0.1620	0.0960	41%
Hexachlorobutadiene	0.0710	0.0300	58%
Hexachlorobenzene	0.4490	0.2400	47%
HCH, alpha	0.0570	0.0560	2%
HCH, beta	0.2730	0.0820	70%
HCH, gamma	0.2380	0.1850	22%
Aldrin	0.0470	ND	up to 100%
Octachlorostyrene	ND	0.0110	-100%
Chlordane, oxy-	0.1290	ND	up to 100%

Sample Parameter	Influent Concentration mg/l	Effluent Concentration mg/l	% reduction
Chlordane, gamma (trans)	0.2550	ND	up to 100%
Chlordane, alpha (cis)	0.2700	ND	up to 100%
Nonachlor, trans-	0.2440	ND	up to 100%
Nonachlor, cis-	0.0660	ND	up to 100%
2,4'-DDD	5.0400	0.0730	99%
4,4'-DDD	0.2870	ND	up to 100%
2,4'-DDT	0.1340	ND	up to 100%
4,4'-DDT	0.3580	ND	up to 100%
HCH, delta	0.1660	ND	up to 100%
alpha-Endosulphan	0.7910	0.1850	77%
Endrin	0.6210	0.6820	-10%
beta-Endosulphan	0.3150	ND	up to 100%
Endrin Ketone	0.3010	ND	up to 100%
Furosemide	2900.0000	1140.0000	61%
Gemfibrozil	434.0000	41.7000	90%
Glyburide	14.8000	6.1800	58%
Hydrochlorothiazide	541.0000	258.0000	52%
2-Hydroxy-ibuprofen	83100.0000	ND	up to 100%
Ibuprofen	26900.0000	ND	up to 100%
Naproxen	10200.0000	92.1000	99%
Triclocarban	183.0000	23.5000	87%
Triclosan	770.0000	162.0000	79%
Warfarin	18.4000	11.2000	39%

Table 2 - Removal estimates for contaminants monitored in Ganges wastewater. Data represents samples collected in July 2014.

Sample Parameter	Unit	Influent Concentration	Effluent Concentration	% reduction
biochemical oxygen demand	mg/L	331	ND	up to 100%
chemical oxygen demand	mg/L	730	ND	up to 100%
carbonaceous biochemical oxygen demand	mg/L	274	ND	up to 100%
cyanide-SAD	mg/L	0.00328	0.00249	24%
cyanide-WAD	mg/L	0.002	0.00186	7%
oil & grease, total	mg/L	21	ND	up to 100%
oil & grease, mineral	mg/L	ND	ND	up to 100%
sulfide	mg/L	0.256	ND	up to 100%
temperature	°C	---	---	up to 100%
enterococci	CFU/100 mL	3300000	10	up to 100%
fecal coliforms	CFU/100 mL	14000000	ND	up to 100%
N - TKN (as N)	mg/L	37.1	0.257	99%
N - NH3 (as N)	mg/L	33	0.26	99%
P - PO4 - total (as P)	mg/L	5.61	0.138	98%
P - PO4 - total (as P)	mg/L	6.76	0.144	98%
P - PO4 - ortho (as P)	mg/L	4.12	ND	up to 100%
total organic carbon	mg/L	101	16.4	84%
total suspended solids	mg/L	314	ND	up to 100%
aluminum	mg/L	0.272	0.0251	91%
antimony	mg/L	0.000123	0.000259	-111%
arsenic	mg/L	0.000651	0.00027	59%
barium	mg/L	0.0144	0.00783	46%
cadmium	mg/L	0.000143	0.000104	27%
calcium	mg/L	14.5	13.8	5%
chromium	mg/L	0.00103	0.00038	63%
cobalt	mg/L	0.000395	0.000159	60%
copper	mg/L	0.103	0.00603	94%
iron	mg/L	0.93	0.0662	93%
lead	mg/L	0.00187	0.00031	83%
magnesium	mg/L	6.14	4.75	23%
manganese	mg/L	0.0699	0.0404	42%
mercury	mg/L	0.0000128	ND	up to 100%
molybdenum	mg/L	0.000679	0.000178	74%
nickel	mg/L	0.00345	0.000915	73%
potassium	mg/L	20.6	16.6	19%
selenium	mg/L	0.000222	0.000093	58%
silver	mg/L	0.000261	0.000021	92%
thallium	mg/L	0.000005	ND	up to 100%
tin	mg/L	0.00091	0.00031	66%
zinc	mg/L	0.0994	0.0483	51%
methyl mercury	mg/L	0.00000128	ND	up to 100%

Sample Parameter	Unit	Influent Concentration	Effluent Concentration	% reduction
monobutyltin	mg/L	0.000001	0.000002	-100%
monobutyltin trichloride	mg/L	0.000002	0.000003	-50%
total phenols	mg/L	0.097	0.0057	94%
phenol	mg/L	0.0025	0.0165	-560%
naphthalene	mg/L	0.00001	0.000033	-230%
phenanthrene	mg/L	0.000015	ND	up to 100%
total LMW-PAH's	mg/L	0.000015	ND	up to 100%
bis(2-ethylhexyl)phthalate	mg/L	0.005	0.0141	-182%
diethyl phthalate	mg/L	0.00025	0.00029	-16%
toluene	mg/L	0.01	ND	up to 100%
trichloromethane	mg/L	0.011	0.0012	89%
bromodichloromethane	mg/L	0.0011	ND	up to 100%
dimethyl ketone	mg/L	0.064	ND	up to 100%
methyl ethyl ketone	mg/L	0.01	ND	up to 100%
alpha-terpineol	mg/L	0.005	0.0153	-206%
HIGH RESOLUTION				
Nonylphenols				
4-Nonylphenols	ng/L	1690	213	87%
4-Nonylphenol monoethoxylates	ng/L	4790	ND	up to 100%
4-Nonylphenol diethoxylates	ng/L	2070	31.3	98%
PAHs				
Naphthalene	ng/L	35	4.19	88%
Acenaphthylene	ng/L	1.81	ND	up to 100%
Acenaphthene	ng/L	12.3	1.48	88%
Fluorene	ng/L	13.4	3.1	77%
Phenanthrene	ng/L	65.6	5.53	92%
Anthracene	ng/L	11.1	0.291	97%
Fluoranthene	ng/L	31.9	1.04	97%
Pyrene	ng/L	36.4	2.14	94%
Benz[a]anthracene	ng/L	10.1	ND	up to 100%
Chrysene	ng/L	15.1	0.398	97%
Benzo[b]fluoranthene	ng/L	7.76	ND	up to 100%
Benzo[j,k]fluoranthenes	ng/L	7.85	ND	up to 100%
Benzo[e]pyrene	ng/L	10.5	ND	up to 100%
Benzo[a]pyrene	ng/L	7.27	ND	up to 100%
Perylene	ng/L	3.81	ND	up to 100%
Indeno[1,2,3-cd]pyrene	ng/L	6.88	ND	up to 100%
Benzo[ghi]perylene	ng/L	14.8	ND	up to 100%
2-Methylnaphthalene	ng/L	15.2	1.79	88%
2,6-Dimethylnaphthalene	ng/L	8.44	ND	up to 100%
2,3,5-Trimethylnaphthalene	ng/L	12.1	0.589	95%
1-Methylphenanthrene	ng/L	13.4	ND	up to 100%
Dibenzothiophene	ng/L	11.1	0.821	93%
PBDEs				
PBDPE-7	pg/L	4.06	1.93	52%

Sample Parameter	Unit	Influent Concentration	Effluent Concentration	% reduction
PBDPE-8	pg/L	7.24	2.38	67%
PBDPE-12	pg/L	4.94	ND	up to 100%
PBDPE-15	pg/L	37.1	4.99	87%
PBDPE-17	pg/L	373	29.8	92%
PBDPE-28	pg/L	1110	36.2	97%
PBDPE-32	pg/L	3.22	ND	up to 100%
PBDPE-35	pg/L	7.7	ND	up to 100%
PBDPE-37	pg/L	20	19.1	4%
PBDPE-47	pg/L	48000	431	99%
PBDPE-49	pg/L	1320	28.3	98%
PBDPE-51	pg/L	217	7.1	97%
PBDPE-66	pg/L	1020	21	98%
PBDPE-71	pg/L	123	2.76	98%
PBDPE-75	pg/L	82.5	3.98	95%
PBDPE-85	pg/L	1480	8.47	99%
PBDPE-99	pg/L	39400	172	up to 100%
PBDPE-100	pg/L	7990	44.5	99%
PBDPE-119	pg/L	84.3	3.61	96%
PBDPE-126	pg/L	23	ND	up to 100%
PBDPE-138	pg/L	370	ND	up to 100%
PBDPE-140	pg/L	113	ND	up to 100%
PBDPE-153	pg/L	8470	10.6	up to 100%
PBDPE-154	pg/L	1980	11.2	99%
PBDPE-155	pg/L	229	ND	up to 100%
PBDPE-183	pg/L	478	9.17	98%
PBDPE-190	pg/L	61	ND	up to 100%
PBDPE-203	pg/L	420	34.6	92%
PBDPE-206	pg/L	3220	271	92%
PBDPE-207	pg/L	3270	220	93%
PBDPE-208	pg/L	1930	281	85%
PBDPE-209	pg/L	46700	4610	90%
PCBs				
Total Monochloro Biphenyls	pg/L	64.9	18.1	72%
Total Dichloro Biphenyls	pg/L	1970	127	94%
Total Trichloro Biphenyls	pg/L	1160	55.1	95%
Total Tetrachloro Biphenyls	pg/L	1410	54.5	96%
Total Pentachloro Biphenyls	pg/L	1300	38.3	97%
Total Hexachloro Biphenyls	pg/L	973	8.6	99%
Total Heptachloro Biphenyls	pg/L	421	3.68	99%
Total Octachloro Biphenyls	pg/L	106	ND	up to 100%
Total Nonachloro Biphenyls	pg/L	12.3	ND	up to 100%
Decachloro Biphenyl	pg/L	5.98	ND	up to 100%
TOTAL PCBs	pg/L	7420	305	96%
PCB-1	pg/L	9.9	5.29	47%
PCB-2	pg/L	9.44	3.69	61%

Sample Parameter	Unit	Influent Concentration	Effluent Concentration	% reduction
PCB-3	pg/L	45.6	9.11	80%
PCB-4	pg/L	15.6	ND	up to 100%
PCB-6	pg/L	16.6	ND	up to 100%
PCB-8	pg/L	50.7	4.81	91%
PCB-11	pg/L	1850	113	94%
PCB-15	pg/L	36.6	6.2	83%
PCB-16	pg/L	40.1	4.13	90%
PCB-17	pg/L	41.1	2.82	93%
PCB-18	pg/L	87.2	9.14	90%
PCB-19	pg/L	10	1.7	83%
PCB-20	pg/L	175	9.23	95%
PCB-21	pg/L	95.2	3.97	96%
PCB-22	pg/L	61.4	3.7	94%
PCB-25	pg/L	9.23	ND	up to 100%
PCB-26	pg/L	22.5	1.99	91%
PCB-27	pg/L	6.05	ND	up to 100%
PCB-31	pg/L	153	8.08	95%
PCB-32	pg/L	29.3	2.47	92%
PCB-35	pg/L	339	6.15	98%
PCB-36	pg/L	54.8	1.73	97%
PCB-37	pg/L	41.9	2.2	95%
PCB-40	pg/L	86.4	3.56	96%
PCB-42	pg/L	33.7	1.49	96%
PCB-43	pg/L	8.44	ND	up to 100%
PCB-44	pg/L	219	9.06	96%
PCB-45	pg/L	38	2.17	94%
PCB-46	pg/L	9.2	ND	up to 100%
PCB-48	pg/L	36.1	1.25	97%
PCB-49	pg/L	88.8	3.55	96%
PCB-50	pg/L	20.3	1.48	93%
PCB-52	pg/L	229	12	95%
PCB-56	pg/L	61.8	2.1	97%
PCB-59	pg/L	12.8	0.825	94%
PCB-60	pg/L	41.4	1.11	97%
PCB-61	pg/L	285	11	96%
PCB-63	pg/L	4.68	ND	up to 100%
PCB-64	pg/L	66.1	2.66	96%
PCB-66	pg/L	120	3.74	97%
PCB-67	pg/L	3.02	ND	up to 100%
PCB-68	pg/L	10.3	ND	up to 100%
PCB-77	pg/L	28.5	0.781	97%
PCB-78	pg/L	4.46	ND	up to 100%
PCB-79	pg/L	7.16	ND	up to 100%
PCB-82	pg/L	24.4	ND	up to 100%
PCB-83	pg/L	121	2.46	98%

Sample Parameter	Unit	Influent Concentration	Effluent Concentration	% reduction
PCB-84	pg/L	57.4	2.06	96%
PCB-85	pg/L	30.5	1.02	97%
PCB-86	pg/L	141	7.46	95%
PCB-88	pg/L	29.5	1.03	97%
PCB-89	pg/L	3.05	ND	up to 100%
PCB-90	pg/L	214	7.34	97%
PCB-92	pg/L	35.5	1.54	96%
PCB-93	pg/L	180	8.38	95%
PCB-96	pg/L	1.77	ND	up to 100%
PCB-103	pg/L	2.12	ND	up to 100%
PCB-104	pg/L	0.742	ND	up to 100%
PCB-105	pg/L	64.7	2.22	97%
PCB-107	pg/L	5.57	ND	up to 100%
PCB-109	pg/L	9.01	ND	up to 100%
PCB-110	pg/L	210	7.04	97%
PCB-114	pg/L	4.52	ND	up to 100%
PCB-118	pg/L	166	6.21	96%
PCB-123	pg/L	3.97	ND	up to 100%
PCB-128	pg/L	28	1.23	96%
PCB-129	pg/L	238	5.49	98%
PCB-130	pg/L	15.2	ND	up to 100%
PCB-131	pg/L	3.24	ND	up to 100%
PCB-132	pg/L	61.8	1.46	98%
PCB-133	pg/L	3.27	ND	up to 100%
PCB-134	pg/L	11.1	ND	up to 100%
PCB-135	pg/L	62.7	1.47	98%
PCB-136	pg/L	24.2	0.942	96%
PCB-137	pg/L	12.5	ND	up to 100%
PCB-139	pg/L	4.9	ND	up to 100%
PCB-141	pg/L	36.5	1.49	96%
PCB-144	pg/L	8.52	ND	up to 100%
PCB-146	pg/L	33.5	0.829	98%
PCB-147	pg/L	144	4.01	97%
PCB-148	pg/L	1.4	ND	up to 100%
PCB-150	pg/L	1.36	ND	up to 100%
PCB-153	pg/L	232	4.09	98%
PCB-155	pg/L	13.1	ND	up to 100%
PCB-156	pg/L	33.3	0.806	98%
PCB-158	pg/L	18.8	0.786	96%
PCB-164	pg/L	11.2	ND	up to 100%
PCB-167	pg/L	9.19	ND	up to 100%
PCB-170	pg/L	54.3	0.836	98%
PCB-171	pg/L	16.4	ND	up to 100%
PCB-172	pg/L	10.2	ND	up to 100%
PCB-174	pg/L	34.9	ND	up to 100%

Sample Parameter	Unit	Influent Concentration	Effluent Concentration	% reduction
PCB-175	pg/L	1.65	ND	up to 100%
PCB-176	pg/L	5.43	ND	up to 100%
PCB-177	pg/L	22.1	ND	up to 100%
PCB-178	pg/L	14.5	ND	up to 100%
PCB-179	pg/L	19.5	ND	up to 100%
PCB-180	pg/L	139	2.1	98%
PCB-183	pg/L	33.5	0.719	98%
PCB-184	pg/L	23.2	ND	up to 100%
PCB-187	pg/L	67.7	1.58	98%
PCB-189	pg/L	2.81	ND	up to 100%
PCB-190	pg/L	9.41	ND	up to 100%
PCB-191	pg/L	1.89	ND	up to 100%
PCB-194	pg/L	29.8	ND	up to 100%
PCB-195	pg/L	9.34	ND	up to 100%
PCB-196	pg/L	10.6	ND	up to 100%
PCB-197	pg/L	4.24	ND	up to 100%
PCB-198	pg/L	35.9	1.15	97%
PCB-201	pg/L	5.37	ND	up to 100%
PCB-202	pg/L	10.7	ND	up to 100%
PCB-203	pg/L	18.9	ND	up to 100%
PCB-206	pg/L	12.3	ND	up to 100%
PCB-208	pg/L	3.84	ND	up to 100%
PCB-209	pg/L	5.98	0.966	84%
OC Pesticides				
1,3-Dichlorobenzene	ng/L	50.6	3.8	92%
1,4-Dichlorobenzene	ng/L	656	62.4	90%
1,2-Dichlorobenzene	ng/L	4.06	0.837	79%
1,3,5-Trichlorobenzene	ng/L	0.245	ND	up to 100%
Pentachlorobenzene	ng/L	0.109	0.066	39%
HCH, alpha	ng/L	0.07	0.054	23%
HCH, beta	ng/L	0.244	0.155	36%
HCH, gamma	ng/L	0.238	0.176	26%
Chlordane, gamma (trans)	ng/L	0.384	ND	up to 100%
4,4'-DDD	ng/L	0.127	ND	up to 100%
4,4'-DDE	ng/L	1.02	ND	up to 100%
2,4'-DDT	ng/L	0.116	ND	up to 100%
4,4'-DDT	ng/L	0.337	ND	up to 100%
alpha-Endosulphan	ng/L	0.366	0.252	31%
Dieldrin	ng/L	0.592	0.129	78%
Endosulphan Sulphate	ng/L	0.238	ND	up to 100%
Methoxychlor	ng/L	0.337	ND	up to 100%
PPCPs				
Furosemide	ng/L	3430	211	94%
2-Hydroxy-ibuprofen	ng/L	41900	342	99%
Ibuprofen	ng/L	17200	137	99%

Sample Parameter	Unit	Influent Concentration	Effluent Concentration	% reduction
Triclocarban	ng/L	75.3	ND	up to 100%
Triclosan	ng/L	960	ND	up to 100%
Warfarin	ng/L	15.9	6.32	60%
Glyburide	ng/L	15.7	ND	up to 100%
Hydrochlorothiazide	ng/L	771	638	17%
Gemfibrozil	ng/L	37.3	ND	up to 100%
Naproxen	ng/L	16800	149	99%

Appendix E

Pump Station Cost Curves

Sewage Lift Stations

PIR Base Asset Code:

C2 Sewage Lift Stations <500 L/s

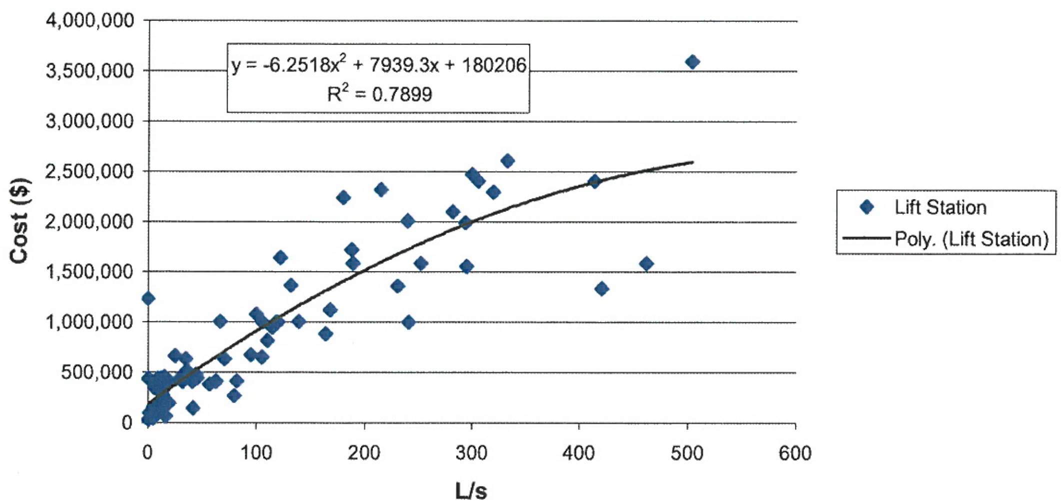
Capacity Measure:

Capacity of the wastewater pumps in L/s

Equation: <500 L/s $y = -6.2518x^2 + 7939.3x + 180206$

R^2: <500 L/s 0.7899

C2 Lift Station <500 L/s



Assumptions and Comments:

- Combined General Multiplier = 1.33 (to be added to base cost curve)
- Costs associated with this asset include the wastewater pumps, manhole structure and associated mechanical and electrical components
- Breakpoint identified at +/- 500 L/s

Sewage Lift Stations

PIR Base Asset Code:

C2 Sewage Lift Stations >500 L/s

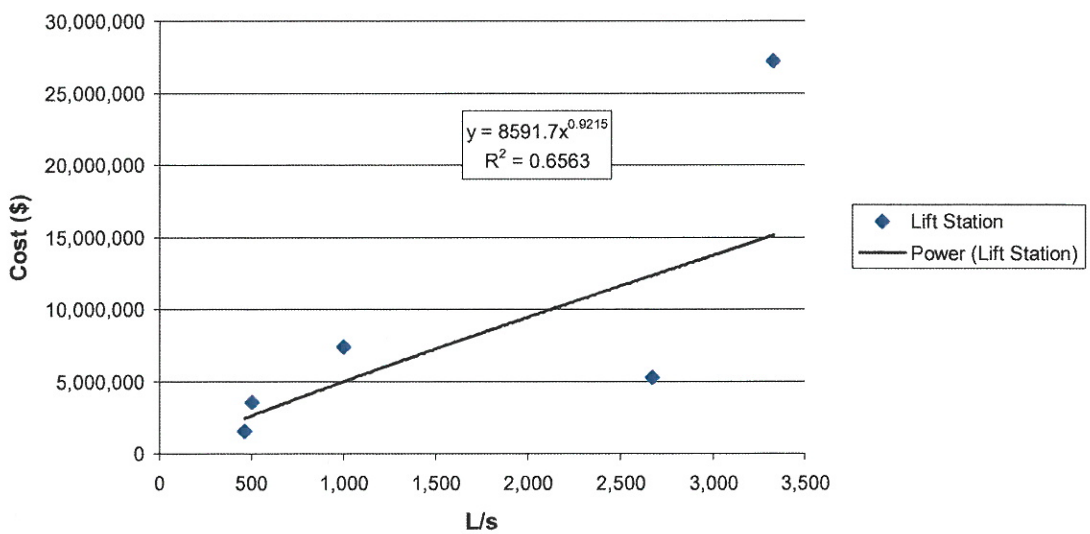
Capacity Measure:

Capacity of the wastewater pumps in L/s

Equation: >500 L/s $y = 8591.7x^{0.9215}$

R^2: >500 L/s 0.6563

C2 Lift Station >500 L/s



Assumptions and Comments:

- Combined General Multiplier = 1.33 (to be added to base cost curve)
- For additional comments see C2 < 500 L/s

Appendix F

Derivation of Labour Costs

Appendix F

Derivation of Labour Costs

Labour Type	2009 Annual Salary [1]	2015 Annual Salary [2]
Plant Manager	$ 140,000	$ 158,000
Chief Plant Operators	$ 120,000	$ 135,000
Chief Area Operator	$ 100,000	$ 113,000
Plant Operator	$ 80,000	$ 90,000
Labourer	$ 50,000	$ 56,000

(1) Stantec Option 1A, Appendix A, December 2009 (includes pension, overheads)

(2) CRD rate increase for WWTP operators averaged 2%/year for 2014 to 2016. Multiply by $1.02^6 = 1.126$

Attachment 3(b)

Capital Regional District

Core Area Liquid Waste Management Plan

Wastewater Treatment System Feasibility and Costing Analysis

Technical Memorandum #2

Review and Refine Option Sets

carollo

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URBAN systems

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Victoria, BC, V8W 1G2

urbansystems.ca

November 20, 2015

Project: 1692.0037.01

Table of Contents

Appendices

1.0 Report Summary and Overview

Phase 2 feasibility and costing analysis provides the Core Area Liquid Waste Management Committee (the Committee) with engineering and financial characterizations of four option sets to treat wastewater and recover resources. A "fifth" option has been added by enhancing the one plant option from a secondary plus disinfection to an enhanced tertiary level treatment plant for flows discharged to the ocean. Each option set differs from the others to illustrate their relative performance with respect to the Project Charter and technical criteria. Option set design will adhere to engineering principles, regulatory requirements and the regional infrastructure context, but must also build on the public input received to date and the needs and aspirations of the Committee and the two sub-committees, Eastside Select and Westside Select. This memorandum summarizes the four proposed option sets that are to form the basis for life-cycle costing in November 2015. Each option set is described in detail including general site requirements, operational strategies, treatment criteria, flow scenarios and growth phasing. The diverse goals and commitments of the Project Charter warrant that the option sets collectively provide for a range of levels of service to assess their relative performance. Decision making on preferred option set(s) can be informed by way of the life-cycle costing analysis on balance with the qualitative and quantitative performance of each option set against the range of criteria, in addition to public consultation from November onward.

1.1 Making of the Option Sets: Collaborative Process to Date

Liquid waste management in the Core Area is represented by a range of audiences, with common and diverse interests. Engagement in 2015 confirmed a list of given conditions for treatment, uncovered values and priorities, summarized site considerations and provided for input on fifteen (15) option sets. Building on this engagement, key elements of the collaborative process for arriving at four option sets for the Core Area include:

- Extensive public engagement in both Eastside and Westside communities including in-person events, surveys, pop-up booths and representation by public advisory committees, among many other methods to receive input;
- Presentations, discussions and recommendations by technical committees including Westside/Eastside Technical Committee(s), the Technical and Community Advisory Committees (reports to the Core Committee), liaising with the Ministry of Environment and contributions from CRD's Wastewater Commission;
- Discussions with various wastewater treatment and resource recovery vendors through Innovation Days (Westside) a Core Area *Request for Technical Information,* and most recently a vendor engagement workshop as led by the Technical Oversight Panel;
- Extensive dialogue, presentations, and broad consideration to industry best practices between Urban Systems/Carollo Engineers and the Technical Oversight Panel; and
- Preliminary findings from Westside Select Committee's Phase II site feasibility and option set analysis including life-cycle cost projections signalling preliminary financial realities for water reuse and energy revenues.

The amount of feedback, input, ideas and public support for getting to life-cycle costing analysis has significantly contributed to the convergence of four option sets. On aggregate, the option sets should deliver on the following drivers:

- Provide a range of option sets which collectively illustrate cost, footprint, and infrastructure and water reuse factors by way of diverse options including a central/1-plant option and up to a distributed option set with multiple facilities in key site nodes;
- Build on public engagement to date including acceptability of sites when assessing the technical merits of preferred locations and look to local community planning aspirations for land use implications;
- Develop a range of option sets that meets the regulatory requirements and other option sets that exceed regulatory requirements including tertiary treated water quality;
- Provide options for resource recovery options including centralized solids recovery at Hartland Landfill or another site adjacent central liquids treatment as well explore the integration of other waste streams;
- Look to minimize costs to residents and businesses in all option sets and provide a range of diverse options that clearly illustrates the results of costs and revenues; and
- Consider site resiliency with respect to sea level rise and seismic factors so that capital investments can be preserved for the long-term.

These drivers align directly with the Project Charter and build on the results of the collaborative process to date. Direction to proceed to life-cycle costing can be based on the collective ability of the option sets to provide for a diverse illustration of the goals and commitments of this project.

1.2 Four Option Sets Summary

Table 1.1 summarizes the engineering aspects of each option set and includes levels of service differentiators. Sections 2 to 8 of this memorandum provide a more detailed account of the parameters and components of each option set.

Also note that the Rock Bay site is common to all Option Sets. Discussions with the Ministry of Environment have identified the possibility of discharging a highly treated effluent into the Inner Harbour instead of conveying secondary effluent through a new pipeline to Clover Point and through a new parallel outfall. However, a detailed and advanced Environmental Impact Study would be required to determine the effluent quality necessary to protect the environment and public health. Ministry approval for this approach is uncertain. The Core Area LWMP committee has approved preparing a cost estimate to increase treatment of Rock Bay to a tertiary level. This will enable an order of magnitude cost estimate comparison of discharging to the Inner Harbour versus a forcemain through the City. Technical Memo 3 will outline the costs associated with the deep outfall but not with the shallow outfall as the criteria for this outfall have yet to be determined.

Table 1.1 – Summary of Engineering Aspects for Each Option

<table>
<tr><th>Option Set Map</th><th>Summary Characterization</th></tr>
<tr><td rowspan="2">Rock Bay (Option 1a and 1b)

</td><td>Engineering Description
Rock Bay treats 100% of the base and wet weather flows.
Flows > 3 x ADWF at Clover Point and > 4 x ADWF at Macaulay Point are screened at those locations before discharge.
Solids recovery is based on either anaerobic digestion or gasification of mixed waste at Rock Bay or at Hartland Landfill.
Extent of new infrastructure is lowest of all option sets; municipal trunk sewers optimization (e.g. Victoria, Oak Bay) will be considered to minimize pumping and piping from Clover outfall back to Rock Bay
Clover Point may include an innovative, compact technology to maximize treatment including direct discharge to the outfall, thereby reducing the scope/cost of pumping to Rock Bay.
The treated effluent line from Rock Bay to Clover Point could be accessed for reuse/heat recovery projects.</td></tr>
<tr><td>Levels of Service Differentiators
Focus on meeting regulations and disinfection plus tertiary quality water for local reuse (up to 10 MLD).
Heat recovery is contemplated at/around the plant.
Focus on minimizing operational complexity
Focus treatment and recovery in one location which has high public acceptability and is aligned with local land uses.
Note that Option 1b would convert all secondary + disinfection flow treatment to an enhanced tertiary level to increase service levels and the feasibility of a harbor discharge.</td></tr>
</table>

<table>
<tr><th>Option Set Map</th><th>Summary Characterization</th></tr>
<tr><td>

Rock Bay and Colwood (Option 2)

</td><td>

Engineering Description

- Rock Bay treats 100% of the base and wet weather flows.
- Flows > 3 x ADWF at Clover Point and > 4 x ADWF are screened at those locations before discharge.
- Rock Bay is designed to handle 100% of the flow in order to provide the alternative method of disposal for reuse plants. Colwood sized to match the feasibility of irrigation and aquifer recharge in the area at an estimated 10 MLD.
- Solids recovery is based on either anaerobic digestion or gasification of solid waste at Rock Bay or at Hartland Landfill; solids at Colwood will be discharged into the CRD trunk line for full treatment at Rock Bay.
- Extent of new conveyance infrastructure is second lowest of all option sets; municipal trunk sewers optimization (e.g. Victoria, Oak Bay) will be considered to minimize pumping and piping from Clover outfall back to Rock Bay; no additional outfall at Colwood is required.
- Clover Point may include an innovative, compact technology to maximize treatment and discharge to the outfall, thereby reducing the scope/cost of pumping to Rock Bay.
- The treated effluent line from Rock Bay to Clover Point could be accessed for reuse/heat recovery projects.

Levels of Service Differentiators

- Focus on increasing the quantity of tertiary effluent to meet potential opportunities for water reuse in Colwood (10 MLD); treatment at Rock Bay will focus on meeting regulations and disinfection plus tertiary quality water for local reuse (up to 10 MLD).
- Heat recovery is contemplated at/around the plants.
- Focus for most of the treatment and recovery at Rock Bay where there is high public acceptability and alignment with local land uses.
- Increases level of service for reuse without extensive new infrastructure.
- Provides for opportunities to phase in greater reuse as flows increase with growth in Colwood-Langford area.

</td></tr>
</table>

Option Set Map	Summary Characterization
4-Plant: Rock Bay, Colwood, Esquimalt Nation and East Saanich (Option 3)  	***Engineering Description*** • Rock Bay would serve as a sub-regional facility for all Eastside flows (69%). Esquimalt Nation plant would treat the remainder of flows (31%). Wet weather flows greater than 3 x ADWF at Clover and > 4 x ADWF at Macaulay would be screened before discharge out their respective outfalls. • Colwood reuse facility (10 MLD) would operate year-round and could increase over time to provide for potable substitution of toilet flushing and irrigation; East Saanich plant (3 MLD) would be commissioned initially for irrigation use only (summer). • Extent of new conveyance infrastructure is second highest of all option sets. • Includes either anaerobic digestion or gasification of mixed waste at Rock Bay or at Hartland Landfill; residual sludge from Colwood and East Saanich would discharge into the CRD main for full treatment at the main facilities • Life-cycle costing results for the four plant option could be quickly converted to a two plant option by removing the Colwood and East Saanich facilities (as needed). ***Levels of Service Differentiators*** • Further increase (beyond the 2-plant) of the quantity of tertiary effluent to meet probable opportunities for reuse in Colwood and East Saanich; treatment at Rock Bay and Esquimalt Nation will focus on meeting regulations and disinfection plus tertiary quality water for local reuse. • Heat recovery is contemplated at/around each plant, except East Saanich (seasonal initially). • Treatment and recovery is centered in two locations with high public acceptability at Rock Bay and Esquimalt Nation; other distributed facilities are smaller footprint in Colwood and East Saanich are located in growth centers with moderate acceptability.

Option Set Map	Summary Characterization
7-Plant: Rock Bay, Colwood, Esquimalt (Town), East Saanich, Langford, View Royal and Saanich Core (Option 4)  	***Engineering Description*** • Rock Bay would handle all of the Eastside flows or 69% of the 2030 flows. All the other six plants would provide tertiary treatment – maximizing resource recovery in the Core Area. The Rock Bay Plant will provide all primary treatment requirements for the Eastside. The Esquimalt (Town) plant would provide the primary treatment requirements of the 2 to 4 x ADWF for Westside, as well as tertiary treatment for the 0 to 2 x ADWF from the two First Nations and the Town of Esquimalt. • Wet weather flows greater than 3 x ADWF at Clover and > 4 x ADWF at Macaulay would be screened before discharge out their respective outfalls. • The Colwood plant would provide tertiary effluent for reuse (10 MLD) whereas View Royal and Langford plants would initially provide tertiary water quality without significant reuse (lack of potential demands); a new outfall is anticipated for the Westside distributed facilities. • Extent of new conveyance infrastructure is highest of all option sets. • East and Core Saanich facilities (3 MLD and 5 MLD respectively) would be commissioned initially for irrigation use only (summer) until sufficient demand occurs for toilet flushing. When not in use, flows would leverage existing infrastructure for treatment at Rock Bay • Solids recovery includes either anaerobic digestion or gasification of mixed waste at Rock Bay or at Hartland Landfill; solids would be dewatered at each plant for trucking to Rock Bay or Hartland.
	Levels of Service Differentiators • Greatest extent of tertiary effluent quality however provides only marginal increase of potential water reuse. Treatment at Rock Bay and Esquimalt (Town) will focus on meeting regulations and disinfection plus tertiary quality water for local reuse. • Heat recovery at 5 of 7 plants (not East or Core Saanich). • All sites are located in growth centers; public acceptability is greatest for Rock Bay; all six distributed facilities cover a relatively small footprint

1.3 Site Feasibility

Phase 1 of public engagement and technical analysis considered approximately 80 public and private sites brought forward by Core Area municipalities. Initially, site profiles centred on access and infrastructure, resource recovery and land use as a technical primer. Public input emphasised the importance of the information in the site profiles but input went further yet to appreciate the types of conditions residents would like to see in future facilities. Future facilities should improve a given location, provide a benefit to the neighborhood, fit within the local form, provide for safe interaction with residents, have no odour or noise, keep trucking to a minimum and should provide aesthetic qualities to promote positive interaction. Many of these considerations are inherent in the Project Charter, which too, frames our technical review of available sites within the proposed option sets.

The list of technically preferred sites across the Core Area evolves. The Eastside Select Committee prioritized 17 locations in July 2015 for further consideration in Phase 2. The Westside Select is considering a narrowed list of feasible sites prior to option sets analysis in November 2015. Collaboration also continues between CRD real estate staff and the technical team to identify sites with the greatest potential under the proposed four option sets. Further discussions with the Committee on site feasibility and a shortened list of preferred sites is scheduled for November 2015 as part of the option sets analysis. As a note, there are feasible sites available for all four proposed option sets.

Three sites on the eastside, Ogden Point, Windsor Park and Royal Jubilee-Trent, were recently removed from proposed option sets due to their lack of evidentiary advantage for cost savings or enhanced resource recovery. In particular for Ogden Point, the opportunity to locate a wet-weather facility at this location including the pumping and piping costs may be better offset by redirecting flows to Rock Bay from strategic locations in the Eastside such as near Bowker Avenue, along Bay Street and near other areas of the City of Victoria.

Life-cycle costing analysis, further site feasibility analysis and option set characterization against the Charter is the emphasis in November 2015 and frames the content of Technical Memorandum #3.

1.4 Life Cycle Costing Analysis and Presentation

Life-cycle costing analysis will be conducted in November 2015 based on the direction from the Core Area Committee on the preferred option sets. The costing methodology is outlined in Technical Memo #1

.

While the spreadsheet models will address the technical requirements, the presentation of life-cycle costing will have graphical figures and will include qualitative characterization of the Charter elements. This approach is intended to support public consultation, and further, to support a balanced review of option sets for Committee direction. Results will be focused towards key differentiators of the option sets and levels of service considerations to illustrate relative performance.

Technical Memo #3 includes life cycle costing and municipal allocations which will be based on existing finance protocols established for the Core Area, in relation to the sewer catchments and facilities illustrated in the map in Appendix A.

2.0 Technology Needs and Considerations

2.1 Representative Sites and Characteristics

Technical Memorandum #1 points to a representative design methodology whereby wastewater treatment plants are categorized into different capacities to suit the range of plants sizes. The plant categories include their level of service, land use considerations and flow capacities. For reference, Table 3.1 from Technical Memo #1 is repeated here.

Table 2.1 - Site Characterization Summary

Site Characterization	Neighbouring Land Use	Flow Range (Average Dry Weather Flow)	Anticipated Plant Purpose – Liquid Train
Small Distributed	Residential	< 5 ML/day	Tertiary treatment for local reuse
Medium Distributed	Residential	6-15 ML/day	Tertiary treatment for local reuse
Large Distributed	Residential	16 – 25 ML/day	Tertiary treatment for local reuse
Extra Large Distributed or Central	Non-Residential	>26 ML/day	Primary & Secondary treatment for outfall and tertiary treatment for local reuse

Core Area option sets include plants based on the categories in Table 2.1.

It is noted that this work in Phase 2 is only addressing representative technologies (as discussed below). Specific providers of technology and project delivery options will be pursued during the subsequent implementation stage.

2.2 Liquid Treatment Options and Representative Designs

Representative design includes the provisional selection of suitable technologies to allow for feasibility and costing analysis. Further design assignments and additional engagement with the private sector for alternative technologies is critical to delivering a treatment and recovery solution that meets Core Area needs while maximizing the efficiency of the market place.

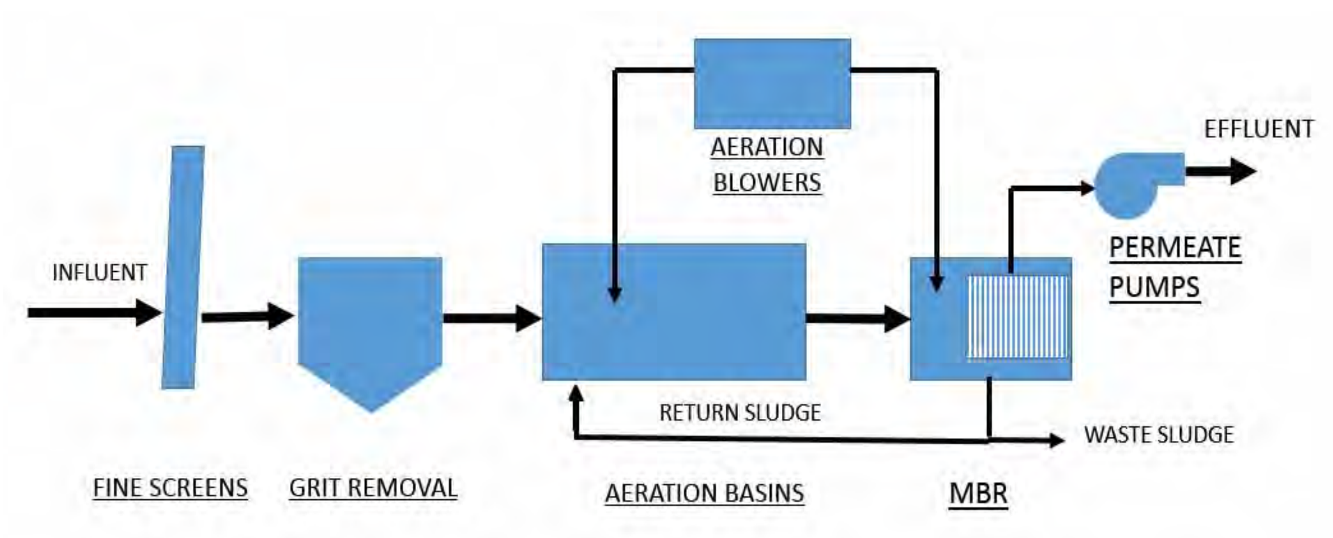
The small, medium and large plants located in residential areas will be part of distributed facilities in the 2, 4 and 7 plant option sets. Three key drivers for distributed facilities are: to reduce footprint, reduce negative interruptions to the surrounding neighborhood and to enable water reuse. These drivers trigger the need for tertiary level plants, which are defined in Technical Memo #1 as achieving the *Greater Exposure Potential* category, with Colwood requiring meeting the *Indirect Potable Reuse* category for aquifer recharge.

Common tertiary technologies reviewed for representative design include membrane bioreactors, sequencing batch reactors with ultrafiltration membranes, moving bed bioreactors with ultrafiltration membranes and continuous flow intermittent cleaning with ceramic membranes. Construction phasing is possible for certain plants in the two, four and seven plant option sets. Common considerations for selecting technologies include:

1. Method of procurement
2. Competition amongst a reasonable number of manufacturers
3. Financial security of manufacturer
4. Proven in the market place
5. Life cycle costing (capital and operating)
6. Flexibility
7. Ability to phase construction
8. Carbon footprint
9. Operational complexity
10. Physical area requirements
11. Amount of commonality with equipment desired within the entire CRD

Membrane bioreactor (MBR) processes were selected for representative design because they are recognized by their ability to reliably meet tertiary quality requirements, they are established in the marketplace, there are multiple manufacturers of the technology (creates competition) and for their small physical footprint. A typical generic MBR plant would include grit removal, fine screens, anoxic and aerated bioreactors, membranes, a waste sludge wasting system and ultraviolet light for primary disinfection with sodium hypochlorite for secondary disinfection (chlorine residual). Odour control facilities would also be provided. A typical process schematic for an MBR process is shown in Figure 2.1 below.

Figure 2.1 – Membrane Bioreactor (MBR)



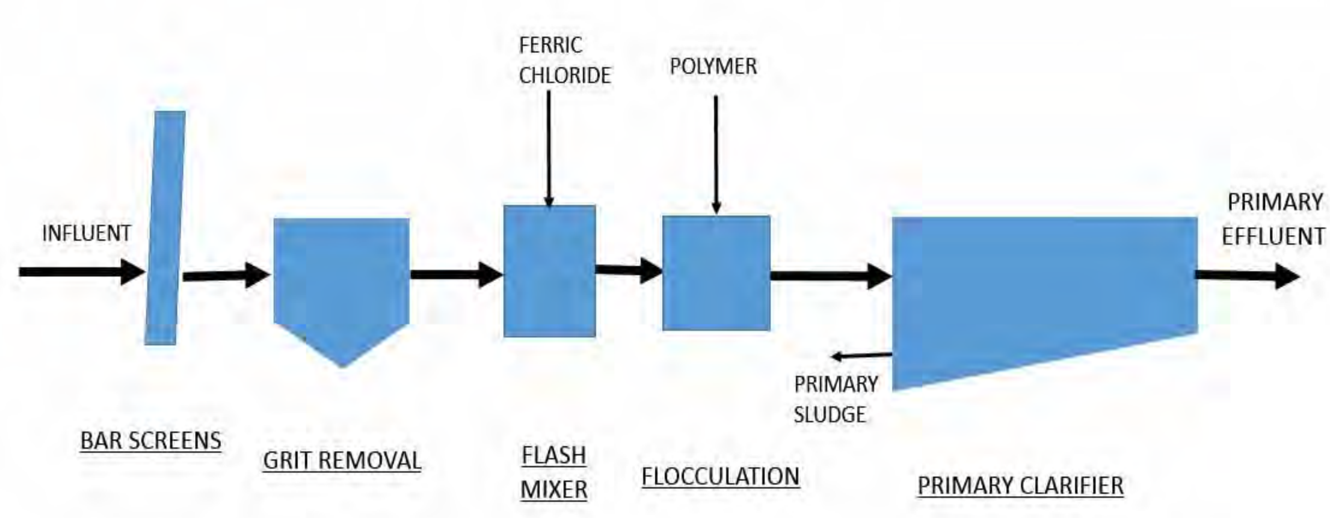
Each distributed facility would extract 2 x ADWF from the CRD trunk sewers. Any wet weather flows above this amount will be left in the trunk sewer to be treated at the extra-large distributed or central plants.

The effluent quality targets for the extra-large distributed or central plants located in non-residential areas are designed to meet the federal and provincial regulations. Regulations require that effluent met a secondary level of treatment for all flows up to 2xADWF and also primary treatment for all flows between 2 to 4 x ADWF to a primary treatment level. Each of the large or extra-large plants is proposed to include 'sidestream' tertiary level treatment to meet the potential water reuse demands in the immediate area. However, it is recognized that because the demand for reuse in the vicinity may be a small fraction of the treatments plants' capacity, these facilities will operate at reduced capacities much of the time.

Primary treatment technologies are wide ranging. A focused set of technologies were reviewed based on design criteria in Technical Memo #1 and include: traditional primary clarification (PC), ballasted flocculation (BF) and chemically enhanced primary treatment (CEPT). The mechanical fine mesh screen systems were reviewed, and since they do not consistently achieve the $CBOD_5$ < 130 mg/L requirement, they are not being selected as the representative technology. However, these filters may be considered again in subsequent stages in an effort to select technologies that, on balance, meet the effluent requirements of the MWR with slight variations on primary quality and secondary quality: the result could be smaller facilities and lower costs. This approach will need to be approved by the Ministry of Environment.

For the primary treatment technology we have selected the CEPT process as the representative technology, because it is established in the market, occupies a relatively small physical footprint and provides a high level of reliability. The CEPT process includes chemical addition, mechanical mixing and primary clarifiers with sludge removal pumps. The primary clarifiers would be covered and odour control facilities provided. Figure 2.2 provides a schematic of a CEPT system with a headworks that includes screens and grit removal.

Figure 2.2 – Chemically Enhanced Primary Treatment (CEPT)



Representative technologies for the large plants were selected in part due to available options for plants with flows of this size and based on the technical criteria from Technical Memo #1. These technologies included conventional activated sludge (CAS), moving bed bioreactors (MBBR) and integrated fixed-film activated sludge (IFAS). Process schematics of CAS, MBBR and IFAS are provided in Figures 2.3, 2.4 and 2.5 below.

Figure 2.3 – Conventional Activated Sludge (CAS)

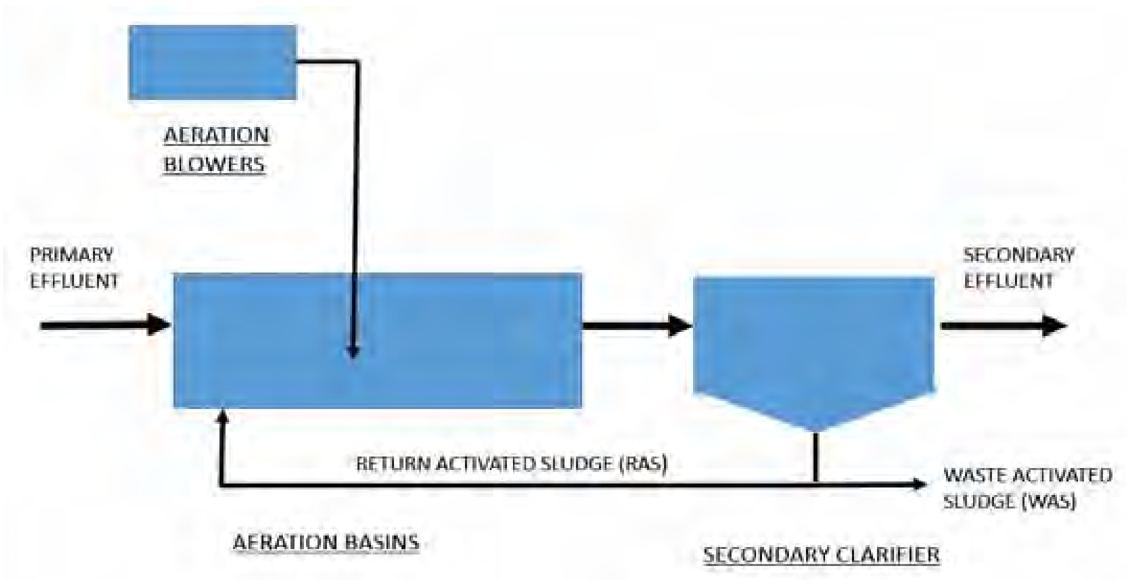


Figure 2.4 – Moving Bed Biological Reactors (MBBR)

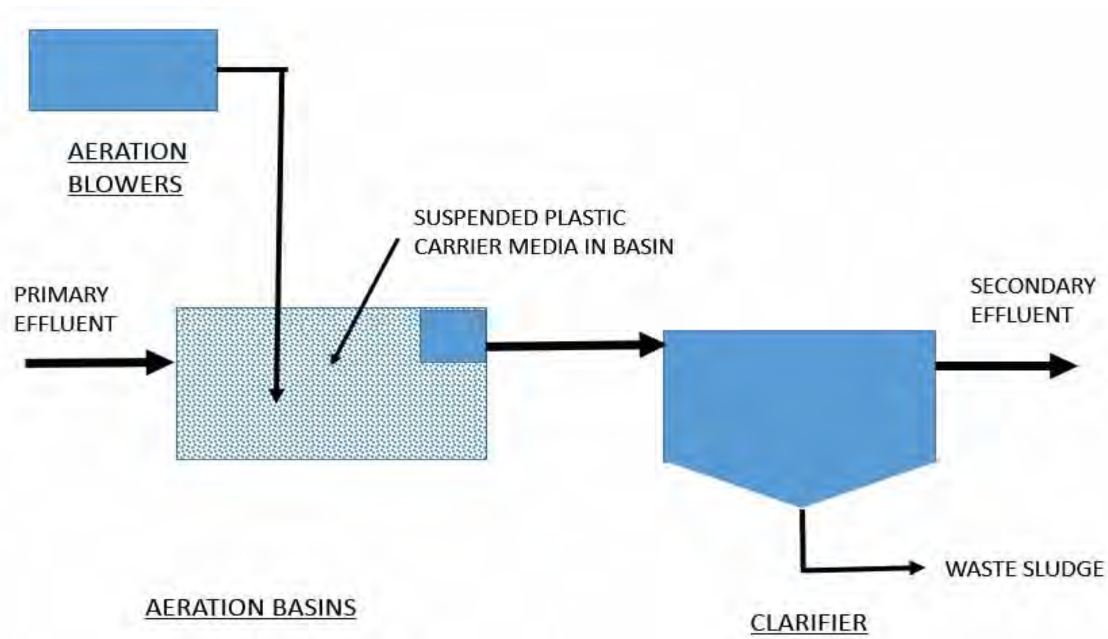
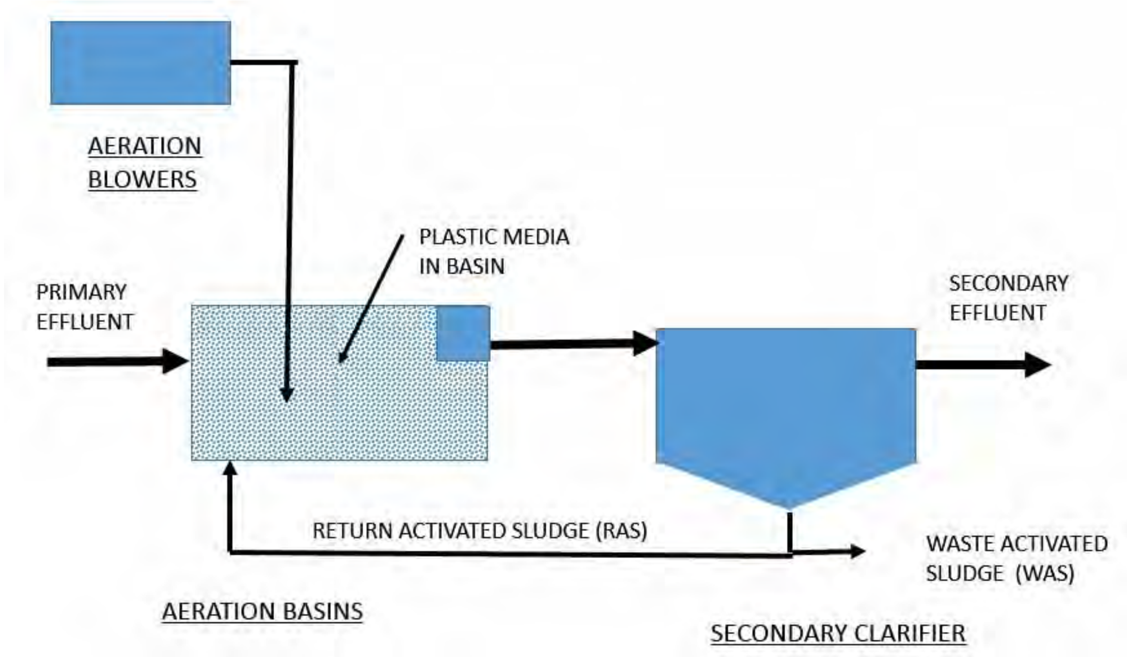


Figure 2.5 – Integrated Fixed-Film Activated Sludge (IFAS)



The MBBR and IFAS systems processes are similar to CAS in that they both typically use aeration and clarification tanks for treatment however they require smaller tanks for biological treatment. This is accomplished by adding media (plastic pieces, ropes, or sponges) to the aeration tanks. Bacteria grow on the surface of the media in a "fixed film," and effectively increase the amount of bacteria that can be held within a given tank size. Both the IFAS and MBBR processes provide a fixed media with an aeration basin. These systems can also be used to upgrade an existing aeration basin in a treatment plant, by retrofitting existing aeration basins with the media to be able to provide increased capacity for the existing basin footprint.

In most option sets and for the extra-large or central plants, secondary treatment includes process-staging which includes CEPT to achieve primary targets followed by CAS to achieve secondary quality. To suit land availability and to minimize footprint, CAS technology was substituted for MBBR or IFAS with the acknowledgement that operating costs are expected to increase for that facility (primarily due to less efficient aeration). Process schematics would differ for the floating media systems and would include: screens to contain the media in the tank, a clarification system, a waste sludge system, and ultraviolet light for primary disinfection. The aeration basins would be covered and odour control facilities would also be included.

Overall, Phase 2 includes characterization of four option sets including multiple flow scenarios which in turn, creates a multi-faceted representative design. Option sets will undergo life-cycle costing based on the selected representative design recognizing that ultimate technologies can be confirmed as future phases unfold.

2.3 Solids Treatment Options and Representative Designs

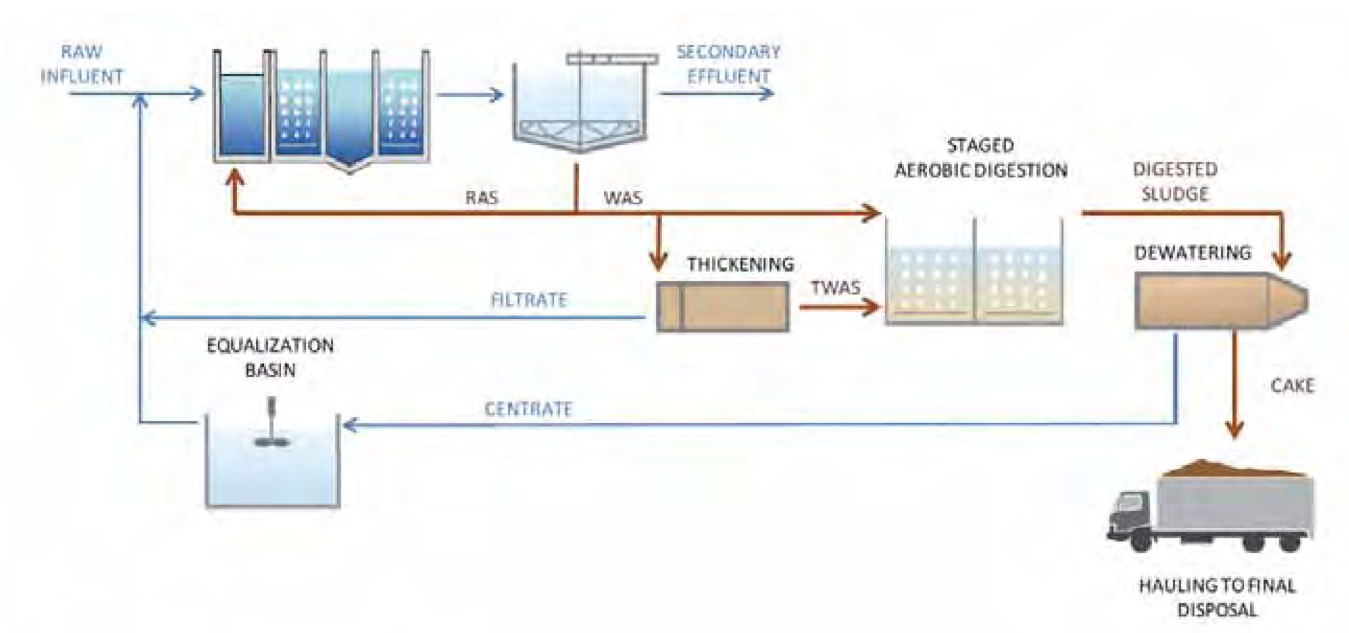
Solids treatment alternatives are narrowed based largely on these local boundary conditions:

1. The land application of any sewage solids is not allowed by CRD policy. This includes highly processed forms like pelletized solids, biochar or solids converted through thermochemical methods. New markets must be developed through partnerships to reflect the value of the by-product in an effort to offset the treatment and development costs.
2. The landfilling of sewage solids is strongly discouraged by the CRD. Under extraordinary circumstances, the landfill may accept sewage solids at a cost of $121 dollars per wet tonne.
3. The CRD is considering an integrated waste resource plant that may include sewage solids in addition to select yard, garden and kitchen waste managed in an integrated manner with solid waste management services.

In addition to these boundary conditions, Phase 2 analysis includes review of three key technologies for the stabilization and treatment of the sewage solids generated at the liquid treatment plants: aerobic digestion, anaerobic digestion and gasification.

Aerobic Digestion - Collected sewage solids are kept under aeration for a period of no less than 28 days (using reactors in series) at a concentration of less than 2% solids (to maintain adequate air transfer and avoid odors and anaerobic conditions). The resulting is a wet-soil like material with high potential for odors, bacterial regrowth and additional degradation. This process is energy intensive and can be capital intensive in larger applications. Figure 2.6 shows a generic flow schematic for the aerobic digestion alternative. Aerobic digestion is suited to small plants in distributed option sets only but will include extensive odour control.

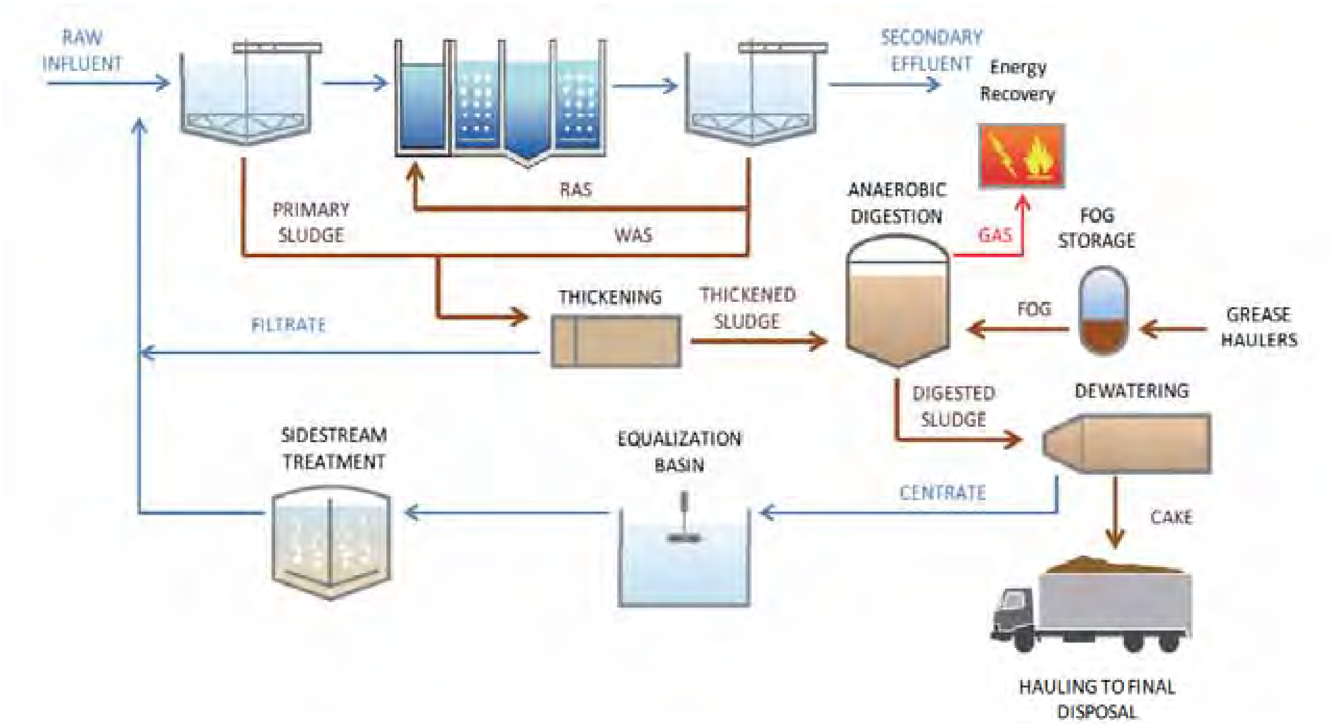
Figure 2.6 – Aerobic Digestion



Anaerobic Digestion - Collected sewage solids are kept under anaerobic (no oxygen) conditions for a period of 15-25 days at a concentration of at least 4% solids to allow the microorganisms to consume the organic matter efficiently and produce a valuable resource in the form of methane gas that can be recovered and reused. These systems produce a wet-soil like material with moderate potential for odors, bacterial regrowth and additional degradation. This process generates energy and is cost effective, compared to aerobic digestion, in facilities larger than 20 ML/d. Anaerobic digestion is particularly suited for facilities that have primary clarification as the performance of the system is far superior to the anaerobic digestion of biological sludge (Waste Activated Sludge).

Figure 2.7 shows the generic process flow diagram for the anaerobic digestion alternative including energy recovery and fats oils and grease digestion to supplement gas production.

Figure 2.7 – Anaerobic Digestion



Gasification is a thermal process that converts part of the organic carbon in the sewage solids into a syngas through non-biological processes. Unlike the previous approaches, this approach will require the participation of a technology manufacturer as the gasification systems require proprietary technology.

The end product of the gasification technology is a biochar that does not look like a soil material. It has the composition and physical properties of activated carbon but is irregular and may produce dust. There is potential value in this product, but there is no defined market in the southern portion of the island. Feasibility and costing analysis will suppose a market can be developed for at or less than the landfill tipping cost of $121/tonne.

It is challenging to achieve energy neutrality for gasification when sewage solids is the only feedstock: water and inorganic content strongly affects energy recovery. Drying sewage solids to a minimum of 80% solids is need for gasification. Manufacturers of gasification technology claim that the use of other feedstocks, like wood waste or yard, garden and kitchen scraps make the process energy positive. Analysis for Phase 2 will include a 3:1 or 4:1 feedstock to sewage solids ratio to generate excess energy for cost off-setting. The increased feedstock will require additional trucking, storage, handling and operational complexity. The following table identifies the feedstock requirements for the gasification process, and the corresponding values for the biosolids.

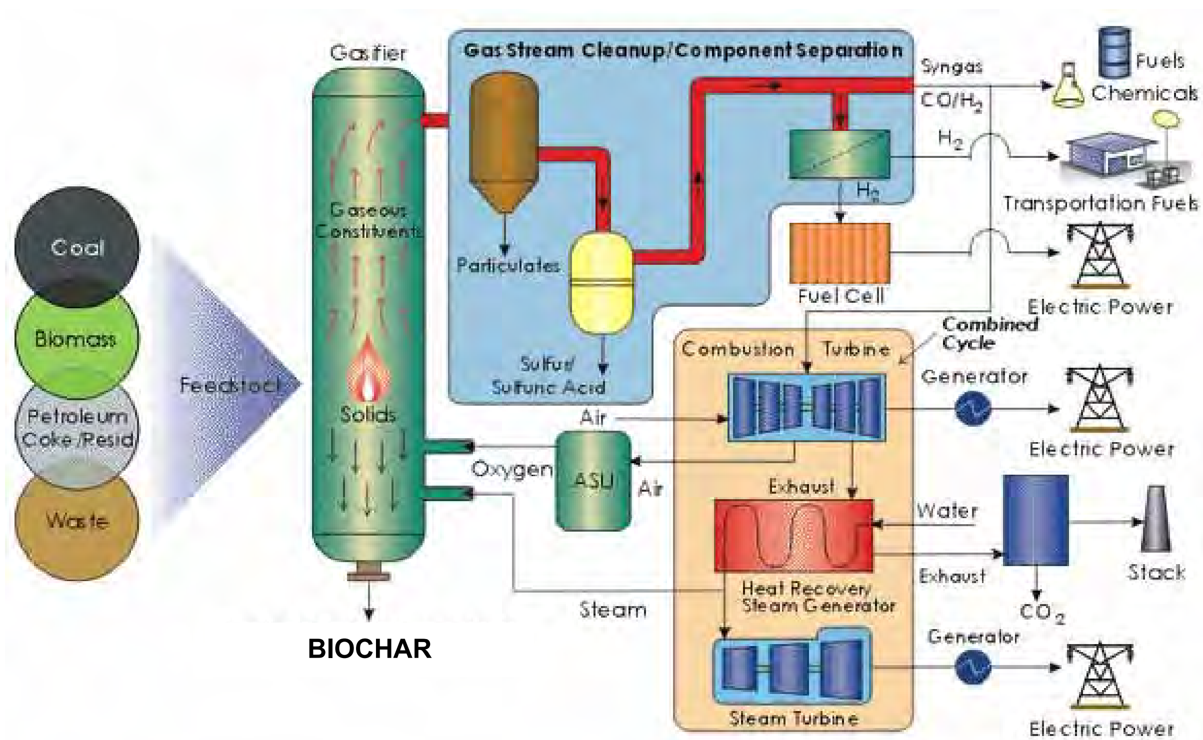
Parameter	Recommended Values (1)	Expected Sludge Value
Moisture Content	< 30%	> 75%
Heat Value Wet Basis	6,520 BTU/lb 15,200 KJ/kg	1,100 BTU/lb (2) 1,100 KJ/kg

(1) *Values recommended from PHG Energy Data*

(2) *Assumes sludge energy value at 6,500 BTU/lb of dry matter at 25% solids.*

Figure 2.8 illustrates the recovery process. In the figure, *biomass* and *waste*, or municipal sludge and yard, garden and kitchen waste are the two primary fuels assessed in Phase 2.

Figure 2.8 – Gasification Process



The ban on land application of wastewater solids represents a limitation on the single best use for the biosolids and the biochar. Managing the residual solids produced from any process presents a significant challenge. There are other disposal options including the sample inventory provided in the following table. Estimated costs or values are based on project experiences and research across North America. However, since there is no established market for solids reuse in the region, alternative uses and costs are presented as possible outcomes pending changes in the regulatory environment or the local market for these materials.

Use	Biosolids Cake	Biosolids Pellets	Biochar	Estimated Cost/(Value) Per Tonne
				
Landfilling	X		X	$121
Soil Amendment	X		X	$30 – ($15)
Potting Soil			X	variable
Fuel Source		X	X	($10 - $30)
Mine Reclamation	X		X	$0
Retail Sale		X	X	($10 - $30)
Nutrient Recovery	X		X	($10 - $30)
Insulation			X	Currently unknown
Air Purification			X	Currently unknown
Water Purification			X	Currently unknown

Technical Memo #3 will include additional review and feasibility of gasification and anaerobic digestion for Core Area option sets at two locations: Rock Bay and Hartland. This approach is consistent with Phase 2 terms of reference and our proposed methodology. In addition, the centralized approach to solids treatment is supported from a life cycle cost perspective, based on the work recently completed for the Westside communities. And, while liquids and solids treatment processes overlap and link together, it's typical to assess solids recovery methods in an isolated manner to illustrate the cost and revenue (or cost-offset) conditions for each approach. Solids recovery scenarios in Technical Memo #3 will include:

1. Providing full level of solids treatment at a central plant;
2. Reintroducing the solids from distributed facilities into the sewer system for treatment at the peak weather facility

3. Providing solids dewatering and transport at the smaller facilities and full treatment at the peak weather facility.
4. Feasibility analysis for solids recovery at Hartland Landfill as an alternative scenario

Purposeful canvassing of the private sector for innovative, financially-backed solids recovery solutions will support the CRD in acquiring the option that best meets the required outcomes of the study. Phase 2 feasibility and financial analysis will include justifiable assumptions for costs, markets and revenues to further inform the refined criteria for solids recovery for both anaerobic digestion and gasification. Please refer to Section 3 for the proposed approach to implementation of a management solution for resource recovery from the resulting solids.

3.0 Resource Recovery Opportunities Characterization Methodology

3.1 Introduction

Recovery of resources available in both the liquids and solids is highly dependent on the market conditions, energy prices, carbon and renewable credit markets and the overall cost for the projects. The following list identifies the resources present in the sewage and the sewage solids that will be considered as resources for recovery. Water recycling through purple pipe, recharge, indirect potable reuse, direct potable reuse and other reclamation alternatives are discussed later in Section 3.2.

Liquid

1. Thermal: Thermal energy recovery from sensible heat contained in the sewage in the form of hotter temperature (then ambient/winter condition) and cooler temperature (than ambient/summer condition).
2. Mechanical: Mechanical energy recovery from the transformation of potential energy into kinetic energy. This type of energy recovery is possible when water has a natural drop in elevation that can be harnessed and converted into energy.

Solids

1. Nutrients: Ammonia and Phosphorus recovery from the sewage solids.
2. Energy: The thermal conversion of the carbon contained in the sewage solids.
3. Bio plastics: The conversion or refinement of bioplastics from the sewage solids.
4. Organic Soil Amendment: The use of treated sewage solids to offset the use of commercial fertilizers
5. Biomethane: The biological conversion of carbon in the sewage solids to a usable gas through anaerobic digestion
6. Biofuels: The conversion of the sewage solids into a usable fuel.
7. Carbon Dioxide: The capture, purification and compression of combustion and digestion by products to produce a commercial pure gas.
8. Electricity: Can be produced from cogeneration of the dried solids or biomethane.

In addition to these recovery options, there are research level efforts to try and recover heavy and precious metals, and other high value organics. Since these are at a research level only at this time, they are not being considered for the evaluation.

As the resource recovery must compete with the products they are offsetting, it is extremely hard for this effort to adequately evaluate the revenue source that could be derived from implementing any of these approaches. In other words, market commodity prices are dynamic and cash flow analysis is subject to multiple caveats and risks. As such we propose the CRD work with the private sector to distribute risk appropriately in an effort to identify and fund the recovery of the resources available in the sewage. A common and well-regarded approach is to issue a Request for Statements of Interest (RFSI). This document, which specifically defines the constraints, goals and evaluation criteria, would be issued to the general private market to propose on resource recovery opportunities with their technologies and provide the CRD with an all-in cost to install the technology, receive (solids or liquid) the product, process it and provide a higher value material as well as the recovered materials extracted from the product. In particular, the market for residual solids recovery (e.g. biochar, biosolids) is uncertain therefore life-cycle costing models will provisionally assume that the cost for delivery of the product a customer will be less than the cost to landfill. The feasibility analysis in Phase 2 will help to refine the criteria for a future RFSI by means of comparing two technologies for solids recovery. Indeed, it is even possible that the private sector could propose a combination of these technologies.

It is noted that the previous grant approval from P3 Canada was based on anaerobic digestion at Hartland Landfill. Any alternative would undergo a business case type application to confirm funding, similar to previous submissions.

Traditional partners in utilizing the resources recovered from the solids include airports, hospitals, government institutions and universities which have long term requirements for heating and power. Often these organizations are willing to convert to the use of bio-fuel based systems as it suits their own capital and sustainability goals.

Through a RFSI process, the CRD will make sure that the market is driving the recovery of resources and how much the CRD is willing to invest to promote the recovery of resources. Procurement options must reflect the level of risk the CRD would like to accept, including financial risk of operation, and how much risk ought to be transferred to the proponent.

Heat recovery is proposed in the areas immediately surrounding each treatment facility as well as in the treated effluent lines to the outfalls. Typically, heat recovery from wastewater treatment plants is best coupled with a broader district energy strategy. At this time, space provisions can be left at select plants to incorporate heat recovery processes as the need arises.

3.2 Water Reuse

3.2.1 Water Reuse Target Market Summary

When treated to a high enough standard, treated effluent can be reused instead of potable water. A target market framework helps to navigate the multiple possibilities for reuse to augment the potable water supply. Water recovery target markets should deliver on the following key themes:

- Demonstrate reliable long-term demands and revenues
- Support community amenities

- Reduce the scope of infrastructure needs
- Demonstrate synergy with conventional public utility services

Conceptual supply-demand estimates focus on water applications that require less than potable-quality water and also demands that are situated in clusters which helps to reduce the cost of additional pipes to convey flows. Ideally, treated effluent reuse throughout the Core Area should include:

- large tracts of irrigable land such as parks and green spaces,
- significant industrial water reuse such as greenhouses or manufacturing operations and
- growth centers where new developments can be encouraged to include additional plumbing systems for toilet flushing or outdoor irrigation
- environmental augmentation

These markets typically present the lowest capital cost for system set up, provide long-term demands, support community amenities such as parks and growth and generally conform to the type of water services provided today.

Spatial analysis based on land use uncovers target markets and illustrates clusters of high demand. Each land parcel is coded based on its land use through the BC Assessment Authority which provides a proxy for water use potential i.e. parks, institutional-vacant, dairy farm, etc. At a conceptual level, these land use codes provide a basis for the potential for land application across the Core Area. Further, local Official Community Plans, land use plans and regional growth centers illustrate where focused, dense development may occur over the next 20 years and beyond. The cost of retrofitting (re-plumbing) existing buildings to allow for treated effluent reuse is prohibitive; it is more feasible to include non-potable water lines in new construction and to phase in non-potable sources over time. Combined, land application and regional growth centers provide for lower-barrier methods for reuse.

Environmental augmentation includes directing treated effluent to natural water courses for beneficial reuse. While these methods don't typically provide revenues, they represent an opportunity to recycle wastewater resources and restore water supplies locally. Typical forms of environmental augmentation include:

- Direct augmentation to streams, rivers or other surface water bodies,
- Indirect augmentation to surface water bodies which includes infiltration to adjacent soils allowing flows to meander into the substrate groundwater or into actual surface flows,
- Aquifer recharge, and
- Wetland enhancement.

Each of these methods requires adequate environmental study to determine the feasibility including risks associated with any option. Water bodies which demonstrate supply issues are typically studied because there is a clearer link to beneficial reuse, instead of simply becoming a vector for disposal. Wetlands throughout the Core Area have not been studied to date.

Colwood has studied the potential for indirect augmentation via aquifer recharge for the permeable soils near Royal Roads University and further west toward Langford. Local infiltration rates are relatively high and may provide for aquifer recharge for 10 to 30 MLD, based on recent reports. If approved by the Director (of the Ministry), this approach could negate the need for an alternate disposal method such as local outfall to the ocean, however we have assumed (for now) any effluent that does not meet the specifications would be discharged into the CRD trunk to be treated by a downstream plant. Westside Technical Staff, in particular the representatives of Colwood, are awaiting formal feedback from the Ministry regarding the potential for aquifer recharge including any waiving of outfall infrastructure. Option sets which include a treatment facility in Colwood take into account the preliminary feasibility results for aquifer recharge. Overall, if the Ministry accepts Colwood's aquifer strategy then the Colwood plant could demonstrate almost 100% reuse: during the winter when there is less need for irrigation, reuse can be focused toward aquifer recharge and toilet flushing, whereas during irrigation seasons, aquifer recharge could be reduced to support land application.

However, beyond Colwood and the creeks identified (preliminary) on the Westside there are no additional water courses known to substantially benefit from direct or indirect stream augmentation. The remainder of the water reuse opportunities relate to irrigation and toilet supply substitution for future development.

3.2.2 Summary of Water Reuse across the Core Area

Table 3.1 summarizes the land application (irrigation), toilet flushing and aquifer recharge possibilities across the Core Area based on the applied target-market framework. It is important to note that while estimates can be developed per municipality, it became clear during analysis and mapping that demands were clustered near growth centers of Colwood-Langford, Esquimalt, Rock Bay (including north downtown) and East Saanich. A small reuse facility may be located in Core Saanich to phase-in reuse over time as growth in the Burnside and Tillicum area occurs. There are significant agricultural lands in north Saanich, west Saanich (towards the Highlands) and further up the Peninsula however the extent of infrastructure needed to reach these lands would be extensive and perhaps unnecessary, until a demonstrable need arises. Overall, establishing five reuse systems provides coverage of most of the major outdoor uses in the Core Area, including growth centers, without the need for extensive reuse infrastructure.

Table 3.1 – Reuse Target Market Scan

Node	Colwood-Langford	Esquimalt	East Saanich	Rock Bay	Core Saanich
Area (ha) w/ Irrigation Potential	275	115	320	50	40
Demand (low) (cm/yr)	45	30	45	30	45
Demand (high) (cm/yr)	60	45	60	45	60
Volume (low) (ML/yr)	1,240	340	1,440	140	180
Volume (high) (ML/yr)	1,650	520	1,930	220	240
Aquifer Recharge (ML/yr)	3,430	n/a	n/a	n/a	n/a
Toilet (2030; ML/yr)	1,780	435	860	1,760	500*

* *Further study is needed to accurately project the real demand for toilet flushing in the Core Saanich/Tillicum areas given the proximity to demands already addressed by a sidestream facility at Rock Bay.*

Securing customers for alternative water supplies can be complex. CRD and municipalities must develop partnerships, agreements or regulations in order to realize actual reuse results. Pricing, liabilities, service governance, standards, and contract tenure will be crucial to securing long-term demand for water reuse.

3.2.3 Water Reuse Infrastructure Systems

Treated effluent systems require their own, separate infrastructure for distribution. Each facility would include a pumping station which raises system pressures to cover the range of elevations and flows and also includes pipes based on conceptual routes. The capacity of each water reuse system will be based on the 2030 flows with consideration to long-term flow increases. This strategy attempts to line up supply with demand to mitigate the costs of oversized or unnecessary infrastructure. The plant in Colwood could reuse up to 100% of the capacity of the plant, if accepted by the Ministry. In short, reuse systems across the Core Area include:

- **Colwood-Langford**: approximately 19,500 meters of reuse pipe and a pumping system equivalent to 10 MLD.
- **Esquimalt:** approximately 17,000 meters of reuse pipe and pumping system equivalent to the proposed demand of roughly 5 MLD for irrigation and toilet flushing
- **East Saanich:** approximately 20,000 meters of reuse pipe and pump system equivalent to the proposed demand, or roughly 3 MLD during peak demand periods
- **Core Saanich:** approximately 10,000 meters of reuse pipe and pumping system equivalent to the proposed demand of roughly 5 MLD for irrigation and toilet flushing
- **Rock Bay:** approximately 18,500 meters of reuse pipe and pump system equivalent to the proposed demand, or roughly 10 MLD during peak demand periods; additional water reuse may occur along the treated effluent line toward Clover Point however these estimates have not yet been included.

Peak design flows are not representative of an average day demand. Also, these peak demand periods are scheduled for longer-term implementation, perhaps 10 years or more, to allow for constructing the works and securing agreements with potential customers. Most reuse facilities would regulate supply to meet demand as demands will fluctuate throughout the year. In other words, Core Saanich and East Saanich plants may be phased in over time or used only during irrigation months. Sidestream tertiary treatment at Rock Bay may also be phased-in or utilized on an as needed-basis.

Overall, additional treatment plants beyond the five reuse target areas listed above would serve to reduce the footprint of downstream facilities but additional plants will be challenged to significantly increase the amount of reuse based on the target-market framework. In effect, while the seven plant option set would provide a higher level of service and boost enhanced tertiary water quality, it may not provide greater reuse opportunities for a long time. Life-cycle costing includes capital allowances for reuse systems including distribution pipes and pump facilities. Technical Memo #3 will study the cost-revenue balance for water reuse systems. Pricing for reclaimed water is proposed at 80% of potable water retail rates except for aquifer recharge which will not result in revenue.

4.0 Existing Outfalls

Option sets include leveraging of both of the existing outfalls at Clover Point and Macaulay Point. The components of each outfall are summarized in Table 4.1.

Table 4.1 – Existing Outfall Characteristics

Parameter	Clover Point	Macaulay Point
1. Grit Removal	No	No
2. Screen Openings	25 mm	25 mm
3. Screens in Parallel	2	2
4. Total Screening Capacity	190 MLD	119 MLD
5. Number of Pumps	4	3
6. Capacity with All Pumps	222 MLD	134 MLD
7. Capacity with One Pump Standby	203 MLD	119 MLD
8. Outfall Diameter	1.07 m	0.9 m
9. Outfall Length from Shore	1,100 m	1,700 m
10. Diffuser Length	196 m	135 m
11. Number of Diffusers	37	28
12. Outfall Depth	67 m	60 m

Upcoming discussions with the Ministry will inform the scope (if any) of environmental impact study required to utilize the outfalls for the 2030 flows or beyond.

It is our understanding that because of deteriorating condition and/or hydraulic restrictions, it is expected that both outfalls will need to be replaced before 2045.

5.0 Option Sets

5.1 Introduction

There are some aspects that are common to all Option Sets. The first is the CRD's approach to reducing infiltration and inflow (I/I) in the Eastside. There are programs in place (and additional ones to come in 2016) to reduce the source of I/I coming from private properties. The District of Oak Bay has an ongoing program to separate storm sewers from sanitary sewers. In addition to these efforts previous LWMP amendments have identified specific capital upgrades to mitigate the quantity of sanitary sewer overflows that occur under storm events. These upgrades include:

- An emergency storage tank near the Arbutus area;
- Extending the siphon from St. Charles and Chandler Road to Clover Point (1600 m);
- The Craigflower Pump Station upgrade (complete);
- Upgrading the Currie Street Pump Station; and
- Upgrading the East Coast Interceptor from the Currie Pump Station to the corner of Lawndale and Richardson (1400 m).

Costs for these upgrades will be included in the overall total in TM #3.

Since 2007 approximately 11 storm events/year have demonstrated flows at Macaulay Point and Clover Point, greater than the current 2 x ADWF. On three occasions since 2007 flows at Macaulay Point have been > 4 x ADWF, whereas the number of exceedances at Clover Point is greater than this. The Ministry of Environment requires, and earlier versions of the LWMP have agreed, that all flows up to 2 x ADWF will be treated to at least a secondary level. In addition, all flows up to 4 x ADWF at Macaulay and up to 3 x ADWF at Clover will be treated to a primary level. The quantity > 2 x ADWF treated to a primary level can be combined with the secondary effluent for discharge out the outfalls. Finally, all flow in excess of these treated primarily or secondarily flows must be screened before discharge.

Solids treatment and resource recovery is being costed based on a central facility at either Rock Bay or at Hartland Landfill. This approach is supported from a life cycle cost perspective based on the work recently completed for the Westside communities. For the Hartland Landfill site the solids could be dewatered and trucked there, or they could be pumped as a dilute liquid. The economics of these two approaches will be examined in TM #3. Figure 5.1 illustrates a potential route if the solids were pumped to Hartland.

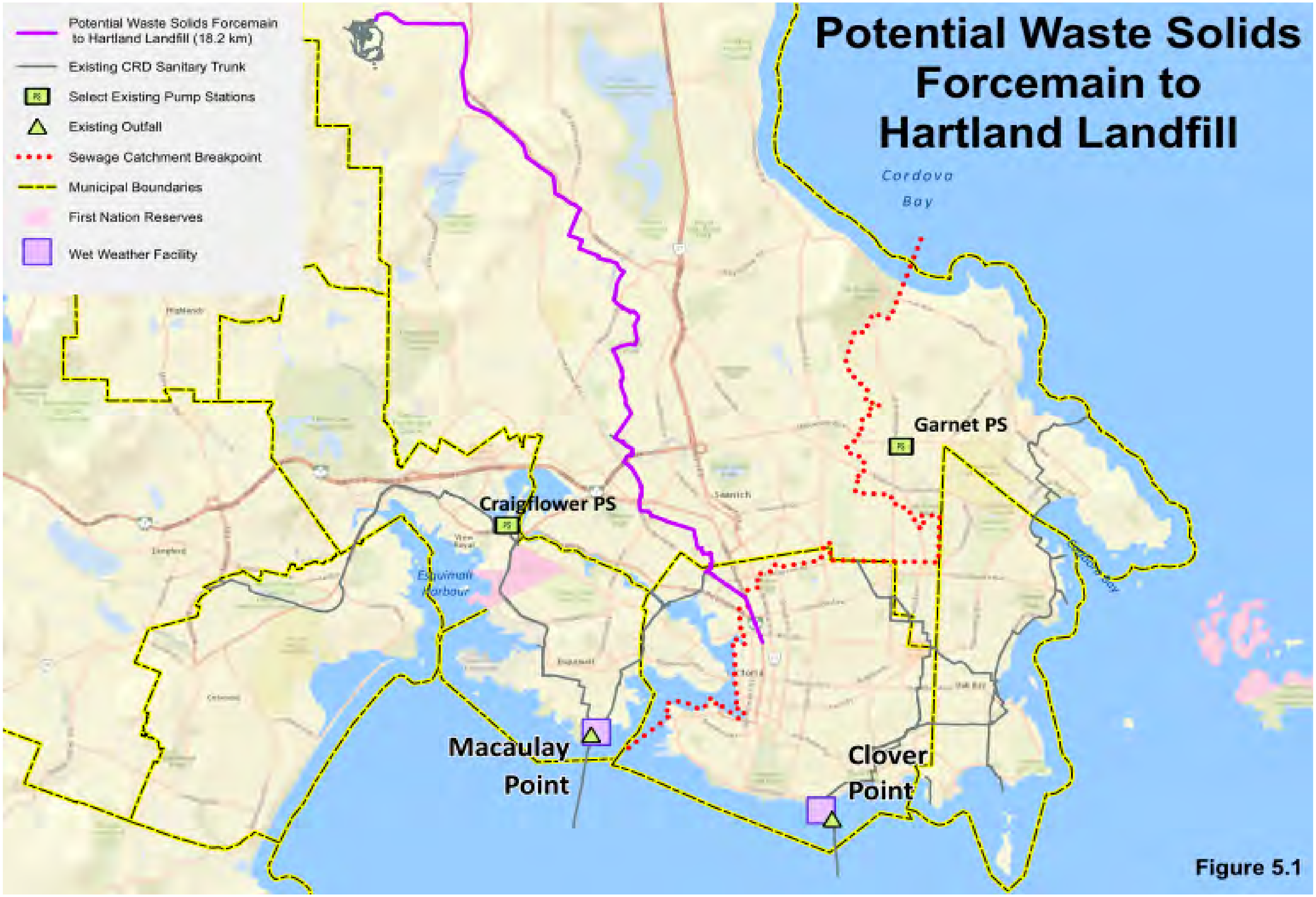

Potential Waste Solids Forcemain to Hartland Landfill
Potential Waste Solids Forcemain to Hartland Landfill (18.2 km)
Existing CRD Sanitary Trunk
Select Existing Pump Stations
Existing Outfall
Sewage Catchment Breakpoint
Municipal Boundaries
First Nation Reserves
Wet Weather Facility
Cordova Bay
Garnet PS
Craigflower PS
Esquimalt Harbour
Macaulay Point
Clover Point

Figure 5.1

A number of suggestions will be made as part of TM #3 for the CRD to consider in order to reduce or defer the capital and operating costs of the selected option. For example:

1. Allow for the selection of alternate technologies through RFEI and RFP processes.
2. Liaise with the Ministry of Environment to consider less expensive primary treatment technologies, but still meeting the intent of the Municipal Wastewater Regulation.
3. Potentially reduce the length of the outfalls if tertiary treatment is implemented (an EIS and agreement from MoE is expected for this to happen).
4. Phasing the construction of plants, for example, an initial plant built at Colwood for 10 MLD, could provide years of service to local flows (i.e., delay construction of any future Westside plant).
5. Phasing the construction of Clover and/or Macaulay outfalls based on actual flows.
6. The possibility of an outfall into the Inner Harbour from Rock Bay, if a tertiary level of treatment is provided (again an EIS and approval from MoE would be required to implement this).
7. Constructing plants using a modular approach. Initial construction could be based on a five or 10 year growth projection and add in modules as actual flows progress. Using this approach could delay key elements of the plant depending on the success of water conservation and I/I reduction programs.

In terms of sea level rise, based on the "Estimated Flood Construction Level and Inundation and Storm Surge in 2100" mapping produced in 2014, the safe construction level in the Rock Bay area appears to be approximately 5 m above sea level. Some of the land in the proposed sites have an elevation of less than 5 m. Site modifications are ongoing therefore the final elevation of the land is not exactly known. In any event, whichever properties are selected, construction will need to account for the potential inundation levels. Conventional cost mitigation strategies are available for example, because sealed storage tanks are often situated at depths of 4 to 5 m anyway – so it will be possible to ensure the top of the tanks and floors of buildings are above the 5 m level, without too much extra cost. This is common to all option sets.

5.2 Option Set 1a and 1b – One Plant at Rock Bay

5.2.1 General Description

Figure 5.2 illustrates the One Plant Option Set (1a and 1b) whereby liquid and solids treatment are centralized at Rock Bay, or liquids only at Rock Bay and solids recovery at Hartland. Option Set 1a involves treatment to a secondary level plus disinfection with a slipstream treating 10 MLD to an enhanced tertiary level for local reuse. Option 1b involves treating all flows up to 2 x ADWF to an enhanced tertiary level. The level of treatment in Option 1b may be to a high enough level that it could be discharged into the Inner Harbour. If the effluent could be discharged to the harbour, then a return pipe back to Clover would not be necessary (unless desired for heat recovery pursuits). However, discharge to the harbour would require a detailed Environment Impact Study would be required to determine the effluent quality necessary to protect the environment and public health. Ministry approval for discharge to the Inner Harbor is uncertain. For this reason TM#3 will not include any reductions in the outfall length for Option 1b.

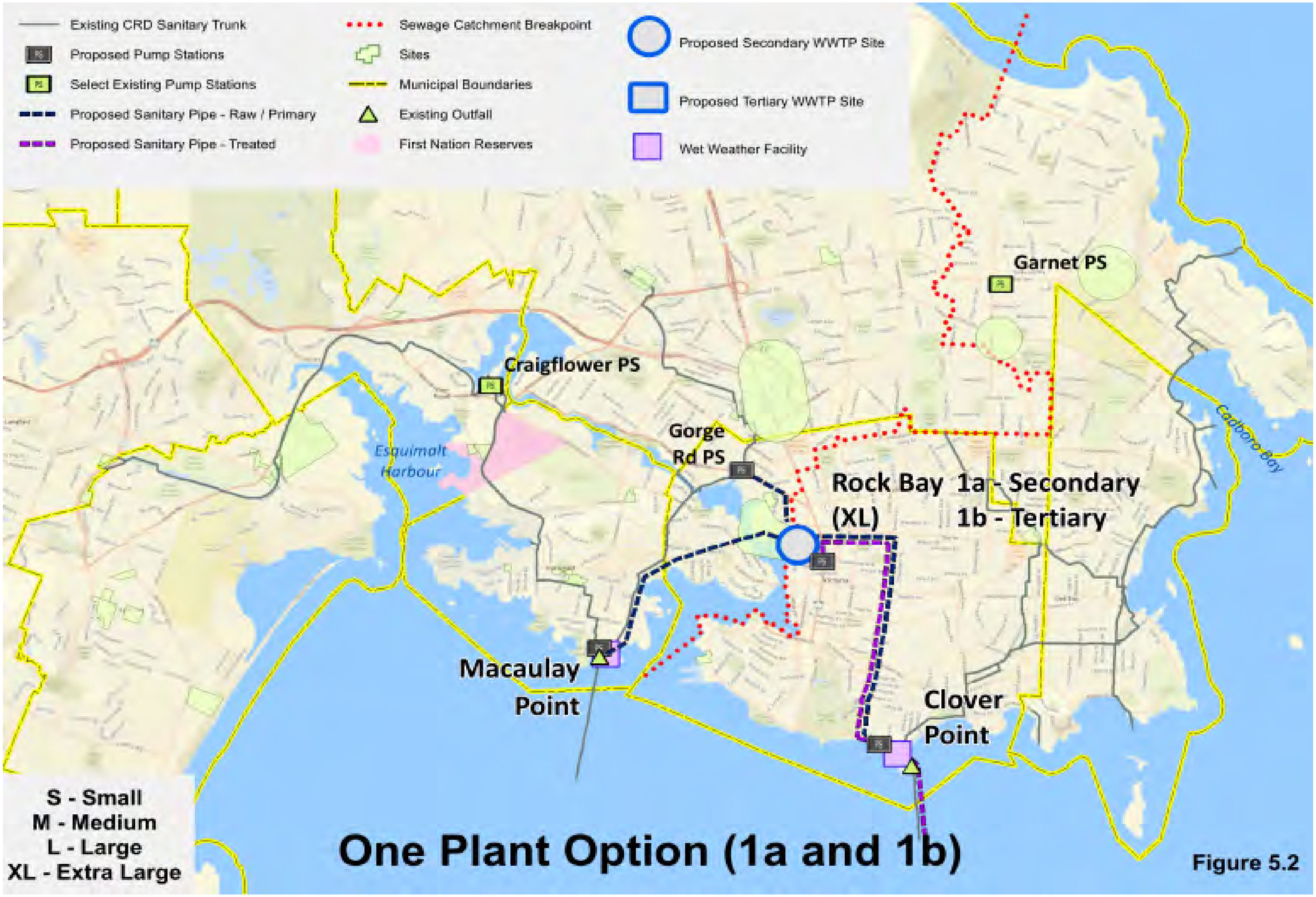

Existing CRD Sanitary Trunk
Proposed Pump Stations
Select Existing Pump Stations
Proposed Sanitary Pipe - Raw / Primary
Proposed Sanitary Pipe - Treated
Sewage Catchment Breakpoint
Sites
Municipal Boundaries
Existing Outfall
First Nation Reserves
Proposed Secondary WWTP Site
Proposed Tertiary WWTP Site
Wet Weather Facility
Garnet PS
Craigflower PS
Gorge
Rd PS
Esquimalt
Harbour
Rock Bay
(XL)
1a - Secondary
1b - Tertiary
Macaulay
Point
Clover
Point
Cadboro Bay
S - Small
M - Medium
L - Large
XL - Extra Large
One Plant Option (1a and 1b)

Figure 5.2

There are three locations from which sewage would be pumped to Rock Bay: from Clover Point; from Gorge Road to collect flows from most of the West Saanich flows; and, third from Macaulay Point. All treated effluent that is not reused would be pumped back to the Clover outfall. The objective with the Gorge Road pump station is to reduce pumping and piping costs from Macaulay Point. Similarly on the Eastside, additional study will help to identify strategic locations for diverting flows to Rock Bay from key points in Victoria and Oak Bay (to reduce the scope of new infrastructure). Even with the pumping and piping configurations, the one plant option set should be considered the least operationally complex.

Treatment levels would be set at secondary levels from Option 1a to meet the federal and provincial regulations plus disinfection. Sidestream tertiary treatment (up to 10 MLD as reuse connections are confirmed) can be implemented as desired to suit the demand projections for the immediate area including land irrigation (local parks), potentially industrial reuse (minimal) and long-term toilet flushing phased-in with growth. Beyond the conceptual water reuse system in the immediate area (as described in Section 3) the treated effluent forcemain between Rock Bay and Clover Point could be accessed for heat recovery or other water reuse opportunities.

Option Sets 1a and 1b also includes primary treatment of the 1 x ADWF above 2 x ADWF at the Clover Point site (0.5 to 0.8 ha) to minimize the quantity of flow that would otherwise be pumped to/from Rock Bay. In this way, only 2 x ADWF needs to be pumped to Rock Bay.

The Rock Bay plant location includes the possibility of four specific parcels which could be strategically assembled to provide for long-term capacity expansion and to provide for additional flexibility in plant layout to find additional cost savings. Additional site information will be presented in November 2015 as feasibility analysis unfolds.

The current, 2030 and 2045 ADWF design flows are summarized below in Table 5.1. The 2045 design flows are provided as a sample scenario to estimate long-term footprint requirements.

Table 5.1 – Current 2030 and 2045 ADWF Design Flows

Sewershed	Current (MLD)	2030 (MLD)	2045 (MLD)
Macaulay Point	36.2 (1)	60.2 (1)	92.6 (1)
Clover Point	34.3	47.7	53.4
Total	**70.5**	**107.9**	**146.0**

(1) Including West Saanich and West Victoria flows

5.2.2 Components

Table 5.2 summarizes the key components for the Rock Bay Option Set 1a. The difference with Option Set 1b is that item 4 below would be tertiary treatment and item 6 would be deleted.

Table 5.2 – Key Components

Key Components Required	2030 (m^3/d)	2045 (m^3/d)
1. Wet Weather Facility at Clover – 1 x ADWF	48,000	53,000
2. Sewage Pumping Locations		
• Clover Point (2 x ADWF)	96,000	107,000
• Gorge Road (4 x ADWF)	80,000	120,000
• Macaulay Point (4 x ADWF)	160,000	250,000
Total	336,000	477,000
3. Primary Treatment	336,000	477,000
4. Secondary Treatment & Disinfection	216,000	292,000
5. Treated Effluent Pumping	336,000	477,000
6. Tertiary Treatment (Slipstream)	10,000	10,000
7. Outfall Capacity		
• Clover Outfall (including 4 X ADWF from Clover sewershed)	432,000+	477,000+ (1)
• Macaulay Outfall (i.e., only the flow greater than 4 x ADWF)	> 4 x ADWF	> 4 x ADWF

(1) *By 2045 the outfall capacity will have to be increased from approximately 200 MLD to 477 MLD+*

Table 5.3 – Piping and Outfall Lengths (1)

From	To	Purpose	Length
Clover Point	Rock Bay WWTP	Screened Raw Sewage(SRS)	5,300 m
Rock Bay WWTP	Clover Point	Treated Effluent	5,300 m
Macaulay Point	Rock Bay WWTP	Screened Raw Sewage	3,700 m
Gorge Road	Rock Bay WWTP	Raw Sewage	1,100 m
Clover Point	End of Outfall	Treated Effluent/SRS	1,300 m
		Total	**16,700 m(2)**
		Optional Reuse Piping	**18,500 m**

(1) *Pipe lengths are approximate pending a routing review.*

(2) *Not including reuse piping*

6.0 Option Set 2 – Two Plants at Rock Bay + Colwood

6.1 General Description

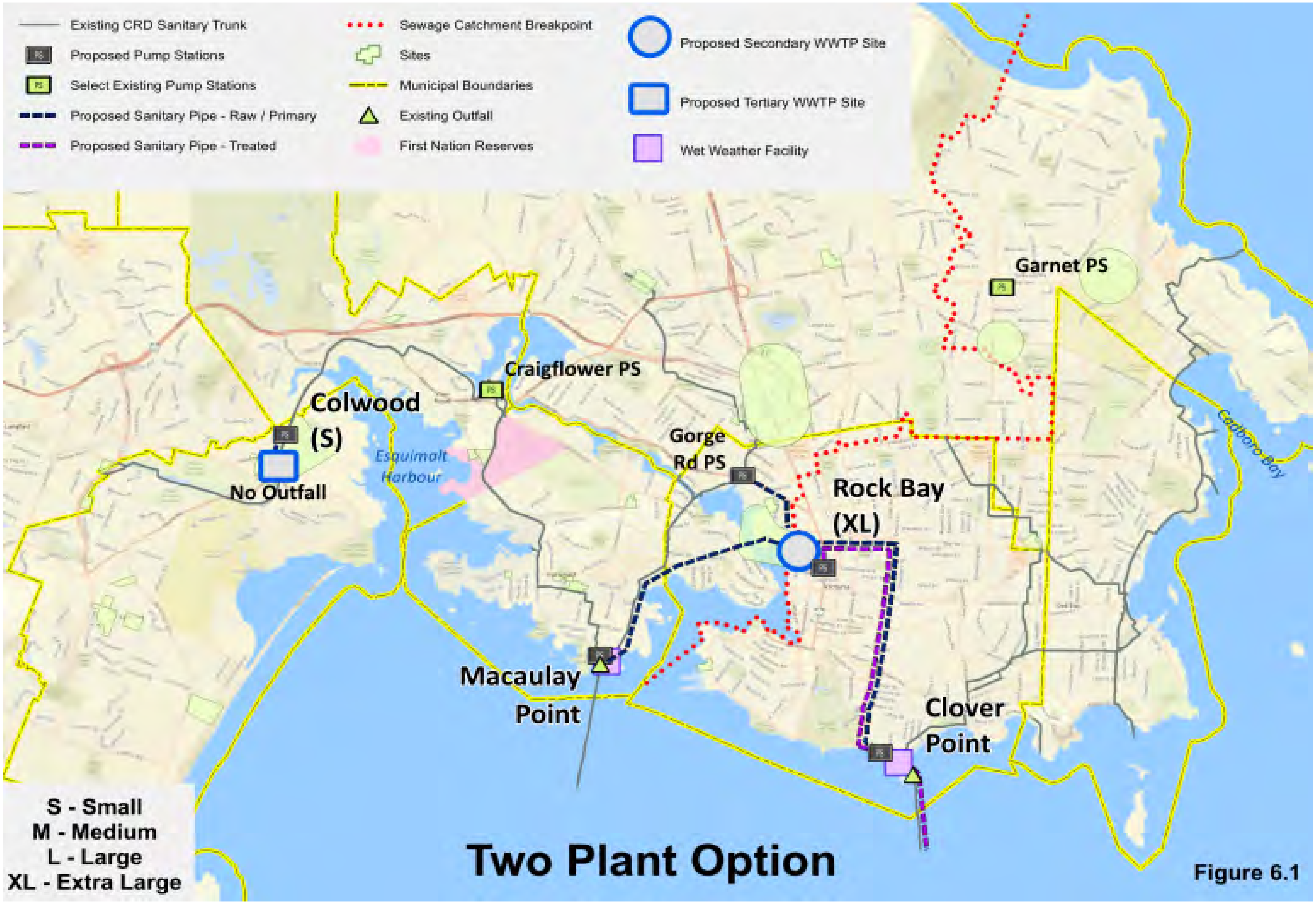
Figure 6.1 illustrates the two plant option set which includes a centralized plant at Rock Bay to provide liquid and solids treatment for most of the Core Area, but also includes a 10 MLD plant in Colwood with a mandate to reuse 100% of the effluent. An alternate location for solids treatment is Hartland Landfill. The City of Colwood has completed some feasibility work that shows the possibility of reusing 100% of the effluent via irrigation and aquifer recharge. The sidestream tertiary capacity at Rock Bay would be up to 10MLD, phased-in as connections are confirmed.

This option set moderately increases levels of service (from the one plant option set) by increasing tertiary quality water at the Colwood plant for reuse where there is elevated reuse potential. The Rock Bay plant would provide secondary treatment as well as disinfection. It is important to note that the distributed reuse facility in Colwood would require an alternative method of disposal (as required by the Ministry of Environment) which has been accounted for by including the capacity of the Colwood plant at Rock Bay in the event that Colwood's flows cannot achieve its targeted water quality (likely infrequent). Since the Rock Bay Plant would be sized to treat 216 MLD to a secondary level, the 10 MLD allocation to Colwood is only approximately 5% of the flow.

In the Rock Bay + Colwood option set there are three locations from which sewage would be pumped to Rock Bay: first is from Clover Point, second is most of the West Saanich flows from Gorge Road (adjacent to the CRD northwest northern trunk) and third, from Macaulay Point. Strategic flow diversions could occur in Oak Bay and Victoria to reduce the scope of new infrastructure and pumping at Clover Point. All treated effluent would be pumped back to the Clover Outfall. The objective with the Gorge Road pump station is to reduce pumping and piping costs from Macaulay Point.

Water reuse in Colwood would consist of an integrated aquifer recharge and irrigation system with the potential for future phasing of substituting potable water for toilet flushing, up to a total of 10 MLD. In addition, the treated effluent forcemain between Rock Bay and Clover Point can be accessed for heat recovery or other water reuse opportunities, in the future. All waste biological solids from Colwood would be returned to the CRD trunk for treatment at the Rock Bay Plant.

This option set also includes primary treatment of the 1 x ADWF above 2 x ADWF at the Clover Point site (0.5 to 0.8 ha) to minimize the quantity of flow that would otherwise be pumped to/from Rock Bay. In this way, only 2 x ADWF needs to be pumped to Rock Bay.


Existing CRD Sanitary Trunk
Proposed Pump Stations
Select Existing Pump Stations
Proposed Sanitary Pipe - Raw / Primary
Proposed Sanitary Pipe - Treated
Sewage Catchment Breakpoint
Sites
Municipal Boundaries
Existing Outfall
First Nation Reserves
Proposed Secondary WWTP Site
Proposed Tertiary WWTP Site
Wet Weather Facility
Garnet PS
Craigflower PS
Colwood
(S)
No Outfall
Esquimalt Harbour
Gorge Rd PS
Rock Bay
(XL)
Macaulay Point
Clover Point
Cadboro Bay
S - Small
M - Medium
L - Large
XL - Extra Large
Two Plant Option
Figure 6.1

The Rock Bay plant location includes the possibility of four sites which could be strategically assembled to provide for long-term capacity expansion and to provide for additional flexibility in plant layout to find additional cost savings. Two sites in Colwood demonstrate distinct advantages for hosting the facility. Additional site information will be presented in November 2015 as feasibility analysis unfolds.

The current 2030 and 2045 ADWF design flows for the Rock Bay Plant are summarized below in Table 6.1. The 2045 design flows are provided as a sample scenario to estimate long-term footprint requirements.

Table 6.1 – Current 2030 and 2045 ADWF Design Flows

Sewershed	Current (MLD)	2030 (MLD)	2045 (MLD)
Macaulay Point	36.2 (1)	60.2 (1)	92.6 (1)
Clover Point	34.3	47.7	53.4
Total	**70.5**	**107.9**	**146.0**

(1) *Including West Saanich and West Victoria flows*

6.2 Components

The following key components to implement this option are summarized in Table 6.2.

Table 6.2 – Key Components

Key Components Required	2030 (m³/d)	2045 (m³/d)
Rock Bay		
1. Wet Weather Facility at Clover – 1 x ADWF	48,000	53,000
2. Sewage Pumping Locations		
• Clover Point (2 x ADWF)	96,000	107,000
• Gorge Road (4 x ADWF)	80,000	120,000
• Macaulay Point (4 x ADWF)	160,000	250,000
Total	**336,000**	**477,000**
3. Primary Treatment	336,000	477,000
4. Secondary Treatment and Disinfection	216,000	292,000
5. Treated Effluent Pumping	336,000	477,000
6. Tertiary Treatment (Slipstream)	10,000	10,000
7. Outfall Capacity		
• Clover Outfall (including 4 x ADWF from Clover sewershed)	432,000+	584,000+ (1)
• Macaulay Outfall (i.e., just flow > 4 x ADWF)	> 4 x ADWF	> 4 x ADWF

Key Components Required	2030 (m³/d)	2045 (m³/d)
Colwood		
1. Raw Sewage Pump Station	10,000	10,000
2. Tertiary Treatment	10,000	10,000
3. Treated Effluent Pumping	10,000	10,000

(1) *By 2045 the outfall capacity will have to be increased from approximately 200 MLD to 584 MLD+*

Table 6.3 summarizes the estimated piping and outfall lengths.

Table 6.3 – Piping and Outfall Lengths (1)

From	To	Purpose	Length
A. Required			
Rock Bay			
• Clover Point	Rock Bay WWTP	Screened Raw Sewage (SRS)	5,300 m
• Rock Bay WWTP	Clover Point	Treated Effluent	5,300 m
• Macaulay Point	Rock Bay WWTP	Screened Raw Sewage	3,700 m
• Gorge Road	Rock Bay WWTP	Raw Sewage	1,100 m
• Clover Point	End of Outfall	Treated Effluent/SRS	1,300 m
Colwood			
• Galloping Goose Trail	Colwood WWTP	Raw Sewage	30 m
• Colwood WWTP	End of Reuse	Irrigation/Aquifer Recharge	19,500 m
		Required Total	**36,230 m (2)**
B. Optional			
Rock Bay			
• Rock Bay WWTP	End of Reuse	Reuse	18,500 m
		Optional Total	**18,500 m**

(1) *Pipe lengths are approximate pending a routing review.*

(2) *Includes Colwood reuse piping only since this is a necessary part of the solution.*

7.0 Option Set 3 – Four Plants

7.1 General Description

Figure 7.1 illustrates the four plant option set. Most wastewater (liquids) would be treated at Esquimalt Nation and at Rock Bay however two distributed facilities in Colwood and East Saanich would provide higher quality treated effluent and additional water reuse. This option set serves to further maximize water reuse. Also note that the four plant option may also be presented as a two plant, sub-regional option set with plants at Rock Bay and Esquimalt Nation only (the works and costs associated with the distributed facilities in Colwood and East Saanich would be 'removed').

The two subregional plants at Rock Bay and Esquimalt Nation would be designed to provide a secondary level of treatment to meet the federal and provincial regulations, but they would also be equipped with disinfection for increased water quality. Sidestream tertiary treatment would be included in the costing for local reuse, for 10 MLD and 5 MLD at Rock Bay and Esquimalt Nation, respectively. The two distributed facilities would provide tertiary treatment for reuse in Colwood and for irrigation near the East Saanich plant. The seasonal nature of demands for the East Saanich plant means that the plant would only operate as needed (initially) with the potential for regular operation (year round) if potable substitution for toilet flushing were to occur. In addition to the aforementioned water reuse opportunities, the treated effluent forcemain between Rock Bay and Clover Point and between Esquimalt Nation and Macaulay Point can be accessed for heat recovery or other water reuse applications.

It is noted that if either or both the Rock Bay and Esquimalt Nation plants were increased to tertiary treatment, there is a possibility that reduced piping and outfalls could ensue. However, this would have to be approved by the Ministry of Environment.

Solids treatment and recovery would occur at either Rock Bay or Hartland Landfill.

The City of Colwood has completed some feasibility work that shows the possibility of reusing 100% of the effluent via irrigation and aquifer recharge with a capacity estimated at 10 MLD. The East Saanich site has opportunities for irrigation and toilet reuse in new developments with a capacity estimated at up to 3MLD. The alternative method of disposal required by the Ministry of Environment for these plants would be to discharge back into the sewer network which can be accommodated by including additional capacity at Rock Bay and Esquimalt Nation. Both distributed plants would also discharge their waste biological solids into the sewer network so dewatering and trucking is not required.

Preferred sites are available in each of the four plant locations. Additional site information will be presented in November 2015 as feasibility analysis unfolds.

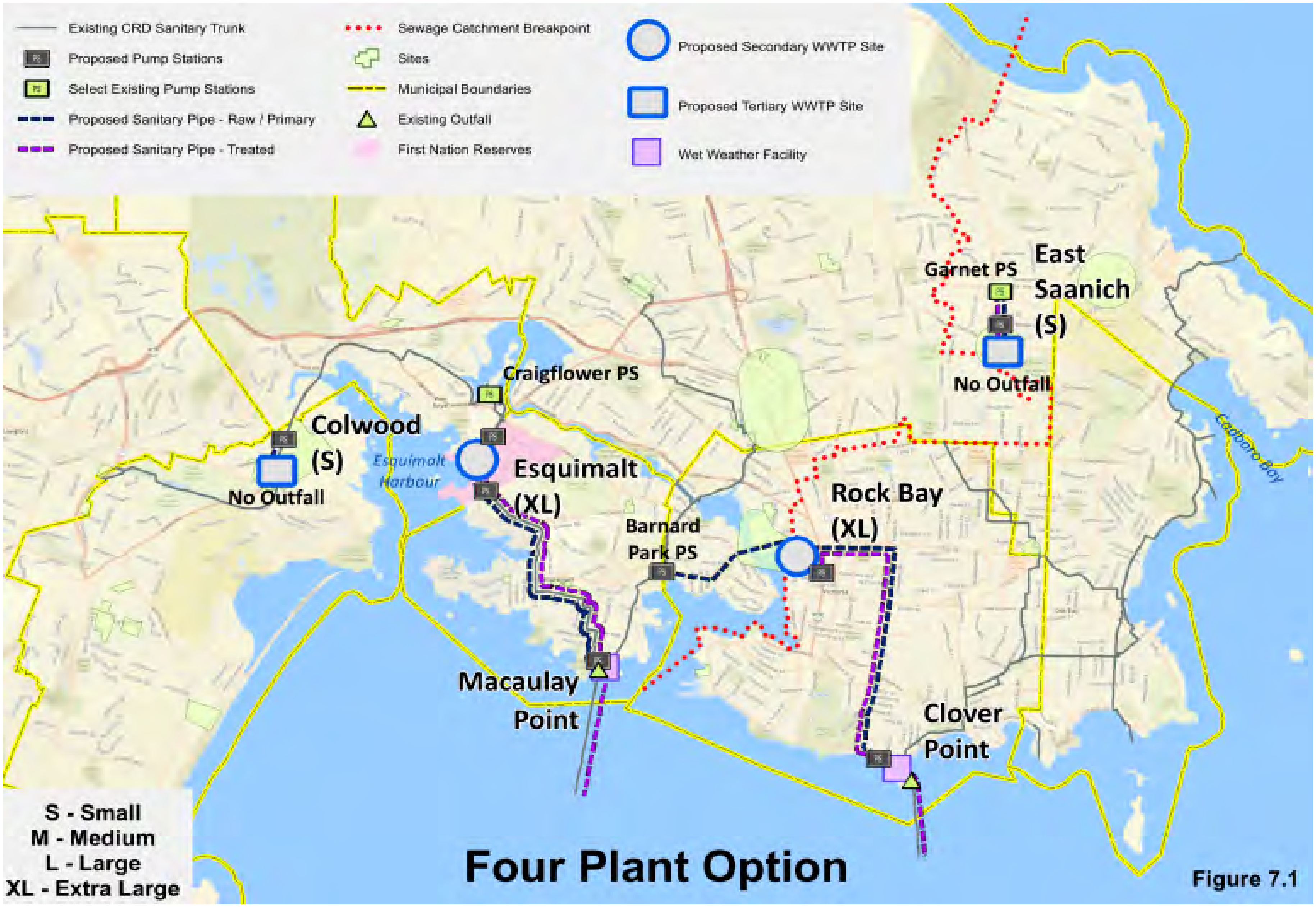

Existing CRD Sanitary Trunk
Proposed Pump Stations
Select Existing Pump Stations
Proposed Sanitary Pipe - Raw / Primary
Proposed Sanitary Pipe - Treated
Sewage Catchment Breakpoint
Sites
Municipal Boundaries
Existing Outfall
First Nation Reserves
Proposed Secondary WWTP Site
Proposed Tertiary WWTP Site
Wet Weather Facility
Garnet PS
East Saanich (S)
No Outfall
Craigflower PS
Colwood (S)
No Outfall
Esquimalt Harbour
Esquimalt (XL)
Barnard Park PS
Rock Bay (XL)
Macaulay Point
Clover Point
Cadboro Bay
S - Small
M - Medium
L - Large
XL - Extra Large
Four Plant Option

Figure 7.1

Rock Bay flows will include wastewater from all Eastside communities including flows currently directed to Macaulay from west Saanich and west Victoria by way of a pump station near Barnard Park. All other eastside flows would be pumped from Clover Point, or, other strategic locations along the eastside to reduce the scope of new infrastructure. This option set also includes maximizing treatment at the Clover Point site (0.5 to 0.8 ha) to minimize the quantity of flow that would otherwise be pumped to/from Rock Bay.

The Esquimalt Nation plant will include two pump stations for collecting flows, including for wastewater that originates upstream of the proposed plant (to avoid having to pump all of the upstream flows from Macaulay Point) and for all other flows that converge at Macaulay (downstream of the plant). It will be possible to utilize the existing screens at Macaulay, so that only screened raw sewage needs to be pumped back to Esquimalt Nation. All treated effluent that is not reused, is pumped back to Macaulay Point for discharge out a new outfall.

The current, 2030 and 2045 ADWF design flows for Rock Bay and Esquimalt Nation are summarized in Table 7.1 below.

Table 7.1 – Current 2030 and 2045 ADWF Design Flows

Plant	Current (MLD)	2030 (MLD)	2045 (MLD)
Esquimalt Nation	14.4	30.1	52.9
Rock Bay	56.1 (1)	77.8 (1)	93.1 (1)
Total	**70.5**	**107.9**	**146.0**

(1) *Including West Saanich and West Victoria*

7.2 Components

The follow key components to implement this option are summarized in Table 7.2.

Table 7.2 – Key Components

Key Components Required	2030 (m³/d)	2045 (m³/d)
Rock Bay		
1. Wet Weather Facility at Clover – 1 x ADWF	48,000	53,000
2. Sewage Pumping Locations		
• Clover Point (2 x ADWF)	96,000	107,000
• Near Barnhard Park (4 x ADWF) – West Saanich and West Victoria	120,000	159,000
3. Primary Treatment	216,000	266,000
4. Secondary Treatment and Disinfection	156,000	186,500
5. Treated Effluent Pumping	216,000	266,000
6. Tertiary Treatment (Slipstream)	10,000	10,000
7. Clover Outfall Capacity (> 4 x ADWF)	317,000+	369,000+ (1)
Esquimalt Nation		
1. Sewage Pumping Locations		
• Near Admirals Road (Langford, Colwood, View Royal) 4 x ADWF	89,000	176,000
• Macaulay Point (Two FNs, Esquimalt Nation) 4 x ADWF	31,000	35,000
2. Primary Treatment	120,000	211,000
3. Secondary Treatment and Disinfection	60,000	105,500
4. Treated Effluent Pumping	120,000	211,000
5. Tertiary Treatment (Slipstream)	10,000	10,000
6. Macaulay Outfall Capacity (> 4 x ADWF)	120,000+	211,000+ (2)
Colwood		
1. Raw Sewage Pump Station	10,000	10,000
2. Tertiary Treatment	10,000	10,000
3. Treated Effluent Pumping Required	10,000	10,000
East Saanich		
1. Garnet Pump Station	3,000	5,000
2. Tertiary Treatment	3,000	5,000
3. Treated Effluent Pumping	3,000	5,000

(1) *By 2045 the Clover Outfall capacity will have to be increased from approximately 200 MLD to 369 MLD+*

(2) By 2045 the Macaulay Outfall capacity will have to be increased from approximately 119 MLD to 211 MLD+

Table 7.3 summarizes the estimated piping and outfall lengths.

Table 7.3 – Piping and Outfall Lengths (1)

From	To	Purpose	Length
A. Required			
Rock Bay			
Clover Point	Rock Bay WWTP	Screened Raw Sewage (SRS)	5,300 m
Rock Bay WWTP	Clover Point	Treated Effluent	5,300 m
Clover Point	End of Outfall	Treated Effluent/SRS	1,300 m
Pump Station near Barnard Park	Rock Bay WWTP	Raw Sewage	2,400 m
Colwood			
Galloping Goose Trail	Colwood WWTP	Raw Sewage	30 m
Colwood WWTP	End of Reuse	Irrigation/Aquifer Recharge	19,500 m
Esquimalt Nation			
Macaulay Point	Esquimalt Nation WWTP	Screened Raw Sewage	4,600 m
Esquimalt Nation WWTP	Macaulay Point	Treated Effluent	4,600 m
Admirals Road	Esquimalt Nation WWTP	Raw Sewage	300 m
Macaulay Point	End of Outfall	Treated Effluent/SRS	1,700 m
East Saanich			
Garnet Pump Station	WWTP	Raw Sewage	900 m
WWTP	Garnet Pump Station	Treated Effluent	900 m
WWTP	End of Reuse	Reuse	20,000 m
		Total	**66,830 m (2)**
B. Optional			
• Rock Bay WWTP	End of Reuse	Reuse	18,500 m
• Esquimalt Nation WWTP	End of Reuse	Reuse	17,000 m
		Optional Total	**35,500 m**

(1) *Pipe lengths are approximate pending a routing review.*

(2) *Includes Colwood and East Saanich reuse piping since these are necessary parts of the solution.*

8.0 Option Set 4 – Seven Plants

8.1 General Description

Figure 8.1 illustrates the seven plant option set with facilities at Langford, Colwood, View Royal, Esquimalt (Town), Rock Bay, Core Saanich and East Saanich. The intent of this option is to maximize water reuse and to further increase treated effluent water quality across the Core Area. Under the seven plant option, the Rock Bay plant would be a large, central-type facility equipped with liquids and solids treatment processes (or solids at Hartland Landfill). The other 6 plants would provide tertiary effluent for reuse around each plant, with the exception of Langford and View Royal whereby local reuse demands are minimal and may be accommodated through adjacent reuse systems at Colwood or Esquimalt (Town). Alternative disposal techniques vary in that three of the tertiary plants in Westside would be discharging all excess effluent to a new outfall and Esquimalt (Town) would discharge out the Macaulay outfall. The two tertiary plants in Eastside would be designed for 100% reuse, with their alternative disposal being the CRD trunk with treatment at Rock Bay.

Preferred sites are available in each of the four plant locations. Additional site information will be presented in November 2015 as feasibility analysis unfolds.

The current, 2030 and 2045 ADWF design flows are summarized in Table 8.1 below.

Table 8.1 – Current 2030 and 2045 ADWF Design Flows

Sewer Shed	Current (MLD)	2030 (MLD)	2045 (MLD)
Rock Bay	56.1 (1)	77.8 (1)	93.1 (1)
East Saanich	3	3	5
Saanich Core	5	5	5
Esquimalt	5.5	7.1	7.9
Colwood	2.2	4.7	13.1
Langford	5.2	14.1	23.1
View Royal	1.5	3.5	7.9

(1) *Includes the flows for East Saanich, Saanich Core, West Saanich and West Victoria*


Existing CRD Sanitary Trunk
Proposed Pump Stations
Select Existing Pump Stations
Proposed Sanitary Pipe - Raw / Primary
Proposed Sanitary Pipe - Treated
Sewage Catchment Breakpoint
Sites
Municipal Boundaries
Existing Outfall
First Nation Reserves
Proposed Secondary WWTP Site
Proposed Tertiary WWTP Site
Wet Weather Facility
View Royal (S)
Craigflower PS
Colwood (S)
Esquimalt Harbour
Langford (M)
Esquimalt (M)
Barnard Park PS
Macaulay Point
Saanich Core (S)
No Outfall
Rock Bay (XL)
Garnet PS
East Saanich (S)
No Outfall
Cadboro Bay
Clover Point
S - Small
M - Medium
L - Large
XL - Extra Large
Seven Plant Option

Figure 8.1

The proposed new outfall near Colwood meets the regulations for alternative disposal.

Rock Bay flows will include wastewater from all Eastside communities including flows currently directed to Macaulay from west Saanich and west Victoria by way of a pump station near Barnard Park. All other eastside flows would be pumped from Clover Point, or, other strategic locations along the eastside to reduce the scope of new infrastructure. This option set also includes maximizing treatment at the Clover Point site (0.5 to 0.8 ha) to minimize the quantity of flow that would otherwise be pumped to/from Rock Bay.

The Esquimalt (Town) plant will also include two pump stations to collect flows, including wastewater originating upstream in the trunk immediately adjacent the site, as well as at Macaulay point to collect all remaining flows that arise downstream of the plant. Also, it will be possible to utilize the existing screens at Macaulay, so that only screened raw sewage needs to be pumped back Esquimalt (Town). All treated effluent that is not reused, is pumped back to Macaulay Point for discharge out a new outfall.

The Langford and Colwood plants would include dewatering and trucking their solids to Rock Bay (or Hartland Landfill) however the View Royal plant would discharge their waste biological solids into the sewer for the Esquimalt (Town) plant to handle them. The Esquimalt (Town) plant would either pump their waste solids or dewater and truck them to either Rock Bay or Hartland Landfill. The East Saanich and Saanich Core plants would discharge their waste biological solids into the sewer for the Rock Bay plant to process.

8.2 Components

The following key components to implement this option are summarized in Table 8.2.

Table 8.2 – Key Components

Key Components Required	2030 (m^3/d)	2045 (m^3/d)
Rock Bay		
1. Wet Weather Facility at Clover – 1 x ADWF	48,000	53,000
2. Sewage Pumping Locations		
• Clover Point (3 x ADWF) – Not including any treatment at Clover	96,000	107,000
• Near Barnhard Park	120,000	159,000
3. Primary Treatment	216,000	266,000
4. Secondary Treatment and Disinfection	156,000	186,500
5. Treated Effluent Pumping	216,000	266,000
6. Tertiary Treatment (Slipstream)	10,000	10,000
7. Clover Outfall Capacity (> 4 x ADWF)	317,000+	369,000+ (1)

Key Components Required	2030 (m³/d)	2045 (m³/d)
East Saanich		
1. Garnet Pump Station (Retrofit)	3,000	5,000
2. Tertiary Treatment	3,000	5,000
3. Treated Effluent Pump Station	3,000	5,000
Saanich Core		
1. Galloping Goose Trail/Boleskine Road Pump Station	5,000	5,000
2. Tertiary Treatment	5,000	5,000
3. Treated Effluent Pump Station	5,000	5,000
Esquimalt (Town)		
1. Sewage Pumping Locations		
• Lyall Street (2 and 4 x ADWF)	63,800	109,400
• Macaulay Point (4 x ADWF)	12,000	14,000
2. Primary Treatment	75,800	123,400
3. Tertiary Treatment	15,600	17,600
4. Treated Effluent Pumping	75,800	123,400
5. Macaulay Outfall Capacity (> 4 x ADWF)	75,800+	123,400+ [(2)]
Colwood		
1. Raw Sewage Pumping	9,400	26,200
2. Tertiary Treatment	9,400	26,200
3. Treated Effluent Pumping	9,400	26,200
Langford		
1. Raw Sewage Pumping	28,200	46,200
2. Tertiary Treatment	28,200	46,200
3. Treated Effluent Pumping	28,200	46,200
View Royal		
1. Craigflower Pump Station (Retrofit)	7,000	15,800
2. Tertiary Treatment	7,000	15,800
3. Treated Effluent Pump Station	7,000	15,800

(1) *By 2045 the Clover Outfall capacity will have to be increased from approximately 200 MLD to 369 MLD+*

(2) *By 2045 the Macaulay Outfall capacity will have to be increased from approximately 119 MLD to 123 MLD+*

Table 8.3 summarizes the estimated piping and outfall lengths.

Table 8.3 – Piping and Outfall Lengths (1)

From	To	Purpose	Length
A. Required			
Rock Bay			
Clover Point	Rock Bay WWTP	Screened Raw Sewage (SRS)	5,300 m
Rock Bay WWTP	Clover Point	Treated Effluent	5,300 m
Clover Point	End of Outfall	Treated Effluent/SRS	1,300 m
Pump Station near Barnard Park	Rock Bay WWTP	Raw Sewage	2,400 m
East Saanich			
Garnet Pump Station	WWTP	Raw Sewage	900 m
WWTP	Garnet Pump Station	Treated Effluent	900 m
WWTP	End of Reuse	Reuse	10,000 m
Saanich Core			
Galloping Goose Trail	WWTP	Raw Sewage	400 m
WWTP	CRD Trunk	Treated Effluent	400 m
WWTP	End of Reuse	Treated Effluent	10,000 m
Esquimalt (Town)			
Macaulay Point	Esquimalt WWTP	Screened Raw Sewage	1,500 m
Esquimalt WWTP	Macaulay Point	Treated Effluent	1,500 m
Lyall Street	Esquimalt WWTP	Raw Sewage	30 m
Macaulay Point	End of Outfall	Treated Effluent/SRS	1,700 m
Colwood			
Galloping Goose Trail	Colwood WWTP	Raw Sewage	30 m
Colwood WWTP	End of Reuse	Irrigation/Aquifer Recharge	19,500 m
Colwood WWTP	Junction with Langford	Treated Effluent	500 m
Langford			
Langford Site	WWTP	Raw Sewage	300 m
WWTP	Junction with Colwood	Treated Effluent	2,000 m
Junction with Colwood	Marine Shore	Treated Effluent	5,000 m
Marine Shore	End of Outfall	Treated Effluent	2,300 m
View Royal			
Craigflower Pump Station	WWTP	Raw Sewage	1,800 m
WWTP	Junction with Colwood	Treated Effluent	3,600 m
		Total	**86,660 m (2)**

From	To	Purpose	Length
B. Optional			
• Rock Bay WWTP	End of Reuse	Reuse	18,500 m
• Esquimalt WWTP	End of Reuse	Reuse	17,000 m
		Optional Total	**35,500 m**

(1) *Pipe lengths are approximate pending a routing review.*

(2) *Includes Colwood, East Saanich and Saanich Core reuse piping since these are necessary parts of the solution.*

Appendix A

Core Area Sewer Catchments and Facilities

Core Area Trunk Sewer System

FLOW TO MACAULAY POINT

Municipality	Percent	Annual Flow (m^3)	Station	Annual Flow (m^3)
Langford	**12.29%**	**1,912,140**	Meaford	1,912,140
Colwood	**7.02%**	**1,092,703**	Parsons	3,004,843
			(Meaford)	-1,912,140
View Royal	**3.67%**	**570,489**	Craigflower Flow	3,842,080
			(Parsons)	-3,004,843
			(Esquimalt Panhandle)	-52,169
			(Songhees)	-208,039
			(Hallowell (estimated))	-6,540
Saanich	**45.43%**	**7,067,058**	Marigold	4,813,387
			Boundary	1,281,722
			Harriet	971,949
Esquimalt Nation	**0.04%**	**6,540**	Hallowell (estimated)	6,540
Songhees Nation	**1.34%**	**208,039**	Songhees	208,039
Esquimalt	**15.17%**	**2,360,338**	Head	679,780
			Wilson	99,305
			Esquimalt Panhandle	52,169
			Langcove ESQ	120,754
			Kinver	211,209
			Lyall	319,080
			Devonshire	853,687
			Pooley Place (estimated)	24,354
Esquimalt DND	**0.56%**	**87,164**	Langcove DND	68,940
			Anson	18,224
Victoria	**14.48%**	**2,252,823**	Sea Terrace	158,245
			Langford Flume	45,874
			Hereward	566,190
			Cecelia	1,007,625
			Gorge (calculated)	349,091
			Chapman Point (calculated)	84,914
			Selkirk (calculated)	40,884
Total	**100%**	**15,557,293**		

For the period of October 1, 2012 to September 30, 2013
Some stations have been omitted from the map
Station names in brackets indcate flows have been subtracted

FLOW TO CLOVER POINT

Municipality	Percent	Annual Flow (m^3)	Station	Annual Flow (m^3)
Saanich	**19.38%**	**3,372,847**	Arbutus	2,621,027
			Penrhyn Lift Station	329,162
			Townley	28,048
			Haultain	125,204
			Haro	269,406
Oak Bay	**16.23%**	**2,824,022**	Currie	6,181,890
			(Trent Flume)	-212,582
			(Arbutus)	-2,621,027
			(Penrhyn Lift Station)	-329,162
			(Haro)	-269,406
			Harling	74,309
Victoria	**64.38%**	**11,202,459**	Clover Point	17,399,328
			(Harling)	-74,309
			(Currie)	-6,181,890
			Trent Flume	212,582
			(Townley)	-28,048
			(Haultain)	-125,204
Total	**100%**	**17,399,328**		

For the period of October 1, 2012 to September 30, 2013
Some stations have been omitted from the map
Station names in brackets indcate flows have been subtracted

† The Trent pump station diverts almost all flow south to Victoria away from Oak Bay. Some flows may go to Oak Bay, through the Trent flume, during major rainfall events or when the Trent pump station is down for maintenance.

* Chapman Pt and Gorge, Selkirk, and Pooley Place flows are not directly measured.

CRD - Parks & Environmental Services - Environmental Engineering - Oct 1, 2015 - Technologist: JPB/SR - Map Document: CoreAreaTrunksCostSharingV4.mxd

February 5, 2016

Capital Regional District

Core Area Liquid Waste Management Plan

Phase 2: Wastewater Treatment System Feasibility and Costing Analysis

Technical Memorandum #3 - Costing and Financial Analysis *R1*

Project: 1692.0037.01

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Table of Contents

Appendices

1.0 REPORT SUMMARY & OVERVIEW

Life-cycle costing analysis provides the Core Area Liquid Waste Management Committee (Committee) with financial information on seven wastewater option sets for treatment and resource recovery. Each option set provides notable differences with respect to locations of treatment, levels of service for treated effluent, new piping and conveyance infrastructure, and opportunities for water reuse and heat recovery at select locations across the Core Area. While the option sets adhere to engineering and regulatory standards, they are suited to the local context by way of design consideration to public consultation results (early 2015), Committee resolutions and direct references to the Project Charter which guides the Phase 2 work to date.

Technical Memorandum #3 presents the life cycle costing results and includes the relative performance of each option set against the Project Charter and Committee aspirations. While costing results frame part of the feasibility for a given option set, illustrating the performance of an option set in light of the project criteria supports the Committee's need to provide direction on a *system* of upgrades and services. Results of this memo are presented to the Committee for potential direction regarding public consultation for each option set and to uncover public sentiment for levels of service and cost. Input provided by the Technical and Community Advisory Committee, Technical Oversight Panel, technical and administrative staff of each of the Core Area municipalities and First Nations frames the presentation to the Committee and continues to be an important resource for this evaluation and decision-making process.

Cost estimates for the seven option sets are based on factors outlined in Technical Memorandum #1 and comply with the terms of reference. Cost estimates in Technical Memorandum #3 differ from the previous liquid waste management plan because the seven proposed option sets reflect a markedly different suite of conditions and factors, such as:

- The terms of reference for Phase 2 clarify that the primary project objective is to characterize the performance of new option sets against revised goals and criteria;
- Cost estimate contingencies for Phase 2 (2015) are 35%, whereas previous liquid waste management plans included contingencies of 14% and 20% for treatment and conveyance, respectively;
- Phase 2 cost estimates include piping and pumping infrastructure (not treatment) sized for a potential 2045 flow scenario rather than the 2030 flow scenario (to avoid the unnecessary and costly impact of upgrading systems within 10 years after construction);
- Cost estimate unit rates for Phase 2 are derived from separate databases and project experiences and do not directly align with estimates of the previous plan; and
- Option sets reflect only the sites which have been brought forward by member municipalities.

Cost estimates for Phase 2 reflect a new direction in liquid waste management as outlined in the seven option sets. It is common for cost estimates to be conservative at the conceptual stage and they include multiple factors with varying levels of uncertainty. Indeed, it is common that cost estimates tend to improve and often decrease as more investigation and optimization is complete on the preferred option set. Technical Memorandum #3 provides the results of life cycle costing analysis and includes criteria performance as it relates to the Project Charter.

1.1 Technical Process Update

Engineering and financial feasibility studies are iterative. Each issue or design element undergoes scoping, testing, refinement and costing. Typically, the iterative process repeats itself to stimulate ideas, strengthen the foundation of solutions and often to reduce project scope and cost. While most engineering and feasibility studies include iterative analysis, Phase 2 for the Core Area has been aided by multiple teams and committees, each looking to significantly contribute towards option sets: collaboration with the Technical Oversight Panel, Westside Technical Staff, Eastside Technical Committee, CRD Staff and the Technical and Community Advisory Committee has improved the option sets. While there is much more iteration and optimization to come, key innovations and technical updates for Phase 2 include:

- **Efficient Pumping:** Option set configurations in Technical Memorandum #2 included a pump station at Gorge Road to capitalize on redirecting flows to Rock Bay over a shorter distance and reduced pumping needs. Costing for TM#3 reveals that constructing one pump station at Macaulay Point to Rock Bay will be more efficient and as a result, reduces capital and operating costs.
- **Wet-Weather Treatment Facilities:** Option set configurations in Technical Memorandum #2 identified the potential for a primary treatment facility at Clover Point for flows in excess of 2x average dry weather flow. The driver for this strategy was to reduce the size of pipes and pumps from/to Clover Point to Rock Bay. Costing for TM #3 reveals that centralizing wet-weather treatment at Rock Bay will reduce capital costs.
- **Sidestream Treatment and Water Reuse:** Each option set includes the provision for water reuse. Providing sidestream tertiary plants allows for reuse systems that treat only enough *supply* to meet potential *demands.* A facility in Colwood, if approved by the Ministry of Environment, would be a leading-edge water reuse system utilizing aquifer recharge and soil irrigation for up to 100% of flows. There are few facilities in Canada capable of achieving this standard and as a concept, provides for interesting public input on choices for water reuse. Overall, while treating to tertiary levels has some environmental appeal, it does come with higher capital and operating costs. Pursuing sidestream water reuse at all facilities in any option set illustrates the relationship of increased levels of service for water and the associated cost.
- **Harbour Outfall Concept Check:** There is a significant cost to convey treated effluent from Rock Bay back to the Clover Point Outfall such that some interest emerged into the feasibility of reducing the outfall and relocating it to the Harbour. An environmental impact study is ultimately needed to assess the potential for this approach; however, costing for Technical Memorandum #3 reveals that the extra treatment costs would outweigh potential outfall cost savings by a factor of roughly 2 to 1.
- **Integration with Solid Waste for Expanded Resource Recovery:** Incorporating resource recovery for both wastewater solids and municipal solid waste is growing in feasibility and application. Phase 2 uncovers key tactics at a concept level for integration and provides information to allow the CRD to consider a road-map for integrated resource recovery.
- **Phasing-in Enhanced Treatment:** Making the jump from preliminary treatment (e.g. screens) to secondary treatment (and beyond) will mark a significant advancement in wastewater and environmental performance for the Core Area. Regardless of the level of treatment selected (i.e.

regulations or beyond), the CRD will have ample opportunity to collect and report on real-time data for effluent and water quality, and quantity. This type of data can lead to reliable information regarding the opportunity to phase-in enhanced treatment over time and defer costs to ratepayers.

- **Treatment Levels of Service:** Wastewater utilities typically design levels of service to meet the regulations. Implementing tertiary levels of treatment where it is not required would demonstrate environmental stewardship including additional removal of some emerging contaminants of concern.
- **Reduced Infrastructure:** Small-scale water reuse plants that *scalp* flows to suit supply-demand for reuse, reconfiguring existing pump stations, selecting sites adjacent to existing infrastructure and many other design elements have led to seven option sets with a reduced amount of new infrastructure. Further innovation is needed to optimize pipe routing and to minimize disruption to local residents and businesses in the preferred option set.
- **Request for Statements of Interest (RFSI):** Based on the analysis of solids alternatives and option sets, there are two viable and comparable solids recovery options in anaerobic digestion or gasification. Each option is defined and costed for public input. There are however other technologies that may be more cost effective but have not been vetted as viable for the CRD. The CRD can use the RFSI approach to tell the market that it will either choose between its current choices, or, consider a more innovative or cost-effective market-based solution that out performs the defined choices based on a suite of goals and criteria for solids treatment and recovery. Myriad solids recovery options and technologies provide for more innovation and market competitiveness: the RFSI positions the Core Area for maximizing what the market can do for solids recovery.
- **Technology Innovation:** Engineering feasibility and costing is based on representative design, whereby select technologies are costed on a provisional basis to support the comparison of the option sets. Representative design gives the private sector ample opportunity to provide innovative solutions to meet the performance targets of the preferred option set because technologies have not been prescribed. Smaller footprint technologies may emerge through canvassing the private sector.
- **Regulatory Innovation:** Regulations often dictate the location and scope of infrastructure. Phase 2 discussions with the provincial Ministry of Environment has opened the door to further innovations in technologies to meet the regulations, for example, by considering less expensive primary treatment options.
- **Construction Phasing:** The Core Area wastewater system will evolve due to dynamic conditions of flow quality and quantity. Incrementally upgrading the system over time will allow for the results of water conservation and inflow and infiltration management to offset the need to increase capacity.

Innovation will continue and the preferred option set(s) will evolve as needed during subsequent design phases to optimize the Charter goals and to meet local needs. Option set summaries illustrate their relative performance including costing, characterization and criteria results.

1.2 Charter Elements and Summary Outcomes

The Project Charter provides guidance to the technical analysis herein and was foundational to creating the seven option sets. Technical Memorandum #3 characterizes each option set in light of the Charter and provides key results and differentiators to enable all readers the opportunity to weigh the tradeoffs for service, benefits and costs. Project criteria stemming from the Charter were developed in Technical Memo #1 which is provided in Appendix A to this report. Section 4 summarizes the performance of each option set under a common framework including life-cycle costing results[1], criteria performance and overall characterization of each option. Table 1-1 below provides an executive summary of the option sets based on the 2030 design capacity scenario of 108 MLD (average dry weather flow) for the Core Area, and costs include full system development such as conveyance, solids, liquid treatment, land and resource recovery infrastructures. Resource incomes are conceptual estimates only based on potential payments for treated effluent reuse and they are highly contingent on securing new utility customers.

Table 1-1: Option Set Summary

<table>
<tr><th>OPTION SET</th><th>SUMMARY CHARACTERIZATION</th><th colspan="2">2030 CAPITAL AND NET-OPERATING COST</th></tr>
<tr><td rowspan="2">Rock Bay Central - Secondary</td><td rowspan="2">The 1 Plant secondary treatment (1a) option set centralizes all flows at Rock Bay, including up to 10 MLD for local reuse. This option set addresses the need to meet pending regulations and provides for the base level of service.</td><td colspan="2">Capital 2030
$1,031 M</td></tr>
<tr><td>2030 Operating
$21.8 M</td><td>Est. Resource Income
Up to $0.9 M</td></tr>
<tr><td rowspan="2">Rock Bay Central – Tertiary</td><td rowspan="2">The 1 Plant full tertiary treatment (1b) option set centralizes all flows at Rock Bay, including up to 10 MLD for local reuse. This option set represents a clear sentiment towards water stewardship by raising levels of service for treated effluent quality.</td><td colspan="2">Capital 2030
$1,131 M</td></tr>
<tr><td>2030 Operating
$26.4M</td><td>Est. Resource Income
Up to $0.9 M</td></tr>
<tr><td rowspan="2">2 Plant: Rock Bay + Colwood</td><td rowspan="2">The 2 Plant option set treats over 80% of flows to secondary levels, on top of up to 20% tertiary quality effluent. This option set represents a notable increase in water reuse from the 1-plant option with minimal extra conveyance infrastructure.</td><td colspan="2">Capital 2030
$1,088 M</td></tr>
<tr><td>2030 Operating
$22.8 M</td><td>Est. Resource Income
Up to $2.4 M</td></tr>
<tr><td rowspan="2">3 Plant Secondary: Colwood/Langford, Esquimalt Nation and Rock Bay</td><td rowspan="2">The 3 Plant option set treats over 80% of flows to secondary levels, on top of up to 20% tertiary quality effluent from sidestream re-use facilities at Esquimalt and Rock Bay. The secondary plant at Colwood/Langford allows for sub-regional flow management, including locating capacity for future growth in the Westshore.</td><td colspan="2">Capital 2030
$1,125 M</td></tr>
<tr><td>2030 Operating
$23.0 M</td><td>Est. Resource Income
Up to $1.6</td></tr>
<tr><td rowspan="2">3 Plant Tertiary: Colwood/Langford (tertiary), Esquimalt Nation and Rock Bay (both secondary)</td><td rowspan="2">The 3 Plant Tertiary option set treats 70% of flows to secondary levels, on top of up to 30% tertiary quality effluent from the Colwood/Langford plant on top of sidestream re-use facilities at Esquimalt and Rock Bay. This option increases water reuse to three systems and raises effluent quality to levels similar to the 4 plant option at a lower cost.</td><td colspan="2">Capital 2030
$1,178 M</td></tr>
<tr><td>2030 Operating
$24.1 M</td><td>Est. Resource Income
Up to $2.8</td></tr>
</table>

[1] Borrowing costs are not included in the operating costs in this report but are available through the CRD.

<table>
<tr><th>OPTION SET</th><th>SUMMARY CHARACTERIZATION</th><th colspan="2">2030 CAPITAL AND NET-OPERATING COST</th></tr>
<tr><td rowspan="2">4 Plant: Rock Bay, Colwood, East Saanich and Esquimalt Nation</td><td rowspan="2">The 4 Plant option set is a sub-regional system treating over 75% of flows to secondary levels, on top of up to 25% tertiary quality effluent. This option set represents the middle ground for distributed facilities and includes water reuse systems in four major growth centers.</td><td colspan="2">Capital 2030
$1,195 M</td></tr>
<tr><td>2030 Operating
$25.3 M</td><td>Est. Resource Income
Up to $3.8M</td></tr>
<tr><td rowspan="2">7 Plant: Rock Bay, Colwood, East Saanich, Esquimalt Township, View Royal, Langford and Core Saanich</td><td rowspan="2">The 7 Plant option set is a sub-regional system treating up to 45% of flows to tertiary quality, including tertiary treatment for all flows on the Westside. This option set represents a distributed system which maximizes the potential for water reuse and situates facilities in 7 growth areas.</td><td colspan="2">Capital 2030
$1,348 M</td></tr>
<tr><td>2030 Operating
$26.6 M</td><td>Est. Resource Income
Up to $4 M</td></tr>
</table>

While resource recovery provides for some cost-offsets by way of new incomes (i.e. contingent incomes), water and heat recovery systems demonstrate an overall increase in costs associated with higher levels of service. Risks related to securing customers and revenues warrants due diligence in expanding the scope of service. The drivers for resource recovery ultimately go beyond financial, in terms of environmental stewardship and water innovation: public sentiment for increased levels of service and their costs is an important outcome of upcoming public consultation. Further public input can shape the direction for services in the Core Area beyond the base expectations of meeting the regulations.

2.0 TECHNICAL CRITERIA OVERVIEW

The Project Charter outlines 10 goals and commitments for option set performance and overall system evaluation. Phase 2 includes technical criteria which relate directly to the goals and commitments. These criteria guide representative design elements, and shape the approach to option sets, technologies, levels of service and resource recovery approaches. These criteria also help to characterize the performance of each option set for further consideration by political and public audiences. Technical criteria within the Project Charter provide a robust framework consistent with a goal-oriented, evaluative process to effectively illustrate and screen multiple options.

Each option set provides various levels of performance: there is no perfect technical answer to a multiple-accounts characterization of the options. Each option set is a *choice* and the engineering feasibility and financial analysis provides figures and statistics to allow for informed input and decision-making based on best available information.

While Appendix B provides the full list of technical criteria and their direct relation to Charter goals and commitments, the following summary-list provides the framework for much of this memorandum. The criteria relate to these performance topics:

- Wastewater treated above regulations
- Ability to reduce operating costs
- Carbon footprint and energy balance
- Ability to enhance treatment levels over time
- Extent of new infrastructure
- Amount of income/cost-offsets through resource recovery
- Integration of other waste streams
- Facility location, land use and relative interruptions

Sections 3 and 4 provide for coverage of the performance of the technical criteria. Two specific technical criteria are not evaluated in detail in the memo due to their inability to provide for meaningful differentiation of the option sets. In the case of ‘extent of alternatives to bring in costs less than original estimate’, no option set can meet this goal in part due to cost escalations from the previous LWMP amendment, because cost contingencies are different than the previous option, but also due to changing conditions such as facility location and levels of service. The 1 plant option with secondary treatment presents the lowest cost option of the available sites. In the case of ‘ability of an alternative to meet the preliminary criteria’, all option sets meet this criterion in that all system configurations are guided by all criteria and perform to some degree against each commitment. All remaining criteria provide for a broad characterization of the performance of any option set. Section 4 provides for a dashboard type presentation of the option sets in light of their performance against technical criteria.

2.1 Key Areas for Policy Direction and Public Input

Key focus areas for future policy direction and public input provide a lens on the multiple-account nature of this assignment. Dialogue with public, political and technical stakeholders continues to reinforce the importance of the following focus areas:

- **Integration with Solid Waste and Location of Solids-Energy Recovery:** the reduction of landfill emissions appears to be the primary driver for integration with solid waste materials. Direction by the Committee to substantively integrate solid waste may lead to gasification of wastewater solids located at Hartland Landfill, as an alternative to anaerobic digestion. Public input on the integration of solid waste and their preferences on location can support the Committee's decision for solids-energy recovery.
- **Water Reuse:** water reuse requires an increase in effluent quality (a form of environmental stewardship) and demonstrates water innovation, but it will also increase operating and capital costs. Committee direction to pursue higher levels of service to include water reuse can be achieved for every option set, to varying degrees. Water reuse feasibility may be presented in tandem with long-term potable supply plans to allow for a fulsome, regional water security dialogue. Phasing-in water reuse can occur in all option sets. Public input on elevated levels of service and water reuse is key.
- **Heat Recovery:** key conditions must be present for financially viable heat recovery systems. In particular, the small energy-price differential between electricity and natural gas at this time greatly reduces the financial viability of heat recovery from wastewater in the form of district heating systems. All option sets provide for one or more heat recovery system opportunities. Committee direction for heat recovery may be to: a) include the concept of heat recovery systems for future implementation (beyond 2030); or to b) include heat recovery costs in the option set summaries; or to c) not include heat recovery in the liquid waste management plan. Public input on the *concept* of heat recovery will be beneficial for future decisions.
- **Centralized or Distributed Facilities:** a key driver for distributed facilities is to recover resources in strategic locations and typically to recover resources where they are first generated. Distributed heat recovery, water reuse and solids-energy facilities all result in increased levels of service and costs (albeit some revenues emerge to offset a portion of the costs). Pursuing heat recovery and water reuse at this time would be driven by social, and partly environmental, outcomes. Public input on the benefits and drawbacks of centralized and distributed facilities can support Committee decision making.
- **Effluent quality:** meeting the regulations is a significant advancement in effluent quality from the current practice of preliminary treatment. Going further to achieve tertiary effluent quality allows for water reuse, may allow for reduced outfall lengths and could result in removal of greater emerging contaminants of concern (for some contaminants only, as secondary treatment removes a large portion of many contaminants already). Committee direction to treat to tertiary levels beyond water reuse demands would demonstrate water stewardship and increase capital and operating costs.

Upcoming public consultation is designed to provide qualitative and quantitative input regarding many of these focus areas to support Committee decision-making.

3.0 RESOURCE RECOVERY FEASIBILITY ANALYSIS

3.1 Solids Management

The Project Charter indicates that any option set must incorporate sustainable practices into the design and consideration of the solids management alternatives. Anaerobic digestion and gasification provide two energy positive processes that meet the terms of reference and the goals and commitments of Phase 2.

- **Anaerobic Digestion** is a process that maintains the wastewater solids at near body temperatures (35-39 degrees C) without the presence of air. Under these mesophilic[2] conditions the bacteria consume themselves and produce an energy-rich byproduct (methane). Typically, anaerobic digestion can reduce the organic content of the solids by 35-50% and the overall mass of the solids by 30%. Anaerobic digestion is the industry standard for stabilization and energy recovery in the wastewater industry. Anaerobic digestion produces a 'wet dirt' material at concentrations from 3% to 5% dry solids. The 'wet dirt' can be dewatered to produce a *cake* with a 20% to 25% dry solids concentration, which contains the residual nutrients and carbon. This material must then be managed or disposed of as the end product of anaerobic digestion. Anaerobic digestion typically produces 1,377 kg of wet cake at 20% dry solids per ML of treated wastewater. Anaerobic digesters do not have any specific setback requirements in the BC *Municipal Wastewater Regulation*. There is however, a requirement under BC regulations that requires a 15 m setback for any gas flare(s).

- **Gasification** is a thermal/chemical process that converts the organic carbon in the wastewater solids into a synthetic gas that offers energy recovery potential but also may be processed into higher value items like plastics or as feedstock for biodiesel production. The process has a challenging requirement to maintain materials at elevated temperatures (>400 degrees Celsius) for a period of time. As this process is thermally based, it is critical that the energy content of the feed stocks be sufficient to maintain the high temperatures and derive energy out of the process. Gasification has been used in the municipal solid waste market as the energy content of these materials is typically sufficient for an efficient and energy positive operation. Gasification proponents claim to process 70% to 90% of the carbon content of the liquid waste solids feed; leaving mostly inorganic ash. The disposal or management of this material is significantly easier since there is only about 25% of the solids that remain as ash or biochar. Gasification will typically produce 14-60 kg of ash or biochar per ML of wastewater treated.

Wastewater solids typically contain large amounts of energy in carbon form. Through the two selected processes, part or all of the energy contained in the reduced carbon is extracted in the form of heat and syngas (low grade gasification gas) or methane (in the case of anaerobic digestion). Energy extracted from the wastewater solids can be converted to electricity through steam turbines (preferred alternative for syngas) or through internal combustion engines to obtain both heat and power.

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[2] Thermophillic digestion is an alternative to mesophilic which can reduce the time required for digestion but also requires greater heat/energy needs.

Figure 3-1 shows the energy content of the municipal solid waste and wastewater solids; Figure 3-2 shows the relative moisture content of Municipal Solid Waste and Wastewater Solids

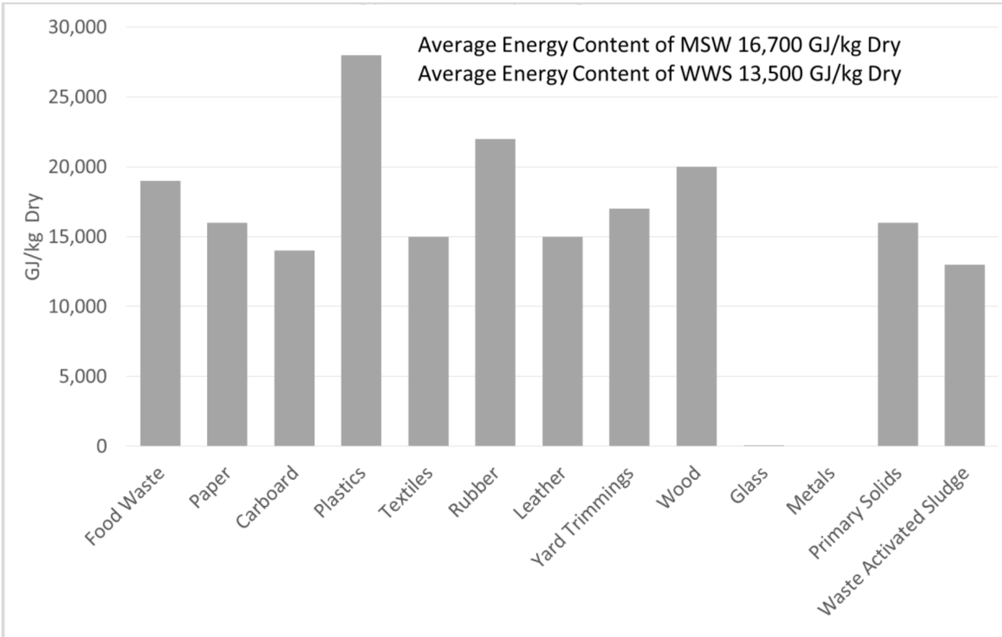
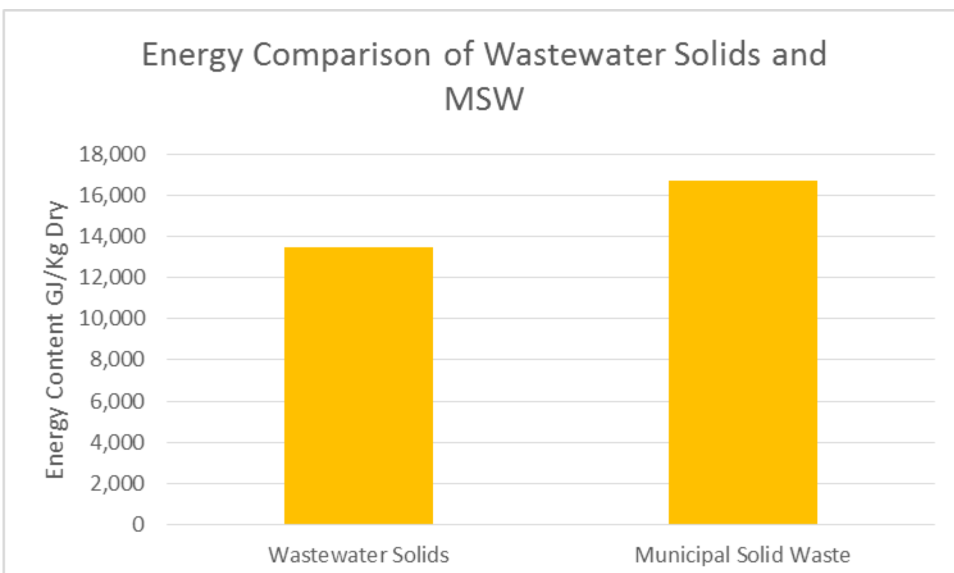


Figure 3-1: Energy Content by Weight Fraction



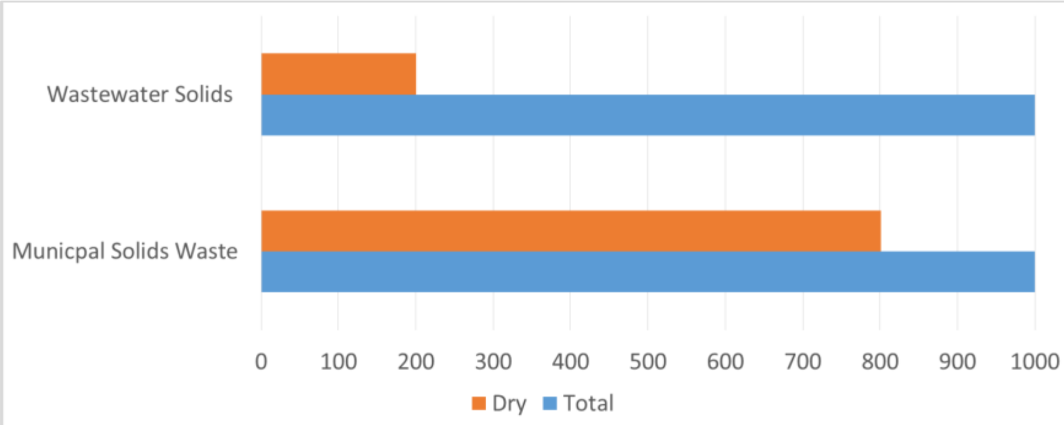


Figure 3-2: Energy Content of MSW and WWS

Figures 3-1 and 3-2 illustrate that wastewater solids contain roughly the same amount of energy as the MSW, however the moisture content (water) in the solids limits the application of thermal technologies. Figure 3-3 shows the Energy content of municipal solid waste (MSW) and wastewater solids (WWS) on a wet basis assuming the energy required to evaporate water is 3.3 GJ/ton of water evaporated.

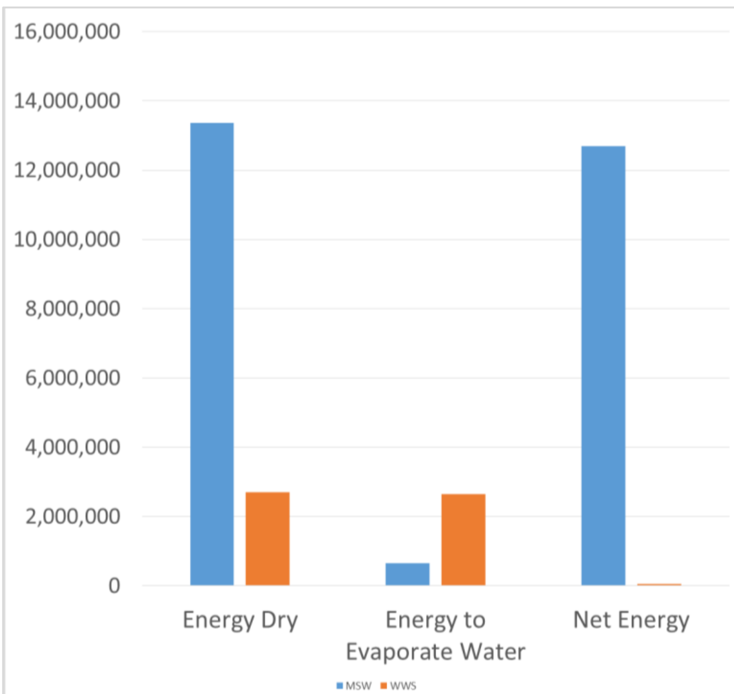


Figure 3-3: Available Energy from MSW and WWS

Anaerobic Digestion – Energy Recovery: The solids produced from the wastewater treatment facilities will be trucked or piped to the solids processing site (either Rock Bay or Hartland; discussion to follow) and introduced into the stabilization process. The separated kitchen scraps (10,000 tons per year) could be received at this station[3], screened and pulped and then introduced into the digesters for conversion to

[3] Costing in TM #3 focuses on solids-energy recovery of wastewater solids and does not present overall costs for inclusion of other solid wastes.

energy. The solids receiving station will be enclosed and odour controlled to avoid any fugitive odours from escaping the site as well as to minimize the visual impact to the neighborhoods. The solids will then be introduced into the digesters and held in enclosed vessels for a period of no less than 18 days. Once the solids are stabilized, they will be conveyed through pumps to the dewatering operation. High speed centrifuges or other methods will dewater the solids to a moisture content of less than 80 percent. The solids will then be held in an enclosed cake storage facility to control any odours and then loaded into the disposal trucks under an enclosed environment to control odours.

The methane gas from the digestion process will be cleaned of hydrogen sulfide and siloxanes and diverted to the c*ombined heat and power* units for the generation of power and heat. The heat generated in the engines will be used to provide the necessary heat for the digestion process and to offset the electrical use of the mechanical equipment at the plant.

Given the CRD policy which prevents land application of biosolids, an alternative to anaerobic digestion would be to dry wastewater sludge to create fuel pellets. These costs are not currently included in the option sets to allow the private sector to propose other alternatives and maintain an open, competitive process for beneficial reuse between the two technologies.

Daily truck traffic for dewatered, stabilized solids would amount to about six trucks per day in 2030.

Gasification – Energy Recovery: As part of the gasification alternative, the solids produced from the wastewater treatment facilities will be conveyed to the solids processing site (either Rock Bay or Hartland; discussion to follow) and introduced into the gasification process. The separated kitchen scraps (10,000 tons per year) could also be received at this station, screened, pulped and stored (holding vessel), potentially combined with yard waste (1,000 tons per year) and the resulting mass can be dosed to the gasifier for energy generation. The wastewater solids will be sent from the holding tank to a solids dryer to reduce their moisture content and then into the gasifier. The solids receiving station will be enclosed and odour controlled to avoid any fugitive odours from escaping the site, as well as to minimize the visual impact to the neighborhoods. Gasified solids are an ash-like material which would be collected and combined with spent odour control materials and loaded into a truck to Hartland, awaiting the market to reuse the materials for beneficial means. Daily truck traffic from the wastewater solids would be almost negligible aside from any additional feedstocks required to enhance the gasification process. Consideration to service governance of solids waste (e.g. service boundaries for regional versus Core Area) and liquid wastes can further inform the feasibility of integration.

The syngas generated from the gasification process will be used as fuel to a steam boiler and the steam will power a steam turbine to generate power. The addition of municipal solid waste should enhance the thermal-energy process to yield significant amounts of excess thermal energy.

Combined Heat and Power

The use of either gasification or anaerobic digestion will yield excess energy that can be converted to electricity or other forms of usable energy. Currently, the project as envisioned is to generate power to offset the mechanical equipment power use in the case of anaerobic digestion the selected technology is an internal combustion engine. In the case of gasification, the selected technology is a steam turbine recognizing that other technologies exist.

Costing Summary

The process descriptions above provide the overall scope of treatment, energy recovery and solids management that will be defined for the proposed Request for Statements of Interest. Overall, net present value analysis at this time strongly suggests that the overall capital and operating costs of anaerobic digestion and gasification can be considered comparable for this type of analysis. Key process components for solids recovery of either anaerobic digestion or gasification may include (depending on the preferred solids-recovery concept):

- Control buildings
- Residuals storage/loadout
- Dewatering facilities
- Energy generation unit(s)
- Gas conditioning/upgrader
- Dryer units and controls
- Receiving stations
- Process units: either gasifier or digester

Operations costs include:

- Labour and waste processing
- Maintenance
- Solids disposal (landfill fees encourage market sector innovation)
- Gas conditioning media
- Revenues from landfill avoidance
- Natural gas
- Power
- Polymer

Key results of the capital, operating and life cycle costing analysis include:

- There are many examples of anaerobic digestion facilities in North America which provide an extensive database of costs for estimating purposes. The limited number of successful gasification (of wastewater solids) facilities increases the uncertainty of their estimates. Gasification proposals within a RFSI may vary widely however that uncertainty is not reflected in these capital costs to allow for a more straightforward comparison (conclusions on the capital costs and associated risks of any proposed technology can stem from the results of the RFSI); these capital costs are comparable given the nature of the cost estimates for Phase 2;

ANAEROBIC DIGESTION – CAPITAL 2030	GASIFICATION – CAPITAL 2030
$258M	$233 M

- Operational costs for gasification may be less than anaerobic digestion by a notable margin; this is primarily related to the mass of solids still present in the digested sludge and the potential cost of its disposal/reuse; market innovation on the reuse of biochar and biosolids will have a significant effect on the operating costs for either technology (which further justifies the value of market engagement through the RFSI),
- Operational costs (including cost-offsets or revenues) for gasification could be up to 40% less than anaerobic digestion for the 2030 scenario,
- Operational costs for gasification decrease further as other municipal solid waste materials are added (relative to anaerobic digestion) because more energy offsets emerge,
- Net present value results between anaerobic digestion and gasification can be considered roughly equal at this conceptual level (the capital cost uncertainty for gasification prevents a clear conclusion on net present value); statements of interest by the wastewater solids market will determine whether even better net present value scenarios exist,
- Capital costs for anaerobic digestion are included in the option set summaries as they represent more reliable costing because they are based on multiple installations across North America at a comparable scale, whereas there are no known operating gasification facilities with biosolids at or near this scale; presenting only the costs for anaerobic digestion will have little effect on public consultation because either process will require debt amortization coupled with operating costs which yield a comparable financial impact to residents on an ongoing basis, and
- Discussions with 3P Canada and senior government funding partners must occur to determine eligibility of gasification and the integration with municipal solid waste (e.g. potential advantage), recognizing that a key driver for eligibility is achieving value for money.

Emissions avoidance and carbon credits are not considered in the financial analysis (however their relative performance is outlined below) due to the uncertainty of eligibility of either wastewater process in BC (there is no wastewater protocol); including carbon credits from non-wastewater solids could be considered in future phases however the analysis would be highly speculative until substantive discussions can occur with the province.

Two financially comparable solids-energy recovery options positions the CRD to canvass the private sector to determine the most cost-effective and environmentally-beneficial alternative.

3.2 RFSI Considerations

A request for statements of interest (RFSI) details the aspirational and obligatory (e.g. risk management, financial assurance) objectives of the CRD in solids recovery, and also serves to identify and assess all of the potential market opportunities to improve upon the alternatives identified in Phase 2. The RFSI provides the CRD the option of evaluating the best technologies in a single, formal process and further provides guidance to the manufacturers on the goals of the CRD for the processing and disposal of the solids generated through the process.

The value of biosolids and their residual resources is driven by the interest and application of users in the resource recovery marketplace. Once the Core Area has a complete and operational treatment system, a growing (yet small) list of proponents will gradually emerge vying for a role in resource recovery activities. The RFSI provides a catalyst for the local market and helps to define the critical information needed in terms of supply and demand, revenue and cost, as well as use and recovery for all residual products. Biosolids recovery financial analysis is always market specific and the life-cycle comparison of any technologies is provisional until better, local and reliable market information is known, for example, from a RFSI.

The RFSI process will also provide opportunity for innovation by encouraging practical, resourceful and complete solutions to recover biosolids including their organics and energy. The RFSI should include the definition of the two *bookend*-type options (anaerobic digestion and gasification) as viable options for the CRD to implement in a way that challenges the market to produce options that are more innovative. For example, a fuel-pellet-focus option may emerge (among many other options) which dries all residuals preserving most of the original calorific value of the organics for use at a kiln or other energy facility. Also, the availability and content of other municipal solid feedstocks should be characterized to inform market proponents of available fuels to drive alternative technologies.

The RFSI process provides significant advantages to this process and strongly encourages innovation by the market. By being goal driven, market solutions will adhere to the progress made during Phase 2 including direction by the Committee and aspirations of the public. The RFSI must specify performance outcomes along with defined evaluation criteria so that responses are directly applicable to the requirements and aspirations of the Core Area, including topics such as:

1. Proposed process must recover and export energy
2. Proposed process should integrate municipal solid waste and wastewater solids
3. Proposed Process must recover and export ammonia
4. Proposed process must minimize carbon emissions
5. Proposed process must not rely on land application or landfilling of solids processed

The comprehensive list of requirements would be detailed to suit political and technical needs, for alignment with senior government funding opportunities (committed or not) and reflect key input received by the public through upcoming public consultation. Each response by the private sector should include an appropriate level of commitment and assurance of cost and responsibilities so that CRD can adequately factor in the proposed options as part of service budgeting and planning.

3.3 Hartland Landfill and Rock Bay

Locating solids-energy treatment and recovery at either Hartland Landfill or Rock Bay is driven by five key factors as outlined in Table 3-1.

Table 3-1: Key Factors and Considerations

FACTOR	CONSIDERATIONS
1. Neighborhood interest in gasification or anaerobic digestion at Rock Bay or Hartland Landfill e.g. odour	» *Local industrial land uses at either location present noise, vibration, aesthetic, air and odour concerns* » *Solids-energy recovery would not significantly affect current neighborhood conditions except if additional municipal solids are received, stockpiled and sorted at Rock Bay; odour management equipment is accounted for at all facilities* » *Neighborhood input (with consideration to the local context for land use) will further influence the suitability of siting solids-energy recovery in Rock Bay.*
2. Cost of land	» *Prime industrial land in Rock Bay is about five times costlier (per hectare) than land at Hartland Landfill.*
3. Costs of trucking and pumping wastewater solids to Hartland Landfill	» *Processing all solids at Rock Bay could eliminate most of the costs of trucking/pumping since there will only be some residuals to convey off the site* » *Trucking solids (20% solids) or pumping solids (at 1 to 2% waste dry solids) from Rock Bay to Hartland present a similar net present value at approximately $38M+; trucking net present value includes a lower capital cost than pumping (a liquid return line to Rock Bay is still required for trucking) but the higher operational costs of trucking, including potential carbon taxes, results in a comparable net present value.*
4. Integration of solid waste[4]	» *Hartland landfill already includes receiving and sorting of different solid wastes which provides distinct advantages. Duplicating this function in Rock Bay would increase costs, noise and traffic.* » *Integrating some municipal solid wastes into the gasification or anaerobic digestion processes would be more efficient at Hartland (which also allows for greater expansion opportunities).* » *Excess heat from the existing landfill methane cogeneration facility would reduce the cost and emissions of drying wastewater solids for either anaerobic digestion or gasification.*
5. Final destination of residuals	» *The market response to residuals is not yet known however the ability to provide excess land for temporary storage until suitable customers exist provides an advantage to Hartland.*

In summary, the cost of land at Rock Bay and the cost of transporting to Hartland (either trucking or pumping to Hartland) offset themselves yielding no clear advantage for two of the five factors (Appendix C outlines trucking and pumping costs). However, Hartland Landfill provides for the opportunity to more

[4] . Further study can confirm the capacity of the local electricity grid to accommodate new power at both locations.

easily integrate other municipal solid wastes, to utilize excess heat resources from the methane cogeneration facility, to provide greater flexibility for storage facilities and for expansion. Overall, if integration with solid waste is pursued then Hartland Landfill provides distinct advantages, including strong engineering and financial feasibility, a lower risk of odour nuisance, and improved resource recovery considerations. Rock Bay is still a viable solids-energy recovery location but is not conducive to integration with municipal solid wastes. Costs for transporting solids to Hartland can be added to the option sets on direction from the Committee.

3.4 Solids Transport: Trucking or Piping Considerations

Solids treatment is best done at a central facility in order to maximize economies of scale and to reduce operational complexity. Any option set with multiple plants requires that solids are conveyed to the desired location, either Rock Bay or Hartland, for treatment and recovery. Each option set (of 7) may include either of the available solids treatment location, and, whether to pump or to truck solids prior to treatment: Seven option sets, two locations and two transport mechanisms yields many, many scenarios. However, the practical transport of solids prior to treatment-recovery in the 2030 scenario can be separated into two distinct strategies:

- *For sub-regional or distributed-type treatment option sets (*3 Plant, 4 Plant and 7 Plant): dewatering and trucking occurs at each major plant with solids trucked to the central facility, either Rock Bay or Hartland, to avoid the cost and impacts arising from separate solids-transport pipes distributed throughout the core area. In other words, multiple plant option sets are not conducive to a piped method of solids transport to Hartland or Rock Bay. Proposed solids transport methods by trucking, for all sub-regional or distributed-type plant option sets, can be summarized as:

Table 3-2: Solids Transport Summary – Distributed-type Options

Option Set	Plant + Solids Transport Method
3 Plant (approach for either secondary or tertiary)	» **Colwood/Langford**: dewater and truck to central facility (either Rock Bay or Hartland; 1-2 trucks per day) » **Esquimalt Nation:** dewater and truck to central facility (either Rock Bay or Hartland; 1-2 trucks per day) » **Rock Bay:** central location of solids treatment, or, dewater and truck to Hartland; 3-4 trucks per day)
4 Plant	» **Colwood:** 1% to 2% waste dry solids returned to the CRD sewer main for dewatering at Esquimalt (no trucks) » **Esquimalt Nation:** dewater and truck to central facility (either Rock Bay or Hartland; 1-2 trucks per day) » **East Saanich:** 1% to 2% waste dry solids returned to the Eastside collection system for processing at Rock Bay (no trucks) » **Rock Bay:** central location of solids treatment, or, dewater and truck to Hartland (3-4 trucks per day)

7 Plant	» **View Royal** 1% to 2% waste dry solids returned to the CRD sewer main for dewatering at Esquimalt (no trucks) » **Colwood + Langford + Esquimalt:** dewater and truck to central facility (either Rock Bay or Hartland; 2-3 trucks per day) » **Core Saanich and East Saanich:** 1% to 2% waste dry solids returned to the Eastside collection system for processing at Rock Bay (no trucks) » **Rock Bay:** central location of solids treatment, or, dewater and truck to Hartland (3-4 trucks per day)

- *For central-type treatment option sets* (Rock Bay Secondary, Rock Bay Tertiary, and 2 Plant): Rock Bay hosts central solids treatment or all solids are pumped or dewatered and trucked to Hartland. Proposed solids transport methods, per option set, can be summarized as:

Table 3-3: Solids Transport Summary - Central Type Options

Option Set	Plant + Solids Transport Method
1 Plant (approach for either secondary or tertiary)	» **Rock Bay:** central location of solids treatment, or: ▪ dewater and truck to Hartland (~6 trucks per day) OR ▪ pump 1% to 2% waste dry solids to Hartland
2 Plant	» **Colwood:** 1% to 2% waste dry solids returned to the CRD sewer main for dewatering at Rock Bay (no trucks) » **Rock Bay:** central location of solids treatment, or: ▪ dewater and truck to Hartland (~6 trucks per day) OR ▪ pump 1% to 2% waste dry solids to Hartland

There are many hybrids and permutations for solids transport including options within *sub-regional or distributed-type treatment option sets* that pump from Rock Bay to Hartland (for Rock Bay flows only) while also employing trucks at the other, smaller facilities. This approach is not cost-effective, and therefore not proposed, because it incurs most of the capital/operating costs of the pump to Hartland scenario as well as the cost and carbon footprint of trucking: this creates the least desirable solids transport scenario. Overall, selecting the preferred option set and choosing the preferred location, either Hartland or Rock Bay, will narrow down the solids transport options.

3.5 Heat Recovery

Charter goals and commitments related to heat recovery comes from public interest in the economic and environmental feasibility of beneficial heating systems from wastewater throughout the Core Area. Analysis for Phase 2 is desktop oriented and spans methodology, supply and demand, heating economics, service infrastructure, costs and income possibilities.

Heat recovery typically occurs via district heating systems (DHS) in select locations which are highly suited for heat distribution. While heat can be extracted from raw wastewater throughout the conveyance system, the efficiencies of low-grade heat extraction are low and strongly encourage heat recovery from treated effluent (after the plant). Three primary factors influence the efficient distribution of excess heat energy from a wastewater facility:

- **Supply:** Heat pumps convert thermal heat in wastewater and concentrate the supply for extraction for use in nearby buildings. Heat availability is a function of the ability to extract heat from the wastewater by dropping the wastewater temperature.

- **Demand:** New developments provide for the lowest-barrier demands because they negate the retrofit costs of existing buildings and their current heating systems. Treatment plants situated adjacent growth centers allow for heat distribution systems to be incrementally installed to suit actual development. This approach eliminates the uncertainty of partnerships with existing/different heat strategies and allows for capital investments to occur when they're needed.

- **Infrastructure Requirements:** Heat distribution systems originate at or near the plant or any treated effluent conveyance line. The further the development is from the source, the higher the infrastructure costs and the lower the feasibility of heat recovery.

All option sets provide treatment facilities near growth centers. Typically, the most feasible DHS scenario arises where infrastructure costs are lowest and the amount of demand is greatest. Key economic factors that drive the financial viability of heat recovery include value of the heat supplied (e.g. $/GJ) relative to the cost of infrastructure and operations.

Cost-Income Analysis

Local and regional planning documents outline growth projections for use at the DHS conceptual stage. Growth rates, densities, timing and building heights can be adjusted to illustrate the demand potential across the Core Area. Planning figures are converted into heating demand estimates for 2030 and 2045 scenarios. Five locations demonstrate highest potential for heat recovery systems including Rock Bay, Langford, Esquimalt, Colwood and View Royal (in descending order of demand). Potential revenues relate to cost offsets from purchasing natural gas at a flat rate of $14.00 per gigajoule (GJ) which includes basic charges, delivery charges, carbon tax savings and storage and transport costs.

Current record lows in natural gas prices combined with increasing electricity prices is narrowing the economic advantage that heat pump technology offers. For example, one unit of natural gas heat currently has a value of $14 per GJ, while a unit of heat pump heat at current electricity prices has a value of $11.67 per GJ. When infrastructure and utility operations costs are included the price differential is largely eliminated which means district heating systems struggle to yield a positive return. If the price of natural gas were to increase by 50% to 100% (some historical evidence) then the feasibility would increase dramatically. Price negotiations, either reduced electricity rates or premium heating charges based on renewable sources, would also affect financial viability of DHS in the short term.

Capital and operations costs are critical to service financing. Operating costs require detailed analysis once the system configuration and the ownership / governance model are known. Table 3-4 outlines two capital and operating cost scenarios, as an example, for two heat recovery systems for the Core Area option sets.

Table 3-4: Capital and Operating Cost Scenarios

SCENARIO	2030 CAPITAL COST	2030 OPERATING COST	2030 INCOME
Rock Bay DHS	$21.3M	$2.15M/year	$2.15M/year
6 DHS under 7 Plant Scenario	$71.3M	$5.15M/year	$5.875M/year

Current energy prices coupled with the cost of DHS infrastructures results in insufficient revenues that may cover operating investments but do not payback capital investments in a reasonable time period. The capital, operating costs and potential incomes for DHSs are not included in the option set summaries.

Ingredients for Successful Heat Recovery

Overall, while a significant heat resource exists in treated effluent, current energy pricing for both electricity and natural gas pose significant challenges to achieve a positive business case. Further, partnerships for DHS face multiple barriers and conditions, such as proximity-to-source needs and retrofit costs of existing buildings, which further encourages greater emphasis on heat recovery potential in the future. Yet, heat recovery from wastewater has serious potential in broader district heating systems when the ingredients in Table 3-5 are applied:

Table 3-5: Ingredients for Successful Heat Recovery

INGREDIENT	APPLICATION
Secure partnerships with reliable building owners who are ready to invest in heating system infrastructure	*New development; preference to single-owner buildings; public agencies*
Low-infrastructure district heating systems	*New buildings situated 'on top' of effluent pipes or adjacent treatment plants*
Natural gas prices significantly exceed electricity pricing	*Future conditions may present this opportunity*
Lens on cost-effective heat recovery utilities	*Business cases based on reinvesting incomes into the utility; unlikely to offset other wastewater costs*
Public support inherent in triple-bottom line business case	*Seek out public input on the concept noting that implementation likely to occur when these ingredients for success can be met (likely in the future)*

Heat recovery from treated effluent is an attractive energy off-set strategy. Each option set provides for a DHS however current energy prices indicate the capital and operating costs will only increase with more, distributed systems. Heat recovery options should be pursued based on the preferred option set as willing customers come forward and energy prices create a viable servicing strategy. Capital and operating costs for heat recovery are not included in base costs but would be added on direction by the Committee.

3.6 Water Recovery

When treated to a high enough standard, treated effluent can be reused instead of potable water. A target market framework helps to navigate the multiple possibilities for reuse to augment the potable water supply. Conceptual supply-demand estimates focus on water applications that require less than potable-quality water and also demands that are situated in clusters which can reduce the cost of additional pipes to convey flows. Water recovery target markets should deliver on the following key themes:

- Demonstrate reliable long-term demands and incomes
- Reduce the scope of infrastructure needs
- Service large tracts of irrigable land such as parks and green spaces
- Support community amenities including augmenting environmental flows such as aquifer recharge
- Pursue future partnerships with industry
- Demonstrate synergy with conventional public utility services
- Service growth centers where new developments can be encouraged to include additional plumbing systems for toilet flushing or irrigation

A servicing approach that meets these themes typically presents the lowest capital cost for system set up, provides long-term demands, supports community amenities such as parks and growth and generally conforms to public utility service delivery. The cost of retrofitting (re-plumbing) existing buildings to allow for treated effluent reuse is prohibitive; it is more feasible to include non-potable water lines in new construction and to phase in non-potable sources over time. Combined, land application and regional growth centers provide for lower-barrier methods for reuse.

Summary of Water Reuse across the Core Area

Technical Memorandum #2 outlines the land application (irrigation), toilet flushing and aquifer recharge possibilities across the Core Area based on the applied target-market framework. All reuse systems could be phased in, with the exception of Colwood which is presented as a full-time water reuse facility employing aquifer recharge until established potable-substitution customers are confirmed. Life cycle costing is based on reuse income for treated effluent phased-in over time: if aquifer recharge is the preferred reuse strategy then life cycle costing would notably change. Overall, establishing five reuse systems provides coverage of most of the major outdoor uses in the Core Area, including growth centers, without the need for extensive reuse infrastructure.

Treated effluent systems require their own, separate infrastructure for distribution. Each facility would include a pumping station which raises system pressures to cover the range of elevations and flows and also includes pipes based on conceptual routes. The capacity of each water reuse system is based on the 2030 flows with consideration to long-term flow increases.

- **Colwood-Langford**: approximately 19.5 km of reuse pipe and a pumping system equivalent to 10 MLD.
- **Esquimalt:** approximately 17 km of reuse pipe and pumping system equivalent to the proposed demand of roughly 5 MLD for irrigation and toilet flushing
- **East Saanich:** approximately 20 km of reuse pipe and pump system equivalent to the proposed demand, or roughly 3 MLD during peak demand periods
- **Core Saanich:** approximately 10 km of reuse pipe and pumping system equivalent to the proposed demand of roughly 5 MLD for irrigation and toilet flushing
- **Rock Bay:** approximately 18.5 km of reuse pipe and pump system equivalent to the proposed demand, or roughly 10 MLD during peak demand periods; additional water reuse may occur along the treated effluent line toward Clover Point however these estimates have not yet been included.

Life-cycle costing includes capital allowances for reuse systems including distribution pipes and pump facilities. Pricing for reclaimed water is proposed at 80% of potable water retail rates for toilet substitution and 80% of wholesale CRD potable rate for land application. Reuse by aquifer recharge will not result in revenue.

Cost-Income Summary

Table 3-6 outlines the capital and operating costs plus potential revenues for two reuse scenarios (however, life cycle costing for water reuse was conducted for all seven option sets). Example treatment capital and operating costs are included given the intention to achieve tertiary effluent for water reuse.

Table 3-6: Cost-Income Summary

SCENARIO	2030 CAPITAL COST	2030 OPERATING COST	2030 Revenues
1 Plant Sidestream Reuse	$24.2M	$300K to $400K/year	Up to $800K/year
7 Plant Option Set with 5 Water Reuse Systems	$205M[5]	$2.5M to $3.0M/year	Up to $4M+/year

Results of the cost-revenue and feasibility analysis for water reuse include five key outcomes:

- Revenues for water reuse are set to be phased in as customers confirm partnerships with CRD or the municipality for service, gradually over a 20-year period. Detailed studies must engage with the individual customer and determine their affordability limits for water service. Questions emerge, such as; *will municipalities pay for the additional cost of park irrigation? Can golf courses afford the proposed rates?*
- Water reclamation provides for innovative uses of treated effluent however it is unlikely to present a positive business case until (if) potable supplies become unreliable. Revenues from water re-use will be challenged to cover both the operating and capital financing costs of their delivery systems, and will likely create an overall operating deficit.

[5] Includes the treatment capacity costs for exceeding secondary effluent.

- Further study is needed to discern which revenues are actual new incomes that do not result in a loss in income to the potable water utility. Generally, however, installing two sets of pipes providing a similar level of service in the same area can lead to some level of redundancy and added cost to be borne by the taxpayer.

- While the seven plant option set would provide a higher level of service and boost enhanced tertiary water quality, it may not provide greater reuse opportunities beyond the four plant option for a long time: this is because supply would likely exceed demand. Pursuing full tertiary treatment for all flows would be driven partly for water reuse but largely to achieve enhanced water quality that is ultimately returned to the environment.

3.7 Carbon and Energy Footprint Discussion

Carbon footprint and offset credits can be a powerful lens for evaluating the feasibility of projects that achieve significant reductions in greenhouse gas (GHG) emissions. The GHG profiles differ significantly between solids-energy recovery and wastewater (liquids) treatment, and therefore are discussed separately below.

Carbon Footprint and Offsets for Solids-Energy Recovery

Solids-energy recovery by either anaerobic digestion or gasification will both create and reduce GHG emissions. The relative performance between these two technologies from an emissions perspective, including the introduction of other wastes, provides helpful direction for the Committee and the region in pursuing either technology.

For context, electricity is considered carbon neutral in BC; therefore, its offset or increased use does not result in any change to the overall GHG footprint. If the business case for either technology is to consider carbon credits, then significantly more analysis is needed to complete the business case and make a fully informed investment decision. For example, there are limits to the amount and types of offsets that the Province of BC will coordinate each year. At minimum, responses to the Request for Statements of Interest should dictate a regulatory compliant carbon footprint and offset scorecard.

At a conceptual level, considerations for either gasification or anaerobic digestion from a GHG emissions perspective include:

- Both anaerobic digestion and gasification create biogas (methane or syngas) which can be captured and reused to fuel/heat the treatment process. Being renewable fuels that are fully consumed, neither gas would be subject to the BC Carbon Tax, nor create significant liabilities under the Climate Action Charter.

- Anaerobic digestion of wastewater solids combined with proper land application of biosolids (if considered by the CRD) likely presents the lowest overall carbon footprint strategy.

- Both anaerobic digestion (if solids drying were also included) and gasification require input gas to fuel the treatment operation. Gases created by both technologies lessen the amount of import carbon-based fuels (i.e. natural gas) for heating and drying. For solids-energy recovery of only wastewater solids, the amount of gas that is created and imported is likely to be similar between the two recovery processes.

- Gasification of dried wastewater solids (on their own) does not produce excess energy that can be exported over and above process requirements, therefore other feedstocks typically drive the gasification process. This introduces biomass-to-energy considerations which are essentially considered emissions neutral in BC, in that carbon penalties are not applied to renewable fuels.
- Hartland Landfill currently utilizes methane capture from decayed materials to generate electricity to sell to the grid, albeit landfill-methane capture still sees emissions of methane released as the gas capture rate is approximately 63% (with intentions to meet 75% in 2016). Any excess methane that is being flared could be utilized in the gasification or anaerobic digestion process. Yard, garden and kitchen organics are already diverted from the landfill and are reportedly beneficially reused therefore there would be limited, if any at all, carbon emissions reductions in their gasification. Emissions reductions from gasification would likely come from other materials that produce elevated emissions, either by their decay or further processing activities, such as scrap wood.
- Importing materials (yard, garden and kitchen organics) that are currently managed by private sector solid waste management companies could reduce GHG emissions through the avoidance of unmanaged decomposing of organic material; however, the carbon footprint reduction would be limited to any inefficiencies of the activities of the private sector companies, which is likely marginal overall. While introducing materials not managed by the CRD would increase biogas production (gasifier), it may not yield a positive net environmental benefit because these materials are already beneficially reused.
- Regulations limit the CRD’s ability to control the flow of materials to Hartland Landfill for gasification. A comprehensive regional service led by the CRD for municipal solid waste could increase the amount of material available for recovery, including the potential benefits and drawbacks of more material going to Hartland and the impacts to the existing management approach including impacts to private sector solid management companies.
- Utilizing paper, plastics and scrap wood (examples) already managed by the CRD for use in the gasifier could be justified by the improved efficiency of gasification over the less efficient landfill-gas capture. Materials already recycled are unlikely to yield an improved carbon footprint.
- Food scraps are already sent from Hartland Landfill to Harvest Power in the Vancouver area for resource recovery via anaerobic digestion. The current carbon footprint would be reduced by eliminating the transport costs and their associated emissions; additional emissions reductions could occur if gasification is considered a more efficient process for resource recovery of yard and kitchen scraps. Unfortunately, the efficiency of gasifiers including wastewater solids and food scraps is difficult to determine due to the lack of operating facilities.

Takeaways from these considerations include:

- Anaerobic digestion of wastewater solids including drying the wet cake appears to show a similar carbon footprint to gasification of wastewater solids alone.

- Gasifying yard and garden waste would not likely present a strong carbon footprint reduction strategy because these materials are already diverted from the landfill and beneficially reused. Carbon footprint reductions at the landfill could focus on sending high-energy content materials that would otherwise decay as part of the less-efficient landfill methane capture into a gasifier, particularly for those materials that are difficult to divert (e.g. some paper, some plastics and scrap wood), because it is reported to be a more efficient recovery process.

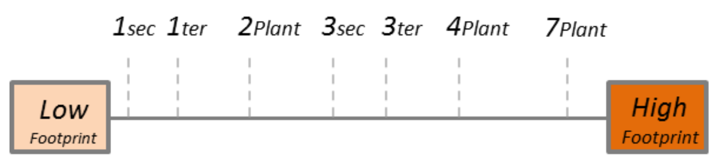
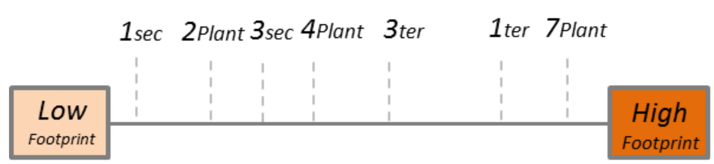
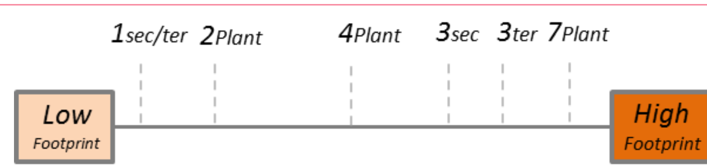
- Anaerobic digestion of wastewater solids and food scraps and gasification of dried wastewater sludge and food scraps likely presents a similar carbon footprint. Whichever process can reliably demonstrate greater efficiency over the other would likely yield a lower carbon footprint.

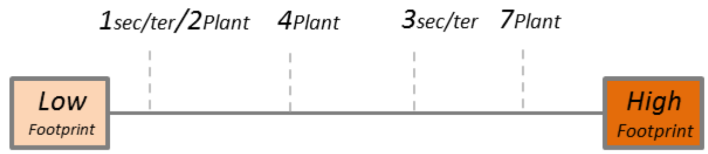
Direction by the Committee to fully integrate wastewater solids with municipal solids for gasification would likely yield an overall reduced carbon footprint, over anaerobic digestion and drying of wastewater solids on its own, because of the potential avoidance of emissions at the landfill, and not necessarily as a function of wastewater process emissions.

Carbon Footprint for Wastewater (Liquids) Treatment

Key factors for carbon and energy footprint in wastewater treatment and conveyance relate to extent of construction, energy use for treatment, energy use for conveyance and trucking to distribute solids to a central solids-energy recovery facility. Table 3-7 outlines the factors and their considerations with respect to how the option sets qualitatively perform against each other for low to high carbon footprint.

Table 3-7: Carbon Footprint for Option Sets

FACTOR	CONSIDERATION	RELATIVE CARBON FOOTPRINT
Extent of Construction	Scope of new infrastructure, total building footprint, redundant facilities.	
Energy use for treatment	Level of treatment	
Energy use for conveyance	Pumping distance, pressure for raw, treated and reclaimed effluent; overall efficiency	

FACTOR	CONSIDERATION	RELATIVE CARBON FOOTPRINT
Trucking to distribute solids to a recovery facility	Distance for trucking and number of trips per day	

Qualitative performance of the criteria reveals the overall carbon and energy ranking of the option sets for wastewater treatment (liquids) including, in order of smallest to largest footprint: Rock Bay – Secondary; 2 Plant, Rock Bay – Tertiary, 3 Plant – Secondary, 4 Plant, 3 Plant – Tertiary, and 7 Plant.

OPTION SET >>

1A Rock Bay - Secondary

Description

- Rock Bay is a central facility for all flows up to 4xADWF including secondary treatment and disinfection plus sidestream tertiary for local reuse in the Rock Bay-North Downtown areas.
- Solids-energy recovery can be centralized at Rock Bay or Hartland Landfill. Truck traffic is estimated at ~5-6 trucks per day in 2030.
- Macaulay catchment flows are directed to Rock Bay for treatment. Any flows not reused are routed through the Clover Point outfall. All flows meet or exceed the regulations.
- Heat recovery systems can be considered around Rock Bay and along the effluent line to Clover.
- Available site(s) are suitable from a technical perspective and align well with public input to date.
- Life cycle costs are reflective of the economies of scale made available by a central plant.

Scenario	2030 Capital	2030 Operating	Est. Resource Income
Rock Bay Secondary	$1,031 M	$21.8 M*	Up to $0.9 M

Life Cycle Costing Analysis | Highlights

- A central plant at Rock Bay demonstrates the lowest capital, operating and life cycle costs
- Resource incomes at Rock Bay water reuse includes gradual, small-scale irrigation demands initially, with phased-in toilet flushing demands over 20+ years
- Sensitivity analysis related to resource incomes and discount rates had minimal effect on the net present value**.

Operating costs account for asset depreciation as per factors outlined in TM #1 but should be refined to complete detailed cash flow analysis. This note applies to all option set summaries.

***Sensitivity analysis related to energy and commodity prices would have a greater effect on net present value performance but was not conducted. This note applies to all option set summaries.*

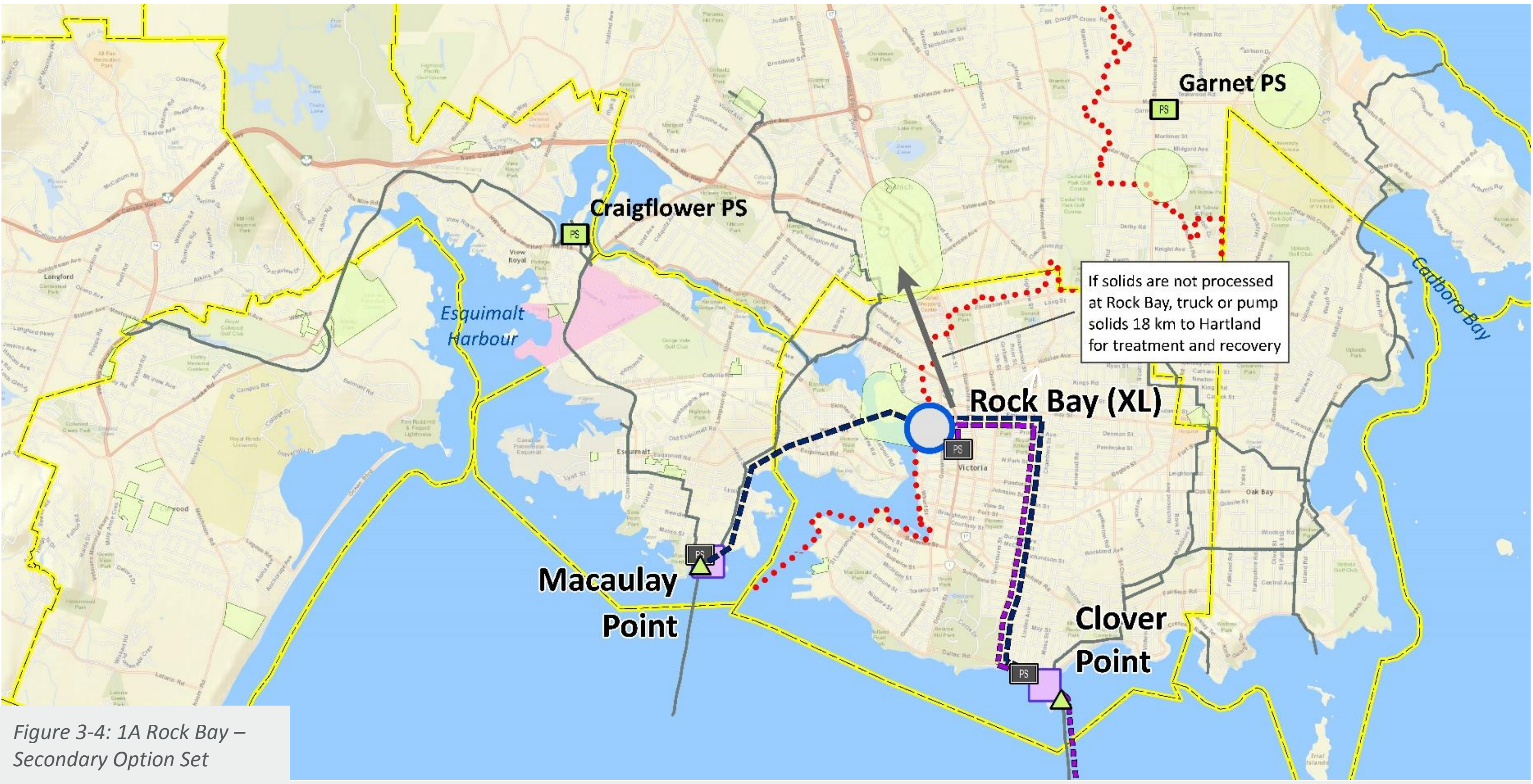


Figure 3-4: 1A Rock Bay – Secondary Option Set

CRITERIA RESULTS >>

» Length of New Conveyance Pipe **16.7 km**	» % of Effluent @ Tertiary Quality **10%**	» Rank: Low Carbon and Energy Footprint **1st**
» Rank: Low Operating Costs **1st**	» Ratio of Income to Costs for Water Reuse **0.45**	» Ratio of Income to Costs for Heat Recovery **0.60**

Option Set Characterization

» *Neighborhood-Land Use: A central plant at Rock Bay appears to align the best of all locations given public sentiment to date. The industrial, mixed-use designation supports the site activities and other routine treatment processes. Capital works at Rock Bay should consider local planning objectives and provide for positive public interaction.*

» *Overall: The 1 Plant secondary treatment (1a) option set centralizes all flows at Rock Bay, including up to 10MLD for local reuse. This option set addresses the need to meet pending regulations and provides for the base level of service.*

Option set >>

1B Rock Bay -Tertiary

Description

- Rock Bay is a central facility for all flows up to 4xADWF including full tertiary treatment plus disinfection. Water reuse can be implemented in the Gorge-Rock Bay-North Downtown areas, or other areas as needed over time. Full tertiary treatment opens up the possibility of a harbour outfall.
- Solids-energy recovery can be centralized at Rock Bay or Hartland Landfill. Truck traffic is estimated at ~5-6 trucks per day in 2030.
- Macaulay catchment flows are directed to Rock Bay for treatment. Any flows not reused are routed through the Clover Point outfall. All flows will exceed the regulations.
- Heat recovery systems can be considered around Rock Bay and along the effluent line to Clover.
- Available site(s) are suitable from a technical perspective and align well with public input to date.
- Life cycle costs are reflective of the economies of scale presented by a central plant however with the added cost of additional energy, operations and treatment processes for tertiary quality.

Scenario	2030 Capital	2030 Operating	Est. Resource Income
Rock Bay Tertiary	$1,131 M	$26.4M	Up to $0.9 M

Life Cycle Costing Analysis | Highlights

- A central plant at Rock Bay with tertiary treatment demonstrates the 4th highest capital costs and 3rd highest operating costs;
- Net present value for Option 1b is approximately 15% higher than for Option 1a
- Resource incomes reflect the proposed reuse system near Rock Bay as in Option 1a
- Sensitivity analysis related to resource incomes and discount rates did not change the relative financial performance of Option 1b

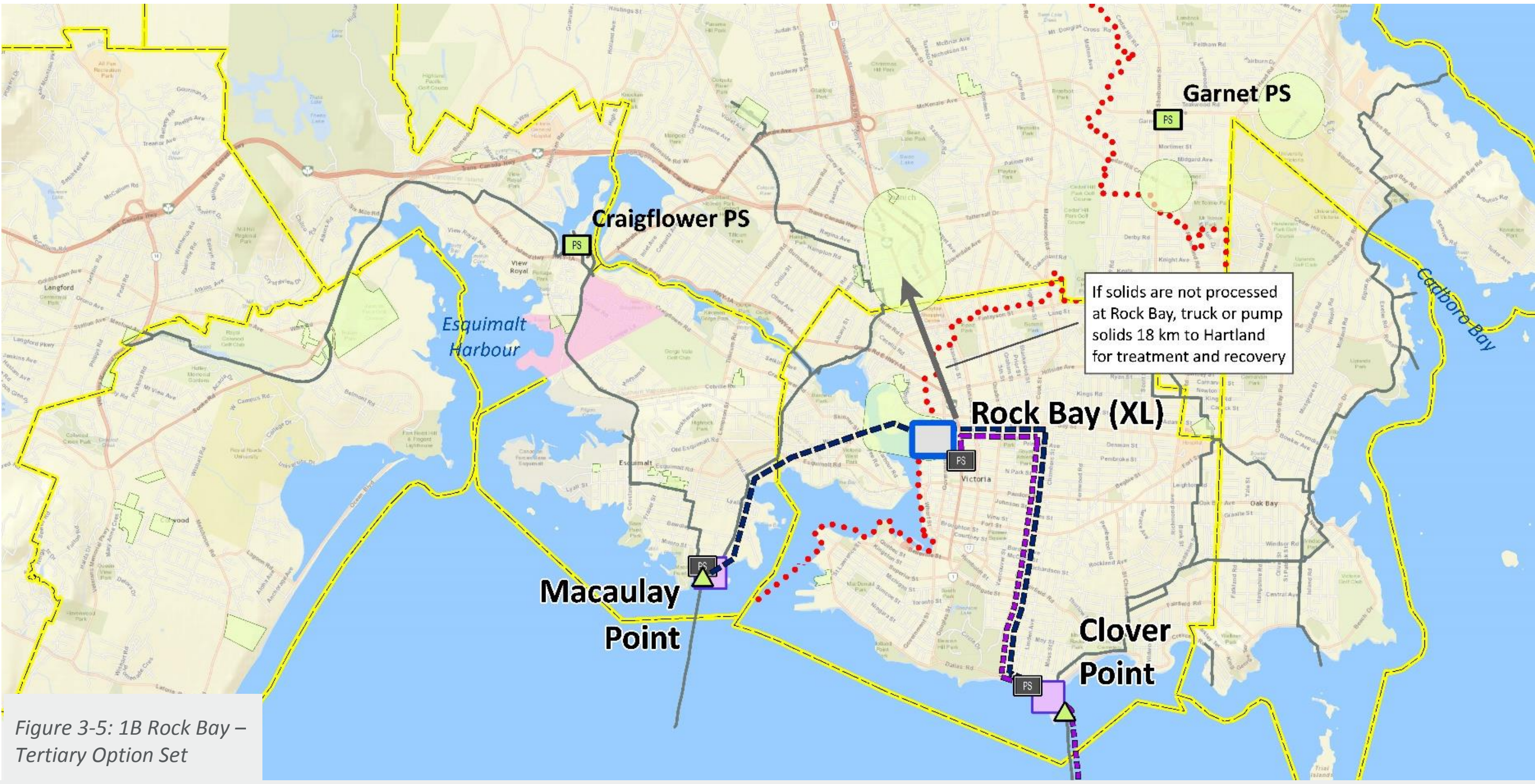


Figure 3-5: 1B Rock Bay – Tertiary Option Set

CRITERIA RESULTS >>

» Length of New Conveyance Pipe 16.7 km	» % of Effluent @ Tertiary Quality Up to 100%	» Rank: Low Carbon and Energy Footprint 3rd
» Rank: Low Operating Cost 6th	» Ratio of Income to Costs for Water Reuse 0.45	» Ratio of Income to Costs for Heat Recovery 0.60

Option Set Characterization

- *Neighborhood-Land Use: A central plant at Rock Bay appears to align the best of all locations given public sentiment to date. The industrial, mixed-use designation supports the site activities including and other routine treatment processes. Capital works at Rock Bay should consider local planning objectives and provide for positive public interaction.*
- *Overall: The 1 Plant full tertiary treatment (1b) option set centralizes all flows at Rock Bay, including up to 10MLD for local reuse. This option set represents a clear sentiment towards water stewardship by raising levels of service for treated effluent quality.*

Option set >>
2-Plant Rock Bay and Colwood

Description

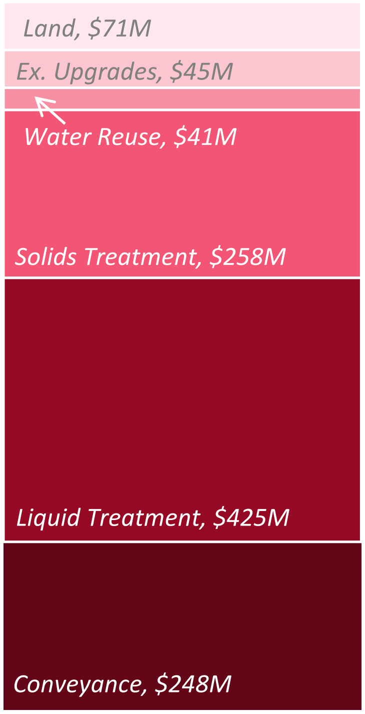
- Rock Bay provides secondary treatment for up to 100% of all flows but accounts for additional capacity at Colwood to treat up to 10MLD at tertiary quality. Sidestream tertiary provided at Rock Bay for local reuse.
- The Colwood plant requires minimal new conveyance infrastructure but requires redundant capacity at Rock Bay to avoid a second outfall. Reuse systems provided at both Rock Bay and Colwood.
- Solids-energy recovery can be centralized at Rock Bay or Hartland Landfill. Truck traffic is estimated at ~5-6 trucks per day in 2030. Waste solids from Colwood flow in the CRD sewer to Rock Bay.
- Flows from the rest of Macaulay catchment (except Colwood) are directed to Rock Bay for treatment. Any flows not reused are routed through the Clover Point outfall.
- Heat recovery systems possible in Colwood (e.g. civic recreational facilities) and adjacent to the treated effluent outfall route from Rock Bay to Clover point.
- Available sites are suitable from a technical perspective and align well with public input to date.
- Life cycle costs illustrate the effect of increased levels of service for tertiary reuse at Colwood.

Scenario	2030 Capital	2030 Operating	Est. Resource Income
2 Plant	$1,088 M	$22.8 M	Up to $2.4 M

Life Cycle Costing Analysis | Highlights

- A central plant at Rock plus tertiary plant in Colwood increases capital and operating costs for expanded water reuse; capital and operating costs both rank 2nd among the option sets
- Net present value for the 2 Plant option is approximately 4% higher than for Option 1a
- Resource incomes for the 2 plant option demonstrate the most cost-effective water reuse approach
- Sensitivity analysis related to discount rates did not change the relative financial performance of the 2 plant option

Total $1,088M



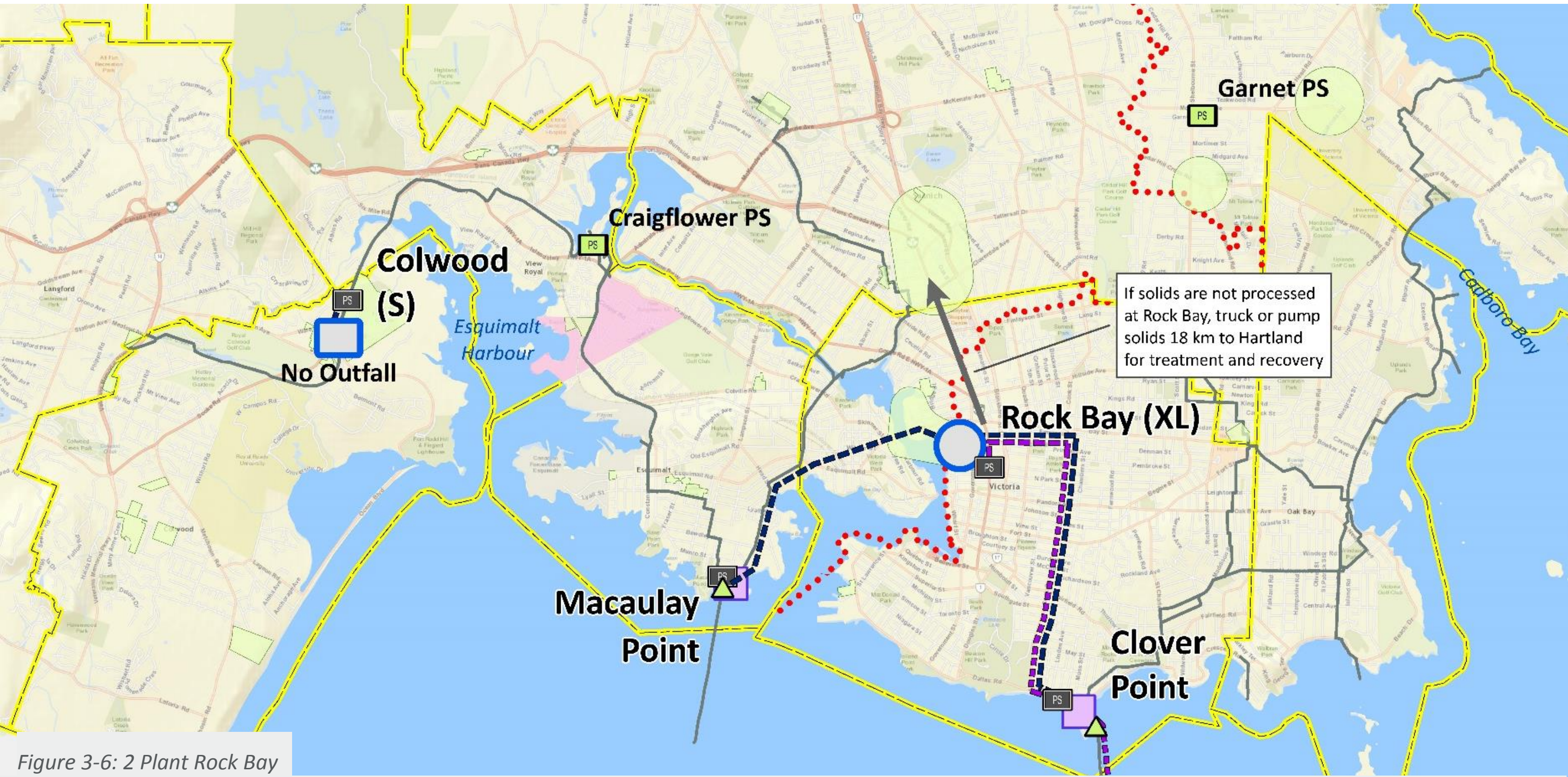


Figure 3-6: 2 Plant Rock Bay & Colwood Option Set

CRITERIA RESULTS >>

» Length of New Conveyance Pipe (incl. Colwood reuse) 36.2 km	» % Of Effluent @ Tertiary Quality Up to 20%	» Rank: Low Carbon and Energy Footprint 2nd
» Rank: Low Operating Cost 2nd	» Ratio of Income to Costs for Water Reuse 0.40	» Ratio of Income to Costs for Heat Recovery 0.60

Option Set Characterization

» *Neighborhood-Land Use: Rock Bay and Colwood are both situated in growth centers, one mixed-use and the other primarily industrial. Odour will be minimized to unnoticeable levels; noise and trucking will be mitigated and not dissimilar from local land uses. Both facilities should include features that align with local planning objectives and provide for public interaction with the facility and neighboring features e.g. harbourfront, local parks.*

» *Overall: The 2 Plant option set treats over 80% of flows to secondary levels, on top of up to 20% tertiary quality effluent. This option set represents a notable increase in water reuse from the 1-plant option with minimal extra conveyance infrastructure.*

OPTION SET >>

3 Plant - Secondary

Description

- Flows are collected, treated and recovered on a sub-regional basis. Flows from west Saanich and west Victoria are routed back to Rock Bay. Flows from View Royal and Esquimalt are conveyed to Esquimalt Nation, whereas flows from Colwood and Langford are dedicated to a second Westshore plant. All flows meet secondary levels, including disinfection, except for tertiary treated flows at Esquimalt and Rock Bay for reuse.
- Solids-energy recovery can be centralized at Rock Bay or Hartland Landfill. Truck traffic is estimated at 1-2 trucks per day for Colwood/Langford, 1-2 trucks for Esquimalt and 3-4 trucks for Rock Bay.
- Three separate flow catchments result from the 3 plants, including separate outfalls: Colwood/Langford direct to Royal Bay; View Royal/Esquimalt direct to Macaulay Point; Saanich/Victoria/Oak Bay direct to Clover Point. All flows meet or exceed the regulations.
- Three heat recovery systems can be considered around each of the plants as well as along the effluent lines to Clover, Macaulay and Royal Bay outfalls.
- Available site(s) are suitable from a technical perspective and align well with public input to date.
- Life cycle costs are reflective of losing economies of scale among three plants and by adding infrastructure for conveyance and outfall to Royal Bay.

Scenario	2030 Capital	2030 Operating	Est. Resource Income
3 Plant - Secondary	$1,125 M	$23.0 M	Up to $1.6 M

Life Cycle Costing Analysis | Highlights

- The 3 plant, secondary treatment option incurs greater costs than the 2-plant option and less than the 4-plant option; operations costs are comparable to the 2-plant option set
- Resource incomes are limited to Rock Bay and Esquimalt Nation sites; incomes are gradual arising from small-scale irrigation demands initially, with phased-in toilet flushing demands over 20+ years
- Sensitivity analysis related to resource incomes and discount rates had minimal effect on the net present value.

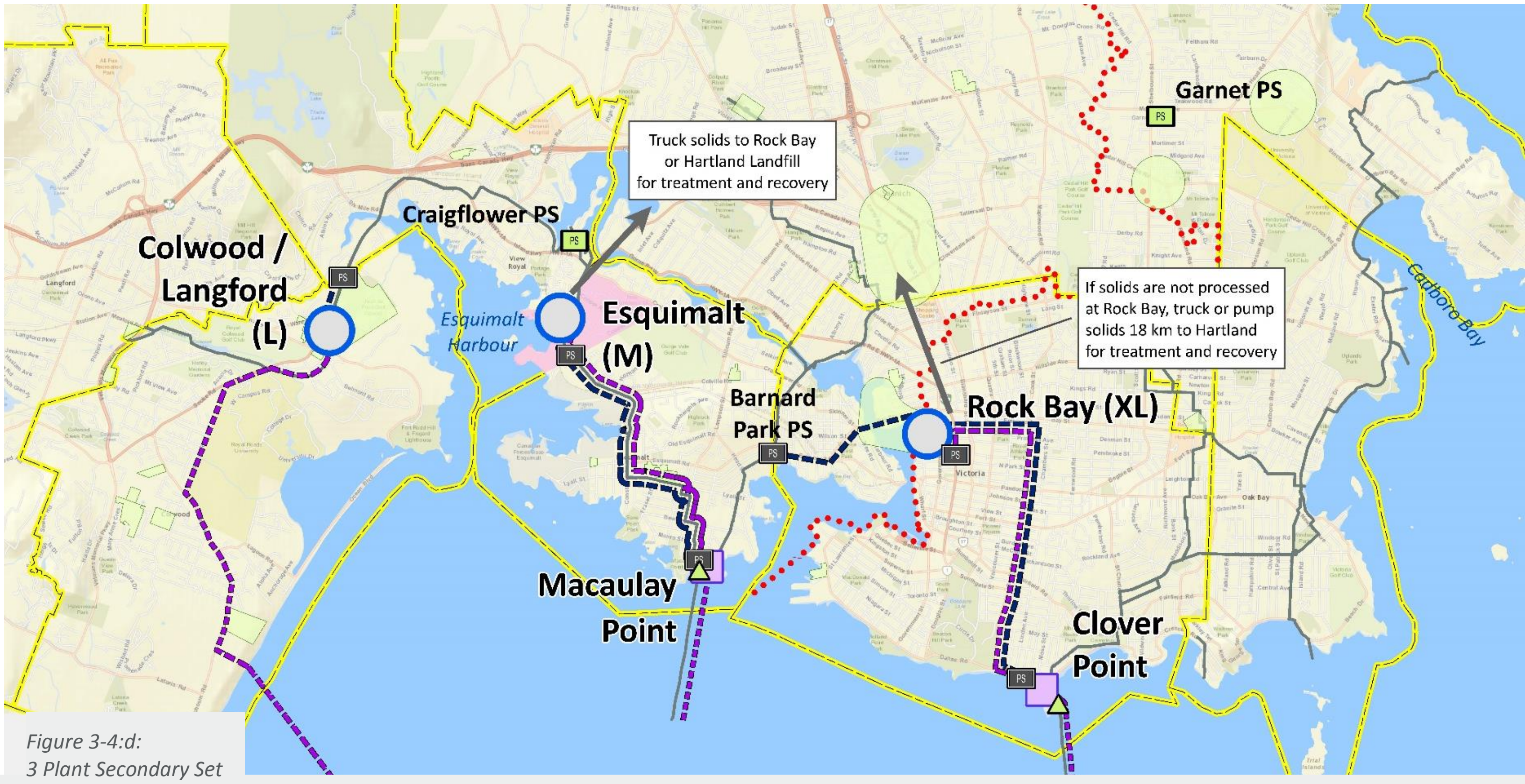


Figure 3-4:d:
3 Plant Secondary Set

CRITERIA RESULTS >>

» Length of New Conveyance Pipe

34.5 km

» % of Effluent @ Tertiary Quality

Up to 20%

» Rank: Low Carbon and Energy Footprint

4th

» Rank: Low Operating Costs

3rd

» Ratio of Income to Costs for Water Reuse

0.48

» Ratio of Income to Costs for Heat Recovery

0.60

Option Set Characterization

» *Neighborhood-Land Use: Rock Bay, Esquimalt Nation and Colwood/Langford are all situated in mixed-use, growth centers. Odour will be minimized to unnoticeable levels; noise and trucking will be mitigated and not dissimilar from local land uses. All facilities should include features that align with local planning objectives and provide for public interaction with the facility.*

» *Overall: This 3 Plant option set treats over 80% of flows to secondary levels, on top of up to 20% tertiary quality effluent from sidestream re-use facilities at Esquimalt and Rock Bay. The secondary plant at Colwood/Langford allows for sub-regional flow management, including locating capacity for future growth in the Westshore.*

OPTION SET >>

3 Plant - Tertiary

Description

- Flows are collected, treated and recovered on a sub-regional basis. Flows from west Saanich and west Victoria are routed back to Rock Bay. Flows from View Royal and Esquimalt are conveyed to Esquimalt Nation, whereas flows from Colwood and Langford are dedicated to a second Westshore plant which treats its flows to tertiary levels. All other flows (incl. at Esquimalt Nation and Rock Bay) meet secondary treatment levels, including disinfection, along with sidestream tertiary treated flows at Esquimalt and Rock Bay for local reuse.
- Solids-energy recovery can be centralized at Rock Bay or Hartland Landfill. Truck traffic is estimated at 1-2 trucks per day for Colwood/Langford, 1-2 trucks for Esquimalt and 3-4 trucks for Rock Bay.
- Three separate flow catchments result from the 3 plants, including separate outfalls: Colwood/Langford direct to Royal Bay; View Royal/Esquimalt direct to Macaulay Point; Saanich/Victoria/Oak Bay direct to Clover Point. All flows meet or exceed the regulations.
- Three heat recovery systems can be considered around each of the plants as well as along the effluent lines to Clover, Macaulay and Royal Bay outfalls.
- Available site(s) are suitable from a technical perspective and align well with public input to date.
- Life cycle costs are reflective of losing economies of scale among three plants, by increasing service levels to treat to tertiary (Colwood/Langford) and by adding infrastructure for conveyance and outfall to Royal Bay.

Scenario	2030 Capital	2030 Operating	Est. Resource Income
3 Plant – Tertiary	$1,178 M	$24.1 M	Up to $3.8 M

Total $1,178M

Life Cycle Costing Analysis | Highlights

- The 3 plant, secondary and tertiary option incurs greater costs than the 2-plant option and less than the 4-plant option; operations costs are greater than the 2-plant option set but less than the 4 plant option.
- Resource incomes can be generated by reuse systems at all 3 plants; incomes are gradual arising from small-scale irrigation demands initially, with phased-in toilet flushing demands over 20+ years
- Sensitivity analysis related to resource incomes and discount rates had minimal effect on the net present value.

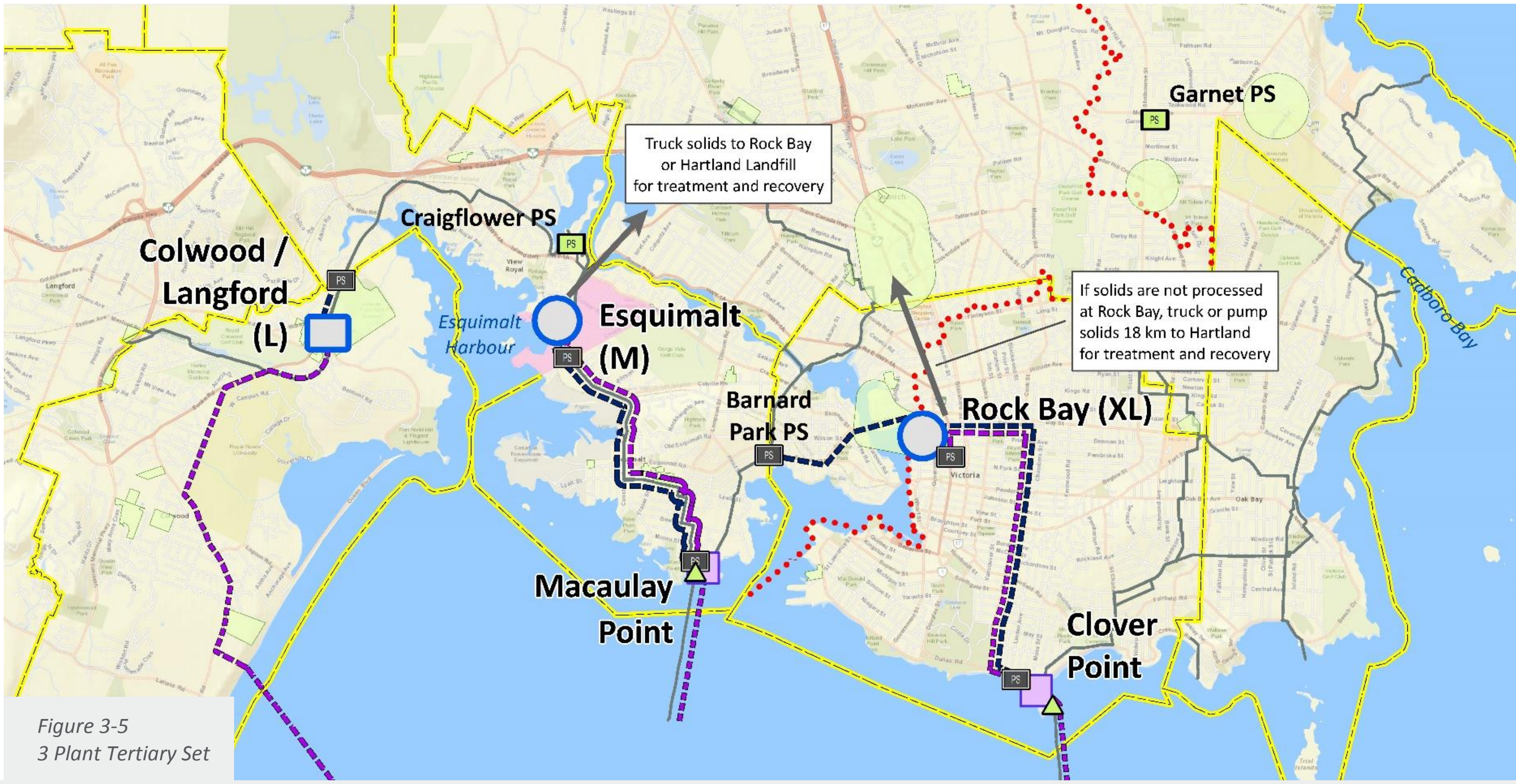


Figure 3-5
3 Plant Tertiary Set

CRITERIA RESULTS >>

» Length of New Conveyance Pipe (incl. Colwood Reuse) 66.8 km	» % of Effluent @ Tertiary Quality Up to 30%	» Rank: Low Carbon and Energy Footprint 6th
» Rank: Low Operating Costs 4th	» Ratio of Income to Costs for Water Reuse 0.50	» Ratio of Income to Costs for Heat Recovery 0.60

Option Set Characterization

- *Neighborhood-Land Use: Rock Bay, Esquimalt Nation and Colwood/Langford are all situated in mixed-use, growth centers. Odour will be minimized to unnoticeable levels; noise and trucking will be mitigated and not dissimilar from local land uses. All facilities should include features that align with local planning objectives and provide for public interaction with the facility.*
- *Overall: The 3 Plant Tertiary option set treats 70% of flows to secondary levels, on top of up to 30% tertiary quality effluent from the Colwood/Langford plant and sidestream re-use facilities at Esquimalt and Rock Bay. This option increases water reuse to three systems and raises effluent quality to levels similar to the 4 plant option, albeit at a lower overall cost.*

Option Set >>
4 Plant

Description

- Flows are collected, treated and recovered on a sub-regional basis. Flows from west Saanich and west Victoria are pumped to Rock Bay. Flows up to 4xADWF from the Westside are pumped from Macaulay back to Esquimalt Nation for secondary treatment (includes disinfection) plus sidestream tertiary for local reuse in both the Rock Bay and Esquimalt areas.
- The Colwood and East Saanich plants require minimal new conveyance infrastructure but require redundant capacity at Esquimalt Nation and Rock Bay (respectively) to avoid additional outfalls. Reuse systems are proposed for all four plants. The East Saanich facility may only be in use during the irrigation season (initially).
- Solids-energy recovery can be centralized at Rock Bay or Hartland Landfill. Truck traffic is estimated at ~5-6 trucks per day in 2030. Solids from Colwood are piped (uses regular collection trunk) to Esquimalt Nation where they are dewatered and combined for trucking to Rock Bay or Hartland.
- Any flows not reused by any of the four plants are routed through the Macaulay and Clover Point outfalls. All flows meet or exceed the regulations, including up to 25% reuse.
- Available sites are technically suitable to host a treatment facility.
- Life cycle costs are reflective of the infrastructure needs to accommodate sub-regional flows and increased treatment levels for reuse.

Scenario	2030 Capital	2030 Operating	Est. Resource Income
4 Plant	$1,195 M	$25.3 M	Up to $3.8 M

Total: $1,195 M

Life Cycle Costing Analysis | Highlights

- Two secondary plants plus an additional two tertiary facilities reflects the 3rd highest capital and 5th highest operating costs;
- Net present value for the 4 plant option is approximately 12% higher than for Option 1a
- Resource incomes for the four plant option are second highest and demonstrate the 2nd most cost-effective water reuse approach
- Sensitivity analysis related to discount rates did not change the relative financial performance

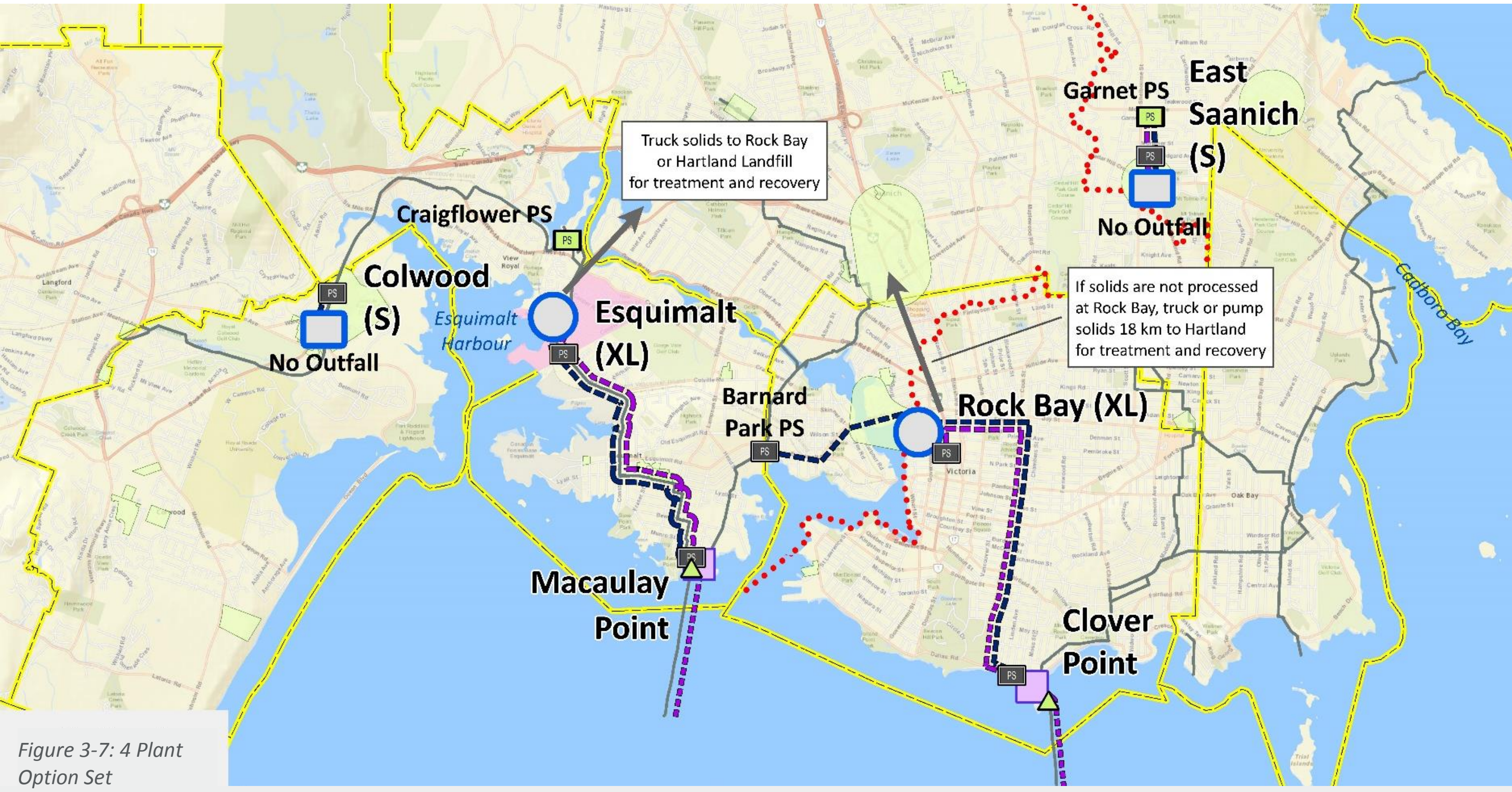


Figure 3-7: 4 Plant Option Set

CRITERIA RESULTS >>

» Length of New Conveyance Pipe (incl. Colwood reuse)

66.8 km

» % of Effluent @ Tertiary Quality

Up to 25%

» Rank: Low Carbon and Energy Footprint

5th

» Rank: Low Operating Cost

5th

» Ratio of Income to Costs for Water Reuse

0.39

» Ratio of Income to Costs for Heat Recovery

0.60

Option Set Characterization

» *Neighborhood-Land Use: Rock Bay, Esquimalt Nation and Colwood are all situated in mixed-use, growth centers. Odour will be minimized to unnoticeable levels; noise and trucking will be mitigated and not dissimilar from local land uses. Each facility should include features that align with local planning objectives and provide for public interaction with the facility and neighboring features e.g. harbor front.*

» *Overall: The 4 Plant option set is a sub-regional system treating over 75% of flows to secondary levels, on top of up to 25% tertiary quality effluent. This option set represents the middle ground for distributed facilities and includes water reuse systems in four major growth centers.*

Option set >>

7 Plant

Description

- Flows are collected, treated and recovered on a sub-regional basis. Flows from west Saanich are partly directed to the Core Saanich Plant, while remaining flows combine with west Victoria flows for pumping to Rock Bay. Westside flows for 0-2x ADWF are treated on a municipal-by-municipal basis with interconnecting piping systems for outfall at either Royal Bay or Macaulay point. Wet-weather flows for the Westside are accommodated at Esquimalt (Town) plant. Almost all flows for Eastside are treated at Rock Bay, except reuse tertiary treatment at East Saanich and Core Saanich.
- The Core Saanich and East Saanich plants require minimal new conveyance infrastructure but require redundant capacity at Rock Bay to avoid additional outfalls.
- Solids-energy recovery can be centralized at Rock Bay or Hartland Landfill. Truck traffic is estimated at 1-2 trucks per day for Colwood and Langford, and ~1-2 trucks per day for Esquimalt in 2030, with solids heading to either Rock Bay or Hartland Landfill. Solids at East Saanich and Core Saanich are piped through existing sewers to Rock Bay.
- Any flows not reused by any of the seven plants are routed through the Macaulay, Clover Point or Royal Bay outfalls. All flows meet or exceed the regulations.
- Available sites are technically suitable to host a treatment facility.
- Life cycle costs are reflective of the infrastructure and capacity needs to treat flows to higher levels of service for the Westside as well as the costs related to additional conveyance, outfalls and water reuse systems.

Scenario	2030 Capital	2030 Operating	Est. Resource Income
7 Plant	$1,348 M	$26.6 M	Up to $4 M

Life Cycle Costing Analysis | Highlights

- 6 tertiary treatment plants coupled with a large secondary treatment plant at Rock Bay reflect the highest capital and operating costs
- Net present value for the 7 plant option is approximately 25% higher than for Option 1a
- Resource incomes are only slightly higher than the 4 plant due to lack of demand relative to supply;
- Sensitivity analysis related to discount rates did not change the relative financial performance

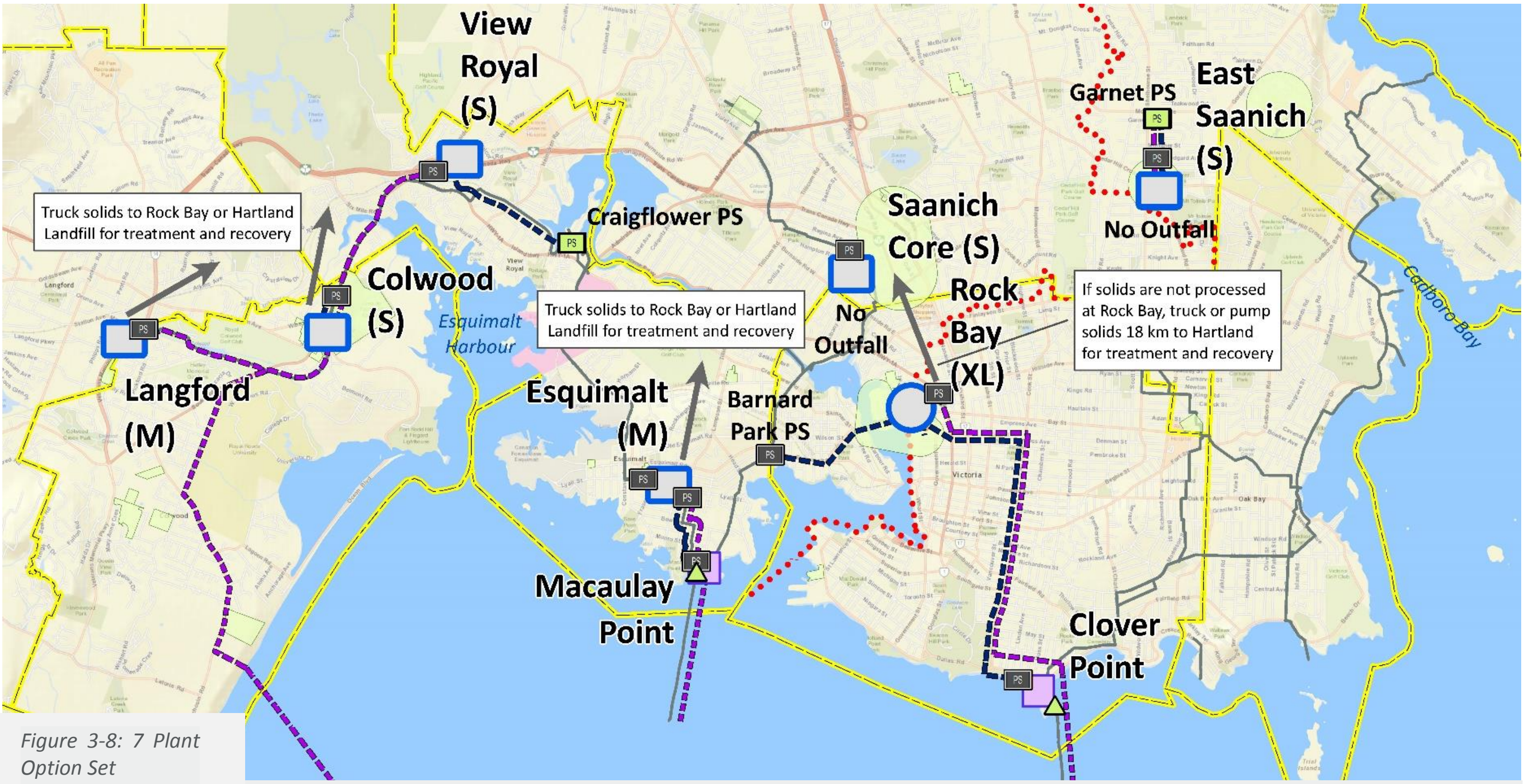


Figure 3-8: 7 Plant Option Set

CRITERIA RESULTS »

» Length of New Conveyance Pipe **86.7 km**	» % of Effluent @ Tertiary Quality **Up to 45%**	» Rank: Low Carbon and Energy Footprint **7th**
» Rank: Low Operating Cost **7th**	» Ratio of Income to Costs for Water Reuse **0.35**	» Ratio of Income to Costs for Heat Recovery **0.55**

Option Set Characterization

- *Neighborhood-Land Use: Rock Bay, Esquimalt Nation and Colwood are all situated in mixed-use, growth centers. Odour will be minimized to unnoticeable levels; noise and trucking will be mitigated and not dissimilar from local land uses. All facilities should include features that align with local planning objectives and provide for public interaction include contribute to local building form.*
- *Overall: The 7 Plant option set is a sub-regional system treating less than 60% of flows to secondary levels, on top of up to 45% tertiary quality effluent (including all flows on the Westside). This option set represents a fully distributed system which maximizes the potential for water reuse and situates facilities in 7 growth areas.*

4.8 Criteria Results: Remaining Focus Areas

Technical criteria stemming from the Project Charter frame the overall performance characteristics of each option set. Sections 3 and 4 of this memo have covered performance results of most of the technical criteria, except for the criteria outlined in Table 4.1. Performance considerations and results illustrate the application of the criteria to the seven option sets and solids-energy technologies.

Table 4-1: Criteria Considerations and Results

Criteria	Performance Considerations	Result
Certainty of long-term demands and revenues (resource recovery)	*Heat recovery and water reuse customers likely to emerge over time based on need (for water) and energy pricing + new development (for heat)*	*Option set 1a and 2 demonstrate the highest income: cost ratios and likely warrant greatest attention*
Extent of support for community building	*Facilities that suit local land use and enhance the existing site use present the highest performance*	*All option sets include sites in growth nodes or industrial-commercial centers allowing for public investment to enhance community building; sites in Esquimalt (Town) and Core Saanich may pose slightly lower performance (Option Set 7) because these are located in parks;*
Ability to produce high-quality air-emissions	*Very little air quality concerns arise from liquid treatment (aside from odours and all option sets include provision of extensive odour control equipment) however emissions for solids-energy recovery are indicative of option set performance*	*Unlike anaerobic digestion, gasification facilities must undergo air quality permitting (Ministry of Environment), however, gasification can lead to reduced carbon emissions via integration with solid wastes which likely outweighs the air quality concerns*
Ability to improve effluent quality over the life of facility	*Changing regulations or environmental conditions may warrant increased levels of treatment; treatment technologies in the representative design allow for additional processes as required*	*This criterion is likely best suited to evaluating private sector proposals for meeting the performance criteria of the LWMP*
Extent to provide for positive public interaction	*Modern wastewater facilities should be designed and operated to suit local aspirations*	*This criterion is likely best suited to evaluating private sector proposals for meeting the performance criteria of the LWMP; public input can inform local objectives for public interaction*

Criteria	Performance Considerations	Result
Reduction of risk/interruption to neighborhoods from facility failure	*Wastewater facilities can experience unplanned maintenance; while typically rare, consideration should be given to the consequences of these events*	*Option set 1a/1b and perhaps 4 plant demonstrate lower interruption risks; Sites in industrial areas likely pose least risk; anaerobic digestion is considered a reliable technology; there are a very limited examples of gasifiers of wastewater solids and reliability-performance is not well known.* *Option set 1a/1b and 2 provide for lowest trucking configurations in particular if solids are pumped and processed at Hartland Landfill.*
Site/design resiliency for seismic and sea level rise	*Reliable, ongoing operation of wastewater facilities post-disaster provides for public health and environmental protection*	*Seismic risks exist throughout the Core Area and no site is unexposed; sea level rise and resiliency at Rock Bay and Esquimalt Nation can be accommodated with site grading and strategic equipment placement.*

4.9 Future Feasibility Considerations

Phase 2 analyses, including results presented in Technical Memorandum #3, outlines the financial and engineering feasibility of the seven proposed option sets. Preferred option set(s) will require additional engineering analysis typical of preliminary design phases, including:

- Pipe route optimization
- The cost benefit of phosphorous and nitrogen removal (treatment) and recovery if a harbour outfall is pursued
- Site specific land improvement costs such as rock, dewatering, seismic design and other geotechnical considerations
- Procurement strategy
- Further refining of unit processes and technology preferences
- Site area and building footprint optimization
- Architectural requirements and off site development
- Further capital cost estimating

Considerations like these are best studied and refined in subsequent design exercises once a preferred option has been selected.

APPENDIX A – TECHNICAL MEMORANDUM #1 (EXCERPT)

Capital Regional District

Core Area Liquid Waste Management Plan

Wastewater Treatment System Feasibility and Costing Analysis

Technical Memorandum #1

Background and Technical Foundation

Engineers...Working Wonders With Water™

October 22, 2015

Project: 1692.0037.01

402 – 645 Fort Street
Victoria, BC, V8W 1G2

urbansystems.ca

Table of Contents

Appendices

1.0 Introduction and Methodology

1.1 Project Background

Phase 2 analysis is an important chapter in an ongoing decision making process. Phase 1 included a constructive engagement process to characterize sites and option sets and collect public input on their values for wastewater treatment. Future phases, Phase 3 and beyond, allow the Core Area Committee and the Regional Board to confirm detailed performance criteria that ultimately becomes an owners' statement of requirements, or similar, for responses by the treatment and resource recovery market(s) to price, build and commission and potentially operate a core area wastewater solution. It is critical that the Phase 2 methodology respect the multi-phase sequence of this project and deliver on specified milestones, such as to assess systems and technologies, however not to select ultimate products and or technologies but rather to help the Core Area Committee define the required characteristics of the future system and provide a characterization of the option sets. All option sets may proceed to Phase 3 or it may become apparent that a subset of the option sets achieve the desired objectives and move forward to subsequent phases. Overall, the three phase analysis is summarized below.

Process Summary	
Phase 1:	Identify Sites and Option Sets and Collect Public Input on Values
Phase 2:	Confirm Performance Criteria and Characterize Financial/Environmental/Social Aspects of Option Sets
Phase 3+:	Finalize/Narrow Options, Determine Preferred Method to Engage with Private Sector, Confirm Funding Approach, Amend LWMP, Select Partners, Deliver Project(s), Operate Systems

.

In effect, Phase 2 technical and costing analysis includes assessments and calculations that enable preliminary performance criteria to be tested and refined. The results of the process and analysis will enable the Committee to decide and direct on future performance criteria and infrastructure siting locations based in part on industry best practice, regional context and long-term service delivery excellence. Phase 2 significantly advances the Committee to confirming its requirements for a Core Area wastewater solution and serves to screen the options based on project criteria.

A process for establishing performance criteria typically involves key ingredients as outlined below.

- **Preliminary Design Criteria:** A project charter frames the project and provides guidance for analysis and outcomes. Preliminary criteria should be derived from the charter goals and commitments and later, the criteria can instruct the engineering and costing analysis.
- **Representative Design:** Employing the preliminary design criteria against technical options and technologies begins to frame up the market possibilities (e.g. technologies, resource recovery pathways, pipe alignments, etc.) for a Core Area system. Representative design includes provisionally selecting technologies and system configurations to characterize the relative value of available options and encourage deeper dialogue on the particulars of any commissioned facilities. While analysis and reporting will refer to specific solutions these are

not recommended outcomes; instead, the results of the representative design allow the criteria to come to life for a deeper understanding including life-cycle costing.

- **Life-Cycle Costing:** Potential ratepayer impacts based on proposed levels of service are crucial to performance criteria. Each option set will be assessed using capital, operating and revenue characteristics which will uncover the trade-offs in Core Area alternatives and likely lead to further iterations in future phases. For Phase 2, these costs are Class D only for the purpose of comparing options with significant contingencies due to the nature of the unknowns.
- **Presentation of Alternatives:** Option sets analysis will convey the ability of multiple solutions to meet the criteria and aspirations of the Core Area. While no single alternative will be able to fully address the criteria, it is the presentation of the alternatives and the ensuing debate that will help to clarify the refined set of technical criteria.
- **Refined Criteria:** Final reporting will center on the evolution and rationale for the stated, refined technical criteria. Future phases will test these criteria further so as to confirm the Committee's final statement of requirements (for one or more contracts) for responses by the wastewater treatment and resource recovery market.

Our work plan and methodology follow these ingredients explicitly. We endeavour to translate the project charter into preliminary design criteria, undertake technical analysis and present alternatives so as to provide information for direction by the Committee on their refined performance criteria. Technology and option set evaluations are provisional for deeper understanding of the criteria.

1.2 Preliminary Criteria

There is a need to focus the broad range of treatment and engineering solutions to arrive at a representative design that can be used to develop Class D life-cycle financial scenarios. While private sector submissions will help to finalize the ultimate system design based on prescribed owner's requirements, establishing criteria based on the Project Charter will guide representative design parameters. These parameters will become a key step in setting performance criteria for the project and ultimately guide the technical analysis through Fall 2015 to support Committee direction on preferred system configurations and outcomes.

These criteria are preliminary but suitable for carrying out Phase 2 and stem from the Committee's Charter. Input from the Technical Oversight Panel and direction by the Committee will enhance these criteria and ensure that design parameters align with Core Area expectations and public input to date. Criteria are used to assess alternatives and arrive at potential options that suit the multiple needs and goals of the project. The Charter's Goals and Commitments (left column) frame the criteria.

The preliminary criteria outlined in this Technical Memo provide the basis for detailed technical criteria to develop a representative design and also allow for a comprehensive presentation of the option sets toward the end of Phase 2. Direction from the Committee in December 2015 will allow the CRD to take further steps to refine the performance criteria for a market response to a Core Area solution.

Technical Memorandum #2 will apply the initial steps of our methodology and the preliminary criteria against the defined option sets for further analysis. Additional feedback from the Technical Oversight Panel and ultimately, direction by the Committee, will finalize the option set analysis through Fall 2015.

1.3 Proposed Option Sets Evaluation: Considerations for Decision Making

Phase 2 feasibility and technical analysis provides for an evaluation of 4 option sets across the Core Area. Each option set includes different extents of infrastructure, facilities, services, risks and operations. Life-cycle costing is a core element of the option set evaluation.

Committee direction from June 2015 centers on life-cycle costing analysis which includes design and construction contingencies, administration costs, escalation, inflation, environmental costs as well as capital, operating and maintenance costs. This type of analysis is consistent with comparisons of major capital projects to screen options and further, supports staff and consultants in determining potential allocations per municipality.

In addition to financial analysis, each option set will be further assessed based on its performance against the preliminary criteria stemming from the Charter and from public values from previous phases. While the assessment will be primarily qualitative in nature, the characterization of social benefits, environmental values, risks and service governance will be supportive for Committee direction. Neither the financial analysis nor the qualitative assessment are enough on their own to confirm direction, but instead, it’s the balance of needs and aspirations reflected across the entire suite of criteria from which reasonable direction can be made.

1.4 Option Set Evaluation Methodology

Evaluating option sets is led by the Project Goals and Commitments and the established technical criteria. Whether centralized or distributed, it is the ability of any one option set to best meet the goals of the project that warrants even further optimization by the Committee in future phases. Designing the option sets must consider the evaluation method, hence why both methods are included.

Option Set Design Consideration

- Confirm flows by catchment area and site node.
- Inventory supply and demand projections for water and heat recovery reuse across site nodes in the Core Area. Locate potential customers and define their product needs including barriers and pricing considerations.
- Locate treatment facilities (liquids and or solids) among available sites with consideration to existing infrastructure, land uses, road access and synergies with neighboring site nodes.

- Apply regulatory requirements and overlay with existing infrastructure to meet reliability needs without excess infrastructure.
- Develop conceptual resource recovery infrastructure systems to convey resources to their demands. Look for synergies with neighboring site nodes to reduce unnecessary infrastructure.
- Incorporate various processes and technologies to meet the resource recovery, regulatory and neighborhood considerations. Each option set should look to address a different level of service (in line with the criteria) to allow for lateral comparison of all option sets.
- Optimize resource recovery infrastructure to suit the supply demand balance e.g. focus toward the size of treatment facility to suit actual reuse needs and look for phasing to support growth.
- Confirm regulatory and risk-management needs including ultimate disposal of water as required. Confirm limitations and service governance considerations for implementation and operation.
- Iterate design considerations for 2030 and 2045 scenarios.

Evaluation

- Summarize the technical and engineering elements and characterize their relative levels of service.
- Create aggregate resource recovery summary (qualitative and quantitative) for comparative and communication purposes including overall benefits to community, climate change considerations, others.
- Inventory life-cycle costing elements including construction, operation, maintenance and revenues.
- Present life-cycle costing results including sensitivity analysis for various risk, revenue and contingency factors.
- Characterize operations and service governance needs, risk considerations, preliminary economic factors (e.g. supply and demand, pricing), qualitative elements such as social-benefits stemming from the ability to deliver on community aspirations such as water reuse, advanced treatment and other returns on investment that aren't readily quantifiable.
- Assess distributed option sets against technical criteria (Section 1.2).
- Discuss option sets against all project goals of the Charter.
- Reflect on criteria, project goals, and financial results and develop balanced scorecard approach to presenting the option sets.
- Consider recommendations for Committee consideration which may include further refinements of the option sets to best suit the needs of the Core Area.

Technical Memorandum #2 will provide extensive inventories of the option set designs whereas Technical Memorandum #3 will present the evaluation of each option set.

2.0 Design Criteria

2.1 Design Horizon

Most of the work undertaken to date targets meeting the population/flow requirements to the year 2030, with preliminary consideration to flows in 2045 and 2065. These design horizons are consistent with funding applications and businesses cases and therefore could be adopted for Phase 2. Phase 2 feasibility and technical analysis will address infrastructure and life cycle costing for both the 2030 and 2045 design years.

2.2 Design Populations

Previous phases of analysis researched and collated residential populations in each of the seven (7) municipalities and two (2) First Nations, as well as developed equivalent populations for the industrial, commercial and institutional sectors within each area. Population and flow projections are a considerable resource for Phase 2 and we propose to utilize available information following a preliminary screening on their suitability at this time.

Growth rates have been estimated a low rate (at 1.3%/year) and a high rate (at 2.1%/year). Aggregate populations provide a scale of growth for the Core Area however Phase 2 design and analysis will consider municipal by municipal growth to account for locally-specific design capacities. Overall, growth rates to 2030 and 2045 are tabulated below and include population equivalent contributions from industrial, commercial, and institutional sources

	@ 1.3%/year growth	@ 2.1%/year growth
Core Area Population (eq.) 2030	436,000	494,000
Core Area Population (eq.) 2045	570,000 (1)	669,000

(1) Derived from Discussion Paper 033-DP-1

Actual flow projections are based on municipal expectations as communicated to the CRD which are outlined in the following section.

2.3 Flows

Table 2.3.1 summarizes the design flows for 2030 and 2045. While there are nuances and potential discrepancies for flow estimates, Table 2.3.1 appears to reflect the most current CRD estimates with general agreement by the municipalities. We intend to move forward for Phase 2 relying upon the flow estimates in column 1, which we note are different than the flow estimates as provided by the Westside Technical Committee.

The flows noted are based on average dry weather flows (ADWF which aligns directly with the regulatory requirements of the Municipal Wastewater Regulation, as outlined in Section 2.5.1.

Recent direction from the Westside Select Committee is that engineering analysis for Westside Option Sets should account for the flows from west Saanich and west Victoria currently destined for the Macaulay outfall. Flows from the Eastside that travel to the Macaulay outfall are represented in Table 2.3.1.

To account for ongoing water conservation programs and demand management initiatives, the projected per capita flow rates decrease around the Core area from 225 to 250 litres per capita per day now to 195 in 2030 and 2045. Flows are presented in megaliters per day (MLD) which is a summation of the population equivalents per catchment area based on the per capita estimates.

Table 2.3.1 - Core Area 2030 and 2045 Design Flow Allocations

Location		ADWF (MLD)		
		2030 (1)	2030 (2)	2045 (3)
A.	**Clover Outfall**			
	- Oak Bay	6.6	-	6.6
	- East Saanich	9.2	-	12.8
	- East Victoria	31.9	-	34.0
	Sub-Total	**47.7**	**-**	**53.4**
B.	**Macaulay Outfall**			
	- Langford	14.1	14.1	23.1
	- Colwood	4.7	4.7	13.1
	- View Royal	3.5	3.5	7.9
	- Esquimalt First Nation	0.3	0.7	0.4
	- Songhees First Nation	0.4	0.7	0.5
	- Esquimalt	7.1	6.2	7.9
	- West Victoria	6.4	1.0	6.8
	- West Saanich	23.7	16.5	32.9
	Sub-Total	**60.2**	**47.4**	**92.6**
	Totals	**107.9**		**146.0**

(1) Core Area LWMP Committee Presentation by CRD Staff, October 14, 2015

(2) Flows assumed by Westside

(3) Derived from CRD 2030 projections (first column). Refer to Appendix A for derivations

2.4 Influent Wastewater Quality and Loads

The CRD collects 24 hour composite samples and tests the influent effluent for numerous parameters. A summary of the 2014 data is included in Appendix B. The most relevant influent sewage concentration data from 2014 are summarized in Table 2.4.1. This data is consistent with historical reports prepared for the Core Area LWMP, the latest being the January 23, 2013 Technical Memo "Indicative/Detailed Design/Wastewater Characterization and Design Loads". Table 2.4.1 also includes a summary of the 2030 maximum month loads, which are used to size the biological components of the plants. To account for flow and load variability, design factors account for the maximum load that the facility will experience in any 30 consecutive days which typically represents the 92 percentile of the data set analyzed for 2014. The proposed flow-load variability factor is set at 1.25 times the average loading.

Table 2.4.1 – Average Influent Quality Concentrations and Maximum Month Loads for 2030 Flows (1)

Parameter	Macaulay		Clover	
	Average (mg/L)	Max Month (kg/d)	Average (mg/L)	Max Month (kg/d)
Carbonaceous BOD_5	226	17,010	192	11,450
Total BOD_5	275	20,700	238	14,190
Total Suspended Solids	270	20,320	238	14,190
Chemical Oxygen Demand (COD)	632	47,560	530	31,600
Ammonia	42	3,160	27	1,610
Alkalinity	217	16,330	168	10,020
Total Kjeldal Nitrogen	54	4,060	40	2,385

(1) Note influent pH ranges from 7.3 to 7.7 typically

2.5 Liquid Effluent Criteria

2.5.1 Introduction

Two regulations currently govern effluent discharges in BC – The Federal Wastewater Systems Effluent Regulation (WSER) and the BC Municipal Wastewater Regulation (MWR). The WSER deals only with discharges to surface waters and has marginally different criteria than the MWR. The MWR addresses discharges to surface water, ground, wet weather flows and for reclaimed water. Both provincial and federal governments intend to harmonize the regulations which will affect the effluent criteria.

There is a strong sentiment within the Core Area to reuse reclaimed water as much as possible. To facilitate this sentiment, it is proposed that effluent destined for reuse meet the *Greater Exposure Potential Category* for reclaimed water as defined in the BC Municipal Wastewater Regulation. This level of quality is similar to the requirements of the Canadian Guidelines for Domestic Reclaimed Water for Use in Toilet and Urinal Flushing and the California Title 22 Regulation and would permit all reclaimed uses except indirect and direct potable reuse applications. It is our understanding that this would also be acceptable for aquifer recharge based on work currently being undertaken by the City of Colwood. If the CRD was to limit the reuse to irrigation on restricted public access sites only, then the standard of effluent quality could be reduced to *Moderate Exposure Potential Category* which is basically equivalent to secondary treatment as defined in Section 2.5.4. Also, secondary treatment is suitable for discharge to most marine environments but the outfall depth must be positioned at 30 m or more which effectively rules out any discharge to the inner harbour.

Stream augmentation is cited in the regulations whereby treatment must be greater than secondary (tertiary) with effluent criteria to suit the receiving environment. However, MWR requires an alternate disposal or storage for reclaimed water (stream augmentation or reuse) as follows:

"Alternate Disposal or Storage

114 (1) A person must not provide or use reclaimed water unless all of the following requirements are met:

(a) There is an alternate method of disposing of the reclaimed water that meets the requirements of this regulation or is authorized by a director.

(b) Treatment processes are built with the minimum number of components specified in the applicable reliability category for the alternate method of disposal, as described in section 35 *[general component and reliability requirements]*;

(c) If there is no immediate means of conveyance of the municipal effluent or reclaimed water to the alternate disposal method, the wastewater facility has 48 hours' emergency storage outside the treatment system.

(2) Despite subsection (1) (a), a director may waive the requirement for an alternate method of disposal for reclaimed water that is not generated from residential development or institutional settings if an alternate method is not required to protect public health or the receiving environment and the wastewater facility has

(a) 48 hours' emergency storage outside the treatment system and the ability to shut down generation of municipal wastewater within 24 hours, or

(b) A dedicated storage system that is designed to accommodate:

i. At least 20 days of design average daily municipal effluent flow at any time,

ii. The maximum anticipated volume of surplus reclaimed water, and

iii. Storm or snowmelt events with a less than 5-year return period.

(3) Despite subsections (1) (a) and (2), if reclaimed water is discharged from a wastewater facility directly into a wetland, a director may waive the requirement for an alternate method of disposal if an alternate method of disposal is not required to protect public health or the receiving environment.

Failure to meet municipal effluent quality requirements

115 (1) If municipal effluent does not meet municipal effluent quality requirements, a provider of reclaimed water must ensure that the municipal effluent is diverted immediately to

(a) An alternate method of disposal, as provided for in section 114 (1) (a) *[alternate disposal or storage]*, or

(b) Emergency storage or a dedicated storage system, as described in section 115 (1) (c) or (2),

Until municipal effluent quality requirements are met and reclaimed water uses may continue.**"**

These regulatory requirements strongly suggest that an alternate ocean outfall is required if stream augmentation is pursued.

A discharge to a wetland may be possible without requiring an alternate method of disposal, but this would require a specific environmental impact study and a waiver from the Director of the Ministry of Environment. A discharge to a wetland has not been considered in our analyses at this time however may be considered at the direction of the Committee.

The MWR and previous liquid waste management plan amendments further regulate the quality of effluent with respect to wet weather flows, as tabulated below:

Effluent Criteria	Macaulay Outfall	Clover Outfall
Secondary	0 – 2 x ADWF	0 – 2 x ADWF
Primary	2 – 4 x ADWF	2 – 3 x ADWF
Screening (6 mm Ø)	> 4 x ADWF	> 3 x ADWF

ADWF = Average Dry Weather Flow

2.5.2 Ammonia and Toxicity

Ammonia and toxicity in wastewater effluent is a complicated topic which is discussed in detail in Appendix C. In summary, the Federal and BC governments have criteria that regulate the amount of ammonia in the effluent, in particular to the un-ionized ammonia concentrations. Our research and analysis concludes (Appendix C) that it is not necessary to reduce ammonia in the wastewater treatment plants to comply with both the federal and provincial regulations before discharging out the Clover and Macaulay outfalls. Enhanced treatment would be required however for any option that contemplates stream augmentation and/or wetland discharges.

2.5.3 Primary Liquid Effluent

The MWR requires primary effluent to meet:

$CBOD_5$ ≤ 130 mg/L

TSS ≤ 130 mg/L

2.5.4 Secondary Liquid Effluent plus Disinfection

Ocean outfall effluent criteria should best address both the federal and provincial regulations, as proposed in the table below, and based on the requirement of outfall diffusers at a minimum depth of 30 m below the surface.

Parameter	Units	Average Concentration	Maximum Concentration
$CBOD_5$	mg/L	≤ 25	≤ 45
TSS	mg/L	≤ 25	≤ 45
Un-ionized Ammonia in Effluent	mg/L	NA	≤ 1.25 (1)
Un-Ionized Ammonia at End of Dilution Zone	mg/L	NA	≤ 0.016 (1)
Total Residual Chlorine	mg/L	NA	≤ 0.02
Faecal Coliforms	cfu/100 mL	NA	≤ 200 (2)

(1) Only one of these parameters need to be met.

(2) It is our understanding that disinfection will be required. This is the standard concentration for discharge to recreational waters.

The frequency of testing and the averaging period is dependent on flow rates as shown below for continuous flow systems.

Flow Range	Testing Frequency	Averaging Period
≤ 2,500 m^3/d	Monthly	Quarterly
> 2,500 but ≤ 17,500 m^3/d	Every 2 Weeks	Quarterly
> 17,500 but ≤ 50,000 m^3/d	Weekly	Monthly
> 50,000 m^3/d	3 Days/Week	Monthly

2.5.5 Enhanced Tertiary Liquid Effluent

In order to provide the ability for reuse we have identified enhanced tertiary treatment targets.

The proposed enhanced tertiary level of treatment is designed to satisfy most reclaimed water applications in the *Greater Exposure Potential* category as defined in the Municipal Wastewater Regulation. Colwood has noted that the BC MoE has confirmed that Indirect Potable Reuse effluent is necessary for aquifer recharge in Colwood, as noted below:

Parameter	Greater Exposure Potential	Indirect Potable Reuse	Monitoring Requirements
pH	6.5 to 9	6.5 to 9	Weekly
$CBOD_5$	$\leq$ 10 mg/L	$\leq$ 5 mg/L	Weekly
TSS	$\leq$ 10 mg/L	$\leq$ 5 mg/L	Weekly
Turbidity	Average 2 NTU Maximum 5 NTU	Maximum 1 NTU	Continuous Monitoring
Faecal Coliform (1)	Median 1 cfu/100 mL Maximum 14 cfu/100 mL	Median 1 cfu/100 ml	Daily

(1) Median is based on the last 5 results.

2.5.6 Emerging Contaminants

In the terms of reference for Phase 2 the base case treatment standard is secondary treatment with advanced oxidation. Advanced oxidation is a chemical treatment process designed to remove organic and sometimes inorganic matter in waste water by oxidation with hydroxyl radicals. Practically in wastewater treatment this is achieved through the use of ozone, hydrogen peroxide and/or ultraviolet light.

Unfortunately, we have not been able to determine what parameters and effluent criteria this system was intended to meet. There are in the order of 1,700 pharmaceuticals and personal care products (PPCPs) alone. At the present time, there are no published standards in Canada for the discharge of emerging contaminants to marine waters. The CRD has prepared a fact sheet on emerging contaminants which can be found in Appendix D. From this fact sheet it is interesting to note the data collected by the CRD on their Ganges MBR plant and Saanich Peninsula secondary plant (conventional activated sludge) for removal efficiencies. Approximately 80% of the contaminants (211 of 266) had removal efficiencies > 90% for the MBR plant. Approximately 45% of the monitored contaminants (145 of 324) had removal efficiencies > 90% for the activated sludge plant.

Urban Systems and Carollo Engineers are of the opinion that treatment targets for emerging contaminants be approached in the following manner:

- That treatment processes and technologies for emerging contaminants be assessed in the future once effluent criteria for emerging contaminants of concern have been identified by the regulators; thorough analysis of options can be conducted for the addition of further treatment works at that time;
- That further monitoring and research be conducted in the early years of operation of the new Core Area system to assess the level of reduction of emerging contaminants already occurring in the effluent; and
- That future proposals by market proponents indicate the level of reduction of emerging contaminants in their proposed system and that proposals are evaluated, in part, by the level of reduction achieved.

Space could be left in the plant(s) if it was desired for emerging contaminant treatment in the future once the specific effluent criteria are known.

2.5.7 Liquid Treatment Summary

In summary it has been assumed for the remainder of Phase 2 that secondary treatment plus disinfection will be provided for all ocean discharges up to 2x ADWF with primary treatment to 3 x at the Clover Outfall and 4 x ADWF at the Macaulay Outfall and any other new outfalls. Water for reclaimed purposes will be treated to Greater Exposure Potential Tertiary Standards given the water quality requirements for anticipated uses. No specific treatment will be added at this time for additional treatment of emerging contaminants of concern beyond what the secondary or tertiary process will achieve.

2.6 Solids Criteria

Solids management is an integral component of wastewater treatment and the processing and disposal of the solids generated during the treatment of the wastewater must be addressed. Unlike the water, the solids management has additional requirements both from a public perception and the acceptability of the materials produced. As such, defining the goals and metrics that the solids management must achieve is critical for the technology evaluation.

Sludge is defined as untreated residual solids, whereas biosolids are treated to an extent defined in the BC Organic Matter Recycling Regulation.

Solids criteria are dependent on end uses, some of the typical criteria and end uses are summarized below:

Table 2.6.1 - Solids Criteria

Criteria	End Use	Comments
Class B Biosolids	Land Application	Stringent regulatory constraints
Class A Biosolids	Land Application	Option to donate or sell to public
Dewatered Sludge (12 – 20% dry solids)	Landfill	Could be quite odourous; occupies large volume
Dried Sludge (60 – 85% dry solids)	Landfill	Less concern with odours, occupies much less volume
Dried Sludge (60 – 85% dry solids)	Biofuel for Incinerators	Minor quantities of ash to dispose
Dried Sludge (60 – 85% dry solids)	Biofuel for Gasification	Biochar and ash to be disposed

In terms of the application of these criteria the following aspects will be considered:

- CRD has a current policy that does not allow the land application of biosolids, within its boundaries.
- CRD strongly discourages solids being discharged to their landfill e.g. residual solids disposal should be minimized.

2.7 Resource Recovery Markets: Design and Evaluation Methodology

Wastewater provides for multiple resources that can be recovered for a variety of beneficial uses. Previous studies served to narrow the broad list of possibilities toward a reasonable list of potential applications, including: water reclamation, heat recovery, solids recovery including potential energy conversion, and fertilizer supplements (i.e. struvite). While each application requires its own unique infrastructure and service-operation requirements, there are common attributes that apply universally to suit the charter and preliminary criteria. Throughout Phase 2, possibilities for resource recovery will be initially examined through a lens for:

- Long-term revenues and demands
- Minimized processing-technology footprint
- Cost of service
- Energy balance
- Complexity of customer agreements or partnerships
- Ability to support other community amenities
- Synergy with public utility services
- Regulatory feasibility

This list of attributes will frame the scan for market opportunities for resource recovery and help to identify target markets where there is greatest potential for applications to meet the project goals. Further, distributed option sets are designed to situate multiple plants throughout the Core Area to capitalize on resource recovery demands. Heat recovery and water reuse demands are distributed in particular and instruct the proposed methodology for identifying target markets, including:

- Review the broad inventory of water reuse and heat recovery possibilities including existing customers and future development.
- Inventory supply and demand projections for water and heat recovery reuse across site nodes in the Core Area. Locate potential customers and define their product needs including barriers and pricing considerations.
- Scan the broad list of recovery possibilities against the list of criteria above:
- Narrow the recovery options based on the results of the scan.
- Develop conceptual resource recovery infrastructure systems to convey resources to their demands. Look for synergies with neighboring site nodes to reduce unnecessary infrastructure.
- Optimize resource recovery infrastructure to suit the supply demand balance e.g. focus toward the size of treatment facility to suit actual reuse needs and look for phasing to support growth.
- Confirm regulatory and risk-management considerations. Confirm limitations and service governance considerations for risks and opportunities related to implementation and operation.

- Confirm cost and revenue projections for life cycle costing analysis.

Table 2.7.1 outlines the preliminary considerations for resource recovery target markets.

Table 2.7.1 Preliminary Resource Recovery Opportunities

Reclaimed Water	• Large parcels, clustered in areas within a few kilometres of site nodes, for irrigation supply at parks and local green spaces • Potable substitution for toilet flushing (only) in new (future flows) town center developments including commercial uses • Aquifer recharge
Heat Recovery	• Opportunities to support local development and sustainability goals by providing hydronic heat opportunities (e.g. low grade heat recovery systems) from pump stations or treatment facilities at various institutional and commercial buildings • Opportunities to integrate with any imminent district energy systems • Heat capture at major treatment facilities to offset heating costs and other fuel costs
Solids Recovery	• Market possibilities whereby treated biosolids are mixed into a beneficial topsoil product and sold for land application elsewhere • Market possibilities for biochar or dried solids which remain after energy recovery processes
Energy Recovery	• Recovery of methane gas from decomposed organic materials to produce electricity, natural gas, bioplastics, diesel fuels, others. • Thermal conversion opportunities of carbon via gasification, incineration or pyrolysis.
Struvite	• Recovery of ammonia and phosphorous as nutrients for use in fertilizers • Confirmation that market possibilities previously identified remain and that they are congruent with solids recovery processes

Each of these applications presents opportunities to recover resources from wastewater. Further consideration to service governance, responsibilities, risks, investment needs and long-term operation will be presented to the Committee and the public as part of the analysis results.

3.0 Facility Characterization Criteria

Technical criteria from Section 2 inform the facility design, or *facility characterization criteria*, which is a significant step toward establishing a representative design for each site (Section 4.0).

The following tables summarize the proposed Facility Characterization Criteria and how they align with the Preliminary Charter Criteria outlined in Section 1.0.

Table 3.1 - Liquid Discharge Requirements

Facility Characterization Criteria	Preliminary Charter Criteria	Comments
Flow Requirements	Meet Regulations (1a)	System must work as a whole but each site in a solution set may play a different part (i.e. Where we treat the flows over 2x average dry weather flow)
Receiving Environment – Regulatory Limits	Meet Regulations (1a)	Tied to discharge location
Receiving Environment – Emerging Contaminants	Improve Effluent Quality (4c)	As outlined earlier this one requires further dialogue and definition if it is to be included
Reuse Requirements	Support Resource Recovery (2c, 3c)	Highly tied to market demand

Table 3.2 - Solids Discharge Requirements

Facility Characterization Criteria	Preliminary Charter Criteria	Comments
Disposal/Reuse Requirements	Support Resource Recovery (2c, 3c)	Consider scale, synergies with energy and solids resource recovery and integration with other regional waste streams.

Table 3.3 - Site Constraints

Facility Characterization Criteria	Preliminary Charter Criteria	Comments
Adjacent Land Use	Safe Solutions (6b, 6c) Community Support (3b)	Certain technologies and solutions integrate better into residential settings than others.
Livability of Neighbourhood	Positive Public Interaction (6b) Community Support (3b) Reduction of Carbon Footprint (5a) Balance Energy Needs (5c)	Certain technologies and solutions integrate better into residential settings than others

Table 3.4 - Risks

Facility Characterization Criteria	Preliminary Charter Criteria	Comments
Certainty for Demand/Revenue	Certainty of Long-Term Demand and Revenue (3a) Ability to Phase with Growth (4a)	Certain technologies and solutions are more resilient to variations in demand/revenues.
Climate Variability Impacts	Site/Design Resiliency (4b)	Location specific
Seismic	Site/Design Resiliency (4b)	Location specific
Neighborhood Impacts	Reduction to Risks to Neighbourhoods from Facility Failure (6b) Reduction of Normal Interruption to Neighbourhood (6c) Ability to Produce High-Quality Air Emissions (5b)	Acceptable levels of risk beyond regulation vary by land use.
Process Risks – Liquids	Safe Solutions (6b, 6c) Reduction to Risks to Neighbourhoods from Facility Failure (6b)	Acceptable levels of risk beyond regulatory requirements vary by land use.
Process Risks – Solids	Safe Solutions (6b, 6c) Reduction to Risks to Neighbourhoods from Facility Failure (6b) Ability to Produce High-Quality Air Emissions (5b)	Acceptable levels of risk beyond regulatory requirements vary by land use.
Process Risks – Energy Recovery	Safe Solutions (6b, 6c) Reduction to Risks to Neighbourhoods from Facility Failure (6b) Ability to Produce High-Quality Air Emissions (5b)	Acceptable levels of risk beyond regulatory requirements vary by land use.

4.0 Methodology to Select Representative WWTP Technology

As outlined in Section 1, the criteria outlined in Section 2 and 3 will be used to arrive at representative designs for the various facility locations within the option sets. We have proposed that four sample site characterizations be used in order to inform the representative design process. These site characterizations will be used to consider facility design requirements, siting considerations and to review indicative technologies. Once the site locations and option sets are confirmed they can be refined prior to costing analysis. The proposed site characterizations are summarized in the table below:

Table 4.1 - Site Characterization Summary

Site Characterization	Neighbouring Land Use	Flow Range (Average Dry Weather Flow)	Anticipated Plant Purpose – Liquid Train
Small Distributed	Residential	< 5 ML/day	Tertiary treatment for local reuse
Medium Distributed	Residential	6-15 ML/day	Tertiary treatment for local reuse
Large Distributed	Residential	16 – 25 ML/day	Tertiary treatment for local reuse
Extra Large Distributed or Central	Non-Residential	26 + ML/day	Primary & Secondary treatment for outfall and tertiary treatment for local reuse

Representative design and analysis for solids treatment and recovery will adhere to the criteria outlined in section 3.0 and be considered in synergy with the liquid treatment and energy recovery needs/opportunities for the site.

5.0 Costing Factors

5.1 Introduction

As outlined in the Treasury Board guide on the Public Works and Government Services website cost estimates for projects fall into a number of defined categories. For this project the CRD terms of reference requested that costs be provided with the accuracy of -15% to +25%. This range is consistent with cost estimates which are suitable for budget planning purposes in the early stages of concept development of a project.

Costs will be presented in 2015 Canadian dollars. It is important to recognize that since 2010, and from 2015 until the systems are constructed, prices of all cost elements can be significantly affected by time and typically, cost escalations. For example, the Engineering News Record (ENR) is an industry guide to the construction industry. The ENR states that the construction cost index for Toronto (BC is currently not represented in the ENR) has increased from 9,434 (2010) to 10,515 (2015). This is equivalent to a construction cost increase of 11.5% over the 5 year period. A review of data available from Stats Canada for the Victoria area indicates that their construction price index has risen from 111.5 (2010) to 122.8 (2014; no 2015 data yet available), using a base index of 100 (2007). This is equivalent to a 10.1 % increase over this 4 year period. This would appear to correlate fairly closely with the 11.5 % increase over 5 years for the ENR index. We have used the Stats Canada index for the purposes of calculating all cost escalations.

The impact of the exchange rate between the Euro, the US and Canadian dollars is also relevant, since a portion of the equipment may be manufactured in the USA or Europe.

Some costing considerations are difficult to predict, like the supply and demand and productivity of skilled labour in the Greater Victoria area, especially if other large scale projects in the province were to occur, such as liquefied natural gas and the Metro Vancouver Lion's Gate WWTP. It is also widely known that construction on Vancouver Island carries a premium compared to the mainland.

We will be using all of the recent construction related projects that Urban Systems and Carollo have completed to inform the estimates we provide, including local estimate considerations provided by municipal staff. Previous cost estimating from other consultants on this project have also been reviewed and have been considered in our evaluations.

5.2 Capital Cost Breakdown

Capital cost estimates include multiple factors and contingencies. For Class D cost estimates we have included *general requirements*, *contractor profit and overhead*, *construction and project contingencies, engineering, administration, interim financing and escalation.* Table 5.1 illustrates these cost factors for an example project with a base construction cost estimate of $1,000,000. For comparative purposes the percentages used in this study are the same as those used in previous studies. We have assumed the mid-point of construction is four years or 2019.

Table 5.1 - Capital Cost Breakdown

Description	Total
Construction Cost	$ 1,000,000
General Requirements (Mobilization, Demobilization, Bonds, Insurance, etc.) – 10%	$ 100,000
Contractor Profit/Overhead – 10%	$ 100,000
Construction/Project Contingency – 35%	$ 350,000
Subtotal of Direct Costs	**$ 1,550,000**
Engineering – 15%	$ 233,000
CRD Administration and Project Management and Miscellaneous – 8%	$ 124,000
Interim Financing– 4%	$ 62,000
Escalation to Mid-Point of Construction – 2%/year (4 years)	$ 124,000
Total Capital Project Cost	**$ 2,093,000**

5.3 Pump Stations

The pump stations that will be used to pump effluent from the existing CRD collection system to the proposed treatment plants are typically designed to be low-lift, high-volume facilities. Because of the unique nature of each pump station (siting, access, pump capacity, proximity to major utilities and sensitive areas, geotechnical considerations, etc.), costs for such facilities can vary widely.

Class D cost estimates are commonly derived from cost curves which are based on extensive cost data gathered from the combination of a wide range of pump stations throughout the industry. These curves typically plot station costs against the size of the stations in L/s. Typical curves are shown in Appendix E.

These particular curves were developed by an extensive study undertaken 11 years ago for the Ministry of Public Infrastructure Renewal in Ontario. In conducting our estimates we assessed the application of estimates from Ontario against our experience in the BC market. The unit rates have been multiplied by 1.6 with consideration of the following:

a. 20% - for temporary and permanent site work.

b. 20% - for standby power and SCADA

c. 20% - inflation from 2004 to 2015.

Where possible, the unit rates have been compared to cost data available from recently designed and constructed projects, to confirm general data conformance. These facilities typically comprise a concrete below grade wet well, in which the sewage is collected and from which the sewage is pumped using submersible pumps. An at-grade superstructure (usually concrete block or similar durable material) is located on top of the wet well (typically poured in place concrete), to house mechanical and electrical equipment, including MCCs, PLCs and standby power.

Where pump stations will be included in the design and construction of a wastewater treatment plant, i.e., are not stand alone facilities, experience informs that a 30% cost deduct should be applied to the unit costs rates to account for common infrastructure and other facility synergies.

Below is a summary of a few examples of anticipated pump station costs, based upon the curves in Appendix E and including the 1.6 multiplier. All rates are in 2015 dollars and pertain only to the Construction Cost portion as outlined in Section 5.2, which would be factored up as per Table 5.1.

Pump Station Size	Construction Cost (CDN$)
350 L/s	$ 3,400,000
750 L/s	$ 6,400,000
925 L/s	$ 8,000,000

Estimates and market pricing (historic) for the Craigflower Pump Station upgrade will be examined further in an effort to further refine these estimates, once the tender information is made available.

5.4 Piping

The piping systems that will be used to service the Core Area option sets will comprise PVC pipe installed in existing rights-of-ways, typically existing road allowances. As such, the unit cost rates allow for pavement and any existing surface improvement restoration. In addition, an allowance has been included for temporary site works, traffic control and associated above ground work.

In general, these pipes will provide the connectivity between the existing CRD sewer trunk mains, proposed pump stations, proposed wastewater treatment plants and proposed outfalls. Typically sanitary collection systems are designed for minimum flow velocities of 0.8 m/sec to ensure that material does not build up within the piping systems. From a capital cost and energy perspective, ideally flows should be near 2.5 m/sec. Given the wide range in flows within the CRD system (0 to 4 x ADWF), detailed analysis is required for any pumped and piped system to ensure that the optimum life cycle range of costs are achieved.

For the purposes of this costing exercise, we have sized our pipes such that the resultant velocities are in the 1.5 to 2.5 m/sec range, based upon 2 x ADWF.

The unit cost rates developed are based upon meeting or exceeding accepted industry design standards, such as those detailed by AWWA.

The following is a summary of the unit cost rates developed by Urban Systems as part of the ongoing work with the CRD. All rates are in 2015 CDN dollars and pertain only to the Construction Cost portion outlined in Section 5.2.

Pipe Diameter (mm)	Construction Unit Cost $/m
300	$ 700
350	$ 740
400	$ 780
450	$ 820
500	$ 870
600	$ 950
750	$ 1,130
900	$ 1,350
1050	$ 1,620
1200	$ 1,850
1350	$ 2,100
1575	$ 2,450

5.5 Outfalls

Developing unit cost rates for outfalls into a marine environment proved to be the most challenging task, given the wide range of unknowns and variabilities. Not too dissimilar from pump stations and their unique features, the unit cost rates for outfalls also vary widely. In particular, geotechnical considerations and seabed profiles will have significant impacts on these costs. However, unlike, pump stations, there is not a large data base on which to draw upon and develop cost curves.

Outfalls are anticipated using steel pipes, installed with concrete collars anchored to the sea floor. Based upon the data available, 2015 costs for these sizes were developed as summarized below and pertain only to the Construction Cost portion outlined in Section 5.2.

Pipe Diameter (mm)	Construction Unit Cost $/m
600	$ 6,150
750	$ 7,000
900	$ 7,800
1050	$ 8,600
1200	$ 9,600
1350	$ 10,800

5.6 Methodology to Provide WWTP Cost Estimates

For Wastewater Treatment Plants the costing methodology is more complicated since each plant includes both liquids and solids treatment processes and costs are largely dependent on the technology selected. For this project we will use the experience database developed by Carollo and Urban Systems in order to determine appropriate costs for the representative facilities. Only the representative technology will be costed in order to arrive at comparative cost estimates between the option sets.

5.7 Revenue Sources

Revenue sources will cover the range of incomes based on exchange of goods or services and also monies that offset costs including potential development contributions or potential partnerships which minimize the extent and impact of new works. Examples of revenues include:

- Utility billings, requisitions, transfers and interest gains
- Retail rates for resource recovery systems including water rates, gas/fuel rates (solids recovery) and incomes collected for any sales related to solids residuals
- Development cost charges and other potential private sector development contributions available to local governments
- Municipal cost-shares for example where infrastructure upgrades are needed for both local and regional benefit
- Grants in terms of secured monies available to CRD
- Other offsetting costs for example, homeowner cost savings that may arise through waste diversion as part of integrated solids recovery

This list of preliminary revenue resources will be refined through high-level feasibility analysis in collaboration with CRD and municipal staff.

5.8 Life Cycle Costing

Life-cycle costs will be prepared for each of the option sets, which will be detailed in Technical Memo #2. Life cycle costing includes capital, as well as operating costs and later, consideration to revenues as part of the aggregate financial scenarios. Operating costs will consider typical cost elements as well as revenue (outlined in Section 5.7) which can reasonably be assumed to accrue given the resource recovery opportunities available. The operating and life cycle costing will be completed in Technical Memo #3.

Below is a summary of the inputs into our life cycle costing model. As this is a constant dollar analysis, all costs will be in $2015. The only escalation that will be included will be 2% per year for initial capital projects for the time from today until midway through construction which is assumed to be 2019.

We propose to conduct sensitivity analysis on the discount rate, escalation factors and revenue projections to monetize the risks inherent in long-term capital financing and service delivery. As a base case, our life cycle analysis will be guided by previous analysis and in particular, will suit treasury board guidelines to suit the funding partners.

Life Cycle: 30 years (2015-2045)

Interest Rate: to be confirmed with funding partners (as needed) e.g. 5%

Inflation Rate: to confirmed with funding partners (as needed) e.g. 2%

Discount Rate: to be confirmed with funding partners (as needed) e.g. 3%

Water Cost: Distribution cost from distribution supplier (i.e., CRD for Westshore & Sooke) is $1.81/m³

Electricity Cost: Average rate $0.08/kwh

Chemical Costs; Current market prices

Labour Rates:

Labour Type	2015 Annual Salary (1)
Plant Manager	$ 158,000
Chief Plant Operators	$ 135,000
Chief Area Operator	$ 113,000
Plant Operator	$ 90,000
Labourer	$ 56,000

(1) Refer to Appendix F for derivation

Vehicle Rates: $40,000/yr./vehicle

Trucking Rates: Current market prices

Disposal Rates: Current tipping charges to CRD Landfill (i.e. $157 per tonne for screenings and pumpings from Sewage Treatment Plants)

Maintenance/Repairs Pump Stations:	1% of Capital/yr.
Equipment Replacement Reserve for Treatment Facilities:	2% of Capital
Operation & Maintenance Contingency:	15%

While there are multiple financial scenarios to consider, it is important that Phase 2 results remain consistent with previous analysis but also reflect a shift in project outcomes and criteria. Further, qualitative evaluation of various social and environmental factors will support the financial analysis and allow the Committee to review the merits of option sets across a balanced scorecard. Phase 2 evaluations should support the committee in screening away option sets that don't effectively meet the goals and commitments of the project in order to refine the project criteria for ultimate design parameters for a Core Area solution. Additional public investment analysis beyond Phase 2 may be needed (e.g. value for money) to suit the needs of the funding partners.

APPENDIX B – TECHNICAL CRITERIA AND PROJECT CHARTER

Charter Goal/Commitment	Preliminary Charter Criteria
1. Meet or exceed federal regulations for secondary treatment by December 31, 2020.	a. Refer to Section 2.5.4. b. Extent of liquids or solids produced in excess of regulations.
2. Minimize costs to residents and businesses (life cycle cost) and provide value for money.	a. Extent of leveraging of existing infrastructure assets; b. Reduction of consumable and operations costs; c. Extent of revenues from resource recovery;
3. Produce an innovative project that brings in costs at less than original estimates.	a. Extent of alternative to bring in costs less than original estimate.
4. Optimize opportunities for resource recovery to accomplish substantial net environmental benefit and reduce operating costs.	a. Certainty of long-term demand and revenue; b. Extent of support for community building; c. Extent of new infrastructure/services to support resource recovery; d. Extent of integration of other regional waste streams
5. Optimize greenhouse gas reduction through the development, construction and operation phases and ensure best practice for climate change mitigation.	a. Reduction of carbon footprint (buildings, treatment, transportation); b. Ability to produce high-quality air emissions; c. Ability to balance energy needs;
6. Develop and implement the project in a transparent manner and engage the public throughout the process.	a. Ability of an alternative to meet the preliminary criteria
7. Develop innovative solutions that account for and respond to future challenges, demands and opportunities, including being open to investigation integration of other parts of the waste stream if doing so offers the opportunities to optimize other goals and commitments in the future.	a. Ability to phase capacity/expansion with growth; b. Ability to improve effluent quality over life of facility; c. Extent of integration of other regional waste streams (above)
8. Optimize opportunities for climate change mitigation	a. Reduction of carbon footprint (buildings, treatment, transportation); b. Ability to produce high-quality air emissions; c. Ability to balance energy needs;
9. Deliver a solution that adds value to the surrounding community and enhances the livability of neighborhoods.	a. Extent to provide for positive public interaction; b. Reduction of risk to neighborhoods from facility failure; c. Reduction of interruption to neighborhood during normal operation;
10. Deliver solutions that are safe and resilient to earthquakes, tsunamis, sea level rise and storm surges.	a. Site/design resiliency for seismic and sea level rise;

CORE AREA SEWAGE AND RESOURCE RECOVERY SYSTEM 2.0

Phase 2: Analysis, Options Costing and Public Engagement

Project Charter - FINAL

October 2, 2015

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1. VISION

In partnership with the public, the Core Area Liquid Waste Management Committee (CALWMC) will deliver a sewage treatment and resource recovery system that is proven, innovative and maximizes the benefits for people and the planet – economic, social, and environmental – for the long term.

2. BACKGROUND

In 2006, an environmental report commissioned by the Ministry of Environment noted the contamination of seabed sites close to Capital Regional District (CRD) outfalls where the region's wastewater is discharged. As a result, the Province mandated that the CRD plan for and initiate secondary sewage treatment for the region.

In 2007, the CRD received a letter from the Ministry of Environment giving six directives for the Core Area Liquid Waste Management Plan (LWMP). These six directives continue to inform the goals and commitments of this project.

Minister's Requirements:

1. Meet the regulatory standard for liquid waste
2. Minimize total project cost to the taxpayer by maximizing economic and financial benefits, including beneficial reuse of resources and generation of offsetting revenue
3. Optimize the distribution of infrastructure based on number 2 above
4. Aggressively pursue opportunities to minimize and reduce greenhouse gas emissions (e.g., reduced requirement of energy for pumping purposes and beneficial reuse of energy)
5. Optimize 'smart growth' results (e.g., district services, density, Dockside Green-like innovation)
6. Examine the opportunity to save money, transfer risk and add value through a public private partnership

In 2012, the federal government passed a law requiring all high-risk Canadian cities to provide secondary sewage treatment by 2020 at the latest. The CRD's core area was considered to be in the high-risk category.

Between 2009 and 2014, the CALWMC, CRD staff and consultants, and the Core Area Wastewater Program Commission (the Commission) worked to create and implement a publicly acceptable sewage treatment and resource recovery system for the Core Area.

While the approved CALWMP continues to identify McLoughlin Point as the location for the wastewater treatment facility, in April 2014, the CRD's revised McLoughlin Point rezoning application did not meet the zoning requirements for Esquimalt. In June 2014, the plan to build one regional plant at McLoughlin Point was put on hold by the CRD Board, in response to public input.

In June 2014, Langford, Colwood, View Royal, Esquimalt and the Songhees Nation formed the Westside Select Committee to begin planning for a new project to treat sewage and recover resources in those municipalities and the Nation. In September 2015, Esquimalt Nation joined the Westside Select Committee. In January 2015, a similar body – the Eastside Select

Committee, comprised of Saanich, Oak Bay and Victoria – was formed to develop a similar plan for the Eastside municipalities.

Since June 2014 and January 2015, respectively, both Select Committees have been engaged in in-depth public engagement activities to share information with the public, build trust, and seek public input on a range of factors including, but not limited to, level of treatment, treatment technologies, siting of treatment plants, costs, risks and long-term social, economic and environmental benefits.

In July 2015, both select committees presented their work and recommendations to the CALWMC. The CALWMC approved the solution sets and recommendations from the Eastside Select Committee, including potential sites and direction with regard to investigating secondary and tertiary treatment, anaerobic digestion and gasification, and resource recovery and revenue generation. The CALWMC received a presentation from the Westside Select Committee outlining five technically preferred sites and two scenarios, detailing its technical work to date. The Committee accepted the Westside Select Committee's proposal to carry on with further public engagement and more detailed costing and engineering analysis as per its terms of reference to be presented to the CALWMC as more fully-developed solutions in fall 2015.

The work of the Eastside and Westside Select Committees, the CALWMC and the public between June 2014 and July 2015 lays the groundwork for the current project, *Core Area Sewage and Resource Recovery System 2.0.*

3. GOALS AND COMMITMENTS

The *Core Area Sewage and Resource Recovery System 2.0* project will deliver the following goals and meet the following commitments. *NB goals should be measurable. Each of these goals needs a corresponding metric so at project completion, the CALWMC can determine whether it achieved its goals.*

Goals

a) Meet or exceed federal regulations for secondary treatment by December 31, 2020

b) Minimize costs to residents and businesses (life cycle cost) and provide value for money

c) Produce an innovative project that brings in costs at less than original estimates

d) Optimize opportunities for resource recovery to accomplish substantial net environmental benefit and reduce operating costs

e) Optimize greenhouse gas reduction through the development, construction and operation phases and ensure best practice for climate change mitigation

Commitments

a) Develop and implement the project in a transparent manner and engage the public throughout the process

b) Deliver a solution that adds value to the surrounding community and enhances the livability of neighbourhoods

c) Deliver solutions that are safe and resilient to earthquakes, tsunamis, sea level rise and storm surges

d) Develop innovative solutions that account for and respond to future challenges, demands and opportunities, including being open to investigating integration of other parts of the waste stream if doing so offers the opportunities to optimize other goals and commitments in the future

e) Optimize greenhouse gas reduction through the development, construction and operation phases and ensure best practice for climate change mitigation

4. SCOPE

The scope of this phase of the *Core Area Sewage and Resource Recovery System 2.0* project, is to complete the Options Development Phase, by submitting an amendment to the Liquid Waste Management Plan and receiving conditional approval from the Minister of Environment of an Amendment for the Core Area. This Plan amendment will be approved by the provincial and federal funding agencies. Completion of this phase includes securing sites for all facilities (wastewater treatment and resource recovery).

The scope of this phase does not include detailed site assessments such as Environmental and Social Reviews, submission of detailed business cases (as may be required by funding agencies), indicative design, finalized cost sharing agreements or the procurement of infrastructure.

5. KEY STAKEHOLDERS

The graphic illustration (see Attachment 1) outlines all of the *Core Area Sewage and Resource Recovery 2.0* project stakeholders and displays the relationships between them. For a description of the roles and responsibilities of each stakeholder, please see Section 6.

6. ROLES AND RESPONSIBILITIES

Project Lead (TBD)

Federal Government – In 2012, the federal government passed a law requiring all high-risk Canadian cities to provide secondary sewage treatment by 2020 at the latest. The CRD's Core Area was considered to be in the high-risk category. The federal government agreed to contribute up to $253 million towards the project out of three different funding programs: Building Canada Fund ($120 million), Green Infrastructure Fund ($50 million) and 3P Canada ($83.4 million).

- Secondary treatment mandated by 2020
- Funding up to $253 million

Provincial Government – In 2006, an environmental report commissioned by the Ministry of Environment noted the contamination of seabed sites close to CRD outfalls where wastewater is discharged. As a result, the CRD was mandated by the province to plan for and initiate secondary wastewater treatment for the region. Provincial funding agreements provide a maximum of $248 million towards the project.

- Funding up to $248 million
- Approval of LWMP amendment and regulatory requirements

Capital Regional District Board (CRD Board) – The CRD Board is responsible for selecting final site locations and securing lands for wastewater treatment facilities, obtaining the rezoning of lands, approving the architectural design for facilities, and approving funding agreements and the budget. The CRD Board is responsible for delivering the project outlined in the Vision.

- Final approving body for funding, budget and major decisions
- Collect and disburse the local portion of the funding of $287 million

Core Area Liquid Waste Management Committee (CALWMC) – A standing committee of the CRD Board, the CALWMC consists of Directors from municipalities and First Nations participating in the Core Area Liquid Waste Management Plan (CALWMP). The committee is responsible for overseeing the CALWMP and making recommendations to the CRD Board about the CALWMP and certain aspects of the Core Area Wastewater Treatment Program.

- Standing Committee of CRD Board
- Responsible for overseeing CALWMP

Core Area Liquid Waste Management Committee (CALWMC) Chair – The CALWMC Chair is selected by the Chair of the CRD Board annually. The CALWMC Chair is responsible for participating in CALWMC agenda meetings and chairing CALWMC meetings. The Chair is also responsible for building and maintaining relationships, and liaising with the Chair of the Core Area Wastewater Program Commission and the Chair of the Technical Oversight Panel. The CALWMC Chair is the public face of the project and is responsible for communicating with other public bodies at the political level, as well as with the media.

Core Area Liquid Waste Management Committee (CALWMC) Vice Chair – The CALWMC Vice Chair is responsible for fulfilling the roles and responsibilities of the CALWMC Chair in the Chair's absence.

Westside Wastewater Treatment and Resource Recovery Select Committee – In June 2014, Westside participants (Colwood, Esquimalt, Langford, View Royal, and Songhees Nation) formed the Westside Wastewater and Resource Recovery Select Committee to evaluate Westside treatment options and develop a sub-regional wastewater treatment and resource recovery plan. The member municipalities' role is to provide political input and take feedback from the public and report to the Westside Select Committee. The participating municipalities also have zoning authority. In September 2015, the Esquimalt Nation joined the Westside Select Committee. The Songhees and Esquimalt Nation representatives provide political input to the Westside Select Committee. The Committee reports to the CALWMC and is supported by CRD staff, Westside staff, consultants and a technical working group.

The Westside Select Committee participants initiated the Westside Solutions Project as a way to engage residents to work collectively to identify solutions for wastewater treatment and resource recovery that meet the unique needs of the Westside communities. The Westside option sets consider flow scenarios that include Eastside flows from Vic West and Saanich West. This work, along with the work from the Eastside Select Committee, will inform the *Core Area Sewage and Resource Recovery 2.0* project and the amendment to the Liquid Waste Management Plan.

- Representatives from Colwood, Esquimalt, Langford, View Royal and Songhees Nation
- Reports to CALWMC
- Evaluates options to develop a sub-regional wastewater treatment plan
- Supported by CRD staff, Westside municipal staff, consultants and a technical working group

Eastside Wastewater Treatment and Resource Recovery Select Committee – In January 2015, Oak Bay, Saanich and Victoria formed the Eastside Wastewater and Resource Recovery Select Committee to engage with their communities and develop wastewater treatment options that meet the needs of the Eastside municipalities. The role of the participating municipalities is to provide political input and take feedback from the public and report to the Eastside Select Committee. The participating municipalities also have zoning authority. The Eastside Select Committee reports to the CALWMC and is supported by CRD staff, participating municipal staff and consultants.

The Eastside option sets consider a regional option, which includes all flows from Eastside and Westside, as well as a sub-regional and distributed option that includes flows from Eastside municipalities only and Eastside Clover Point outfall catchment flows. The Eastside Select Committee's plan, in combination with the work from the Westside Select Committee, will inform the *Core Area Sewage and Resource Recovery 2.0* project and could form the basis for an amendment to the CALWMP.

- Representatives from Oak Bay, Saanich and Victoria
- Reports to CALWMC
- Working to develop wastewater treatment options for Eastside municipalities
- Supported by CRD staff, participating municipal staff, and consultants

CRD Chief Administrative Officer – The CAO oversees all administrative operations and staff, ensures CRD Board policies are implemented, oversees the operations and functions of the CRD, and aligns the organization to achieve strategic priorities set by the Board. This includes working with federal and provincial staff to coordinate funding agreements and providing advice to the CRD Board regarding potential risks and opportunities for the CRD Board.

- Oversees CRD operations and staff
- Works with partners and stakeholders
- Provides advice to the CRD Board

General Manager of Parks & Environmental Services – The GM of Parks & Environmental Services provides general direction and leadership to CRD staff and advises the CALWMC and the Eastside and Westside Wastewater Treatment and Resource Recovery Select Committees regarding the technical and legal aspects of the CALWMP and the wastewater treatment planning process. The General Manager's role is also to provide information to the Core Area Municipalities' CAOs and First Nations Administrators.

- Provides general direction and leadership to CRD staff
- Advises on technical and legal aspects of the CALWMP
- Informs Core Area Municipal CAOs and First Nation Administrators about the project

General Manager of Finance & Technology – The GM of Finance & Technology is the Chief Financial Officer for the CRD. The GM of Finance and Technology is responsible for the budget and all financial services, information technology and geographic information services (IT & GIS), property and real estate services, insurance and risk management, facilities management, and arts development for the Capital Region.

Corporate Officer – The CRD Corporate Officer provides support and procedural advice to the CRD Board and the CALWMC, and is responsible for maintaining the official records of these bodies. The officer also processes requests for records in accordance with the Freedom of Information and Protection of Privacy Act.

First Nations Liaison – The First Nations Liaison serves as a point of contact for First Nations communities involved with the project and provides departmental support and assistance in the areas of service delivery, referral processes, outreach, engagement and relationship building.

Manager, Corporate Communications – The Senior Manager of Corporate Communications provides professional expertise and leads the CRD Corporate Communications team, which works with the General Manager of Parks & Environmental Services and the CAO on overall communications for the CRD Board. There is a communications coordinator dedicated to working on the CALWMP.

Technical Oversight Panel (ToP) – The role of the Technical Oversight Panel is to review the costing and feasibility studies developed by the Engineering Team during the planning phase of the project and to ensure that the studies for the wastewater treatment options include the necessary due diligence. The Technical Oversight Panel will also advise on how to best engage the private sector in this phase of the project. Fundamental to providing independent technical oversight and confirming due diligence is to ensure that the engagement of the private sector in this phase of the project and the innovative solutions that may come forward is informed by, not necessarily bound by (as per the ToP Terms of Reference), decisions to date regarding sites, option sets, timelines, definitions of treatment and other potential limitations on analysis and costing.

The role of the ToP does not include public consultation, media interaction, land acquisition and rezoning, contract management or direction of the Engineering Team The ToP receives information from and liaises with the Engineering Team (Urban Systems and Carollo Associates), and provides feedback and recommendations to the CALWMC. The Chair of the ToP reports to the CALWMC biweekly. The ToP liaises with the Eastside and Westside Select Committee.

- Independent Technical Oversight Panel
- Reviews costing and feasibility studies

- Reports findings to the CALWMC

Independent Engineering Resources – The Independent Engineering Team's role is to conduct the Feasibility and Costing Analysis (Urban Systems partnered with Carollo) for the CALWMP Wastewater Treatment System. The Engineering Team is also working with the Westside Select Committee to do a more detailed analysis on the Westside flows. The team provides information to and liaises with the ToP, and reports to and receives direction from the CALWMC. Additional external resources may be required for staff to prepare the LWMP amendment. The team is assessing the feasibility of a regional and sub-regional system in the Core. The team is also looking at a distributed system option based on the potential sites put forward from the Eastside Select Committee and Westside Select Committee.

- Conducts feasibility and costing analysis
- Assesses feasibility of regional and sub-regional systems in the Core Area
- Assists with preparation of LWMP amendment

Fairness and Transparency Advisor (FTA) – The FTA's role is to act as a point of contact for the public to submit complaints regarding the process of costing the options, working with the host jurisdiction(s) and preparing an amendment to the LWMP and to ensure that the process is fair, transparent, impartial and objective. The FTA is independent of the CRD. The FTA's role is to investigate appropriate complaints and report to the Board, through the CALWMC, the results of an investigation, to help strengthen the fairness, transparency or objectiveness of the process followed. The FTA is to provide monthly status reports to the CALWMC. The role of the FTA does not restrict the public from going to other sources for complaints and requests to review processes, such as the office of the Ombudsperson.

- Independent of the CRD
- Investigates public complaints regarding process
- Ensures process is fair, transparent, impartial and objective

Core Area Wastewater Treatment Program Commission (the Commission) – As part of the funding negotiations with the Province, the CRD was required to establish an independent non-political governance body to manage, implement and commission the Core Area Wastewater Treatment Program. The Commission governs the implementation and operation of the Wastewater Treatment Program and oversees the procurement process for all components of the Program. The Commission operates autonomously of the CALWMC and Regional Board; however, the Commission is required to seek CRD Board and funder approval on predetermined items as detailed in the CRD Commission bylaw. Several steps have been taken to scale back operations and reduce costs as the CRD continues its planning work to find a new solution to wastewater treatment. The Commission remains in place waiting to implement whatever system of wastewater projects the CRD Board decides upon, and is approved by the Province.

- Independent Commission required by Province
- Manages implementation and operations of the Wastewater Treatment Program
- Oversees procurement process

Technical and Community Advisory Committee (TCAC) – The Technical and Community Advisory Committee is an LWMP requirement of the province, and provides technical and community consultation advice and input to the CALWMC. The TCAC assists the CALWMC in making appropriate recommendations to the CRD Board in the following areas: (a) plant design criteria and treatment technology, including opportunities for resource recovery, sludge management, odour control and general plant design criteria, (b) number and location of treatment plants, and (c) timing/scheduling of treatment.

- Provides technical and community consultation advice
- Makes recommendations regarding design criteria, treatment technology, number and location of treatment plants, and schedule for treatment

Eastside Public Advisory Committee (EPAC) – The Eastside Public Advisory Committee takes input from the public and provides guidance to the Eastside Wastewater and Resource Recovery Select Committee on the public consultation process.

- Takes input from the public
- Provides Eastside Select Committee on the public consultation process

Core Area CAOs + First Nation Administrators – The Core Area CAOs and First Nations Administrators are the principle policy advisors to councils, and provide support to the Eastside and Westside Select Committees. The Core Area CAOs and First Nations Administrators receive project-specific information and updates from the CRD's General Manager of Parks & Environmental Services regarding the progress of the CALWMC and the Eastside and Westside Select Committees.

- Principle policy advisors
- Receive project information
- Provide recommendations from municipal staff perspective

Municipal Councils – The role of municipal councils is to make land-use decisions for facility siting and to negotiate development agreements with the CRD.

Westside Communications Team – The Westside Communications Team is made up of Communications Coordinators from Colwood, Esquimalt, CRD and Aurora Consultants. The Team provides communication and public consultation support to the Westside Select Committee.

Eastside Communications Team – The Eastside Communications Team consists of a consultant from Public Assembly and the CRD Communications Manager and CRD CALWMP Communications Coordinator. The Eastside Communications Team provides communication and public consultation support to the Eastside Select Committee.

Westside Technical Team – The Westside Technical Team consists of municipal staff, supported by Urban Systems. The technical team provides technical information and input to the Westside Select Committee.

- Comprised of municipal staff and supported by Urban Systems and Aurora Innovations for facilitation and coordination support
- Provides technical advice to the Westside Select Committee

Eastside Technical Team – The Eastside Technical Team is comprised of municipal staff and supported by Urban Systems and CRD Staff. The Technical Team provides support and input to the Eastside Select Committee.

- Comprised of municipal staff; provides support and information to the Eastside Select Committee

7. MILESTONES

The Proposed Work Plan Overlay, which was adopted and submitted to 3P Canada in March 2014, provides the overarching timelines and milestones through the completion of the project (Attachment 2). A draft schedule identifying key tasks and milestones of the feasibility and costing exercise to be achieved by the end of 2015 during Phase 2 of the Core Area Sewage and Resource Recovery System 2.0 project is included for discussion (Attachment 3). The scheduling and implementation of the public consultation on the preferred solution sets (after the costing analysis) is anticipated to occur in early December, but is dependent on all of the deadlines being met up until that point.

A detailed schedule is under development and will be circulated for comment.

8. BUDGET

Funding for the project will be drawn from the Core Area Liquid Waste Management Plan operating reserve, funded by all participants in the service based on projected design capacity for 2030. A total budget of $1,250,000 has been identified to support this phase of the project, including engineering and public consultation consulting fees, Technical Oversight Panel honorarium and disbursements, Fairness and Transparency Advisor, public consultation process delivery and CRD staff time.

Phase 2 Budget

Item	Cost
Project Oversight (FTA & ToP)	$280,000
Public Consultation	$240,000
Feasibility and Costing Analysis	$450,000
Property and Zoning	$75,000
LWMP Amendment No. 10	$75,000
Staff and Wages	$300,000
Miscellaneous and Legal	$30,000
TOTAL	$1,450,000

9. CONSTRAINTS, ASSUMPTIONS, RISKS AND DEPENDENCIES

a) Constraints

- The timelines for this phase of the project are extremely aggressive with no buffer
- The schedule is dependent on multiple parties and governance bodies meeting their sub-project schedules

b) Assumptions

- The Minister of Environment will provide direct *conditional* approval of the Liquid Waste Management Plan upon submission to the Province

c) Risks

- The costing analysis and public consultation processes will be subject to criticism due to time constraints
- The governance model of the project is complex, leading to miscommunication or contradictory decision making
- Municipal councils do not endorse siting preferences of the CRD Board
- Potential loss of senior government funding if timelines are not met

d) Risk Mitigation

- Ensure regular, open reporting of all parties to the Core Area Liquid Waste Management Committee to ensure “no surprises” when public consultation is formally conducted
- Engage in close municipal council and staff involvement as preferred sites emerge and municipal planning/siting processes are initiated
- Ensure ongoing and open discussions with the funding agencies to ensure “no surprises” when the LWMP amendment is submitted for approval and the project is submitted for funding
- Ensure transparent and deep engagement with the community
- Ensure there is enough time required to rezone and that there is public support for rezoning

Attachments:	Attachment 1:	Planning Process – Core Area Liquid Waste Management Plan – Roles, Input & Relationships
	Attachment 2:	Proposed Work Plan Overlay – 3P Canada Funding Considerations
	Attachment 3:	Proposed Feasibility and Costing Analysis Schedule (Urban Systems) – August 31, 2015

APPENDIX C – COST TABLES

Cost Components for Option 1a - One Secondary Plant (x 1,000)

Cost Component	Capital Cost Incurred (1)		Operating Cost (1)		
	2015	2030	at 2015	at 2030	at 2045
1. Conveyance					
(a) Clover Pt PS and Forcemain to Rock Bay	$ 51,400	N/A	$ 540	$ 640	$ 730
(b) Macaulay Pt PS and Forcemain to Rock Bay	$ 65,400	N/A	$ 620	$ 730	$ 840
(c) Effluent PS and Forcemain to Clover Point	$ 83,900	N/A	$ 1,000	$ 1,190	$ 1,400
(d) Replace Clover Outfall	$ 32,500	N/A	incl. in (c)		incl. in (c)
(e) Reline Macaulay Outfall	$ 11,100	N/A	incl. in (b)		incl. in (b)
Conveyance Subtotal:	$ 244,300	$ -	$ 2,160	$ 2,560	$ 2,970
2. Liquid Treatment (Secondary)	$ 392,000	$ 162,000	$ 7,000	$ 10,100	$ 12,650
3. Solids Treatment - AD at Rock Bay	$ 258,000	$ 90,600	$ 5,000	$ 8,800	$ 10,300
4. Reuse					
(a) Tertiary Slipstream	$ 8,100	N/A	$ 230	$ 230	$ 230
(b) Effluent Pumping/Piping/Controls	$ 16,100	N/A	$ 70	$ 75	$ 80
Reuse Subtotal:	$ 24,200	$ -	$ 300	$ 305	$ 310
5. Existing System Capacity Upgrades					
(a) Craigflower PS - Constructed	$ 12,100	N/A	N/A	N/A	N/A
(b) Arbutus Attenuation Tank - incl land	$ 20,000	N/A	N/A	N/A	N/A
(c) Siphon Extension (1600 m)	$ 7,500	N/A	N/A	N/A	N/A
(d) Upgrade Currie St PS	$ 2,300	N/A	N/A	N/A	N/A
(e) Upgrade East Coast Interceptor (1400 m)	$ 3,100	N/A	N/A	N/A	N/A
Existing System Subtotal:	$ 45,000	$ -	$ -	$ -	$ -
6. Land Costs	$ 67,200				
Total:	**$ 1,030,700**	**$ 252,600**	**$ 14,460**	**$ 21,765**	**$ 26,230**

(1) Includes all contingencies, engineering, etc. outlined in TM #1

Summary - One Plant Option - Rock Bay - Secondary Treatment

One-Time and Ongoing Costs

Capital Costs to 2045 (1)	Annual Costs (at 2030)			Annual Resource Income (at 2030)
	O&M	Borrowing	Total	
$ 1,283,300,000	$ 21,800,000	$ -	$ 21,800,000	$ 900,000

Notes
(1) Includes initial construction costs in 2015 as well as plant upgrades in 2030. Also includes land costs.

	Initial Capital Costs (at 2015)	Net Annual Costs (at 2030)
One Plant - Rock Bay - Secondary Treatment	$ 1,030,700,000	$ 20,900,000

Net Present Value

Assumptions	
Interest Rate	7%
Inflation	2%
Real Discount Rate	5%
Time period	2015 to 2045

A real discount rate is used because we are using constant dollars.

Resource Income (from 2015 to 2045)

	Total Revenue (no discounting)	Present Value
Reclaimed water use	$ 23,300,000	$ 8,600,000
Heat recovery	$ -	$ -
Carbon credits	$ -	
Total	$ 23,300,000	$ 8,600,000

Costs (from 2015 to 2045)

	Total Costs (no discounting)	Present Value
Capital Costs	$ 1,283,300,000	$ 1,097,300,000
O&M	$ 633,900,000	$ 287,900,000
Borrowing Costs	$ -	$ -
Total	$ 1,917,200,000	$ 1,385,200,000

Net Present Value (2015 to 2045)	-$ 1,376,600,000

Ratio of Resource Income to Costs (at 2030)

Total annual revenues	$ 900,000
Total annual costs	$ 21,800,000
Ratio of revenues to costs	4%

Notes
(1) All costs in constant 2015 dollars.

Capital Costs - One Plant Option - Rock Bay - Secondary Treatment

	Capital costs to be incurred in 2015	Capital costs to be incurred in 2030
Total Construction Costs	$ 1,030,700,000	$ 252,600,000
Grants		
Net Project Costs	$ 1,030,700,000	$ 252,600,000

Notes

(1) Construction costs include general requirements (10%), contractor profit/overhead (10%), contingency (35%), escalation (2%/yr for four years), engineering (15%), CRD admin (8%) and interim financing (4%).
(2) Construction costs include land costs.
(3) Grant information from CRD.

Year	Capital Costs
2015	$ 1,030,700,000
2016	$ -
2017	$ -
2018	$ -
2019	$ -
2020	$ -
2021	$ -
2022	$ -
2023	$ -
2024	$ -
2025	$ -
2026	$ -
2027	$ -
2028	$ -
2029	$ -
2030	$ 252,600,000
2031	$ -
2032	$ -
2033	$ -
2034	$ -
2035	$ -
2036	$ -
2037	$ -
2038	$ -
2039	$ -
2040	$ -
2041	$ -
2042	$ -
2043	$ -
2044	$ -
2045	$ -
Total Capital Costs	$ 1,283,300,000

Present Value of Total Capital Costs (2015 to 2045) $ 1,097,338,000

Annual Costs - One Plant Option - Rock Bay - Secondary Treatment

Year	O&M Costs	Annual Borrowing Costs	Total Annual Costs
2015	$ -		$ -
2016	$ 14,460,000		$ 14,460,000
2017	$ 14,981,786		$ 14,981,786
2018	$ 15,503,571		$ 15,503,571
2019	$ 16,025,357		$ 16,025,357
2020	$ 16,547,143		$ 16,547,143
2021	$ 17,068,929		$ 17,068,929
2022	$ 17,590,714		$ 17,590,714
2023	$ 18,112,500		$ 18,112,500
2024	$ 18,634,286		$ 18,634,286
2025	$ 19,156,071		$ 19,156,071
2026	$ 19,677,857		$ 19,677,857
2027	$ 20,199,643		$ 20,199,643
2028	$ 20,721,429		$ 20,721,429
2029	$ 21,243,214		$ 21,243,214
2030	$ 21,765,000		$ 21,765,000
2031	$ 22,062,667		$ 22,062,667
2032	$ 22,360,333		$ 22,360,333
2033	$ 22,658,000		$ 22,658,000
2034	$ 22,955,667		$ 22,955,667
2035	$ 23,253,333		$ 23,253,333
2036	$ 23,551,000		$ 23,551,000
2037	$ 23,848,667		$ 23,848,667
2038	$ 24,146,333		$ 24,146,333
2039	$ 24,444,000		$ 24,444,000
2040	$ 24,741,667		$ 24,741,667
2041	$ 25,039,333		$ 25,039,333
2042	$ 25,337,000		$ 25,337,000
2043	$ 25,634,667		$ 25,634,667
2044	$ 25,932,333		$ 25,932,333
2045	$ 26,230,000		$ 26,230,000
Total	$ 633,883,000	$ -	$ 633,883,000
Present Value	$ 287,932,000	$ -	$ 287,932,000

Notes
(1) O&M estimates provided by Urban Systems for 2016, 2030 and 2045. These have been highlighted in blue.
(2) O&M costs between 2016, 2030 and 2045 have been interpolated linearly.

Revenue- One Plant Option - Rock Bay - Secondary Treatment

Assumptions	Water Rate (per cubic metre) (1)	Reclaimed water use rate (per cubic metre) 80% of Water Rate	Reclaimed water use rate for toilet flushing (per ML)	Reclaimed water use rate for land application
Rock Bay	$1.26	$1.01	$1,011.30	$ 510.00
Colwood	$1.81	$1.45	$1,448.00	$ 510.00
Esquimalt First Nation	$1.26	$1.01	$1,011.30	$ 510.00
East Saanich	$1.54	$1.23	$1,233.60	$ 510.00
Esquimalt Bullen Park	$1.26	$1.01	$1,011.30	$ 510.00
East Saanich	$1.54	$1.23	$1,233.60	$ 510.00
Saanich Core	$1.54	$1.23	$1,233.60	$ 510.00
Langford	$1.81	$1.45	$1,448.00	$ 510.00
View Royal	$1.81	$1.45	$1,448.00	$ 510.00

Notes:
(1) Source: Respective municipal websites.

	Rock Bay							
	Reclaimed Water Use (ML/yr)							
Year	Land Application (1)	Toilet Flushing(2)	Total Reclaimed Water Use	Total Annual Revenues from Reclaimed Water Use	Heat Recovery	Total Annual Revenues from Heat Recovery	Carbon Offsets	TOTAL
2015	0	0	0	$ -				$ -
2016	19	0	19	$ 9,520				$ 9,520
2017	37	0	37	$ 19,040				$ 19,040
2018	56	0	56	$ 28,560				$ 28,560
2019	75	0	75	$ 38,080				$ 38,080
2020	93	73	167	$ 121,741				$ 121,741
2021	93	147	240	$ 195,882				$ 195,882
2022	93	220	313	$ 270,023				$ 270,023
2023	93	293	387	$ 344,164				$ 344,164
2024	93	367	460	$ 418,305				$ 418,305
2025	93	440	533	$ 492,446				$ 492,446
2026	93	513	607	$ 566,587				$ 566,587
2027	93	587	680	$ 640,727				$ 640,727
2028	93	660	753	$ 714,868				$ 714,868
2029	93	733	826	$ 789,009				$ 789,009
2030	93	806	900	$ 863,150				$ 863,150
2031	93	880	973	$ 937,291				$ 937,291
2032	93	953	1046	$ 1,011,432				$ 1,011,432
2033	93	1026	1120	$ 1,085,573				$ 1,085,573
2034	93	1100	1193	$ 1,159,714				$ 1,159,714
2035	93	1173	1266	$ 1,233,855				$ 1,233,855
2036	93	1173	1266	$ 1,233,855				$ 1,233,855
2037	93	1173	1266	$ 1,233,855				$ 1,233,855
2038	93	1173	1266	$ 1,233,855				$ 1,233,855
2039	93	1173	1266	$ 1,233,855				$ 1,233,855
2040	93	1173	1266	$ 1,233,855				$ 1,233,855
2041	93	1173	1266	$ 1,233,855				$ 1,233,855
2042	93	1173	1266	$ 1,233,855				$ 1,233,855
2043	93	1173	1266	$ 1,233,855				$ 1,233,855
2044	93	1173	1266	$ 1,233,855				$ 1,233,855
2045	93	1173	1266	$ 1,233,855				$ 1,233,855
Total	2613	21701	24314	$ 23,278,516				$ 23,278,516
Present Value (2015 to 2045)				$ 8,608,000				$ 8,608,000

Notes
(1) Land application assumed to start at 0 in 2015 and increase linearly to max re-use in 2020.
(2) Flushing substitution assumed to be at 0 until 2020 and increase linearly to max re-use in 2035.
(3) Quantity data from Urban Systems, Nov 18, 2015.

Cost Components for Option 1b - One Tertiary Plant (x 1000)

Cost Component	Capital Cost Incurred (1)		Operating Cost (1)		
	2015	2030	at 2015	at 2030	at 2045
1. Conveyance					
(a) Clover Pt PS and Forcemain to Rock Bay	$ 51,400	N/A	$ 540	$ 640	$ 730
(b) Macaulay Pt PS and Forcemain to Rock Bay	$ 65,400	N/A	$ 620	$ 730	$ 840
(c) Effluent PS and Forcemain to Clover Point	$ 83,900	N/A	$ 1,000	$ 1,190	$ 1,400
(d) Replace Clover Outfall	$ 32,500	N/A	incl. in (c)		incl. in (c)
(e) Reline Macaulay Outfall	$ 11,100	N/A	incl. in (b)		incl. in (b)
Conveyance Subtotal:	$ 244,300	$ -	$ 2,160	$ 2,560	$ 2,970
2. Liquid Treatment (Tertiary)	$ 500,000	$ 220,000	$ 12,000	$ 15,000	$ 19,300
3. Solids Treatment - AD at Rock Bay	$ 258,000	$ 90,600	$ 5,000	$ 8,800	$ 10,300
4. Reuse					
(a) Effluent Pumping/Piping/Controls	$ 16,100	N/A	$ 70	$ 75	$ 80
5. Existing System Capacity Upgrades					
(a) Craigflower PS - Constructed	$ 12,100	N/A	N/A	N/A	N/A
(b) Arbutus Attenuation Tank- incl land	$ 20,000	N/A	N/A	N/A	N/A
(c) Siphon Extension (1600 m)	$ 7,500	N/A	N/A	N/A	N/A
(d) Upgrade Currie St PS	$ 2,300	N/A	N/A	N/A	N/A
(f) Upgrade East Coast Interceptor (1400 m)	$ 3,100	N/A	N/A	N/A	N/A
Existing System Subtotal:	$ 45,000	$ -	$ -	$ -	$ -
6. Land Costs	$ 67,200				
Total:	**$ 1,130,600**	**$ 310,600**	**$ 19,230**	**$ 26,435**	**$ 32,650**

(1) Includes all contingencies, engineering, etc. outlined in TM #1

Summary - One Plant Option - Rock Bay - Tertiary Treatment

One-Time and Ongoing Costs

Capital Costs to 2045 [1]	Annual Costs (at 2030)			Annual Resource Income (at 2030)
	O&M	Borrowing	Total	
$ 1,441,200,000	$ 26,400,000	$ -	$ 26,400,000	$ 900,000

Notes
(1) Includes initial construction costs in 2030 as well as plant upgrades in 2030. Also includes land costs.

	Initial Capital Costs (at 2015)	Net Annual Costs (at 2030)
One Plant - Rock Bay - Tertiary Treatment	$ 1,130,600,000	$ 25,500,000

Net Present Value

Assumptions	
Interest Rate	7%
Inflation	2%
Discount Rate	5%
Time period	2015 to 2045

Resource Income (from 2015 to 2045)

	Total Revenue (no discounting)	Present Value
Reclaimed water use	$ 23,300,000	$ 8,600,000
Heat recovery	$ -	$ -
Carbon credits	$ -	
Total	$ 23,300,000	$ 8,600,000

Costs (from 2015 to 2045)

	Total Costs (no discounting)	Present Value
Capital Costs	$ 1,441,200,000	$ 1,219,100,000
O&M	$ 788,700,000	$ 360,800,000
Borrowing Costs	$ -	$ -
Total	$ 2,229,900,000	$ 1,579,900,000

Net Present Value (2015 to 2045)	-$ 1,571,300,000

Ratio of Resource Income to Costs (at 2030)

Total annual revenues	$ 900,000
Total annual costs	$ 26,400,000
Ratio of revenues to costs	3%

Notes
(1) All costs in constant 2015 dollars.

Capital Costs - One Plant Option - Rock Bay - Tertiary Treatment

	Capital costs to be incurred in 2015	Capital costs to be incurred in 2030
Total Construction Costs	$ 1,130,600,000	$ 310,600,000
Grants		
Net Project Costs	$ 1,130,600,000	$ 310,600,000

Notes

(1) Construction costs include general requirements (10%), contractor profit/overhead (10%), contingency (35%), escalation (2%/yr for four years), engineering (15%), CRD admin (8%) and interim financing (4%).
(2) Construction costs include land costs.

Year	Capital Costs
2015	$ 1,130,600,000
2016	$ -
2017	$ -
2018	$ -
2019	$ -
2020	$ -
2021	$ -
2022	$ -
2023	$ -
2024	$ -
2025	$ -
2026	$ -
2027	$ -
2028	$ -
2029	$ -
2030	$ 310,600,000
2031	$ -
2032	$ -
2033	$ -
2034	$ -
2035	$ -
2036	$ -
2037	$ -
2038	$ -
2039	$ -
2040	$ -
2041	$ -
2042	$ -
2043	$ -
2044	$ -
2045	$ -
Total Capital Costs	$ 1,441,200,000

Present Value of Total Capital Costs (2015 to 2045) $ 1,219,051,000

Annual Costs - One Plant Option - Rock Bay - Tertiary Treatment

Year	O&M Costs	Annual Borrowing Costs	Total Annual Costs
2015	$ -		$ -
2016	$ 19,230,000		$ 19,230,000
2017	$ 19,744,643		$ 19,744,643
2018	$ 20,259,286		$ 20,259,286
2019	$ 20,773,929		$ 20,773,929
2020	$ 21,288,571		$ 21,288,571
2021	$ 21,803,214		$ 21,803,214
2022	$ 22,317,857		$ 22,317,857
2023	$ 22,832,500		$ 22,832,500
2024	$ 23,347,143		$ 23,347,143
2025	$ 23,861,786		$ 23,861,786
2026	$ 24,376,429		$ 24,376,429
2027	$ 24,891,071		$ 24,891,071
2028	$ 25,405,714		$ 25,405,714
2029	$ 25,920,357		$ 25,920,357
2030	$ 26,435,000		$ 26,435,000
2031	$ 26,849,333		$ 26,849,333
2032	$ 27,263,667		$ 27,263,667
2033	$ 27,678,000		$ 27,678,000
2034	$ 28,092,333		$ 28,092,333
2035	$ 28,506,667		$ 28,506,667
2036	$ 28,921,000		$ 28,921,000
2037	$ 29,335,333		$ 29,335,333
2038	$ 29,749,667		$ 29,749,667
2039	$ 30,164,000		$ 30,164,000
2040	$ 30,578,333		$ 30,578,333
2041	$ 30,992,667		$ 30,992,667
2042	$ 31,407,000		$ 31,407,000
2043	$ 31,821,333		$ 31,821,333
2044	$ 32,235,667		$ 32,235,667
2045	$ 32,650,000		$ 32,650,000
Total	$ 788,733,000	$ -	$ 788,733,000
Present Value	$ 360,798,000	$ -	$ 360,798,000

Notes

(1) O&M estimates provided by Urban Systems for 2016, 2030 and 2045. These have been highlighted in blue.

(2) O&M costs between 2016, 2030, and 2045 have been interpolated linearly.

Revenue- One Plant Option - Rock Bay - Tertiary Treatment

Assumptions	Water Rate (per cubic metre)	Reclaimed water use rate (per cubic metre) 80% of Water Rate	Reclaimed water use rate for flushing (per ML)	Water rate for land application
Rock Bay	$1.26	$1.01	$1,011.30	$ 510
Colwood	$1.81	$1.45	$1,448.00	$ 510
Esquimalt First Nation	$1.26	$1.01	$1,011.30	$ 510
East Saanich	$1.54	$1.23	$1,233.60	$ 510
Esquimalt Bullen Park	$1.26	$1.01	$1,011.30	$ 510
East Saanich	$1.54	$1.23	$1,233.60	$ 510
Saanich Core	$1.54	$1.23	$1,233.60	$ 510
Langford	$1.81	$1.45	$1,448.00	$ 510
View Royal	$1.81	$1.45	$1,448.00	$ 510

	Rock Bay							
	Reclaimed Water Use (ML/yr)							
Year	Land Application (1)	Toilet Flushing(2)	Total Reclaimed Water Use	Total Annual Revenues from Reclaimed Water Use	Heat Recovery	Total Annual Revenues from Heat Recovery	Carbon Offsets	TOTAL
2015	0	0	0	$ -				$ -
2016	19	0	19	$ 9,520				$ 9,520
2017	37	0	37	$ 19,040				$ 19,040
2018	56	0	56	$ 28,560				$ 28,560
2019	75	0	75	$ 38,080				$ 38,080
2020	93	73	167	$ 121,741				$ 121,741
2021	93	147	240	$ 195,882				$ 195,882
2022	93	220	313	$ 270,023				$ 270,023
2023	93	293	387	$ 344,164				$ 344,164
2024	93	367	460	$ 418,305				$ 418,305
2025	93	440	533	$ 492,446				$ 492,446
2026	93	513	607	$ 566,587				$ 566,587
2027	93	587	680	$ 640,727				$ 640,727
2028	93	660	753	$ 714,868				$ 714,868
2029	93	733	826	$ 789,009				$ 789,009
2030	93	806	900	$ 863,150				$ 863,150
2031	93	880	973	$ 937,291				$ 937,291
2032	93	953	1046	$ 1,011,432				$ 1,011,432
2033	93	1026	1120	$ 1,085,573				$ 1,085,573
2034	93	1100	1193	$ 1,159,714				$ 1,159,714
2035	93	1173	1266	$ 1,233,855				$ 1,233,855
2036	93	1173	1266	$ 1,233,855				$ 1,233,855
2037	93	1173	1266	$ 1,233,855				$ 1,233,855
2038	93	1173	1266	$ 1,233,855				$ 1,233,855
2039	93	1173	1266	$ 1,233,855				$ 1,233,855
2040	93	1173	1266	$ 1,233,855				$ 1,233,855
2041	93	1173	1266	$ 1,233,855				$ 1,233,855
2042	93	1173	1266	$ 1,233,855				$ 1,233,855
2043	93	1173	1266	$ 1,233,855				$ 1,233,855
2044	93	1173	1266	$ 1,233,855				$ 1,233,855
2045	93	1173	1266	$ 1,233,855				$ 1,233,855
Total	2613	21701	24314	$ 23,278,516		-		$ 23,278,516
Present Value (2015 to 2045)				$ 8,608,000				$ 8,608,000

Notes

(1) Land application assumed to start at 0 in 2015 and increase linearly to max re-use in 2020.

(2) Flushing substitution assumed to be at 0 until 2020 and increase linearly to max re-use in 2035.

Cost Components for Option 2 - Two Plants (x 1000)

Cost Component	Capital Cost Incurred [1]		Operating Cost [1]		
	2015	2030	at 2015	at 2030	at 2045
1. Conveyance - Rock Bay					
(a) Clover Pt PS and Forcemain to Rock Bay	$ 51,400	N/A	$ 540	$ 640	$ 730
(b) Macaulay Pt PS and Forcemain to Rock Bay	$ 65,400	N/A	$ 620	$ 730	$ 840
(c) Effluent PS and Forcemain to Clover Point	$ 83,900	N/A	$ 1,000	$ 1,190	$ 1,400
(d) Replace Clover Outfall	$ 32,500	N/A	incl. in (c)		incl. in (c)
(e) Reline Macaulay Outfall	$ 11,100	N/A	incl. in (b)		incl. in (b)
Conveyance - Rock Bay Subtotal:	$ 244,300	$ -	$ 2,160	$ 2,560	$ 2,970
2. Liquid Treatment - Rock Bay - Secondary	$ 392,000	$ 162,000	$ 7,000	$ 10,100	$ 12,650
3. Solids Treatment - AD at Rock Bay	$ 258,000	$ 90,600	$ 5,000	$ 8,800	$ 10,300
4. Reuse - Rock Bay					
(a) Tertiary Slipstream	$ 8,100	N/A	$ 230	$ 230	$ 230
(b) Effluent Pumping/Piping/Controls	$ 16,100	N/A	$ 70	$ 75	$ 80
Reuse - Rock Bay Subtotal:	$ 24,200	$ -	$ 300	$ 305	$ 310
6. Existing System Capacity Upgrades					
(a) Craigflower PS - Constructed	$ 12,100	N/A	N/A	N/A	N/A
(b) Arbutus Attenuation Tank - incl land	$ 20,000	N/A	N/A	N/A	N/A
(c) Siphon Extension (1600 m)	$ 7,500	N/A	N/A	N/A	N/A
(d) Upgrade Currie St PS	$ 2,300	N/A	N/A	N/A	N/A
(f) Upgrade East Coast Interceptor (1400 m)	$ 3,100	N/A	N/A	N/A	N/A
Existing System Subtotal:	$ 45,000	$ -	$ -	$ -	$ -
7. Conveyance - Colwood					
(a) Galloping Goose Trail PS/Forcemain To/From	$ 4,400	N/A	$ 70	$ 70	$ 75
8. Liquid Treatment - Colwood - Tertiary	$ 32,500	N/A	$ 600	$ 900	$ 900
9. Reuse - Colwood					
(a) Effluent Pumping/Piping/Controls	$ 16,600	N/A	$ 70	$ 75	$ 80
10. Land Costs	$ 71,000				
Total:	**$ 1,088,000**	**$ 252,600**	**$ 15,200**	**$ 22,810**	**$ 27,285**

[1] Includes all contingencies, engineering, etc. outlined in TM #1

Summary - Two Plant Option - Rock Bay and Colwood

One-Time and Ongoing Costs

Capital Costs to 2045 [1]	Annual Costs (at 2030)			Annual Resource Income (at 2030)
	O&M	Borrowing	Total	
$ 1,340,600,000	$ 22,800,000	$ -	$ 22,800,000	$ 2,500,000

Notes
(1) Includes initial construction costs in 2015 as well as plant upgrades in 2030. Also includes land costs.

	Intial Capital Costs (at 2015)	Net Annual Costs (at 2030)
Two Plants	$ 1,088,000,000	$ 20,300,000

Net Present Value

Assumptions	
Interest Rate	7%
Inflation	2%
Discount Rate	5%
Time period	2015 to 2045

Resource Income (from 2015 to 2045)

	Total Revenue (no discounting)	Present Value
Reclaimed water use	$ 66,900,000	$ 25,600,000
Heat recovery	$ -	$ -
Total	$ 66,900,000	$ 25,600,000

Costs (from 2015 to 2045)

	Total Costs (no discounting)	Present Value
Capital Costs	$ 1,340,600,000	$ 1,151,900,000
O&M	$ 663,000,000	$ 301,600,000
Borrowing Costs	$ -	$ -
Total	$ 2,003,600,000	$ 1,453,500,000

Net Present Value (2015 to 2045)	-$ 1,427,900,000

Ratio of Resource Income to Costs (at 2030)

Total annual revenues	$ 2,500,000
Total annual costs	$ 22,800,000
Ratio of revenues to costs	11%

Notes
(1) All costs in constant 2015 dollars.

Capital Costs - Two Plant Option - Rock Bay and Colwood

	Capital costs to be incurred in 2015	Capital costs to be incurred in 2030
Total Construction Costs	$ 1,088,000,000	$ 252,600,000
Grants		
Net Project Costs	$ 1,088,000,000	$ 252,600,000

Notes
(1) Construction costs include general requirements (10%), contractor profit/overhead (10%), contingency (35%), escalation (2%/yr for four years), engineering (15%), CRD admin (8%) and interim financing (4%).
(2) Construction costs include land costs.

Year	Capital Costs
2015	$ 1,088,000,000
2016	$ -
2017	$ -
2018	$ -
2019	$ -
2020	$ -
2021	$ -
2022	$ -
2023	$ -
2024	$ -
2025	$ -
2026	$ -
2027	$ -
2028	$ -
2029	$ -
2030	$ 252,600,000
2031	$ -
2032	$ -
2033	$ -
2034	$ -
2035	$ -
2036	$ -
2037	$ -
2038	$ -
2039	$ -
2040	$ -
2041	$ -
2042	$ -
2043	$ -
2044	$ -
2045	$ -
Total Capital Costs	$ 1,340,600,000

Present Value of Total Capital Costs (2015 to 2045) $ 1,151,909,000

Annual Costs - Two Plant Option - Rock Bay and Colwood

Year	O&M Costs	Annual Borrowing Costs	Total Annual Costs
2015	$ -		$ -
2016	$ 15,200,000		$ 15,200,000
2017	$ 15,743,571		$ 15,743,571
2018	$ 16,287,143		$ 16,287,143
2019	$ 16,830,714		$ 16,830,714
2020	$ 17,374,286		$ 17,374,286
2021	$ 17,917,857		$ 17,917,857
2022	$ 18,461,429		$ 18,461,429
2023	$ 19,005,000		$ 19,005,000
2024	$ 19,548,571		$ 19,548,571
2025	$ 20,092,143		$ 20,092,143
2026	$ 20,635,714		$ 20,635,714
2027	$ 21,179,286		$ 21,179,286
2028	$ 21,722,857		$ 21,722,857
2029	$ 22,266,429		$ 22,266,429
2030	$ 22,810,000		$ 22,810,000
2031	$ 23,108,333		$ 23,108,333
2032	$ 23,406,667		$ 23,406,667
2033	$ 23,705,000		$ 23,705,000
2034	$ 24,003,333		$ 24,003,333
2035	$ 24,301,667		$ 24,301,667
2036	$ 24,600,000		$ 24,600,000
2037	$ 24,898,333		$ 24,898,333
2038	$ 25,196,667		$ 25,196,667
2039	$ 25,495,000		$ 25,495,000
2040	$ 25,793,333		$ 25,793,333
2041	$ 26,091,667		$ 26,091,667
2042	$ 26,390,000		$ 26,390,000
2043	$ 26,688,333		$ 26,688,333
2044	$ 26,986,667		$ 26,986,667
2045	$ 27,285,000		$ 27,285,000
Total	$ 663,025,000	$ -	$ 663,025,000
Present Value	$ 301,552,000	$ -	$ 301,552,000

Notes

(1) O&M estimates provided by Urban Systems for 2016, 2030 and 2045. These have been highlighted in blue.

(2) O&M costs between 2016, 2030, and 2045 have been interpolated linearly.

Revenue- Two Plant Option - Rock Bay and Colwood

Assumptions	Water Rate (per cubic metre)	Reclaimed water use rate (per cubic metre) 80% of Water Rate	Reclaimed water use rate for flushing (per ML)	Water rate for land application
Rock Bay	$ 1.26	$ 1.01	$ 1,011.30	$ 510.00
Colwood	$ 1.81	$ 1.45	$ 1,448.00	$ 510.00
Esquimalt First Nation	$ 1.26	$ 1.01	$ 1,011.30	$ 510.00
East Saanich	$ 1.54	$ 1.23	$ 1,233.60	$ 510.00
Esquimalt Bullen Park	$ 1.26	$ 1.01	$ 1,011.30	$ 510.00
East Saanich	$ 1.54	$ 1.23	$ 1,233.60	$ 510.00
Saanich Core	$ 1.54	$ 1.23	$ 1,233.60	$ 510.00
Langford	$ 1.81	$ 1.45	$ 1,448.00	$ 510.00
View Royal	$ 1.81	$ 1.45	$ 1,448.00	$ 510.00

	Rock Bay								Colwood								Total Resource Income			
	Reclaimed Water Use (ML/yr)								Reclaimed Water Use (ML/yr)											
Year	Land Application [1]	Toilet Flushing[2]	Total Reclaimed Water Use	Total Annual Revenues from Reclaimed Water Use	Heat Recovery	Total Annual Revenues from Heat Recovery	Carbon Offsets	TOTAL	Land Application [1]	Toilet Flushing[2]	Total Reclaimed Water Use	Total Annual Revenues from Reclaimed Water Use	Heat Recovery	Total Annual Revenues from Heat Recovery	Carbon Offsets	TOTAL	Reclaimed Water Use	Heat Recovery	Carbon Offsets	Total
2015	0	0	0	$ -				$ -	0	0	0	$ -				$ -	$ -			$ -
2016	19	0	19	$ 9,520				$ 9,520	165	0	165	$ 84,320				$ 84,320	$ 93,840			$ 93,840
2017	37	0	37	$ 19,040				$ 19,040	331	0	331	$ 168,640				$ 168,640	$ 187,680			$ 187,680
2018	56	0	56	$ 28,560				$ 28,560	496	0	496	$ 252,960				$ 252,960	$ 281,520			$ 281,520
2019	75	0	75	$ 38,080				$ 38,080	661	0	661	$ 337,280				$ 337,280	$ 375,360			$ 375,360
2020	93	73	167	$ 121,741				$ 121,741	827	74	901	$ 529,024				$ 529,024	$ 650,764			$ 650,764
2021	93	147	240	$ 195,882				$ 195,882	827	148	975	$ 636,447				$ 636,447	$ 832,329			$ 832,329
2022	93	220	313	$ 270,023				$ 270,023	827	223	1049	$ 743,871				$ 743,871	$ 1,013,893			$ 1,013,893
2023	93	293	387	$ 344,164				$ 344,164	827	297	1123	$ 851,294				$ 851,294	$ 1,195,458			$ 1,195,458
2024	93	367	460	$ 418,304				$ 418,304	827	371	1198	$ 958,718				$ 958,718	$ 1,377,022			$ 1,377,022
2025	93	440	533	$ 492,445				$ 492,445	827	445	1272	$ 1,066,141				$ 1,066,141	$ 1,558,586			$ 1,558,586
2026	93	513	607	$ 566,586				$ 566,586	827	519	1346	$ 1,173,565				$ 1,173,565	$ 1,740,151			$ 1,740,151
2027	93	587	680	$ 640,727				$ 640,727	827	594	1420	$ 1,280,988				$ 1,280,988	$ 1,921,715			$ 1,921,715
2028	93	660	753	$ 714,868				$ 714,868	827	668	1494	$ 1,388,412				$ 1,388,412	$ 2,103,280			$ 2,103,280
2029	93	733	826	$ 789,009				$ 789,009	827	742	1569	$ 1,495,835				$ 1,495,835	$ 2,284,844			$ 2,284,844
2030	93	806	900	$ 863,150				$ 863,150	827	816	1643	$ 1,603,259				$ 1,603,259	$ 2,466,408			$ 2,466,408
2031	93	880	973	$ 937,291				$ 937,291	827	890	1717	$ 1,710,682				$ 1,710,682	$ 2,647,973			$ 2,647,973
2032	93	953	1046	$ 1,011,432				$ 1,011,432	827	964	1791	$ 1,818,106				$ 1,818,106	$ 2,829,537			$ 2,829,537
2033	93	1026	1120	$ 1,085,572				$ 1,085,572	827	1039	1865	$ 1,925,529				$ 1,925,529	$ 3,011,101			$ 3,011,101
2034	93	1100	1193	$ 1,159,713				$ 1,159,713	827	1113	1939	$ 2,032,953				$ 2,032,953	$ 3,192,666			$ 3,192,666
2035	93	1173	1266	$ 1,233,854				$ 1,233,854	827	1187	2014	$ 2,140,376				$ 2,140,376	$ 3,374,230			$ 3,374,230
2036	93	1173	1266	$ 1,233,854				$ 1,233,854	827	1187	2014	$ 2,140,376				$ 2,140,376	$ 3,374,230			$ 3,374,230
2037	93	1173	1266	$ 1,233,854				$ 1,233,854	827	1187	2014	$ 2,140,376				$ 2,140,376	$ 3,374,230			$ 3,374,230
2038	93	1173	1266	$ 1,233,854				$ 1,233,854	827	1187	2014	$ 2,140,376				$ 2,140,376	$ 3,374,230			$ 3,374,230
2039	93	1173	1266	$ 1,233,854				$ 1,233,854	827	1187	2014	$ 2,140,376				$ 2,140,376	$ 3,374,230			$ 3,374,230
2040	93	1173	1266	$ 1,233,854				$ 1,233,854	827	1187	2014	$ 2,140,376				$ 2,140,376	$ 3,374,230			$ 3,374,230
2041	93	1173	1266	$ 1,233,854				$ 1,233,854	827	1187	2014	$ 2,140,376				$ 2,140,376	$ 3,374,230			$ 3,374,230
2042	93	1173	1266	$ 1,233,854				$ 1,233,854	827	1187	2014	$ 2,140,376				$ 2,140,376	$ 3,374,230			$ 3,374,230
2043	93	1173	1266	$ 1,233,854				$ 1,233,854	827	1187	2014	$ 2,140,376				$ 2,140,376	$ 3,374,230			$ 3,374,230
2044	93	1173	1266	$ 1,233,854				$ 1,233,854	827	1187	2014	$ 2,140,376				$ 2,140,376	$ 3,374,230			$ 3,374,230
2045	93	1173	1266	$ 1,233,854				$ 1,233,854	827	1187	2014	$ 2,140,376				$ 2,140,376	$ 3,374,230			$ 3,374,230
Total	2613	21701	24314	$ 23,278,503		-		$ 23,278,503	23147	21960	45106	$ 43,602,156	-			$ 43,602,156	$ 66,880,659	-	-	$ 66,880,659
Present Value (2015 to 2045)				$ 8,608,000				$ 8,608,000				$ 17,025,000				$ 17,025,000	$ 25,632,000			$ 25,632,000

Notes
(1) Land application assumed to start at 0 in 2015 and increase linearly to max re-use in 2020.
(2) Flushing substitution assumed to be at 0 until 2020 and increase linearly to max re-use in 2035.

Table 5 – Cost Components for Option 5a – Three Plants (x 1000)

Cost Component	Capital Cost Incurred [1]		Operating Cost [1]		
	2015	2030	at 2015	at 2030	at 2045
1. Conveyance - Rock Bay					
(a) Clover Pt PS and Forcemain to Rock Bay	$ 51,400	N/A	$ 560	$ 650	$ 730
(b) Barnhard Park PS and Forcemain to Rock Bay	$ 39,600	N/A	$ 320	$ 330	$ 340
(c) Effluent PS and Forcemain to Clover Point	$ 53,700	N/A	$ 710	$ 760	$ 800
(d) Replace Clover Outfall	$ 23,500	N/A	in c above	in c above	in c above
Conveyance - Rock Bay Subtotal:	$ 168,200	$ -	$ 1,590	$ 1,740	$ 1,870
2. Liquid Treatment - Rock Bay (Secondary)	$ 282,000	$ 70,000	$ 5,000	$ 7,800	$ 9,900
3. Solids Treatment - AD at Rock Bay	$ 258,000	$ 90,600	$ 5,000	$ 8,800	$ 10,300
4. Reuse - Rock Bay					
(a) Tertiary Slipstream	$ 8,100	N/A	$ 230	$ 230	$ 230
(b) Effluent Pumping/Piping/Controls	$ 16,100	N/A	$ 70	$ 75	$ 80
Reuse - Rock Bay Subtotal:	$ 24,200	$ -	$ 300	$ 305	$ 310
5. Existing System Capacity Upgrades					
(a) Craigflower PS - Constructed	$ 12,100	N/A	N/A	N/A	N/A
(b) Arbutus Attenuation Tank- incl land	$ 20,000	N/A	N/A	N/A	N/A
(c) Siphon Extension (1600 m)	$ 7,500	N/A	N/A	N/A	N/A
(d) Upgrade Currie St PS	$ 2,300	N/A	N/A	N/A	N/A
(e) Upgrade East Coast Interceptor (1400 m)	$ 3,100	N/A	N/A	N/A	N/A
Existing System Subtotal:	$ 45,000	$ -	$ -	$ -	$ -
6. Conveyance - Colwood					
(a) East Boundary PS/FM to Plant	$ 14,500	N/A	$ 133	$ 140	$ 146
7. Liquid Treatment - Colwood/Langford (Secondary)	$ 71,100	$ 72,600	$ 1,300	$ 2,100	$ 3,800
8. Conveyance - Colwood/Langford					
(a) Effluent PS and FM to Shore	$ 31,900		$ 214	$ 250	$ 285
(b) New Outfall	$ 33,800		in b above	in b above	in b above
9. Conveyance - Esquimalt FN					
(a) Admirals Rd Trunk Tie-in and FM to Plant	$ 1,900		$ 43	$ 44	$ 45
(b) Macaulay Pt PS and Forcemain to WWTP	$ 16,600		$ 138	$ 140	$ 143
(c) Effluent PS and Forcemain to Macaulay	$ 18,700		$ 176	$ 188	$ 200
(d) Replace Macaulay Outfall	$ 12,600		in c above	in c above	in c above
Conveyance - Esquimalt FN Subtotal:	$ 49,800	$ -	$ 357	$ 372	$ 388
10. Liquid Treatment - Esquimalt (Secondary)	$ 51,700	$ 20,200	$ 900	$ 1,300	$ 2,000
11. Reuse - Esquimalt					
(a) Tertiary Slipstream	$ 4,100	N/A	$ 120	$ 120	$ 120
(b) Effluent Pumping/Piping/Controls	$ 14,000	N/A	$ 50	$ 60	$ 70
Reuse Esquimalt FN Subtotal:	$ 18,100	$ -	$ 170	$ 180	$ 190
13. Land Costs	$ 77,000 [2]	N/A			
Total:	**$ 1,125,300**	**$ 253,400**	**$ 14,964**	**$ 22,987**	**$ 29,189**

(1) Includes all contingencies, engineering, etc. outlined in TM #1

(2) Remove East Saanich and Langford VM Way at Meadford Way, but increase area at Colwood. Allow similar land cost to the Four Plant Option.

Summary - Three Plant Option - 5a (Secondary Treatment at Colwood/Langford)

One-Time and Ongoing Costs

Capital Costs to 2045 [(1)]	Annual Costs (at 2030)			Annual Resource Income (at 2030)
	O&M	Borrowing	Total	
$ 1,378,700,000	$ 23,000,000	$ -	$ 23,000,000	$ 1,200,000

Notes
(1) Includes initial construction costs in 2015 as well as plant upgrades in 2030. Also includes land costs.

	Initial Capital Costs (at 2015)	Net Annual Costs (at 2030)
Four Plants	$ 1,125,300,000	$ 21,800,000

Net Present Value

Assumptions	
Interest Rate	7%
Inflation	2%
Discount Rate	5%
Time period	2015 to 2045

Resource Income (from 2015 to 2045)

	Total Revenue (no discounting)	Present Value
Reclaimed water use	$ 31,900,000	$ 12,100,000
Heat recovery	$ -	$ -
Total	$ 31,900,000	$ 12,100,000

Costs (from 2015 to 2045)

	Total Costs (no discounting)	Present Value
Capital Costs	$ 1,378,700,000	$ 1,187,800,000
O&M	$ 679,100,000	$ 305,700,000
Borrowing Costs	$ -	$ -
Total	$ 2,057,800,000	$ 1,493,500,000

Net Present Value (2015 to 2045)	-$ 1,481,400,000

Ratio of Resource Income to Costs (at 2030)

Total annual revenues	$ 1,200,000
Total annual costs	$ 23,000,000
Ratio of revenues to costs	5%

Notes
(1) All costs in constant 2015 dollars.

Capital Costs - Three Plant Option - 5a (Secondary Treatment at Colwood/Langford)

	Capital costs to be incurred in 2015	Capital costs to be incurred in 2030
Total Construction Costs	$ 1,125,300,000	$ 253,400,000
Grants		
Net Project Costs	$ 1,125,300,000	$ 253,400,000

Notes

(1) Construction costs include general requirements (10%), contractor profit/overhead (10%), contingency (35%), escalation (2%/yr for four years), engineering (15%), CRD admin (8%) and interim financing (4%).

(2) Construction costs include land costs.

Year	Capital Costs
2015	$ 1,125,300,000
2016	$ -
2017	$ -
2018	$ -
2019	$ -
2020	$ -
2021	$ -
2022	$ -
2023	$ -
2024	$ -
2025	$ -
2026	$ -
2027	$ -
2028	$ -
2029	$ -
2030	$ 253,400,000
2031	$ -
2032	$ -
2033	$ -
2034	$ -
2035	$ -
2036	$ -
2037	$ -
2038	$ -
2039	$ -
2040	$ -
2041	$ -
2042	$ -
2043	$ -
2044	$ -
2045	$ -
Total	$ 1,378,700,000

Present Value of Total Capital Costs (2015 to 2045) $ 1,187,800,000

Annual Costs - Three Plant Option - 5a (Secondary Treatment at Colwood/Langford)

Year	O&M Costs	Annual Borrowing Costs	Total Annual Costs
2015	$ -		$ -
2016	$ 14,964,000		$ 14,964,000
2017	$ 15,537,071		$ 15,537,071
2018	$ 16,110,143		$ 16,110,143
2019	$ 16,683,214		$ 16,683,214
2020	$ 17,256,286		$ 17,256,286
2021	$ 17,829,357		$ 17,829,357
2022	$ 18,402,429		$ 18,402,429
2023	$ 18,975,500		$ 18,975,500
2024	$ 19,548,571		$ 19,548,571
2025	$ 20,121,643		$ 20,121,643
2026	$ 20,694,714		$ 20,694,714
2027	$ 21,267,786		$ 21,267,786
2028	$ 21,840,857		$ 21,840,857
2029	$ 22,413,929		$ 22,413,929
2030	$ 22,987,000		$ 22,987,000
2031	$ 23,400,467		$ 23,400,467
2032	$ 23,813,933		$ 23,813,933
2033	$ 24,227,400		$ 24,227,400
2034	$ 24,640,867		$ 24,640,867
2035	$ 25,054,333		$ 25,054,333
2036	$ 25,467,800		$ 25,467,800
2037	$ 25,881,267		$ 25,881,267
2038	$ 26,294,733		$ 26,294,733
2039	$ 26,708,200		$ 26,708,200
2040	$ 27,121,667		$ 27,121,667
2041	$ 27,535,133		$ 27,535,133
2042	$ 27,948,600		$ 27,948,600
2043	$ 28,362,067		$ 28,362,067
2044	$ 28,775,533		$ 28,775,533
2045	$ 29,189,000		$ 29,189,000
Total	$ 679,054,000	$ -	$ 679,054,000
Present Value	$ 305,724,000	$ -	$ 305,724,000

Notes

(1) O&M estimates provided by Urban Systems for 2016, 2030 and 2045. These have been highlighted in blue.

(2) O&M costs between 2016, 2030, and 2045 have been interpolated linearly.

Resource Income- Three Plant Option - 5a (Secondary Treatment at Colwood/Langford)

Assumptions	Water Rate (per cubic metre)[1]	Reclaimed water use rate (per cubic metre) 80% of Water Rate	Reclaimed water use rate for flushing (per ML)	Water rate for land use
Rock Bay	$ 1.26	$ 1.01	$ 1,011.30	$ 510.00
Colwood	$ 1.81	$ 1.45	$ 1,448.00	$ 510.00
Esquimalt First Nation	$ 1.26	$ 1.01	$ 1,011.30	$ 510.00
East Saanich	$ 1.54	$ 1.23	$ 1,233.60	$ 510.00
Esquimalt Bullen Park	$ 1.26	$ 1.01	$ 1,011.30	$ 510.00
East Saanich	$ 1.54	$ 1.23	$ 1,233.60	$ 510.00
Saanich Core	$ 1.54	$ 1.23	$ 1,233.60	$ 510.00
Langford	$ 1.81	$ 1.45	$ 1,448.00	$ 510.00
View Royal	$ 1.81	$ 1.45	$ 1,448.00	$ 510.00

Notes
(1) Source: Respective municipal websites.

	Rock Bay								Esquimalt First Nation								Total Resource Income			
	Reclaimed Water Use (ML/yr)								Reclaimed Water Use (ML/yr)											
Year	Land Application [1]	Toilet Flushing[2]	Total Reclaimed Water Use	Total Annual Revenues from Reclaimed Water Use	Heat Recovery	Total Annual Revenues from Heat Recovery	Carbon Offsets	TOTAL	Land Application [1]	Toilet Flushing[2]	Total Reclaimed Water Use	Total Annual Revenues from Reclaimed Water Use	Heat Recovery	Total Annual Revenues from Heat Recovery	Carbon Offsets	TOTAL	Reclaimed Water Use	Heat Recovery	Carbon Offsets	Total
2015	0	0	0	$ -				$ -	0	0	0	$ -				$ -	$ -			$ -
2016	19	0	19	$ 9,520				$ 9,520	45	0	45	$ 23,120				$ 23,120	$ 32,640			$ 32,640
2017	37	0	37	$ 19,040				$ 19,040	91	0	91	$ 46,240				$ 46,240	$ 65,280			$ 65,280
2018	56	0	56	$ 28,560				$ 28,560	136	0	136	$ 69,360				$ 69,360	$ 97,920			$ 97,920
2019	75	0	75	$ 38,080				$ 38,080	181	0	181	$ 92,480				$ 92,480	$ 130,560			$ 130,560
2020	93	73	167	$ 121,762				$ 121,762	227	18	245	$ 133,930				$ 133,930	$ 255,692			$ 255,692
2021	93	147	240	$ 195,924				$ 195,924	227	36	263	$ 152,260				$ 152,260	$ 348,184			$ 348,184
2022	93	220	313	$ 270,086				$ 270,086	227	54	281	$ 170,589				$ 170,589	$ 440,675			$ 440,675
2023	93	293	387	$ 344,248				$ 344,248	227	73	299	$ 188,919				$ 188,919	$ 533,167			$ 533,167
2024	93	367	460	$ 418,410				$ 418,410	227	91	317	$ 207,249				$ 207,249	$ 625,659			$ 625,659
2025	93	440	533	$ 492,572				$ 492,572	227	109	335	$ 225,579				$ 225,579	$ 718,151			$ 718,151
2026	93	513	607	$ 566,734				$ 566,734	227	127	354	$ 243,909				$ 243,909	$ 810,642			$ 810,642
2027	93	587	680	$ 640,896				$ 640,896	227	145	372	$ 262,238				$ 262,238	$ 903,134			$ 903,134
2028	93	660	753	$ 715,058				$ 715,058	227	163	390	$ 280,568				$ 280,568	$ 995,626			$ 995,626
2029	93	733	827	$ 789,220				$ 789,220	227	181	408	$ 298,898				$ 298,898	$ 1,088,118			$ 1,088,118
2030	93	807	900	$ 863,382				$ 863,382	227	199	426	$ 317,228				$ 317,228	$ 1,180,609			$ 1,180,609
2031	93	880	973	$ 937,544				$ 937,544	227	218	444	$ 335,558				$ 335,558	$ 1,273,101			$ 1,273,101
2032	93	953	1047	$ 1,011,705				$ 1,011,705	227	236	462	$ 353,887				$ 353,887	$ 1,365,593			$ 1,365,593
2033	93	1027	1120	$ 1,085,867				$ 1,085,867	227	254	480	$ 372,217				$ 372,217	$ 1,458,085			$ 1,458,085
2034	93	1100	1193	$ 1,160,029				$ 1,160,029	227	272	499	$ 390,547				$ 390,547	$ 1,550,576			$ 1,550,576
2035	93	1173	1267	$ 1,234,191				$ 1,234,191	227	290	517	$ 408,877				$ 408,877	$ 1,643,068			$ 1,643,068
2036	93	1173	1267	$ 1,234,191				$ 1,234,191	227	290	517	$ 408,877				$ 408,877	$ 1,643,068			$ 1,643,068
2037	93	1173	1267	$ 1,234,191				$ 1,234,191	227	290	517	$ 408,877				$ 408,877	$ 1,643,068			$ 1,643,068
2038	93	1173	1267	$ 1,234,191				$ 1,234,191	227	290	517	$ 408,877				$ 408,877	$ 1,643,068			$ 1,643,068
2039	93	1173	1267	$ 1,234,191				$ 1,234,191	227	290	517	$ 408,877				$ 408,877	$ 1,643,068			$ 1,643,068
2040	93	1173	1267	$ 1,234,191				$ 1,234,191	227	290	517	$ 408,877				$ 408,877	$ 1,643,068			$ 1,643,068
2041	93	1173	1267	$ 1,234,191				$ 1,234,191	227	290	517	$ 408,877				$ 408,877	$ 1,643,068			$ 1,643,068
2042	93	1173	1267	$ 1,234,191				$ 1,234,191	227	290	517	$ 408,877				$ 408,877	$ 1,643,068			$ 1,643,068
2043	93	1173	1267	$ 1,234,191				$ 1,234,191	227	290	517	$ 408,877				$ 408,877	$ 1,643,068			$ 1,643,068
2044	93	1173	1267	$ 1,234,191				$ 1,234,191	227	290	517	$ 408,877				$ 408,877	$ 1,643,068			$ 1,643,068
2045	93	1173	1267	$ 1,234,191				$ 1,234,191	227	290	517	$ 408,877				$ 408,877	$ 1,643,068			$ 1,643,068
Total	2613	21707	24320	$ 23,284,740		-		$ 23,284,740	6,347	5,365	11,712	$ 8,662,421	-			$ 8,662,421	$ 31,947,161	-	-	$ 31,947,161
Present Value (2015 to 2045)				$ 8,610,000		$ -		$ 8,610,000				$ 3,469,000				$ 3,469,000	$ 12,079,000			$ 12,079,000

Notes
(1) Land application assumed to start at 0 in 2015 and increase linearly to max re-use in 2020.
(2) Flushing substitution assumed to be at 0 until 2020 and increase linearly to max re-use in 2035.
(3) Quantity estimates for 2020 and 2035 provided by Urban Systems, Nov. 18th, 2015.

Table 6 – Cost Components for Option 5b – Three Plants (x 1000)

Cost Component	Capital Cost Incurred [1]		Operating Cost [1]		
	2015	2030	at 2015	at 2030	at 2045
1. Conveyance - Rock Bay					
(a) Clover Pt PS and Forcemain to Rock Bay	$ 51,400	N/A	$ 560	$ 650	$ 730
(b) Barnhard Park PS and Forcemain to Rock Bay	$ 39,600	N/A	$ 320	$ 330	$ 340
(c) Effluent PS and Forcemain to Clover Point	$ 53,700	N/A	$ 710	$ 760	$ 800
(d) Replace Clover Outfall	$ 23,500	N/A	in c above	in c above	in c above
Conveyance - Rock Bay Subtotal:	$ 168,200	$ -	$ 1,590	$ 1,740	$ 1,870
2. Liquid Treatment - Rock Bay (Secondary)	$ 282,000	$ 70,000	$ 5,000	$ 7,800	$ 9,900
3. Solids Treatment - AD at Rock Bay	$ 258,000	$ 90,600	$ 5,000	$ 8,800	$ 10,300
4. Reuse - Rock Bay					
(a) Tertiary Slipstream	$ 8,100	N/A	$ 230	$ 230	$ 230
(b) Effluent Pumping/Piping/Controls	$ 16,100	N/A	$ 70	$ 75	$ 80
Reuse - Rock Bay Subtotal:	$ 24,200	$ -	$ 300	$ 305	$ 310
5. Existing System Capacity Upgrades					
(a) Craigflower PS - Constructed	$ 12,100	N/A	N/A	N/A	N/A
(b) Arbutus Attenuation Tank- incl land	$ 20,000	N/A	N/A	N/A	N/A
(c) Siphon Extension (1600 m)	$ 7,500	N/A	N/A	N/A	N/A
(d) Upgrade Currie St PS	$ 2,300	N/A	N/A	N/A	N/A
(e) Upgrade East Coast Interceptor (1400 m)	$ 3,100	N/A	N/A	N/A	N/A
Existing System Subtotal:	$ 45,000	$ -	$ -	$ -	$ -
6. Conveyance - Colwood					
(a) East Boundary PS/FM to Plant	$ 14,500	N/A	$ 133	$ 140	$ 146
7. Liquid Treatment - Colwood/Langford (Tertiary)	$ 106,800	$ 119,500	$ 2,000	$ 3,100	$ 5,800
8. Reuse - Colwood					
(a) Effluent Pumping/Piping/Controls	$ 16,600	N/A	$ 70	$ 75	$ 80
9. Conveyance - Colwood/Langford					
(a) Effluent PS and FM to Shore	$ 31,900		$ 214	$ 250	$ 285
(b) New Outfall	$ 33,800		in b above	in b above	in b above
10. Conveyance - Esquimalt FN					
(a) Admirals Rd Trunk Tie-in and FM to Plant	$ 1,900		$ 43	$ 44	$ 45
(b) Macaulay Pt PS and Forcemain to WWTP	$ 16,600		$ 138	$ 140	$ 143
(c) Effluent PS and Forcemain to Macaulay	$ 18,700		$ 176	$ 188	$ 200
(d) Replace Macaulay Outfall	$ 12,600		in c above	in c above	in c above
Conveyance - Esquimalt FN Subtotal:	$ 49,800	$ -	$ 357	$ 372	$ 388
11. Liquid Treatment - Esquimalt (Secondary)	$ 51,700	$ 20,200	$ 900	$ 1,300	$ 2,000
12. Reuse - Esquimalt					
(a) Tertiary Slipstream	$ 4,100	N/A	$ 120	$ 120	$ 120
(b) Effluent Pumping/Piping/Controls	$ 14,000	N/A	$ 50	$ 60	$ 70
Reuse Esquimalt FN Subtotal:	$ 18,100	$ -	$ 170	$ 180	$ 190
13. Land Costs	$ 77,000 [2]	N/A			
Total:	**$1,177,600**	**$ 300,300**	**$ 15,734**	**$ 24,062**	**$ 31,269**

(1) Includes all contingencies, engineering, etc. outlined in TM #1

(2) Remove East Saanich and Langford VM Way at Meadford Way, but increase area at Colwood. Allow similar land cost to the Four Plant Option.

Summary - Three Plant Option - 5b Tertiary Treatment at Colwood/Langford

One-Time and Ongoing Costs

Capital Costs to 2045 [1]	Annual Costs (at 2030)			Annual Resource Income (at 2030)
	O&M	Borrowing	Total	
$ 1,477,900,000	$ 24,100,000	$ -	$ 24,100,000	$ 2,800,000

Notes
(1) Includes initial construction costs in 2015 as well as plant upgrades in 2030. Also includes land costs.

	Initial Capital Costs (at 2015)	Net Annual Costs (at 2030)
Four Plants	$ 1,177,600,000	$ 21,300,000

Net Present Value

Assumptions	
Interest Rate	7%
Inflation	2%
Discount Rate	5%
Time period	2015 to 2045

Resource Income (from 2015 to 2045)

	Total Revenue (no discounting)	Present Value
Reclaimed water use	$ 75,500,000	$ 29,100,000
Heat recovery	$ -	$ -
Total	$ 75,500,000	$ 29,100,000

Costs (from 2015 to 2045)

	Total Costs (no discounting)	Present Value
Capital Costs	$ 1,477,900,000	$ 1,259,100,000
O&M	$ 717,100,000	$ 322,000,000
Borrowing Costs	$ -	$ -
Total	$ 2,195,000,000	$ 1,581,100,000

Net Present Value (2015 to 2045)	-$ 1,552,000,000

Ratio of Resource Income to Costs (at 2030)

Total annual revenues	$ 2,800,000
Total annual costs	$ 24,100,000
Ratio of revenues to costs	12%

Notes
(1) All costs in constant 2015 dollars.

Capital Costs - Three Plant Option - 5b Tertiary Treatment at Colwood/Langford)

	Capital costs to be incurred in 2015	Capital costs to be incurred in 2030
Total Construction Costs	$ 1,177,600,000	$ 300,300,000
Grants		
Net Project Costs	$ 1,177,600,000	$ 300,300,000

Notes

(1) Construction costs include general requirements (10%), contractor profit/overhead (10%), contingency (35%), escalation (2%/yr for four years), engineering (15%), CRD admin (8%) and interim financing (4%).

(2) Construction costs include land costs.

Year	Capital Costs
2015	$ 1,177,600,000
2016	$ -
2017	$ -
2018	$ -
2019	$ -
2020	$ -
2021	$ -
2022	$ -
2023	$ -
2024	$ -
2025	$ -
2026	$ -
2027	$ -
2028	$ -
2029	$ -
2030	$ 300,300,000
2031	$ -
2032	$ -
2033	$ -
2034	$ -
2035	$ -
2036	$ -
2037	$ -
2038	$ -
2039	$ -
2040	$ -
2041	$ -
2042	$ -
2043	$ -
2044	$ -
2045	$ -
Total	$ 1,477,900,000

Present Value of Total Capital Costs (2015 to 2045) $ 1,259,095,000

Annual Costs - Three Plant Option - 5b Tertiary Treatment at Colwood/Langford)

Year	O&M Costs	Annual Borrowing Costs	Total Annual Costs
2015	$ -		$ -
2016	$ 15,734,000		$ 15,734,000
2017	$ 16,328,857		$ 16,328,857
2018	$ 16,923,714		$ 16,923,714
2019	$ 17,518,571		$ 17,518,571
2020	$ 18,113,429		$ 18,113,429
2021	$ 18,708,286		$ 18,708,286
2022	$ 19,303,143		$ 19,303,143
2023	$ 19,898,000		$ 19,898,000
2024	$ 20,492,857		$ 20,492,857
2025	$ 21,087,714		$ 21,087,714
2026	$ 21,682,571		$ 21,682,571
2027	$ 22,277,429		$ 22,277,429
2028	$ 22,872,286		$ 22,872,286
2029	$ 23,467,143		$ 23,467,143
2030	$ 24,062,000		$ 24,062,000
2031	$ 24,542,467		$ 24,542,467
2032	$ 25,022,933		$ 25,022,933
2033	$ 25,503,400		$ 25,503,400
2034	$ 25,983,867		$ 25,983,867
2035	$ 26,464,333		$ 26,464,333
2036	$ 26,944,800		$ 26,944,800
2037	$ 27,425,267		$ 27,425,267
2038	$ 27,905,733		$ 27,905,733
2039	$ 28,386,200		$ 28,386,200
2040	$ 28,866,667		$ 28,866,667
2041	$ 29,347,133		$ 29,347,133
2042	$ 29,827,600		$ 29,827,600
2043	$ 30,308,067		$ 30,308,067
2044	$ 30,788,533		$ 30,788,533
2045	$ 31,269,000		$ 31,269,000
Total	$ 717,056,000	$ -	$ 717,056,000
Present Value	$ 322,022,000	$ -	$ 322,022,000

Notes

(1) O&M estimates provided by Urban Systems for 2016, 2030 and 2045. These have been highlighted in blue.

(2) O&M costs between 2016, 2030, and 2045 have been interpolated linearly.

Resource Income- Three Plant Option - 5b Tertiary Treatment at Colwood/Langford)

Assumptions	Water Rate (per cubic metre)[1]	Reclaimed water use rate (per cubic metre) 80% of Water Rate	Reclaimed water use rate for flushing (per ML)	Water rate for land use
Rock Bay	$ 1.26	$ 1.01	$ 1,011.30	$ 510.00
Colwood	$ 1.81	$ 1.45	$ 1,448.00	$ 510.00
Esquimalt First Nation	$ 1.26	$ 1.01	$ 1,011.30	$ 510.00
East Saanich	$ 1.54	$ 1.23	$ 1,233.60	$ 510.00
Esquimalt Bullen Park	$ 1.26	$ 1.01	$ 1,011.30	$ 510.00
East Saanich	$ 1.54	$ 1.23	$ 1,233.60	$ 510.00
Saanich Core	$ 1.54	$ 1.23	$ 1,233.60	$ 510.00
Langford	$ 1.81	$ 1.45	$ 1,448.00	$ 510.00
View Royal	$ 1.81	$ 1.45	$ 1,448.00	$ 510.00

Notes
(1) Source: Respective municipal websites.

Rock Bay

Year	Reclaimed Water Use (ML/yr): Land Application [1]	Reclaimed Water Use (ML/yr): Toilet Flushing[2]	Reclaimed Water Use (ML/yr): Total Reclaimed Water Use	Total Annual Revenues from Reclaimed Water Use	Heat Recovery	Total Annual Revenues from Heat Recovery	Carbon Offsets	TOTAL
2015	0	0	0	$ -				$ -
2016	19	0	19	$ 9,520				$ 9,520
2017	37	0	37	$ 19,040				$ 19,040
2018	56	0	56	$ 28,560				$ 28,560
2019	75	0	75	$ 38,080				$ 38,080
2020	93	73	167	$ 121,762				$ 121,762
2021	93	147	240	$ 195,924				$ 195,924
2022	93	220	313	$ 270,086				$ 270,086
2023	93	293	387	$ 344,248				$ 344,248
2024	93	367	460	$ 418,410				$ 418,410
2025	93	440	533	$ 492,572				$ 492,572
2026	93	513	607	$ 566,734				$ 566,734
2027	93	587	680	$ 640,896				$ 640,896
2028	93	660	753	$ 715,058				$ 715,058
2029	93	733	827	$ 789,220				$ 789,220
2030	93	807	900	$ 863,382				$ 863,382
2031	93	880	973	$ 937,544				$ 937,544
2032	93	953	1047	$ 1,011,705				$ 1,011,705
2033	93	1027	1120	$ 1,085,867				$ 1,085,867
2034	93	1100	1193	$ 1,160,029				$ 1,160,029
2035	93	1173	1267	$ 1,234,191				$ 1,234,191
2036	93	1173	1267	$ 1,234,191				$ 1,234,191
2037	93	1173	1267	$ 1,234,191				$ 1,234,191
2038	93	1173	1267	$ 1,234,191				$ 1,234,191
2039	93	1173	1267	$ 1,234,191				$ 1,234,191
2040	93	1173	1267	$ 1,234,191				$ 1,234,191
2041	93	1173	1267	$ 1,234,191				$ 1,234,191
2042	93	1173	1267	$ 1,234,191				$ 1,234,191
2043	93	1173	1267	$ 1,234,191				$ 1,234,191
2044	93	1173	1267	$ 1,234,191				$ 1,234,191
2045	93	1173	1267	$ 1,234,191				$ 1,234,191
Total	2613	21707	24320	$ 23,284,740		-		$ 23,284,740
Present Value (2015 to 2045)				$ 8,610,000		$ -		$ 8,610,000

Colwood

Year	Reclaimed Water Use (ML/yr): Land Application [1]	Reclaimed Water Use (ML/yr): Toilet Flushing[2]	Reclaimed Water Use (ML/yr): Total Reclaimed Water Use	Total Annual Revenues from Reclaimed Water Use	Heat Recovery	Total Annual Revenues from Heat Recovery	Carbon Offsets	TOTAL
2015	0	0	0	$ -				$ -
2016	165	0	165.3333333	$ 84,320				$ 84,320
2017	331	0	330.6666667	$ 168,640				$ 168,640
2018	496	0	496	$ 252,960				$ 252,960
2019	661	0	661.3333333	$ 337,280				$ 337,280
2020	827	74	901	$ 528,993				$ 528,993
2021	827	148	975	$ 636,387				$ 636,387
2022	827	223	1049	$ 743,780				$ 743,780
2023	827	297	1123	$ 851,173				$ 851,173
2024	827	371	1198	$ 958,567				$ 958,567
2025	827	445	1272	$ 1,065,960				$ 1,065,960
2026	827	519	1346	$ 1,173,353				$ 1,173,353
2027	827	593	1420	$ 1,280,747				$ 1,280,747
2028	827	668	1494	$ 1,388,140				$ 1,388,140
2029	827	742	1568	$ 1,495,533				$ 1,495,533
2030	827	816	1643	$ 1,602,927				$ 1,602,927
2031	827	890	1717	$ 1,710,320				$ 1,710,320
2032	827	964	1791	$ 1,817,713				$ 1,817,713
2033	827	1038	1865	$ 1,925,107				$ 1,925,107
2034	827	1113	1939	$ 2,032,500				$ 2,032,500
2035	827	1187	2013	$ 2,139,893				$ 2,139,893
2036	827	1187	2013	$ 2,139,893				$ 2,139,893
2037	827	1187	2013	$ 2,139,893				$ 2,139,893
2038	827	1187	2013	$ 2,139,893				$ 2,139,893
2039	827	1187	2013	$ 2,139,893				$ 2,139,893
2040	827	1187	2013	$ 2,139,893				$ 2,139,893
2041	827	1187	2013	$ 2,139,893				$ 2,139,893
2042	827	1187	2013	$ 2,139,893				$ 2,139,893
2043	827	1187	2013	$ 2,139,893				$ 2,139,893
2044	827	1187	2013	$ 2,139,893				$ 2,139,893
2045	827	1187	2013	$ 2,139,893				$ 2,139,893
Total	23,147	21,953	45,100	$ 43,593,227	-			$ 43,593,227
Present Value (2015 to 2045)				$ 17,021,000		$0		$ 17,021,000

Esquimalt First Nation

Year	Reclaimed Water Use (ML/yr): Land Application [1]	Reclaimed Water Use (ML/yr): Toilet Flushing[2]	Reclaimed Water Use (ML/yr): Total Reclaimed Water Use	Total Annual Revenues from Reclaimed Water Use	Heat Recovery	Total Annual Revenues from Heat Recovery	Carbon Offsets	TOTAL
2015	0	0	0	$ -				$ -
2016	45	0	45	$ 23,120				$ 23,120
2017	91	0	91	$ 46,240				$ 46,240
2018	136	0	136	$ 69,360				$ 69,360
2019	181	0	181	$ 92,480				$ 92,480
2020	227	18	245	$ 133,930				$ 133,930
2021	227	36	263	$ 152,260				$ 152,260
2022	227	54	281	$ 170,589				$ 170,589
2023	227	73	299	$ 188,919				$ 188,919
2024	227	91	317	$ 207,249				$ 207,249
2025	227	109	335	$ 225,579				$ 225,579
2026	227	127	354	$ 243,909				$ 243,909
2027	227	145	372	$ 262,238				$ 262,238
2028	227	163	390	$ 280,568				$ 280,568
2029	227	181	408	$ 298,898				$ 298,898
2030	227	199	426	$ 317,228				$ 317,228
2031	227	218	444	$ 335,558				$ 335,558
2032	227	236	462	$ 353,887				$ 353,887
2033	227	254	480	$ 372,217				$ 372,217
2034	227	272	499	$ 390,547				$ 390,547
2035	227	290	517	$ 408,877				$ 408,877
2036	227	290	517	$ 408,877				$ 408,877
2037	227	290	517	$ 408,877				$ 408,877
2038	227	290	517	$ 408,877				$ 408,877
2039	227	290	517	$ 408,877				$ 408,877
2040	227	290	517	$ 408,877				$ 408,877
2041	227	290	517	$ 408,877				$ 408,877
2042	227	290	517	$ 408,877				$ 408,877
2043	227	290	517	$ 408,877				$ 408,877
2044	227	290	517	$ 408,877				$ 408,877
2045	227	290	517	$ 408,877				$ 408,877
Total	6,347	5,365	11,712	$ 8,662,421	-			$ 8,662,421
Present Value (2015 to 2045)				$ 3,469,000				$ 3,469,000

Total Resource Income

Year	Reclaimed Water Use	Heat Recovery	Carbon Offsets	Total
2015	$ -			$ -
2016	$ 116,960			$ 116,960
2017	$ 233,920			$ 233,920
2018	$ 350,880			$ 350,880
2019	$ 467,840			$ 467,840
2020	$ 784,685			$ 784,685
2021	$ 984,570			$ 984,570
2022	$ 1,184,455			$ 1,184,455
2023	$ 1,384,340			$ 1,384,340
2024	$ 1,584,225			$ 1,584,225
2025	$ 1,784,111			$ 1,784,111
2026	$ 1,983,996			$ 1,983,996
2027	$ 2,183,881			$ 2,183,881
2028	$ 2,383,766			$ 2,383,766
2029	$ 2,583,651			$ 2,583,651
2030	$ 2,783,536			$ 2,783,536
2031	$ 2,983,421			$ 2,983,421
2032	$ 3,183,306			$ 3,183,306
2033	$ 3,383,191			$ 3,383,191
2034	$ 3,583,076			$ 3,583,076
2035	$ 3,782,962			$ 3,782,962
2036	$ 3,782,962			$ 3,782,962
2037	$ 3,782,962			$ 3,782,962
2038	$ 3,782,962			$ 3,782,962
2039	$ 3,782,962			$ 3,782,962
2040	$ 3,782,962			$ 3,782,962
2041	$ 3,782,962			$ 3,782,962
2042	$ 3,782,962			$ 3,782,962
2043	$ 3,782,962			$ 3,782,962
2044	$ 3,782,962			$ 3,782,962
2045	$ 3,782,962			$ 3,782,962
Total	$ 75,540,388	-	-	$ 75,540,388
Present Value (2015 to 2045)	$ 29,100,000			$ 29,100,000

Notes
(1) Land application assumed to start at 0 in 2015 and increase linearly to max re-use in 2020.
(2) Flushing substitution assumed to be at 0 until 2020 and increase linearly to max re-use in 2035.
(3) Quantity estimates for 2020 and 2035 provided by Urban Systems, Nov. 18th, 2015.

Cost Components for Option 3 - Four Plants (x 1000)

Cost Component	Capital Cost Incurred [1]		Operating Cost [1]		
	2015	2030	at 2015	at 2030	at 2045
1. Conveyance - Rock Bay					
(a) Clover Pt PS and Forcemain to Rock Bay	$ 51,400	N/A	$ 560	$ 650	$ 730
(b) Barnhard Park PS and Forcemain to Rock Bay	$ 39,600	N/A	$ 320	$ 330	$ 340
(c) Effluent PS and Forcemain to Clover Point	$ 53,700	N/A	$ 710	$ 760	$ 800
(d) Replace Clover Outfall	$ 23,500	N/A	incl. in (c)		incl. in (c)
Conveyance - Rock Bay Subtotal:	$ 168,200	$ -	$ 1,590	$ 1,740	$ 1,870
2. Liquid Treatment - Rock Bay (Secondary)	$ 282,000	$ 70,000	$ 5,000	$ 7,800	$ 9,900
3. Solids Treatment - AD at Rock Bay	$ 258,000	$ 90,600	$ 5,000	$ 8,800	$ 10,300
4. Reuse - Rock Bay					
(a) Tertiary Slipstream	$ 8,100	N/A	$ 230	$ 230	$ 230
(b) Effluent Pumping/Piping/Controls	$ 16,100	N/A	$ 70	$ 75	$ 80
Reuse - Rock Bay Subtotal:	$ 24,200	$ -	$ 300	$ 305	$ 310
5. Existing System Capacity Upgrades					
(a) Craigflower PS - Constructed	$ 12,100	N/A	N/A	N/A	N/A
(b) Arbutus Attenuation Tank- incl land	$ 20,000	N/A	N/A	N/A	N/A
(c) Siphon Extension (1600 m)	$ 7,500	N/A	N/A	N/A	N/A
(d) Upgrade Currie St PS	$ 2,300	N/A	N/A	N/A	N/A
(e) Upgrade East Coast Interceptor (1400 m)	$ 3,100	N/A	N/A	N/A	N/A
Existing System Subtotal:	$ 45,000	$ -	$ -	$ -	$ -
6. Conveyance - Colwood					
(a) Galloping Goose Trail PS/Forcemain To/From	$ 4,400	N/A	$ 70	$ 70	$ 75
7. Liquid Treatment - Colwood (Tertiary)	$ 32,500	N/A	$ 600	$ 900	$ 900
8. Reuse - Colwood					
(a) Effluent Pumping/Piping/Controls	$ 16,600	N/A	$ 70	$ 75	$ 80
9. Conveyance - Esquimalt FN					
(a) Admirals Rd Trunk Tie-in and FM to Plant	$ 4,600	N/A	N/A		N/A
(b) Macaulay Pt PS and Forcemain to WWTP	$ 16,600	N/A	$ 130	$ 140	$ 150
(c) Effluent PS and Forcemain to Macaulay	$ 42,600	N/A	$ 320	$ 420	$ 530
(d) Replace Macaulay Outfall	$ 34,200	N/A	incl. in (c)		incl. in (c)
Conveyance - Esquimalt FN Subtotal:	$ 98,000	$ -	$ 450	$ 560	$ 680
10. Liquid Treatment - Esquimalt (Secondary)	$ 141,000	$ 100,000	$ 3,000	$ 4,500	$ 6,000
11. Reuse - Esquimalt					
(a) Tertiary Slipstream	$ 4,100	N/A	$ 120	$ 120	$ 120
(b) Effluent Pumping/Piping/Controls	$ 14,000	N/A	$ 50	$ 60	$ 70
Reuse Esquimalt FN Subtotal:	$ 18,100	$ -	$ 170	$ 180	$ 190
12. Conveyance - East Saanich					
(a) Garnet PS Upgrade and Forcemain To/From	$ 4,000	N/A	$ 50	$ 60	$ 70
13. Liquid Treatment - East Saanich (Tertiary)	$ 10,000	$ 6,500	$ 200	$ 300	$ 500
14. Reuse - East Saanich					
(a) Effluent Pumping/Piping/Controls	$ 16,100	N/A	$ 50	$ 55	$ 60
15. Land Costs	$ 77,200	N/A			
Total:	**$ 1,195,300**	**$ 267,100**	**$ 16,550**	**$ 25,345**	**$ 30,935**

[1] Includes all contingencies, engineering, etc. outlined in TM #1

Summary - Four Plant Option

One-Time and Ongoing Costs

Capital Costs to 2045 [1]	Annual Costs (at 2030)			Annual Resource Income (at 2030)
	O&M	Borrowing	Total	
$ 1,462,400,000	$ 25,300,000	$ -	$ 25,300,000	$ 3,800,000

Notes
(1) Includes initial construction costs in 2015 as well as plant upgrades in 2030. Also includes land costs.

	Initial Capital Costs (at 2015)	Net Annual Costs (at 2030)
Four Plants	$ 1,195,300,000	$ 21,500,000

Net Present Value

Assumptions	
Interest Rate	7%
Inflation	2%
Discount Rate	5%
Time period	2015 to 2045

Resource Income (from 2015 to 2045)

	Total Revenue (no discounting)	Present Value
Reclaimed water use	$ 102,300,000	$ 40,200,000
Heat recovery	$ -	$ -
Total	$ 102,300,000	$ 40,200,000

Costs (from 2015 to 2045)

	Total Costs (no discounting)	Present Value
Capital Costs	$ 1,462,400,000	$ 1,260,700,000
O&M	$ 739,100,000	$ 334,600,000
Borrowing Costs	$ -	$ -
Total	$ 2,201,500,000	$ 1,595,300,000

Net Present Value (2015 to 2045)	-$ 1,555,100,000

Ratio of Resource Income to Costs (at 2030)

Total annual revenues	$ 3,800,000
Total annual costs	$ 25,300,000
Ratio of revenues to costs	15%

Notes
(1) All costs in constant 2015 dollars.

Capital Costs - Four Plant Option

	Capital costs to be incurred in 2015	Capital costs to be incurred in 2030
Total Construction Costs	$ 1,195,300,000	$ 267,100,000
Grants		
Net Project Costs	$ 1,195,300,000	$ 267,100,000

Notes

(1) Construction costs include general requirements (10%), contractor profit/overhead (10%), contingency (35%), escalation (2%/yr for four years), engineering (15%), CRD admin (8%) and interim financing (4%).

(2) Construction costs include land costs.

Year	Capital Costs
2015	$ 1,195,300,000
2016	$ -
2017	$ -
2018	$ -
2019	$ -
2020	$ -
2021	$ -
2022	$ -
2023	$ -
2024	$ -
2025	$ -
2026	$ -
2027	$ -
2028	$ -
2029	$ -
2030	$ 267,100,000
2031	$ -
2032	$ -
2033	$ -
2034	$ -
2035	$ -
2036	$ -
2037	$ -
2038	$ -
2039	$ -
2040	$ -
2041	$ -
2042	$ -
2043	$ -
2044	$ -
2045	$ -
Total	$ 1,462,400,000

Present Value of Total Capital Costs (2015 to 2045) $ 1,260,743,000

Annual Costs - Four Plant Option

Year	O&M Costs	Annual Borrowing Costs	Total Annual Costs
2015	$ -		$ -
2016	$ 16,550,000		$ 16,550,000
2017	$ 17,178,214		$ 17,178,214
2018	$ 17,806,429		$ 17,806,429
2019	$ 18,434,643		$ 18,434,643
2020	$ 19,062,857		$ 19,062,857
2021	$ 19,691,071		$ 19,691,071
2022	$ 20,319,286		$ 20,319,286
2023	$ 20,947,500		$ 20,947,500
2024	$ 21,575,714		$ 21,575,714
2025	$ 22,203,929		$ 22,203,929
2026	$ 22,832,143		$ 22,832,143
2027	$ 23,460,357		$ 23,460,357
2028	$ 24,088,571		$ 24,088,571
2029	$ 24,716,786		$ 24,716,786
2030	$ 25,345,000		$ 25,345,000
2031	$ 25,717,667		$ 25,717,667
2032	$ 26,090,333		$ 26,090,333
2033	$ 26,463,000		$ 26,463,000
2034	$ 26,835,667		$ 26,835,667
2035	$ 27,208,333		$ 27,208,333
2036	$ 27,581,000		$ 27,581,000
2037	$ 27,953,667		$ 27,953,667
2038	$ 28,326,333		$ 28,326,333
2039	$ 28,699,000		$ 28,699,000
2040	$ 29,071,667		$ 29,071,667
2041	$ 29,444,333		$ 29,444,333
2042	$ 29,817,000		$ 29,817,000
2043	$ 30,189,667		$ 30,189,667
2044	$ 30,562,333		$ 30,562,333
2045	$ 30,935,000		$ 30,935,000
Total	$ 739,108,000	$ -	$ 739,108,000
Present Value	$ 334,562,000	$ -	$ 334,562,000

Notes

(1) O&M estimates provided by Urban Systems for 2016, 2030 and 2045. These have been highlighted in blue.

(2) O&M costs between 2016, 2030, and 2045 have been interpolated linearly.

Resource Income- Four Plant Option

Assumptions	Water Rate (per cubic metre)[1]	Reclaimed water use rate (per cubic metre) 80% of Water Rate	Reclaimed water use rate for flushing (per ML)	Water rate for land use
Rock Bay	$ 1.26	$ 1.01	$ 1,011.30	$ 510.00
Colwood	$ 1.81	$ 1.45	$ 1,448.00	$ 510.00
Esquimalt First Nation	$ 1.26	$ 1.01	$ 1,011.30	$ 510.00
East Saanich	$ 1.54	$ 1.23	$ 1,233.60	$ 510.00
Esquimalt Bullen Park	$ 1.26	$ 1.01	$ 1,011.30	$ 510.00
East Saanich	$ 1.54	$ 1.23	$ 1,233.60	$ 510.00
Saanich Core	$ 1.54	$ 1.23	$ 1,233.60	$ 510.00
Langford	$ 1.81	$ 1.45	$ 1,448.00	$ 510.00
View Royal	$ 1.81	$ 1.45	$ 1,448.00	$ 510.00

Notes
(1) Source: Respective municipal websites.

	Rock Bay							
	Reclaimed Water Use (ML/yr)							
Year	Land Application (1)	Toilet Flushing(2)	Total Reclaimed Water Use	Total Annual Revenues from Reclaimed Water Use	Heat Recovery	Total Annual Revenues from Heat Recovery	Carbon Offsets	TOTAL
2015	0	0	0	$ -				$ -
2016	19	0	19	$ 9,520				$ 9,520
2017	37	0	37	$ 19,040				$ 19,040
2018	56	0	56	$ 28,560				$ 28,560
2019	75	0	75	$ 38,080				$ 38,080
2020	93	73	167	$ 121,762				$ 121,762
2021	93	147	240	$ 195,924				$ 195,924
2022	93	220	313	$ 270,086				$ 270,086
2023	93	293	387	$ 344,248				$ 344,248
2024	93	367	460	$ 418,410				$ 418,410
2025	93	440	533	$ 492,572				$ 492,572
2026	93	513	607	$ 566,734				$ 566,734
2027	93	587	680	$ 640,896				$ 640,896
2028	93	660	753	$ 715,058				$ 715,058
2029	93	733	827	$ 789,220				$ 789,220
2030	93	807	900	$ 863,382				$ 863,382
2031	93	880	973	$ 937,544				$ 937,544
2032	93	953	1047	$ 1,011,705				$ 1,011,705
2033	93	1027	1120	$ 1,085,867				$ 1,085,867
2034	93	1100	1193	$ 1,160,029				$ 1,160,029
2035	93	1173	1267	$ 1,234,191				$ 1,234,191
2036	93	1173	1267	$ 1,234,191				$ 1,234,191
2037	93	1173	1267	$ 1,234,191				$ 1,234,191
2038	93	1173	1267	$ 1,234,191				$ 1,234,191
2039	93	1173	1267	$ 1,234,191				$ 1,234,191
2040	93	1173	1267	$ 1,234,191				$ 1,234,191
2041	93	1173	1267	$ 1,234,191				$ 1,234,191
2042	93	1173	1267	$ 1,234,191				$ 1,234,191
2043	93	1173	1267	$ 1,234,191				$ 1,234,191
2044	93	1173	1267	$ 1,234,191				$ 1,234,191
2045	93	1173	1267	$ 1,234,191				$ 1,234,191
Total	2613	21707	24320	$ 23,284,740		-		$ 23,284,740
Present Value (2015 to 2045)				$ 8,610,000		$ -		$ 8,610,000

	Colwood							
	Reclaimed Water Use (ML/yr)							
Year	Land Application (1)	Toilet Flushing(2)	Total Reclaimed Water Use	Total Annual Revenues from Reclaimed Water Use	Heat Recovery	Total Annual Revenues from Heat Recovery	Carbon Offsets	TOTAL
2015	0	0	0	$ -				$ -
2016	165	0	165	$ 84,320				$ 84,320
2017	331	0	331	$ 168,640				$ 168,640
2018	496	0	496	$ 252,960				$ 252,960
2019	661	0	661	$ 337,280				$ 337,280
2020	827	74	901	$ 528,993				$ 528,993
2021	827	148	975	$ 636,387				$ 636,387
2022	827	223	1049	$ 743,780				$ 743,780
2023	827	297	1123	$ 851,173				$ 851,173
2024	827	371	1198	$ 958,567				$ 958,567
2025	827	445	1272	$ 1,065,960				$ 1,065,960
2026	827	519	1346	$ 1,173,353				$ 1,173,353
2027	827	593	1420	$ 1,280,747				$ 1,280,747
2028	827	668	1494	$ 1,388,140				$ 1,388,140
2029	827	742	1568	$ 1,495,533				$ 1,495,533
2030	827	816	1643	$ 1,602,927				$ 1,602,927
2031	827	890	1717	$ 1,710,320				$ 1,710,320
2032	827	964	1791	$ 1,817,713				$ 1,817,713
2033	827	1038	1865	$ 1,925,107				$ 1,925,107
2034	827	1113	1939	$ 2,032,500				$ 2,032,500
2035	827	1187	2013	$ 2,139,893				$ 2,139,893
2036	827	1187	2013	$ 2,139,893				$ 2,139,893
2037	827	1187	2013	$ 2,139,893				$ 2,139,893
2038	827	1187	2013	$ 2,139,893				$ 2,139,893
2039	827	1187	2013	$ 2,139,893				$ 2,139,893
2040	827	1187	2013	$ 2,139,893				$ 2,139,893
2041	827	1187	2013	$ 2,139,893				$ 2,139,893
2042	827	1187	2013	$ 2,139,893				$ 2,139,893
2043	827	1187	2013	$ 2,139,893				$ 2,139,893
2044	827	1187	2013	$ 2,139,893				$ 2,139,893
2045	827	1187	2013	$ 2,139,893				$ 2,139,893
Total	23,147	21,953	45,100	$ 43,593,227	-			$ 43,593,227
Present Value (2015 to 2045)				$ 17,021,000		$0		$ 17,021,000

	Esquimalt First Nation							
	Reclaimed Water Use (ML/yr)							
Year	Land Application (1)	Toilet Flushing(2)	Total Reclaimed Water Use	Total Annual Revenues from Reclaimed Water Use	Heat Recovery	Total Annual Revenues from Heat Recovery	Carbon Offsets	TOTAL
2015	0	0	0	$ -				$ -
2016	45	0	45	$ 23,120				$ 23,120
2017	91	0	91	$ 46,240				$ 46,240
2018	136	0	136	$ 69,360				$ 69,360
2019	181	0	181	$ 92,480				$ 92,480
2020	227	18	245	$ 133,930				$ 133,930
2021	227	36	263	$ 152,260				$ 152,260
2022	227	54	281	$ 170,589				$ 170,589
2023	227	73	299	$ 188,919				$ 188,919
2024	227	91	317	$ 207,249				$ 207,249
2025	227	109	335	$ 225,579				$ 225,579
2026	227	127	354	$ 243,909				$ 243,909
2027	227	145	372	$ 262,238				$ 262,238
2028	227	163	390	$ 280,568				$ 280,568
2029	227	181	408	$ 298,898				$ 298,898
2030	227	199	426	$ 317,228				$ 317,228
2031	227	218	444	$ 335,558				$ 335,558
2032	227	236	462	$ 353,887				$ 353,887
2033	227	254	480	$ 372,217				$ 372,217
2034	227	272	499	$ 390,547				$ 390,547
2035	227	290	517	$ 408,877				$ 408,877
2036	227	290	517	$ 408,877				$ 408,877
2037	227	290	517	$ 408,877				$ 408,877
2038	227	290	517	$ 408,877				$ 408,877
2039	227	290	517	$ 408,877				$ 408,877
2040	227	290	517	$ 408,877				$ 408,877
2041	227	290	517	$ 408,877				$ 408,877
2042	227	290	517	$ 408,877				$ 408,877
2043	227	290	517	$ 408,877				$ 408,877
2044	227	290	517	$ 408,877				$ 408,877
2045	227	290	517	$ 408,877				$ 408,877
Total	6,347	5,365	11,712	$ 8,662,421	-			$ 8,662,421
Present Value (2015 to 2045)				$ 3,469,000				$ 3,469,000

	East Saanich								Total Resource Income			
	Reclaimed Water Use (ML/yr)											
Year	Land Application (1)	Toilet Flushing(2)	Total Reclaimed Water Use	Total Annual Revenues from Reclaimed Water Use	Heat Recovery	Total Annual Revenues from Heat Recovery	Carbon Offsets	TOTAL	Reclaimed Water Use	Heat Recovery	Carbon Offsets	Total
2015	0	0	0	$ -				$ -	$ -			$ -
2016	192	0	192	$ 97,920				$ 97,920	$ 214,880			$ 214,880
2017	384	0	384	$ 195,840				$ 195,840	$ 429,760			$ 429,760
2018	576	0	576	$ 293,760				$ 293,760	$ 644,640			$ 644,640
2019	768	0	768	$ 391,680				$ 391,680	$ 859,520			$ 859,520
2020	960	36	996	$ 533,804				$ 533,804	$ 1,318,489			$ 1,318,489
2021	960	72	1032	$ 578,008				$ 578,008	$ 1,562,578			$ 1,562,578
2022	960	108	1068	$ 622,212				$ 622,212	$ 1,806,667			$ 1,806,667
2023	960	143	1103	$ 666,416				$ 666,416	$ 2,050,756			$ 2,050,756
2024	960	179	1139	$ 710,620				$ 710,620	$ 2,294,845			$ 2,294,845
2025	960	215	1175	$ 754,824				$ 754,824	$ 2,538,935			$ 2,538,935
2026	960	251	1211	$ 799,028				$ 799,028	$ 2,783,024			$ 2,783,024
2027	960	287	1247	$ 843,232				$ 843,232	$ 3,027,113			$ 3,027,113
2028	960	323	1283	$ 887,436				$ 887,436	$ 3,271,202			$ 3,271,202
2029	960	358	1318	$ 931,640				$ 931,640	$ 3,515,291			$ 3,515,291
2030	960	394	1354	$ 975,844				$ 975,844	$ 3,759,380			$ 3,759,380
2031	960	430	1390	$ 1,020,048				$ 1,020,048	$ 4,003,469			$ 4,003,469
2032	960	466	1426	$ 1,064,252				$ 1,064,252	$ 4,247,558			$ 4,247,558
2033	960	502	1462	$ 1,108,456				$ 1,108,456	$ 4,491,647			$ 4,491,647
2034	960	538	1498	$ 1,152,660				$ 1,152,660	$ 4,735,736			$ 4,735,736
2035	960	573	1533	$ 1,196,864				$ 1,196,864	$ 4,979,826			$ 4,979,826
2036	960	573	1533	$ 1,196,864				$ 1,196,864	$ 4,979,826			$ 4,979,826
2037	960	573	1533	$ 1,196,864				$ 1,196,864	$ 4,979,826			$ 4,979,826
2038	960	573	1533	$ 1,196,864				$ 1,196,864	$ 4,979,826			$ 4,979,826
2039	960	573	1533	$ 1,196,864				$ 1,196,864	$ 4,979,826			$ 4,979,826
2040	960	573	1533	$ 1,196,864				$ 1,196,864	$ 4,979,826			$ 4,979,826
2041	960	573	1533	$ 1,196,864				$ 1,196,864	$ 4,979,826			$ 4,979,826
2042	960	573	1533	$ 1,196,864				$ 1,196,864	$ 4,979,826			$ 4,979,826
2043	960	573	1533	$ 1,196,864				$ 1,196,864	$ 4,979,826			$ 4,979,826
2044	960	573	1533	$ 1,196,864				$ 1,196,864	$ 4,979,826			$ 4,979,826
2045	960	573	1533	$ 1,196,864				$ 1,196,864	$ 4,979,826			$ 4,979,826
Total	26,880	10,607	37,487	$ 26,793,184	-			$ 26,793,184	$ 102,333,572	-	-	$ 102,333,572
Present Value (2015 to 2045)				$ 11,087,000				$ 11,087,000	$ 40,187,000			$ 40,187,000

Notes
(1) Land application assumed to start at 0 in 2015 and increase linearly to max re-use in 2020.
(2) Flushing substitution assumed to be at 0 until 2020 and increase linearly to max re-use in 2035.
(3) Quantity estimates for 2020 and 2035 provided by Urban Systems, Nov. 18th, 2015.

Cost Components for Option 4 - Seven Plants (x 1000)

Cost Component	Capital Cost Incurred [1]		Operating Cost [1]		
	2015	2030	at 2015	at 2030	at 2045
1. Conveyance - Rock Bay					
(a) Clover Pt PS and Forcemain to Rock Bay	$ 51,400	N/A	$ 560	$ 645	$ 730
(b) Barnhard Pk PS and Forcemain to Rock Bay	$ 39,600	N/A	$ 320	$ 335	$ 350
(c) Effluent PS and Forcemain to Clover	$ 53,700	N/A	$ 710	$ 755	$ 800
(d) Replace Clover Outfall	$ 23,500	N/A	incl. in (c)		incl. in (c)
Conveyance - Rock Bay Subtotal:	$ 168,200	$ -	$ 1,590	$ 1,735	$ 1,880
2. Liquid Treatment - Rock Bay (Secondary)	$ 282,000	$ 70,000	$ 5,000	$ 7,800	$ 9,900
3. Solids Treatment - AD at Rock Bay	$ 258,000	$ 90,600	$ 5,000	$ 8,800	$ 10,300
4. Reuse - Rock Bay					
(a) Tertiary Slipstream	$ 8,100	N/A	$ 230	$ 230	$ 230
(b) Effluent Pumping/Piping/Controls	$ 16,100	N/A	$ 70	$ 75	$ 80
Reuse - Rock Bay Subtotal:	$ 24,200	$ -	$ 300	$ 305	$ 310
5. Existing System Capacity Upgrades					
(a) Craigflower PS - Constructed	$ 12,100	N/A	N/A	N/A	N/A
(b) Arbutus Attenuation Tank- incl land	$ 20,000	N/A	N/A	N/A	N/A
(c) Siphon Extension (1600 m)	$ 7,500	N/A	N/A	N/A	N/A
(d) Upgrade Currie St PS	$ 2,300	N/A	N/A	N/A	N/A
(e) Upgrade East Coast Interceptor (1400 m)	$ 3,100	N/A	N/A	N/A	N/A
Existing System Subtotal:	$ 45,000	$ -	$ -	$ -	$ -
6. Conveyance - Esquimalt					
(a) Lyall St PS and Forcemain to WWTP	$ 24,100	N/A	$ 230	$ 235	$ 240
(b) Macaulay Pt PS and Forcemain to WWTP	$ 10,100	N/A	$ 120	$ 120	$ 120
(c) Effluent PS and Forcemain to Macaulay Point	$ 19,900	N/A	$ 230	$ 275	$ 320
(d) Replace Macaulay Outfall	$ 34,200	N/A	incl. in (c)		incl. in (c)
Conveyance - Esquimalt Subtotal:	$ 88,300	$ -	$ 580	$ 630	$ 680
7. Liquid Treatment - Esquimalt (Tertiary)	$ 67,000	$ 12,000	$ 1,200	$ 1,900	$ 2,200
8. Reuse - Esquimalt					
(a) Effluent Pumping/Piping/Controls	$ 14,000	N/A	$ 50	$ 50	$ 50
9. Conveyance - View Royal					
(a) Retrofit Craigflower PS and all conveyance to Colwood	$ 14,700	N/A	$ 130	$ 145	$ 160
10. Liquid Treatment - View Royal (Tertiary)	$ 23,000	$ 22,000	$ 400	$ 700	$ 1,300
11. Conveyance - Colwood					
(a) PS at Colwood Border/Forcemain To WWTP	$ 9,900	N/A	$ 80	$ 95	$ 110
(b) View Royal and Colwood Effluent to Junction with Langford	$ 1,100	N/A	$ 5	$ 5	$ 5
Conveyance - Colwood Subtotal:	$ 11,000	$ -	$ 85	$ 100	$ 115
12. Liquid Treatment - Colwood (Tertiary)	$ 32,500	$ 50,600	$ 600	$ 900	$ 2,200
13. Reuse - Colwood					
(a) Effluent Pumping/Piping/Controls (high peak flows)	$ 19,100	N/A	$ 70	$ 75	$ 80

Cost Components for Option 4 - Seven Plants (x 1000)

Cost Component	Capital Cost Incurred [1]		Operating Cost [1]		
	2015	2030	at 2015	at 2030	at 2045
14. Conveyance - Langford					
(a) Raw Sewage PS and Forcemain to WWTP	$ 11,800	N/A	$ 130	$ 135	$ 140
(b) Effluent Pumping and Forcemain to Junction with Colwood/Langford	$ 10,300	N/A	$ 80	$ 85	$ 90
(c) Junction to Marine Shore	$ 12,000	N/A	$ 30	$ 45	$ 60
(d) New Outfall	$ 33,800	N/A	incl. in (c)		incl. in (c)
Conveyance - Langford Subtotal:	$ 67,900	$ -	$ 240	$ 265	$ 290
15. Liquid Treatment - Langford (Tertiary)	$ 82,000	$ 54,000	$ 1,500	$ 2,200	$ 3,700
16. Conveyance - East Saanich					
(a) Garnet PS Upgrade and Forcemain To/From	$ 4,000	N/A	$ 50	$ 55	$ 60
17. Liquid Treatment - East Saanich (Tertiary)	$ 10,000	$ 7,000	$ 200	$ 300	$ 500
18. Reuse - East Saanich					
(a) Effluent Pumping/Piping/Controls	$ 16,100	N/A	$ 50	$ 55	$ 60
19. Conveyance - Saanich Core					
(a) Galloping Goose Trail PS and Forcemain To/From	$ 3,100	N/A	$ 60	$ 65	$ 70
20. Liquid Treatment - Saanich Core (Tertiary)	$ 16,000	N/A	$ 300	$ 500	$ 500
21. Reuse - Saanich Core					
(a) Effluent Pumping/Piping/Controls	$ 8,800	N/A	$ 50	$ 50	$ 50
22. Land Costs	$ 93,400	N/A			
Total:	**$ 1,348,300**	**$ 306,200**	**$ 17,455**	**$ 26,630**	**$ 34,405**

[1] Includes all contingencies, engineering, etc. outlined in TM #1

Summary - Seven Plant Option

One-Time and Ongoing Costs

Capital Costs to 2045 [1]	Annual Costs (at 2030)			Annual Resource Income (at 2030)
	O&M	Borrowing	Total	
$ 1,654,500,000	$ 26,600,000	$ -	$ 26,600,000	$ 4,100,000

Notes
(1) Includes initial construction costs in 2015 as well as plant upgrades in 2030. Also includes land costs.

	Initial Capital Costs (at 2015)	Net Annual Costs (at 2030)
Seven Plants	$ 1,348,300,000	$ 22,500,000

Net Present Value

Assumptions	
Interest Rate	7%
Inflation	2%
Discount Rate	5%
Time period	2015 to 2045

Resource Income (from 2015 to 2045)

	Total Revenue (no discounting)	Present Value
Reclaimed water use	$ 111,700,000	$ 43,700,000
Heat recovery	$ -	$ -
Total	$ 111,700,000	$ 43,700,000

Costs (from 2015 to 2045)

	Total Costs (no discounting)	Present Value
Capital Costs	$ 1,654,500,000	$ 1,424,400,000
O&M	$ 792,300,000	$ 356,200,000
Borrowing Costs	$ -	$ -
Total	$ 2,446,800,000	$ 1,780,600,000

Net Present Value (2015 to 2045)	-$ 1,736,900,000

Ratio of Resource Income to Costs (at 2030)

Total annual revenues	$ 4,100,000
Total annual costs	$ 26,600,000.00
Ratio of revenues to costs	15%

Notes
(1) All costs in constant 2015 dollars.

Capital Costs - Seven Plant Option

	Capital costs to be incurred in 2015	Capital costs to be incurred in 2030
Total Construction Costs	$ 1,348,300,000	$ 306,200,000
Grants		
Net Project Costs	$ 1,348,300,000	$ 306,200,000

Notes
(1) Construction costs include general requirements (10%), contractor profit/overhead (10%), contingency (35%), escalation (2%/yr for four years), engineering (15%), CRD admin (8%) and interim financing (4%).
(2) Construction costs include land costs.

Year	Capital Costs
2015	$ 1,348,300,000
2016	$ -
2017	$ -
2018	$ -
2019	$ -
2020	$ -
2021	$ -
2022	$ -
2023	$ -
2024	$ -
2025	$ -
2026	$ -
2027	$ -
2028	$ -
2029	$ -
2030	$ 306,200,000
2031	$ -
2032	$ -
2033	$ -
2034	$ -
2035	$ -
2036	$ -
2037	$ -
2038	$ -
2039	$ -
2040	$ -
2041	$ -
2042	$ -
2043	$ -
2044	$ -
2045	$ -
Total Capital Costs	$ 1,654,500,000

Present Value of Total Capital Costs (2015 to 2045)	$ 1,424,369,000

Annual Costs - Seven Plant Option

Year	O&M Costs	Annual Borrowing Costs	Total Annual Costs
2015	$ -		$ -
2016	$ 17,455,000		$ 17,455,000
2017	$ 18,110,357		$ 18,110,357
2018	$ 18,765,714		$ 18,765,714
2019	$ 19,421,071		$ 19,421,071
2020	$ 20,076,429		$ 20,076,429
2021	$ 20,731,786		$ 20,731,786
2022	$ 21,387,143		$ 21,387,143
2023	$ 22,042,500		$ 22,042,500
2024	$ 22,697,857		$ 22,697,857
2025	$ 23,353,214		$ 23,353,214
2026	$ 24,008,571		$ 24,008,571
2027	$ 24,663,929		$ 24,663,929
2028	$ 25,319,286		$ 25,319,286
2029	$ 25,974,643		$ 25,974,643
2030	$ 26,630,000		$ 26,630,000
2031	$ 27,148,333		$ 27,148,333
2032	$ 27,666,667		$ 27,666,667
2033	$ 28,185,000		$ 28,185,000
2034	$ 28,703,333		$ 28,703,333
2035	$ 29,221,667		$ 29,221,667
2036	$ 29,740,000		$ 29,740,000
2037	$ 30,258,333		$ 30,258,333
2038	$ 30,776,667		$ 30,776,667
2039	$ 31,295,000		$ 31,295,000
2040	$ 31,813,333		$ 31,813,333
2041	$ 32,331,667		$ 32,331,667
2042	$ 32,850,000		$ 32,850,000
2043	$ 33,368,333		$ 33,368,333
2044	$ 33,886,667		$ 33,886,667
2045	$ 34,405,000		$ 34,405,000
Total	$ 792,288,000	$ -	$ 792,288,000
Present Value	$ 356,170,000	$ -	$ 356,170,000

Notes

(1) O&M estimates provided by Urban Systems for 2016, 2030 and 2045. These have been highlighted in blue.

(2) O&M costs between 2016, 2030, and 2045 have been interpolated linearly.

Resource Income- Seven Plant Option

Assumptions	Water Rate (per cubic metre)	Reclaimed water use rate (per cubic metre) 80% of Water Rate	Reclaimed water use rate (per ML) for flushing	Reclaimed water use rate (per ML) for land application
Rock Bay	$ 1.26	$ 1.01	$ 1,011	$ 510
Colwood	$ 1.81	$ 1.45	$ 1,448	$ 510
Esquimalt First Nation	$ 1.26	$ 1.01	$ 1,011	$ 510
East Saanich	$ 1.54	$ 1.23	$ 1,234	$ 510
Esquimalt Bullen Park	$ 1.26	$ 1.01	$ 1,011	$ 510
East Saanich	$ 1.54	$ 1.23	$ 1,234	$ 510
Saanich Core	$ 1.54	$ 1.23	$ 1,234	$ 510
Langford	$ 1.81	$ 1.45	$ 1,448	$ 510
View Royal	$ 1.81	$ 1.45	$ 1,448	$ 510

Rock Bay

Year	Reclaimed Water Use (ML/yr): Land Application (1)	Reclaimed Water Use (ML/yr): Toilet Flushing(2)	Reclaimed Water Use (ML/yr): Total Reclaimed Water Use	Total Annual Revenues from Reclaimed Water Use	Heat Recovery	Total Annual Revenues from Heat Recovery	Carbon Offsets	TOTAL
2015	0	0	0	$ -				$ -
2016	19	0	19	$ 9,520				$ 9,520
2017	37	0	37	$ 19,040				$ 19,040
2018	56	0	56	$ 28,560				$ 28,560
2019	75	0	75	$ 38,080				$ 38,080
2020	93	73	167	$ 121,762				$ 121,762
2021	93	147	240	$ 195,924				$ 195,924
2022	93	220	313	$ 270,086				$ 270,086
2023	93	293	387	$ 344,248				$ 344,248
2024	93	367	460	$ 418,410				$ 418,410
2025	93	440	533	$ 492,572				$ 492,572
2026	93	513	607	$ 566,734				$ 566,734
2027	93	587	680	$ 640,896				$ 640,896
2028	93	660	753	$ 715,058				$ 715,058
2029	93	733	827	$ 789,220				$ 789,220
2030	93	807	900	$ 863,382				$ 863,382
2031	93	880	973	$ 937,544				$ 937,544
2032	93	953	1047	$ 1,011,705				$ 1,011,705
2033	93	1027	1120	$ 1,085,867				$ 1,085,867
2034	93	1100	1193	$ 1,160,029				$ 1,160,029
2035	93	1173	1267	$ 1,234,191				$ 1,234,191
2036	93	1173	1267	$ 1,234,191				$ 1,234,191
2037	93	1173	1267	$ 1,234,191				$ 1,234,191
2038	93	1173	1267	$ 1,234,191				$ 1,234,191
2039	93	1173	1267	$ 1,234,191				$ 1,234,191
2040	93	1173	1267	$ 1,234,191				$ 1,234,191
2041	93	1173	1267	$ 1,234,191				$ 1,234,191
2042	93	1173	1267	$ 1,234,191				$ 1,234,191
2043	93	1173	1267	$ 1,234,191				$ 1,234,191
2044	93	1173	1267	$ 1,234,191				$ 1,234,191
2045	93	1173	1267	$ 1,234,191				$ 1,234,191
Total	2613	21707	24320	$ 23,284,740		-		$ 23,284,740
Present Value (2015 to 2045)				$ 8,610,000				$ 8,610,000

Colwood

Year	Reclaimed Water Use (ML/yr): Land Application (1)	Reclaimed Water Use (ML/yr): Toilet Flushing(2)	Reclaimed Water Use (ML/yr): Total Reclaimed Water Use	Total Annual Revenues from Reclaimed Water Use	Heat Recovery	Total Annual Revenues from Heat Recovery	Carbon Offsets	TOTAL
2015	0	0	0	$ -				$ -
2016	165	0	165	$ 84,320				$ 84,320
2017	331	0	331	$ 168,640				$ 168,640
2018	496	0	496	$ 252,960				$ 252,960
2019	661	0	661	$ 337,280				$ 337,280
2020	827	74	901	$ 528,993				$ 528,993
2021	827	148	975	$ 636,387				$ 636,387
2022	827	223	1049	$ 743,780				$ 743,780
2023	827	297	1123	$ 851,173				$ 851,173
2024	827	371	1198	$ 958,567				$ 958,567
2025	827	445	1272	$ 1,065,960				$ 1,065,960
2026	827	519	1346	$ 1,173,353				$ 1,173,353
2027	827	593	1420	$ 1,280,747				$ 1,280,747
2028	827	668	1494	$ 1,388,140				$ 1,388,140
2029	827	742	1568	$ 1,495,533				$ 1,495,533
2030	827	816	1643	$ 1,602,927				$ 1,602,927
2031	827	890	1717	$ 1,710,320				$ 1,710,320
2032	827	964	1791	$ 1,817,713				$ 1,817,713
2033	827	1038	1865	$ 1,925,107				$ 1,925,107
2034	827	1113	1939	$ 2,032,500				$ 2,032,500
2035	827	1187	2013	$ 2,139,893				$ 2,139,893
2036	827	1187	2013	$ 2,139,893				$ 2,139,893
2037	827	1187	2013	$ 2,139,893				$ 2,139,893
2038	827	1187	2013	$ 2,139,893				$ 2,139,893
2039	827	1187	2013	$ 2,139,893				$ 2,139,893
2040	827	1187	2013	$ 2,139,893				$ 2,139,893
2041	827	1187	2013	$ 2,139,893				$ 2,139,893
2042	827	1187	2013	$ 2,139,893				$ 2,139,893
2043	827	1187	2013	$ 2,139,893				$ 2,139,893
2044	827	1187	2013	$ 2,139,893				$ 2,139,893
2045	827	1187	2013	$ 2,139,893				$ 2,139,893
Total	23147	21953	45100	$ 43,593,227	-			$ 43,593,227
Present Value (2015 to 2045)				$ 17,021,000		$0		$ 17,021,000

Esquimalt Bullen Park

Year	Reclaimed Water Use (ML/yr): Land Application (1)	Reclaimed Water Use (ML/yr): Toilet Flushing(2)	Reclaimed Water Use (ML/yr): Total Reclaimed Water Use	Total Annual Revenues from Reclaimed Water Use	Heat Recovery	Total Annual Revenues from Heat Recovery	Carbon Offsets	TOTAL
2015	0	0	0	$ -				$ -
2016	45	0	45	$ 23,120				$ 23,120
2017	91	0	91	$ 46,240				$ 46,240
2018	136	0	136	$ 69,360				$ 69,360
2019	181	0	181	$ 92,480				$ 92,480
2020	227	18	245	$ 133,930				$ 133,930
2021	227	36	263	$ 152,260				$ 152,260
2022	227	54	281	$ 170,589				$ 170,589
2023	227	73	299	$ 188,919				$ 188,919
2024	227	91	317	$ 207,249				$ 207,249
2025	227	109	335	$ 225,579				$ 225,579
2026	227	127	354	$ 243,909				$ 243,909
2027	227	145	372	$ 262,238				$ 262,238
2028	227	163	390	$ 280,568				$ 280,568
2029	227	181	408	$ 298,898				$ 298,898
2030	227	199	426	$ 317,228				$ 317,228
2031	227	218	444	$ 335,558				$ 335,558
2032	227	236	462	$ 353,887				$ 353,887
2033	227	254	480	$ 372,217				$ 372,217
2034	227	272	499	$ 390,547				$ 390,547
2035	227	290	517	$ 408,877				$ 408,877
2036	227	290	517	$ 408,877				$ 408,877
2037	227	290	517	$ 408,877				$ 408,877
2038	227	290	517	$ 408,877				$ 408,877
2039	227	290	517	$ 408,877				$ 408,877
2040	227	290	517	$ 408,877				$ 408,877
2041	227	290	517	$ 408,877				$ 408,877
2042	227	290	517	$ 408,877				$ 408,877
2043	227	290	517	$ 408,877				$ 408,877
2044	227	290	517	$ 408,877				$ 408,877
2045	227	290	517	$ 408,877				$ 408,877
Total	6,347	5,365	11,712	$ 8,662,421	-			$ 8,662,421
Present Value (2015 to 2045)				$ 3,469,000				$ 3,469,000

East Saanich

Year	Reclaimed Water Use (ML/yr): Land Application (1)	Reclaimed Water Use (ML/yr): Toilet Flushing(2)	Reclaimed Water Use (ML/yr): Total Reclaimed Water Use	Total Annual Revenues from Reclaimed Water Use	Heat Recovery	Total Annual Revenues from Heat Recovery	Carbon Offsets	TOTAL
2015	0	0	0	$ -				$ -
2016	192	0	192	$ 97,920				$ 97,920
2017	384	0	384	$ 195,840				$ 195,840
2018	576	0	576	$ 293,760				$ 293,760
2019	768	0	768	$ 391,680				$ 391,680
2020	960	36	996	$ 533,804				$ 533,804
2021	960	72	1032	$ 578,008				$ 578,008
2022	960	108	1068	$ 622,212				$ 622,212
2023	960	143	1103	$ 666,416				$ 666,416
2024	960	179	1139	$ 710,620				$ 710,620
2025	960	215	1175	$ 754,824				$ 754,824
2026	960	251	1211	$ 799,028				$ 799,028
2027	960	287	1247	$ 843,232				$ 843,232
2028	960	323	1283	$ 887,436				$ 887,436
2029	960	358	1318	$ 931,640				$ 931,640
2030	960	394	1354	$ 975,844				$ 975,844
2031	960	430	1390	$ 1,020,048				$ 1,020,048
2032	960	466	1426	$ 1,064,252				$ 1,064,252
2033	960	502	1462	$ 1,108,456				$ 1,108,456
2034	960	538	1498	$ 1,152,660				$ 1,152,660
2035	960	573	1533	$ 1,196,864				$ 1,196,864
2036	960	573	1533	$ 1,196,864				$ 1,196,864
2037	960	573	1533	$ 1,196,864				$ 1,196,864
2038	960	573	1533	$ 1,196,864				$ 1,196,864
2039	960	573	1533	$ 1,196,864				$ 1,196,864
2040	960	573	1533	$ 1,196,864				$ 1,196,864
2041	960	573	1533	$ 1,196,864				$ 1,196,864
2042	960	573	1533	$ 1,196,864				$ 1,196,864
2043	960	573	1533	$ 1,196,864				$ 1,196,864
2044	960	573	1533	$ 1,196,864				$ 1,196,864
2045	960	573	1533	$ 1,196,864				$ 1,196,864
Total	26,880	10,607	37,487	$ 26,793,184	-			$ 26,793,184
Present Value (2015 to 2045)				$ 11,087,000				$ 11,087,000

Saanich Core

Year	Reclaimed Water Use (ML/yr): Land Application (1)	Reclaimed Water Use (ML/yr): Toilet Flushing(2)	Reclaimed Water Use (ML/yr): Total Reclaimed Water Use	Total Annual Revenues from Reclaimed Water Use	Heat Recovery	Total Annual Revenues from Heat Recovery	Carbon Offsets	TOTAL
2015	0	0	0	$ -				$ -
2016	24	0	24	$ 12,240				$ 12,240
2017	48	0	48	$ 24,480				$ 24,480
2018	72	0	72	$ 36,720				$ 36,720
2019	96	0	96	$ 48,960				$ 48,960
2020	120	21	141	$ 86,900				$ 86,900
2021	120	42	162	$ 112,600				$ 112,600
2022	120	63	183	$ 138,300				$ 138,300
2023	120	83	203	$ 164,000				$ 164,000
2024	120	104	224	$ 189,700				$ 189,700
2025	120	125	245	$ 215,400				$ 215,400
2026	120	146	266	$ 241,100				$ 241,100
2027	120	167	287	$ 266,800				$ 266,800
2028	120	188	308	$ 292,500				$ 292,500
2029	120	208	328	$ 318,200				$ 318,200
2030	120	229	349	$ 343,900				$ 343,900
2031	120	250	370	$ 369,600				$ 369,600
2032	120	271	391	$ 395,300				$ 395,300
2033	120	292	412	$ 421,000				$ 421,000
2034	120	313	433	$ 446,700				$ 446,700
2035	120	333	453	$ 472,400				$ 472,400
2036	120	333	453	$ 472,400				$ 472,400
2037	120	333	453	$ 472,400				$ 472,400
2038	120	333	453	$ 472,400				$ 472,400
2039	120	333	453	$ 472,400				$ 472,400
2040	120	333	453	$ 472,400				$ 472,400
2041	120	333	453	$ 472,400				$ 472,400
2042	120	333	453	$ 472,400				$ 472,400
2043	120	333	453	$ 472,400				$ 472,400
2044	120	333	453	$ 472,400				$ 472,400
2045	120	333	453	$ 472,400				$ 472,400
Total	3,360	6,167	9,527	9,320,800	-			$ 9,320,800
Present Value (2015 to 2045)				$ 3,561,000		$0		$ 3,561,000

Total Resource Income

Year	Reclaimed Water Use	Heat Recovery	Carbon Offsets	Total
2015	$ -			$ -
2016	$ 227,120			$ 227,120
2017	$ 454,240			$ 454,240
2018	$ 681,360			$ 681,360
2019	$ 908,480			$ 908,480
2020	$ 1,405,389			$ 1,405,389
2021	$ 1,675,178			$ 1,675,178
2022	$ 1,944,967			$ 1,944,967
2023	$ 2,214,756			$ 2,214,756
2024	$ 2,484,545			$ 2,484,545
2025	$ 2,754,335			$ 2,754,335
2026	$ 3,024,124			$ 3,024,124
2027	$ 3,293,913			$ 3,293,913
2028	$ 3,563,702			$ 3,563,702
2029	$ 3,833,491			$ 3,833,491
2030	$ 4,103,280			$ 4,103,280
2031	$ 4,373,069			$ 4,373,069
2032	$ 4,642,858			$ 4,642,858
2033	$ 4,912,647			$ 4,912,647
2034	$ 5,182,436			$ 5,182,436
2035	$ 5,452,226			$ 5,452,226
2036	$ 5,452,226			$ 5,452,226
2037	$ 5,452,226			$ 5,452,226
2038	$ 5,452,226			$ 5,452,226
2039	$ 5,452,226			$ 5,452,226
2040	$ 5,452,226			$ 5,452,226
2041	$ 5,452,226			$ 5,452,226
2042	$ 5,452,226			$ 5,452,226
2043	$ 5,452,226			$ 5,452,226
2044	$ 5,452,226			$ 5,452,226
2045	$ 5,452,226			$ 5,452,226
Total	$ 111,654,372			$ 111,654,372
Present Value (2015 to 2045)	$ 43,747,000			$ 43,747,000

Notes
(1) Land application assumed to start at 0 in 2015 and increase linearly to max re-use in 2020.
(2) Flushing substitution assumed to be at 0 until 2020 and increase linearly to max re-use in 2035.

Summary - Hartland Trucking Option (not including land costs)

One-Time and Ongoing Costs

Capital Costs to 2045 [1]	Annual Costs (at 2030)		
	Trucking	Pumping	Total
$ 19,300,000	$ 663,000	$ 70,000	$ 733,000

Notes
(1) Includes initial construction costs in 2015. Does not include land costs.

Net Present Value

Assumptions	
Interest Rate	7%
Inflation	2%
Discount Rate	5%
Time period	2015 to 2045

Costs (from 2015 to 2045) - Trucking

	Total Costs (no discounting)	Present Value
Capital Costs	$ 19,300,000	$ 18,381,000
Trucking Costs	$ 20,121,000	$ 9,022,000
Pumping Costs	$ 2,100,000	$ 989,000
Total	**$ 41,521,000**	**$ 28,392,000**

Notes
(1) All costs in constant 2015 dollars.

Summary - Hartland Pumping Option (not including land costs)

One-Time and Ongoing Costs

Capital Costs to 2045 [1]	Annual Costs (at 2030)		
	O&M	Borrowing	Total
$ 36,400,000	$ 324,000	$ -	$ 324,000

Notes
(1) Includes initial construction costs in 2015. Does not include land costs.

Net Present Value

Assumptions	
Interest Rate	7%
Inflation	2%
Discount Rate	5%
Time period	2015 to 2045

Costs (from 2015 to 2045) - Hartland Pumping (not including land costs)

	Total Costs (no discounting)	Present Value
Capital Costs	$ 36,400,000	$ 34,667,000
O&M	$ 9,750,000	$ 4,633,000
Borrowing Costs	$ -	$ -
Total	**$ 46,150,000**	**$ 39,300,000**

Notes
(1) All costs in constant 2015 dollars.

Capital Regional District

Core Area Liquid Waste Management Plan

Phase 2: Wastewater Treatment System Feasibility and Costing Analysis

Technical Memorandum #4 – Analysis Summary

Project: 1692.0037.01
urbansystems.ca
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Victoria, BC, V8W 1G2

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Appendices

EXECUTIVE SUMMARY

Phase 2 centers on technical and financial analysis regarding wastewater treatment and resource recovery for the Core Area. Regional services require clear definition of levels of service. Technical findings on their own do not justify a specific direction, rather, it is the synthesis of technical, public and political needs and aspirations that determine the direction for level of services. Technical Memorandum #4 summarizes the technical and financial analysis to support Committee decision-making. Phase 2 policy areas include:

Water Reuse: Water innovation and stewardship drives the concept for reuse, however there are technical and financial challenges to overcome. Phase 2 findings suggest that any reuse systems could be introduced incrementally when customers and water rates validate their installation. The two plant option (Colwood and Rock Bay) enables a notable increase in water reuse from a single central plant.

Solids Recovery[1]: The decision to integrate municipal and wastewater solids in the near-term shapes the location of solids recovery. Phase 2 findings suggests that Hartland Landfill offers distinct advantages if there is direction by the Committee to process both wastewater and municipal solids on a regional scale. Alternatively, to pursue solids recovery at Rock Bay would focus capacity on primarily wastewater solids.

Level of Treatment: Secondary treatment fulfills regulatory requirements yet tertiary treatment offers enhanced water quality but with increased capital and operating costs. Rock Bay Secondary provides up to 10% tertiary treatment: selecting 100% tertiary treatment is a local decision regarding preferred level of service based on public and political input. The capital costs to achieve 100% tertiary treatment is similar to a two-plant, sub-regional option.

Conveyance and Site Design: The cost and routing of conveyance infrastructure requires appropriate resources and collaboration with municipal partners to mitigate against neighborhood interruption. Direction by the Committee to prioritize routing optimization and site design reflects technical and public findings through the planning process.

Number of Facilities and Location: Among the seven option sets, a central plant (Rock Bay) or two plant option set lowers complexity and enables economies of scale to lower costs e.g. two plants at Esquimalt Nation and Rock Bay is roughly equivalent in capital cost to *1 Plant Rock Bay Tertiary*. There are technical and financial disadvantages to increasing the number of plants. However, adding more facilities could be done incrementally to service growth or if reuse/recovery systems prove their feasibility beyond the 2030 scenario, in locations such as Colwood, East Saanich and Esquimalt.

These technical policy areas can be combined with public input and preferences for the Committee's benefit of selecting levels of service, siting and infrastructure for establishing the plan forward.

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[1] The Request for Statements of Interest (RFSI) process will yield market-specific economic and feasibility information to decide on an effective approach to wastewater solids recovery.

1.0 PHASE 2 APPROACH AND METHODOLOGY

1.1 Phase 2 Objectives

The Project Charter details the aspirations and commitments set out by the Core Area Liquid Waste Management Committee (the Committee). Current treatment standards in the Core Area include screening prior to outfall which triggers new works to comply with federal and provincial regulations. Phase 2 provides the analysis and results to illustrate options for new levels of service to meet and exceed the looming regulatory changes. Each technical memorandum delivered to the Committee outlines the ingredients for service delivery, engineering, treatment, recovery and financial considerations, including:

- Capital and operational requirements for secondary, tertiary and/or sidestream tertiary treatment;
- Water reuse including locations, potential customers, pricing considerations and capital/operating requirements;
- Heat recovery economics and the opportunity to build systems when energy pricing supports it;
- Solids recovery including the location, options for wastewater byproducts only and the opportunity to integrate wastewater services with solid waste services; and
- Collection and conveyance infrastructure including outfalls, pump stations, trunk mains and the opportunity to manage flows on a core area-wide basis, or, sub-regionally.

The information summarized in this memo and presented throughout Phase 2 provides the technical basis for the Committee to assess trade-offs and establish the next level of service. Combining the technical data with public input meets legislative requirements but goes further to enable this Committee to deliver on its commitments to ratepayers to decide on preferred concepts for wastewater treatment and resource recovery.

Representative Design

Representative design includes provisionally selecting technologies and processes to illustrate how they perform against technical criteria. While analysis and reporting will refer to provisional solutions including costs estimates that are based on representative technologies, the process outcomes are not locked-in, which allows for further innovations by the market at the time of procurement. Representative design helps the process to allow for fair comparisons among the 7 option sets and provides a placeholder for innovation until the market responds to the opportunity in delivering a regional treatment solution in the Capital Region.

1.2 Phase 2 Methodology

Life-cycle costing analysis provides the Committee with financial information on seven wastewater option sets for treatment and resource recovery. Phase 2 life-cycle costing analysis should be integrated with the results of recent public consultation so as to buttress the technical findings with community aspirations: a thoughtful blend of public, political and technical outcomes from Phase 2 supports the Committee in making a decision on a preferred system for wastewater treatment.

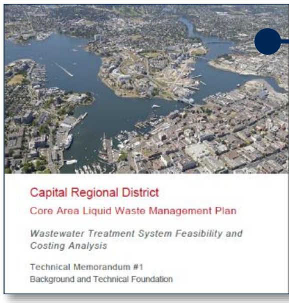
The Phase 2 methodology includes technical criteria and analysis that reflects the goals of Phase 2 as outlined in the Project Charter. These criteria frame the technical choices and how to characterize the performance of the seven option sets. In other words, this approach builds in public preferences to date to design the option sets, but later, this approach also ensures that performance results are framed by how well they deliver on local service expectations. Public education, dialogue and reflection on the technical results of Phase 2 helps to refine the regional aspirations and further informs the Committee on selecting a preferred direction. Later, technical criteria can be combined with the results of public consultation so that implementation of the project, including procurement processes and private sector proposals, that can respond to the concrete objectives and requirements that emerge from this process.

Levels of service, costs and environmental performance frame the comparison among the seven option sets. Ratepayer feedback on proposed levels of service are essential to assessing criteria including thresholds for affordability and environmental expectations. Each option outlines its capital and operating costs as well as revenue estimates alongside its level of service which allows stakeholders to weigh the trade-offs among the alternatives. Because the technical criteria go beyond financial, option set characterizations are broad and allow for a deeper appreciation of the costs and benefits of services, such as water reuse, heat recovery and distributed systems. While no single alternative can fully address the range of criteria, it is the presentation of the alternatives and the ensuing debate that will help to clarify the technical-social feedback that supports Committee direction.

Cost Estimating

Cost estimates for the seven option sets reflect the terms of reference set by the Committee and adhere to senior government guidelines for public works and government services. Each option set includes a detailed list of works and their capacities including pipes, pump stations, treatment plants, solids recovery and other infrastructure to build the proposed system. Industry-relevant unit rates apply to the list of works to create construction costs. Various factors such as overhead and profit, engineering fees, project management, interim financing and escalation overlay the construction costs to develop program-budget costs. The resulting costs are well suited to public consultation and appropriate for decision making to narrow down to a preferred concept.

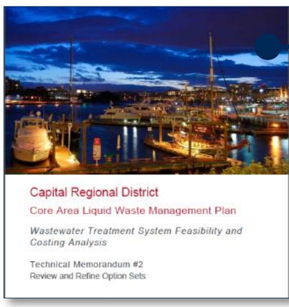
Overall, the four technical memos provide the detailed account of the Phase 2 technical methodology including analysis and results.



Technical Memorandum #1

Background and Technical Foundation

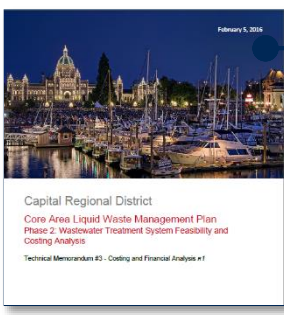
Details the overall Phase 2 methodology, summarizes design flows, explains the role of representative design, describes how option sets will be developed and itemizes cost estimating factors (Appendix C).



Technical Memorandum #2

Review and Refine Option Sets

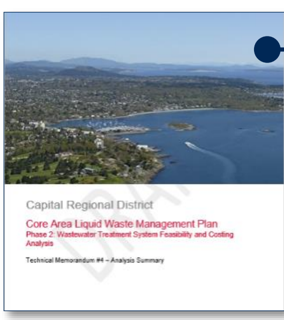
Details the representative technologies for costing and effluent performance, outlines the solids treatment and recovery options, itemizes the infrastructure and system components (e.g. lineal meters of pipe, cubic meters of capacity) and confirms the level of service for treatment and infrastructure across the option sets (Appendix B).



Technical Memorandum #3

Costing and Financial Analysis

Details the capital, operating and life-cycle costing results, summarizes the overall technical characterization of each option set, identifies the financial feasibility of resource recovery and lays out policy considerations for public and political direction (Appendix A).



Technical Memorandum #4

Analysis Summary

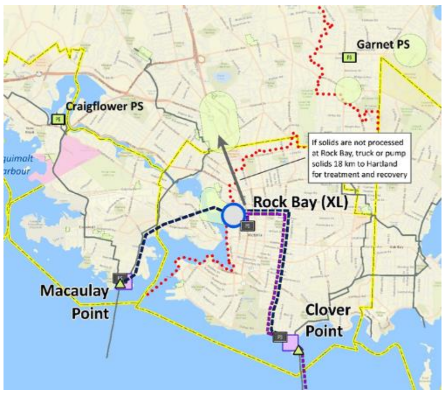
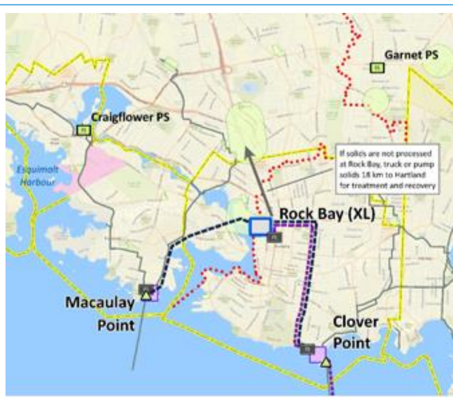
The content of Technical Memorandum #4 supports future engagement with senior government (e.g. funders, regulators) and Committee implementation activities. Results for option set costs, solids treatment, heat and water recovery and criteria performance form most of Technical Memorandum #4. Decision-making considerations stem primarily from the technical findings to help frame key policy choices for the Committee as they decide on a preferred concept for funding and ultimately a formal LWMP amendment. Life-cycle costing and overall option set performance frames the choices for the Committee in setting the level of service.

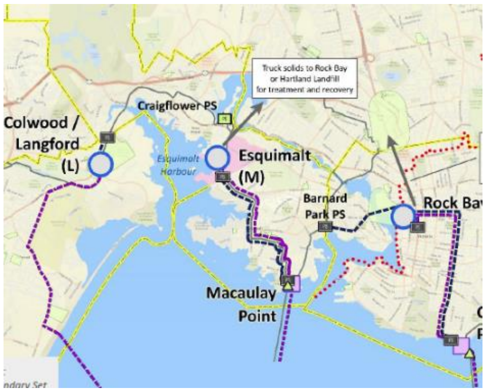
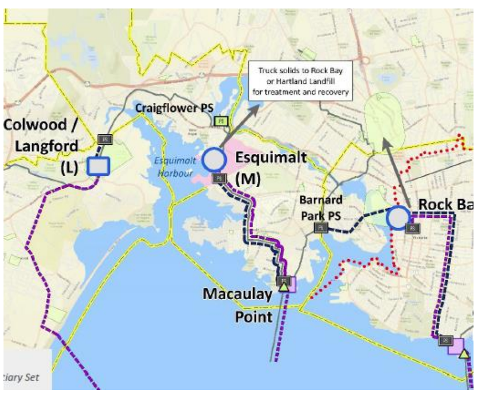
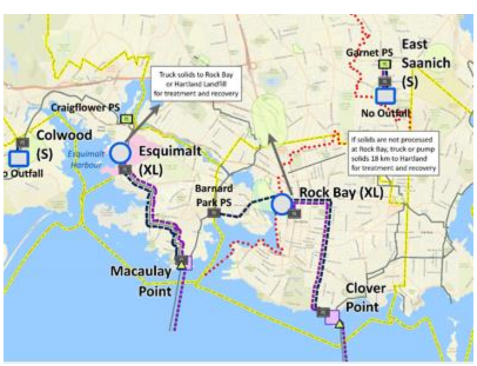
2.0 OPTION SETS SUMMARY RESULTS

2.1 Summary Table of Key Results

Table 2-1 below provides an executive summary of the seven option sets including their description and summary performance. The location, level of treatment and cost implications frame the key levels of service considerations for collection and liquid treatment infrastructure.

Table 2-1: Option Set Summary

<table>
<tr><th>Area</th><th>Description</th><th colspan="2">Performance</th></tr>
<tr><td rowspan="2">
</td><td rowspan="2">Rock Bay Central Secondary
The 1 Plant secondary treatment (1a) option set centralizes all flows at Rock Bay, including up to 10MLD for local reuse. This option set addresses the need to meet pending regulations and provides for the base level of service.</td><td>Capital 2030
$1,031M</td><td>2030 Operating
$21.8M
Est. Resource Income up to
$0.9M</td></tr>
<tr><td>Rank: Low Operating Cost
1st</td><td>Rank: Low Carbon & Energy Footprint
1st</td></tr>
<tr><td rowspan="2">
</td><td rowspan="2">Rock Bay Central – Tertiary
The 1 Plant full tertiary (all flows) treatment (1b) option set centralizes all flows at Rock Bay, including up to 10MLD for local reuse. This option set represents a clear sentiment towards water stewardship by raising levels of service for treated effluent quality.</td><td>Capital 2030
$1,131M</td><td>2030 Operating
$26.4M
Est. Resource Income up to
$0.9M</td></tr>
<tr><td>Rank: Low Operating Cost
6th</td><td>Rank: Low Carbon & Energy Footprint
3rd</td></tr>
<tr><td rowspan="2">
</td><td rowspan="2">2 Plant: Rock Bay + Colwood
The 2 Plant option set treats over 80% of flows to secondary levels, on top of up to 20% tertiary quality effluent. This option set represents a notable increase in water reuse from the 1-plant option with minimal extra conveyance infrastructure.</td><td>Capital 2030
$1,088M</td><td>2030 Operating
$22.8M
Est. Resource Income up to
$2.4M</td></tr>
<tr><td>Rank: Low Operating Cost
2nd</td><td>Rank: Low Carbon & Energy Footprint
2nd</td></tr>
</table>

Area	Description	Performance	
	3 Plant Secondary: Colwood/Langford, Esquimalt Nation and Rock Bay The 3 Plant option set treats over 80% of flows to secondary levels, on top of up to 20% tertiary quality effluent from sidestream re-use facilities at Esquimalt and Rock Bay. The secondary plant at Colwood/Langford allows for sub-regional flow management, including locating capacity for future growth in the Westshore.	Capital 2030 **$1,125M**	2030 Operating **$23.0M** Est. Resource Income up to **$1.6M**
		Rank: Low Operating Cost **3rd**	Rank: Low Carbon & Energy Footprint **4th**
	3 Plant Tertiary*: Colwood/Langford (*tertiary), Esquimalt Nation and Rock Bay The 3 Plant Tertiary option set treats 70% of flows to secondary levels, on top of up to 30% tertiary quality effluent from the Colwood/Langford plant on top of sidestream re-use facilities at Esquimalt and Rock Bay. This option increases water reuse to three systems and raises effluent quality to levels similar to the 4 plant option at a lower cost.	Capital 2030 **$1,178M**	2030 Operating **$24.0M** Est. Resource Income up to **$2.8M**
		Rank: Low Operating Cost **4th**	Rank: Low Carbon & Energy Footprint **6th**
	4 Plant: Rock Bay, Colwood, East Saanich and Esquimalt Nation The 4 Plant option set is a sub-regional system treating over 75% of flows to secondary levels, on top of up to 25% tertiary quality effluent. This option set represents the middle ground for distributed facilities and includes water reuse systems in four major growth centers.	Capital 2030 **$1,195M**	2030 Operating **$25.3M** Est. Resource Income up to **$3.8M**
		Rank: Low Operating Cost **5th**	Rank: Low Carbon & Energy Footprint **5th**

Area	Description	Performance	
	7 Plant: Rock Bay, Colwood, East Saanich, Esquimalt Township, View Royal, Langford and Core Saanich The 7 Plant option set is a sub-regional system treating up to 45% of flows to tertiary quality, including tertiary treatment for all flows on the Westside. This option set represents a highly distributed system which maximizes the potential for water reuse and situates facilities in 7 growth areas.	Capital 2030 **$1,348M**	2030 Operating **$26.6M**
			Est. Resource Income up to **$4M**
		Rank: Low Operating Cost **7th**	Rank: Low Carbon & Energy Footprint **7th**

2.2 Resource Recovery Feasibility Analysis

Recovery of resources available in both the liquids and solids is highly dependent on the market conditions, energy prices, environmental credits and the overall cost for the projects. Many resources can be considered and market responses based on supply or demand, and use or disposal, and price or cost will shape the preferred concept in the core area.

Liquid Resources

- *Hydraulic/Nutrients*
- *Thermal*
- *Mechanical*

Solids Resources

- *Nutrients*
- *Energy*
- *Bio plastics*
- *Organic Soil Amendment*
- *Biomethane*
- *Biofuels*
- *Carbon Dioxide*
- *Electricity*

Solids Management and the Advantage of a RFSI

The Project Charter indicates that any option set must incorporate sustainable practices into the design and consideration of the solids management alternatives. Anaerobic digestion and gasification provide two energy positive processes that directly align with the terms of reference and the goals and commitments of Phase 2.

» **Anaerobic Digestion** is a process that maintains the wastewater solids at near body temperatures (35-39 degrees C) without the presence of air. Under these mesophilic[2] conditions the bacteria consume themselves and produce an energy-rich byproduct (methane).

[2] Thermophillic digestion is an alternative to mesophilic which can reduce the time required for digestion but also requires greater heat/energy needs.

- Anaerobic digestion can reduce the organic content of the solids by 35-50% and the overall mass of the solids by 30%.
- Anaerobic digestion is the industry standard for stabilization and energy recovery in the wastewater industry.
- Anaerobic digestion typically produces 1,377 kg of wet cake at 20% dry solids per ML of treated wastewater.
- Methane gas from the digestion process would be cleaned of hydrogen sulfide and siloxanes and diverted to the c*ombined heat and power* units for the generation of power and heat. The heat generated in the engines will be used to provide the necessary heat for the digestion process and the electricity used to offset the electrical use of the mechanical equipment at the plant.

Hartland versus Rock Bay

Solids treatment and resource recovery is an important servicing decision which relates to technology, economics, environmental performance and location. Responses from the private sector will further address three of the four factors, yet location remains an important decision by the Committee. Hartland Landfill and Rock Bay offer different advantages and challenges. Neighborhood impacts, cost of land, costs of solids conveyance, integration of other municipal wastes and the destination of final residuals frames the opportunity with each site. Hartland Landfill provides distinct technical advantages including integration with other municipal waste, synergies with existing cogeneration facilities and greater flexibility in preparing (e.g. storing) residuals for market reuse. Alternatively, Rock Bay sites reduce infrastructure needs. Responses from the RFSI become more reliable with a single site.

» **Gasification** is a thermal/chemical process that converts the organic carbon in the wastewater solids into a synthetic gas that offers energy recovery potential but also may be processed into higher value items like plastics or as feedstock for biodiesel production. As this process is thermally based, it is critical that the energy content of the feed stocks be sufficient to maintain the high temperatures and derive energy out of the process.

- Gasification has been used in the municipal solid waste market as the energy content of these materials is typically sufficient for an efficient and energy positive operation.
- Gasification proponents claim to process 70% to 90% of the carbon content of the liquid waste solids feed; leaving mostly inorganic ash.
- Gasification will typically produce 14-60 kg of ash or biochar per ML of waste treated.
- Gasification generates syngas which can fuel a steam-boiler-turbine to generate power. The addition of municipal solid waste should enhance the thermal-energy process to yield significant amounts of excess thermal energy.

Key results of the capital, operating and life cycle costing analysis for solids recovery include:

- Capital costs for anaerobic digestion and gasification are deemed comparable, at $258M and $233M, respectively.
- Net present value results between anaerobic digestion and gasification can be considered roughly equal at this conceptual level (the capital cost uncertainty for gasification prevents a clear conclusion on net present value); statements of interest from the wastewater solids market will determine whether better net present value scenarios exist.
- Operational costs for gasification may be less than anaerobic digestion by a notable margin; this is primarily related to the mass of solids still present in the digested sludge and the potential cost of its disposal/reuse; market innovation on the reuse of biochar and biosolids will have a significant effect on the operating costs for either technology (which further justifies the value of market engagement).
- Operational costs for gasification decrease further as other municipal solid waste materials are added (relative to anaerobic digestion) because more energy offsets emerge.

Two financially comparable solids-energy recovery options positions the CRD to canvass the private sector to determine the most cost-effective and environmentally-beneficial alternative.

RFSI Considerations

A request for statements of interest (RFSI) details the aspirational and obligatory (e.g. risk management, financial assurance) objectives of the CRD in solids recovery, and also serves to identify and assess all of the potential market opportunities to improve upon the alternatives identified in Phase 2. The RFSI provides the CRD the option of evaluating the best technologies in a single, formal process and further informs the manufacturers on the goals of the CRD for the processing and disposal of the solids generated through the process.

The RFSI process will also provide opportunity for innovation by encouraging practical, resourceful and complete solutions to recover biosolids including their organics and energy. The RFSI should include the definition of the two *bookend*-type options (anaerobic digestion or gasification) as viable options for the CRD to implement in a way that challenges the market to produce options that are more innovative.

By being goal driven, market solutions will adhere to the progress made during Phase 2 including direction by the Committee and aspirations of the public. The RFSI can identify goals like:

1. Proposed process must recover and export energy
2. Proposed process should integrate municipal solid waste and wastewater solids
3. Proposed Process must recover and export ammonia

4. Proposed process must minimize carbon emissions
5. Proposed process must not rely on land application or landfilling of solids processed

The comprehensive list of requirements would be detailed to suit political and technical needs, for alignment with senior government funding opportunities (committed or not) and reflect key input received by the public through ongoing public consultation. The RFSI package should include extensive information on the resources available and the types of responses to be submitted.

Heat Recovery

Charter goals and commitments related to heat recovery comes from public interest in the economic and environmental feasibility of beneficial heating systems from wastewater throughout the Core Area. Analysis for Phase 2 covers planning projections, supply and demand, heating economics, service infrastructure, costs and income possibilities.

Heat recovery typically occurs via district heating systems (DHS) in select locations which are highly suited for heat distribution. Three primary factors influence the efficient distribution of excess heat energy from a wastewater facility: supply, demand and infrastructure requirements. All option sets provide treatment facilities near growth centers. Typically, the most feasible DHS scenario arises where infrastructure costs are lowest and amount of demand is greatest. Key economic factors that drive the financial viability of heat recovery include value of the heat supplied (e.g. $/GJ) relative to the cost of infrastructure and operations.

Cost-Income Analysis

Current record lows in natural gas prices combined with increasing electricity prices is narrowing the economic advantage that heat pump technology offers. For example, one unit of natural gas heat currently has a value of $14 per GJ, while a unit of heat pump heat at current electricity prices has a value of $11.67 per GJ. When infrastructure and utility operations costs are included, the price differential is largely eliminated which means district heating systems struggle to yield a positive return. Capital and operating costs estimates developed for Phase 2 identify 0.5:1 income to cost ratio. Overall, current energy prices coupled with the cost of DHS infrastructures results in insufficient revenues that may cover operating investments but do not payback capital investments in a reasonable time period.

Ingredients for Successful Heat Recovery

Heat recovery from wastewater has serious potential in broader district heating systems when the ingredients in Table 2-2 are applied:

Table 2-2: Ingredients for Successful Heat Recovery

INGREDIENT	APPLICATION
Secure partnerships with reliable building owners who are ready to invest in heating system infrastructure	*New development; preference to single-owner buildings; public agencies*
Low-infrastructure district heating systems	*New buildings situated 'on top' of effluent pipes or adjacent treatment plants*
Natural gas prices significantly exceed electricity pricing	*Future conditions may present this opportunity*
Lens on cost-effective heat recovery utilities	*Business cases based on reinvesting incomes into the utility; unlikely to offset other wastewater costs*
Public support inherent in triple-bottom line business case	*Seek out public input on the concept noting that implementation likely to occur when these ingredients for success can be met (likely in the future)*

Heat recovery from treated effluent is an attractive energy off-set strategy especially when economic conditions justify the business case for any system. Heat recovery systems in the Core Area should remain an ongoing dialogue among public, private and governmental stakeholders so that when conditions align, the CRD can partner with municipalities and developers to implement cost-effective options.

Water Recovery

When treated to a high enough standard, treated effluent can be reused instead of potable water. Water recovery target markets should deliver on the following key themes:

- Demonstrate reliable long-term demands and incomes
- Support community amenities such as stream and aquifer augmentation
- Reduce the scope of infrastructure needs
- Pursue future partnerships with industry
- Service large tracts of irrigable land such as parks and green spaces
- Demonstrate synergy with conventional public utility services
- Service growth centers where new developments can be encouraged to include additional plumbing systems for toilet flushing or irrigation

A servicing approach that meets these themes typically presents the lowest capital cost for system set up, provides long-term demands, supports community amenities such as parks and growth and generally conforms to public utility service delivery. Combined, land application and regional growth centers provide for lower-barrier locations for reuse.

Summary of Water Reuse across the Core Area

Treated effluent systems require their own, separate infrastructure for distribution. Each facility would include a pumping station which raises system pressures to cover the range of elevations and flows and also includes pipes based on conceptual routes. The capacity of each water reuse system is based on the 2030 flows with consideration to long-term flow increases. Life-cycle costing includes capital allowances for reuse systems including distribution pipes and pump facilities. Pricing for reclaimed water is proposed at 80% of potable water retail rates for toilet substitution and 80% of wholesale CRD potable rate for land application. Reuse by aquifer recharge (if pursued) will not result in revenue.

Flows and Capacities

Flow quality and quantity are fundamental ingredients to designing and costing wastewater treatment systems because they dictate the size of pipes, pumps and treatment systems. Municipalities and the CRD regularly explore and clarify dry weather (e.g. routine, non-rain events) and wet weather flows (e.g. irregular, weather dependent flow). The 2030 design-flow projection of 108MLD for dry-weather periods has municipal and Committee support, which provides a strong foundation to technical analysis. Regulations stipulate the redundancy requirements and expectations for treatment between 0x to 2x ADWF and 2x to 4x ADWF, and beyond. Going forward, the incentive to reduce flows, mitigate I/I, conserve potable water use and regulate the source quality of wastewater can help to defer treatment plant capacity upgrades.

Water Reuse Feasibility Summary

Results of the cost-revenue and feasibility analysis for water reuse include five key outcomes:

- If pursued, revenues for water reuse are set to be phased-in as customers confirm partnerships with CRD or the municipality for service, gradually over a 20-year period. The feasibility of securing new customers should be explored further so that supply matches demand and there is long-term pricing security.
- Water reuse provides for innovative uses of treated effluent however it is unlikely to present a positive business case until (if) potable supplies become unreliable. Revenues from water re-use will be challenged to cover both the operating and capital financing costs of their delivery systems, and will likely create an overall operating deficit.

- Further study is needed to discern which revenues are actual new incomes that do not result in a loss in income to the potable water utility. Generally, however, installing two sets of pipes providing a similar level of service in the same area can lead to some level of redundancy and added cost to be borne by the taxpayer.
- While the seven plant option set would provide a higher level of service and boost enhanced tertiary water quality, it may not provide greater reuse opportunities beyond the four plant option for a long time: this is because supply would likely exceed demand.
- Pursuing full tertiary treatment for all flows would be driven partly for water reuse but largely to achieve enhanced water quality that is ultimately returned to the environment.

3.0 CONSIDERATIONS FOR DIRECTION

3.1 Overall Summary

Phase 2 centers on technical and financial analysis regarding wastewater treatment and resource recovery for the Core Area. Regional services require clear definition of levels of service. Technical findings on their own do not justify a specific direction, rather, it is the synthesis of technical, public and political needs and aspirations that determine the direction for level of services. Technical Memorandum #4 summarizes the technical and financial analysis to support Committee decision-making. Phase 2 policy areas include:

Water Reuse: Water innovation and stewardship drives the concept for reuse, however there are technical and financial challenges to overcome. Phase 2 findings suggest that any reuse systems could be introduced incrementally when customers and water rates validate their installation. The two plant option (Colwood and Rock Bay) enables a notable increase in water reuse from a single central plant.

Solids Recovery[3]: The decision to integrate municipal and wastewater solids in the near-term shapes the location of solids recovery. Phase 2 findings suggests that Hartland Landfill offers distinct advantages if there is direction by the Committee to process both wastewater and municipal solids on a regional scale. Alternatively, to pursue solids recovery at Rock Bay would focus capacity on primarily wastewater solids.

Level of Treatment: Secondary treatment fulfills regulatory requirements yet tertiary treatment offers enhanced water quality but with increased capital and operating costs. Rock Bay Secondary provides up to 10% tertiary treatment: selecting 100% tertiary treatment is a local decision regarding preferred level

[3] The Request for Statements of Interest (RFSI) process will yield market-specific economic and feasibility information to decide on an effective approach to wastewater solids recovery.

of service based on public and political input. The capital costs to achieve 100% tertiary treatment is similar to a two-plant, sub-regional option.

Conveyance and Site Design: The cost and routing of conveyance infrastructure requires appropriate resources and collaboration with municipal partners to mitigate against neighborhood interruption. Direction by the Committee to prioritize routing optimization and site design reflects technical and public findings through the planning process.

Number of Facilities and Location: Among the seven option sets, a central plant (Rock Bay) or two plant option set lowers complexity and enables economies of scale to lower costs e.g. two plants at Esquimalt Nation and Rock Bay is roughly equivalent in capital cost to *1 Plant Rock Bay Tertiary*. There are technical and financial disadvantages to increasing the number of plants. However, adding more facilities could be done incrementally to service growth or if reuse/recovery systems prove their feasibility beyond the 2030 scenario, in locations such as Colwood, East Saanich and Esquimalt.

These technical policy areas can be combined with public input and preferences for the Committee's benefit of selecting levels of service, siting and infrastructure for establishing the plan forward.

March 4, 2016

File: 1692.0037.01

Capital Regional District (CRD)
625 Fisgard Street, PO Box 1000
Victoria, BC V8W 2S6

Attention: Larisa Hutcheson; GM Parks and Environmental Services

RE: Core Area Wastewater - Analysis Summary for Motions of February 26 and March 2, 2016: Cost and Option Set Alternatives

The *Core Area Liquid Waste Management Committee* (the Committee) is considering multiple option sets for wastewater treatment and resource recovery. Phase 2 comprises technical and financial analysis as well as public consultation to provide foundational information to the Committee to set levels of service, identify facility locations and define amendments to the Liquid Waste Management Plan.

Phase 2 analysis and findings encompass seven option sets ranging from centralized to distributed, secondary to tertiary, and solids recovery technologies and locations. While continuing to consider these seven option sets, the Committee would like to explore options to reduce conveyance costs at already proposed and new locations. This technical letter summarizes analysis stemming from motions of the February 26 and March 2 meetings which is to study elements of preliminary *value engineering*, including contracting levels of service for key elements and to study costing at alternative treatment locations: the information provided in this memo supports Committee is making a decision on a new plan for Core Area liquid waste management.

Motions and Staff direction arising from the February 26 and March 2 meetings include the following cost and option set alternatives:

1. **Costing and feasibility information to reduce the overall costs for a central, tertiary plant at Rock Bay** (i.e. cost saving potential for Option 1b Rock Bay tertiary, at the conceptual planning stage).

2. **3 Plant Tertiary Option:** *two tertiary plants and 1 primary plant to serve two catchments to reduce conveyance costs.*

   a) Costing and feasibility information for two tertiary plants at McLoughlin/Macaulay and Rock Bay with consideration to a primary plant at Clover Point to reduce the scope of conveyance infrastructure through urban areas of Victoria.
      - Flows from the East Coast Interceptor undergo primary treatment at Clover Point (maximizing known available land of <0.5ha at Clover Point) with 0x to 2x dry weather flows conveyed to Rock Bay for tertiary treatment
      - Flows from the Macaulay catchment treated to a tertiary level at McLoughlin (where suitable land space exists)

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- Provision for a future plant in Colwood/Langford to accommodate flows for the Westshore beyond 2030
- All solids conveyed to Hartland Landfill for processing and potential integrated resource recovery

3. **2 Plant Configuration at Sites Adjacent the Outfalls:** *two plants to serve two existing catchments with new facilities located at sites adjacent the outfalls to largely eliminate conveyance costs.*

   b) Costing and feasibility information for two tertiary treatment plants for flows from the two existing sewer catchments (Clover Point and Macaulay Point) at McLoughlin/Macaulay and Clover Point sites.
      - Flows from the East Coast Interceptor would be treated to tertiary level at Clover Point, by means of an ultra-compact facility, with site feasibility confirmed by CRD Staff
      - Flows from the Macaulay catchment treated to a tertiary level at McLoughlin (where suitable land exists)
      - Provision for a future plant in Colwood/Langford to accommodate flows for the Westshore beyond 2030
      - All solids conveyed to Hartland Landfill for processing and potential integrated resource recovery

Analysis Summary

Overall Cost Alternative Considerations

The Committee's interest in cost reductions and cost alternatives at the planning-comparison stage is best met by contracting, eliminating or deferring select infrastructure. Future value-engineering exercises will uncover more detailed information which will inform contingencies and likely reduce overall costs, however those decisions are based on the results of subsequent design phases. Cost-alternatives and reductions for select infrastructure based on the motions arising from February 26 and March 2, include:

a) **Defer the installation of water reuse systems** to save initial capital costs and allow for gradual installation of reuse systems as warranted. There are no water reuse systems in any of the three option set alternatives.

b) **Defer upgrades to the existing long outfalls** (>1,500m) because their condition is likely adequate to carry beyond the 2030 design scenario.

c) **Install moderate-length outfalls (250m) for tertiary quality water** at Clover and/or Macaulay Points to avoid upsizing the long outfalls for future flows.

d) **Eliminate the Barnhard Pump Station** in option sets with 2 or more plants to eliminate the cost of conveying flows from the Macaulay catchment (flows from West Saanich and Vic West) back to eastside plants (previously included to respect municipal service governance)

e) Include the costs to convey solids to Hartland Landfill however these costs are separated from the base total to allow for a straight-line comparison to the costs of the option sets previously presented to the Committed (which accounted for a solids recovery plant in Rock Bay)

Considerations for a Westshore Plant (e.g. Colwood, Langford) for 2030

Each of the two new option set alternatives that include the McLoughlin site also include the provision for a Westshore plant serving Colwood and or Langford. Multiple option sets prepared for both the *Westside Select Committe*e and the *Core Area Committee* during Phase 2 provide key insights into the cost feasibility of a plant there.

A Westshore plant is considered suitable and more cost-effective for the future, toward 2045, so as to locate additional treatment capacity for growth, near the actual location of growth. Including a plant in the option set alternatives for the 2030 scenario would increase overall costs because of the loss in economies of scale for smaller plants and more significantly, due to the need for additional infrastructure to convey treated effluent to either Macaulay Point or a new outfall.

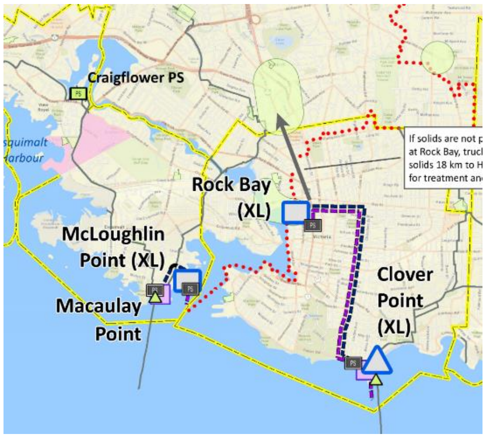
Cost and Technical Feasibility Results for Three Option Set Alternatives

Results summaries per option set outline the considerations and cost reductions with each of the three option set alternatives. Overall considerations follow the technical results table, to support upcoming Committee dialogue.

Map	Description + Cost Alternatives
	**1 Plant Rock Bay Tertiary** Central, tertiary plant at Rock Bay. ***Cost Management*** • Defer water reuse until there are sufficient connections for a system • Defer upsize to existing outfalls; instead install 250m outfalls for higher quality effluent • Although not reflected in costs in this letter, further optimization could reduce costs through conveyance • Cost reduced by $54M Capital 2030 Cost: **$1,077M**

URBAN systems

<table>
<tr><th>Map</th><th>Description + Cost Alternatives</th></tr>
<tr><td>



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3 Plant: Clover Pt., McLoughlin and Rock Bay Tertiary

2 tertiary plants and 1 primary plant to serve both catchments and to reduce conveyance costs.

Cost Management

- Reduce size of pipes and pumps from Clover to Rock Bay by up to 45%;
- Eliminate Barnhard PS and provide adequate capacity for each existing catchment
- Defer water reuse until there are sufficient connections for a system
- Defer upsize to existing outfalls; instead install 250m outfalls for higher quality effluent
- Suitable land exists at all locations; primary treatment at Clover has a projected footprint of 0.4ha

Capital 2030 Cost: **$1,089M**

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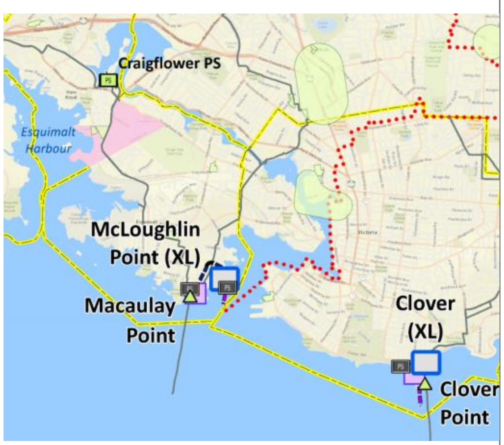

</td><td>

2 Plant: Clover Pt. and McLoughlin Tertiary

Two plants to serve the existing catchments with new facilities located at sites adjacent the outfalls to largely eliminate conveyance costs.

Cost Management

- Eliminate conveyance infrastructure from Clover or Macaulay points through urban areas
- Defer water reuse until there are sufficient connections for a system
- Defer upsize to existing outfalls; instead install 250m outfalls for higher quality effluent
- A tertiary plant Clover point requires 1.25ha of land, yet further site analysis and design work is needed to potentially reduce this footprint further.

Capital 2030 Cost: **$1,052M**

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Overall Cost Considerations for Committee

The results of recent analysis suggest that key cost elements can be eliminated or deferred to manage overall costs. And further, that locating two plants at each outfall is a key strategy to reduce the cost of conveyance and this approach enables greater levels of treatment at similar or less cost to a centralized option. However, land availability at Clover Point must be determined if a tertiary plant is to be considered at this location.

Further consideration to the three plant configuration with primary treatment at Clover maximizes the land and sites available as part of the Committee's motion, and reduces the size of conveyance infrastructure, and offers treatment plants at sites with confirmed land areas. Further route optimization through urban areas (a standard but important optimization exercise) is a fundamental need for subsequent design phases, to both lower costs and to minimize impacts to neighborhoods.

Thank you for the opportunity to provide ongoing services to the Committee.

Sincerely,

URBAN SYSTEMS LTD.

Ehren Lee, P.Eng.
Principal

/el

Cc: Dan Telford, Senior Manager Environmental Services, CRD

Encl: Cost Breakdowns for Three Alternatives

C:\Business\CRD\Letter to Core Committee March 2016\2016-02-22 Feb 26 motions - Letter to Core Committee.docx

Cost Components for Option 1b - One Tertiary Plant (x 1000)

Cost Component	Capital Cost Incurred [1] 2015	Capital Cost Incurred [1] 2030
1. Conveyance		
(a) Clover Pt PS and Forcemain to Rock Bay	$ 51,400	N/A
(b) Macaulay Pt PS and Forcemain to Rock Bay	$ 65,400	N/A
(c) Effluent PS and Forcemain to Clover Point	$ 83,900	N/A
(d) Tertiary Outfall Clover	$ 6,500	N/A
Conveyance Subtotal:	$ 207,200	$ -
2. Liquid Treatment (Tertiary)	$ 500,000	$ 220,000
3. Solids Treatment - AD	$ 258,000	$ 90,600
4. Existing System Capacity Upgrades		
(a) Craigflower PS - Constructed	$ 12,100	N/A
(b) Arbutus Attenuation Tank- incl land	$ 20,000	N/A
(c) Siphon Extension (1600 m)	$ 7,500	N/A
(d) Upgrade Currie St PS	$ 2,300	N/A
(e) Upgrade East Coast Interceptor (1400 m)	$ 3,100	N/A
Existing System Subtotal:	$ 45,000	$ -
5. Land Costs*	$ 67,200	N/A
Total:	**$ 1,077,400**	**$ 310,600**
6. Solids Conveyance - All to Hartland	$ 36,400	

[1] Includes all contingencies, engineering, etc. outlined in TM #1

* Land costs include raw land, site development, contingencies and pro-rated mitigation sum; all data sourced by CRD Real Estate.

Cost Components for 3 Plants: Clover-Rock Bay - McLoughlin (x 1000)

Cost Component			Capital Cost Incurred [1] 2015	Capital Cost Incurred [1] 2030
1.	Conveyance - Rock Bay & Clover			
	(a)	Clover Pt PS and Forcemain to Rock Bay	$ 29,600	*TBD*
	(b)	Effluent PS and Forcemain to Clover Point	$ 29,600	*TBD*
	(c)	Clover Pt Primary + Outfall Pumpstations	$ 41,100	*TBD*
	(d)	New Tertiary Only Outfall	$ 4,200	*TBD*
		Conveyance - Rock Bay Subtotal:	$ 104,500	$ -
2.	Liquid Treatment - Rock Bay (Tertiary)		$ 180,700	*TBD*
3.	Liquid Treatment - Clover Point (Primary)		$ 38,700	*TBD*
4.	Conveyance - McLoughlin			
	(a)	Macaulay Pt PS and Forcemain to McLoughlin	$ 54,700	*TBD*
	(b)	Effluent PS to Outfall	$ 44,900	*TBD*
	(c)	New Tertiary Only Outfall	$ 5,700	*TBD*
		Conveyance - McLoughlin Subtotal:	$ 105,300	$ -
5.	Liquid Treatment - McLoughlin (Tertiary)		$ 293,100	*TBD*
6.	Solids Treatment - AD at Hartland		$ 258,000	*TBD*
7.	Existing System Capacity Upgrades			
	(a)	Craigflower PS - Constructed	$ 12,100	N/A
	(b)	Arbutus Attenuation Tank- incl land	$ 20,000	N/A
	(c)	Siphon Extension (1600 m)	$ 7,500	N/A
	(d)	Upgrade Currie St PS	$ 2,300	N/A
	(e)	Upgrade East Coast Interceptor (1400 m)	$ 3,100	N/A
		Existing System Subtotal:	$ 45,000	$ -
8.	Land Costs*		$ 63,500	N/A
		SubTotal	**$ 1,088,800**	*TBD*
9.	Solids Conveyance - All to Hartland		$ 47,800	*TBD*

[1] Includes all contingencies, engineering, etc. outlined in TM #1

* Land costs include raw land, site development, contingencies and pro-rated mitigation sum; all data sourced by CRD Real Estate.

Cost Components for 2 Plants: Clover - McLoughlin (x 1000)

Cost Component			Capital Cost Incurred [1]	
			2015	2030
1.	Conveyance - Clover			
	(a)	Clover Pt RS + TE Pumpstations	$ 54,500	*TBD*
	(b)	New Tertiary Only Outfall	$ 4,200	*TBD*
		Conveyance - Clover Subtotal:	$ 58,700	$ -
2.	Liquid Treatment - Clover Point (Tertiary)		$ 219,400	*TBD*
3.	Conveyance - McLoughlin			
	(a)	Macaulay Pt PS and Forcemain to McLoughlin	$ 54,700	*TBD*
	(b)	Effluent PS to Outfall	$ 44,900	*TBD*
	(c)	New Tertiary Only Outfall	$ 5,700	*TBD*
		Conveyance - McLoughlin Subtotal:	$ 105,300	$ -
4.	Liquid Treatment - McLoughlin (Tertiary)		$ 293,100	*TBD*
5.	Solids Treatment - AD at Hartland		$ 258,000	*TBD*
6.	Existing System Capacity Upgrades			
	(a)	Craigflower PS - Constructed	$ 12,100	N/A
	(b)	Arbutus Attenuation Tank- incl land	$ 20,000	N/A
	(c)	Siphon Extension (1600 m)	$ 7,500	N/A
	(d)	Upgrade Currie St PS	$ 2,300	N/A
	(e)	Upgrade East Coast Interceptor (1400 m)	$ 3,100	N/A
		Existing System Subtotal:	$ 45,000	$ -
7.	Land Costs*		$ 72,000	N/A
		SubTotal	**$ 1,051,500**	*TBD*
8.	*Solids Conveyance - All to Hartland*		*$ 48,300*	

[1] Includes all contingencies, engineering, etc. outlined in TM #1

* Land costs include raw land, site development, contingencies and pro-rated mitigation sum; all data sourced by CRD Real Estate.