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Desktop Study

Potential Resource Recovery Opportunities

April 2013
KWL Project No. 601.008

Prepared for:

Corporation of the Township of Esquimalt

Prepared by:

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Executive Summary

The Township of Esquimalt (the Township) retained Kerr Wood Leidal Associates Ltd. (KWL) to conduct a review of potential recoverable resources as a result of the Capital Regional District (CRD) Core Area Wastewater Treatment Project. This study provides an overview of resource recovery opportunities for the Township of Esquimalt, and includes:

- Review of the proposed CAWTP infrastructure and resource recovery plans;
- Identification of potential resources that could be supplied to the Township as a result of the CAWTP;
- Identification of beneficial uses of recovered resources within the Township; and
- Cost estimates and economic analysis on a select number of options.

This report provides high-level recommendations on how best to proceed with potential resource recovery avenues. The resource streams considered in this study included:

- Heat recovered from raw sewage or treated wastewater effluent;
- Reclaimed non-potable water from treated wastewater effluent;
- Biogas;
- Biosolids; and
- Nutrient recovery.

The CRD is currently in the process of planning wastewater treatment facilities as part of the Core Area Wastewater Treatment Program (CAWTP). The BC Ministry of Environment has mandated secondary treatment to be in place by the end of 2016. The CRD will be moving towards sustainable wastewater management during the detailed planning and implementation of the treatment facilities to integrate water, energy, waste and infrastructure management while meeting the regulatory requirements.

There are a number of opportunities for the Township to recover and utilize resource streams due to the proximity of the proposed McLoughlin WWTP and associated infrastructure. The available supply of all resource streams is significantly larger than the projected demand for recoverable resources within the Township. In terms of heat recovery and district energy potential, the most viable location for a district energy system (DES) is in the Esquimalt Village area with potential for both raw sewage heat recovery and treated effluent heat recovery. Raw sewage heat is also available for the industrial park area within the Township.

A ‘purple pipe’ effluent reuse system can be made available for irrigation and indoor non-potable water use within the Township. While a non-potable ‘purple pipe’ water system used to supply water to the irrigation and other non-potable water demands would introduce a high capital cost, it would provide additional benefits to the CRD and City of Victoria water systems by decreasing peak hour demand. Of significance, there is potential to combine the effluent reuse system with a DES to reduce capital and O&M costs by providing common infrastructure.

In terms of potential for biogas production and use, the recovered biogas from the biosolids handling system could be converted to heat, electricity and/or biomethane. The available energy from biogas will depend on the location of the biosolids treatment and energy facility – a location within the Township would enable the use of effluent heat for facility heating demands which would free up more biogas energy for external use.

The construction of a natural gas refuelling station would not result in a favourable business case for the Township if it is the only station. However, the Township may benefit financially and environmentally by converting their vehicle fleet to compressed natural gas, which has an estimated payback period of less than 5 years. Another option is purchasing biomethane for use to supplement the heat energy supply to existing heating systems.

The proposed biosolids treatment facility will produce a significant quantity of biosolids and other potential nutrient-rich products. Land application of nutrient-rich biosolids would be challenging due to permitting requirements but phosphorous and nitrogen recovered from the biosolids treatment could be converted to struvite fertilizer material. The supply of such fertilizer products is significantly larger than the Township's current demand for fertilizer product.

One of the possible locations for the proposed biosolids treatment facility is in the Township's industrial park. The most likely additional resource recovery opportunity associated with this is to increase the amount of heat recovered from a biogas combined heat and power system to supply local heating uses, up to 5 GWh per year. This has an estimated cost of $3 million for heat distribution infrastructure, but it is not known whether a business case exists for the utilization or availability of this heat. Further biosolids processing within the Township may result in a minor increase in economic activity and would be considered a secondary opportunity.

KWL developed the following recommendations for the Township in terms of proceeding further with resource recovery activities:

1. **District Energy System** – Development of a district energy system in the Esquimalt Village area using raw sewage or treated WWTP effluent to replace the need for conventional heating to the proposed Esquimalt Village Project, the Legion Rise residential tower development, Town Hall & Library, the Archie Browning Recreation Centre and the Esquimalt Recreation Centre.
2. **Integrated DES and Purple Pipe Treated Effluent Distribution System** – Construction of an effluent supply system that can provide treated effluent for DES heat recovery as well as for irrigation and non-potable water reuse. There is further opportunity for integration should the CRD be interested in supplying the Downtown Victoria neighbourhood with treated effluent heat.
3. **Biogas Combined Heat and Power** – Recovery of approximately 5 GWh per year of residual biogas heat energy from the proposed biosolids treatment facility. This energy could be used in a district energy system which would tie-in existing boilers in the vicinity of the proposed biosolids treatment facility site, should it be located within the Township's industrial area.
4. **CNG Refuelling Station and Fleet Conversion** – The addition of a CNG fuelling station at the proposed biosolids treatment facility and the conversion of the Township's fleet vehicles to operate using compressed natural gas should be investigated further to determine whether a business case is there.

In summary, there are some potential positive opportunities as a result of the CAWTP implementation, wherein the Township can access recovered resources to reduce costs, greenhouse gas emissions and utilize locally-available products.

1. Introduction

1.1 Background

The Township of Esquimalt (the Township) retained Kerr Wood Leidal Associates Ltd. (KWL) to conduct a review of potential recoverable resources as a result of the Capital Regional District (CRD) Core Area Wastewater Treatment Project (CAWTP).

1.2 Scope

The scope of work for this draft report includes the following:

- Review of the proposed CAWTP infrastructure and resource recovery plans;
- Identification of potential resources that could be supplied to the Township as a result of the CAWTP;
- Identification of beneficial uses of recovered resources within the Township; and
- Cost estimates and economic analysis on a select number of options.

This report provides high-level recommendations on how best to proceed with potential resource recovery avenues.

1.3 Core Area Wastewater Treatment Project

The CRD is currently in the process of planning wastewater treatment facilities for the Core Area of Greater Victoria. The BC Ministry of Environment has mandated secondary treatment to be in place by the end of 2016. The CRD will be moving towards sustainable wastewater management during the detailed planning and implementation of the treatment facilities to integrate water, energy, waste and infrastructure management while meeting the regulatory requirements.

The new treatment facilities will be designed and implemented to satisfy the requirements under the Federal Wastewater Systems Effluent Regulations (WSER) and the BC Provincial Municipal Wastewater Regulation (MWR). At the time of writing of this report, harmonization of the Federal WSER and the BC MWR has not been established. Thus, both regulations are in effect and the CRD is required to meet both the MWR and the WSER.

The WSER requires municipal wastewater treatment plants to meet a performance requirement of average carbonaceous BOD of 25 mg/L and average TSS of 25 mg/L. The unionized ammonia limit is 1.25 mg/L N at 15 degrees C +/- 1 degrees C, and the total residual chlorine limit is 0.02 mg/L Cl2. The MWR requires secondary treatment with effluent not to exceed 45 mg/L BOD5 and 45 mg/L TSS. For flows in excess of two times average dry weather flow (ADWF), the MWR requires primary treatment capable of providing 130 mg/L TSS and 130 mg/L BOD. It is anticipated that flows less than or equal to 2 times ADWF will be provided with secondary treatment prior to discharge via marine outfall. Flows from 2-4 times ADWF will be provided with primary treatment for the CRD. Flows above 4 times ADWF will bypass the wastewater treatment facilities.

According to the Stantec Wastewater Treatment Plan – Option 1A Prime 2 report dated June 10, 2011, lamella plate primary clarifiers have been identified as a representative technology to provide primary treatment of the wastewater in a compact process footprint. Biological Aerated Filters have been identified as a representative technology for secondary treatment at the McLoughlin Point WWTP.

Biosolids treatment at the McLoughlin Point WWTP represents significant opportunities for resource recovery. The biosolids treatment technology is proposed to include thermophillic anaerobic digestion capable of producing a Class A biosolids, biosolids drying, recovery of biogas such as biomethane, and nutrient recovery such as struvite as fertilizer. In addition, the biosolids facilities are anticipated to include facilities to co-digest fats, oils and greases (FOG) and other food trucked liquid waste to enhance the production of biomethane.

The CRD-operated Hartland landfill is the site currently identified for the wastewater biosolids handling facilities in the Stantec Wastewater Treatment Plan – Option 1A Prime2 report. This option identifies four pumping stations and a 17.7 km pipeline to transfer sludge to a biosolids treatment facility at the Hartland landfill. This location may provide good synergies for acceptance of FOG to enhance digester gas production. In the future, waste to energy facilities could be used as an add-on process for integrated biosolids and solid waste processing.

2. Resource Availability

Figure 2-1 (at end of section) illustrates the overall resource recovery potential from the wastewater and biosolids treatment processes.

2.1 Heat Recovery

Heat can be recovered from a number of sources in the context of a wastewater management system:

- Heat can be extracted from liquid streams using heat exchangers and/or heat pumps;
- Chemical energy embodied in organic materials can be converted to heat through biological processes such as digestion and the combustion of converted organics; and
- Kinetic energy may be recoverable using turbines in some instances, however this was previously determined to have limited potential[1].

The most readily-available heat sources anticipated under the proposed CAWTP are:

- Sensible heat recovered from raw sewage and treated effluent;
- Biogas combusted in either boilers or combined heat and power (CHP) systems;
- Biogas upgraded to biomethane for distribution in the natural gas grid; and
- Dried biosolids that can be consumed in solid-fuel boilers.

The following section discusses the magnitude of potentially available heat from the above sources. Generally, recovered heat from wastewater systems requires a “district energy system” (DES) to distribute heat to homes and businesses.

Raw Sewage

Heat can be recovered from raw sewage using specially-designed heat exchangers or heat pumps. Raw sewage can be a challenging medium for heat recovery due to the presences of solids such as fibres, fats, oils, grease and grit. Fouling of heat exchange surfaces can also happen quickly, which requires the heat exchange equipment to include automatic backflushing and cleaning systems. There are several existing raw sewage heat exchange products currently available:

- In-line pipe heat exchangers that extract heat from sewage flow without diversion by circulating an intermediate fluid through a heat exchange jacket built into the pipe wall (e.g. Rabtherm, KASAG);
- Off-line heat exchangers that require sewage to be pumped from a sewer or pumping station to a heat recovery facility, where the heat exchangers transfer heat from the sewage to an intermediate water loop that feeds heat pumps (e.g. DDI, Sewage SHARC, Alfa-Laval); and
- Off-line heat pumps, which are similar to heat exchangers, except that the heat pump evaporator coil is in direct contact with the sewage, eliminating the need for a separate heat exchanger (TECSIR, Friotherm).

[1] Capital Regional District Core Area Wastewater Treatment Program Development Phase, Discussion Paper 036-DP-2. Associated Engineering, KWL, CH2M Hill, 2008.

Of the above approaches, the Sewage SHARC and TECSIR have been installed in BC. The Sewage SHARC has been used in a townhouse development in North Vancouver[2], and the TECSIR system is used in the City of Vancouver's Southeast False Creek Neighbourhood Energy Utility[3].

The amount of heat recoverable from sewage is directly proportional to the sewage flow and change in sewage temperature. The available energy is expressed by the following equation:

$$E = mC\Delta T$$

Where:

E = Sewage heating power (MW)
m = Volumetric flow rate of sewage (m^3/s)
C = Specific heat of water (4.187 MJ / $m^3 \cdot$ ºC)
ΔT = Change in sewage temperature (ºC)

The flow parameters of greatest interest for sewage heat recovery are average dry and wet weather flows. The temperature of sewage changes seasonally, ranging from 15ºC in the winter up to 20-25ºC in the summer. This is thought to be due to greater quantities of groundwater and inflow and infiltration (I&I), and higher heat losses during the winter compared to summertime. Most of the heat available in the sewer system is from domestic hot water use.

For the purpose of estimating available heat for use in the Township, three key parameters are considered:

- The ability of heat extraction equipment to reduce the source sewage temperature (ΔT), which is typically 3-5ºC for a single-pass;
- The minimum acceptable entering water temperature to a wastewater treatment facility, which by rule of thumb is considered to be approximately 11ºC for most biological treatment processes; and
- The available sewage flow, which can be considered as the average flow or the minimum hourly flow over a 24-hour period.

In this case, the assumed conditions for evaluating heat supply are a 4ºC ΔT and average dry weather flow (ADWF) conditions. KWL reviewed two key locations on each of the major CRD trunk sewers in the Township for raw sewage heat supply, described in the following table.

Table 2-1: Estimated Raw Sewage Heating Energy Availability

Location	2016 Average DWF (m^3/d)	2016 Recoverable Heat (MW)	2031 Average DWF (m^3/d)	2031 Recoverable Heat (MW)
Esquimalt Village	22,000	5.3	52,000	12.6
Industrial Park	31,500	7.6	36,000	8.7

The numbers shown in the table above represent the heat capacity of the sewage streams, which provide context for how much heat can be recovered. Unless the demand is larger than the above, the annual heating demand profile of connected buildings will be a limiting factor in the actual amount of energy recovered on an annual basis.

[2] Adera Developments Seven35 townhouses. 35 kW Sewage SHARC system.

[3] The Southeast False Creek NEU includes a 2.7 MW TECSIR "Sewage Chiller", which provides approximately 75% of the annual energy for the NEU.

Treated Effluent

The extraction of heat from treated effluent is essentially governed by the same principles as for raw sewage, except that specialized heat exchangers are not required since the solids have been removed from the sewage stream. It is still advisable to separate heat pumps from the treated effluent using heat exchangers in order to prevent damage to heat pumps and reduce fouling.

The total treated effluent flow under average dry weather conditions is anticipated to be 181 ML/d in 2016 and 196 ML/d in 2031. The recoverable heat capacity with a 5ºC ΔT would be 44 MW in 2016, and 48 MW in 2031.

2.2 Reclaimed Water

Treated Effluent from McLoughlin WWTP

The proposed McLoughlin Point WWTP will treat approximately 37 million cubic metres of sewage (Mm^3) per year, with approximately this amount being discharged through an upgraded outfall at Macaulay Point. The proposed WWTP will be configured to provide primary and secondary treatment, plus further treatment of a side stream of the secondary effluent discharge for reclaimed water use.

The additional treatment for effluent reclamation will include fine screening, additional aeration, membrane filtration, ultraviolet disinfection, and chlorination via sodium hypochlorite. This is included in the current plan for the McLoughlin WWTP.

The theoretical supply of reclaimed water from treated effluent can be as high as 37 Mm^3/yr, however, it is likely that the quantity of reclaimed water will be significantly lower, and dependent on the demand for reclaimed water. According to the Stantec Wastewater Treatment Plan – Option 1A Prime 2 report dated June 10, 2011, an allowance of 12 ML/d (4.4 Mm^3/year) has been identified for reclaimed water.

Treated Effluent from Decentralized Treatment Facilities

It is possible to construct ‘satellite’ or ‘decentralized’ wastewater treatment facilities geographically located near areas with high demand for reclaimed water. In the Township, the close proximity of the McLoughlin WWTP would likely render a decentralized WWTP option as infeasible when the capital and operating cost of the additional satellite facilities are considered, as a large centralized facility has been shown to have a lower cost to construct and operate per unit volume treated[4], and costs for water distribution infrastructure using a large treated effluent source would be comparatively smaller.

The value of resource streams recovered from such facilities generally cannot justify the additional expense, particularly in existing sewered areas such as Esquimalt. These types of facilities may offer benefits in unsewered areas, such as parts of the Western Communities as they can potentially avoid construction of other major trunk sewerage infrastructure. Each opportunity for this approach must be considered in a situational context.

[4]Capital Regional District Core Area Wastewater Treatment Program Development Phase, Discussion Paper 036-DP-2. Associated Engineering, KWL, CH2M Hill, 2008.

2.3 Biogas / Biomethane

Biogas is produced in most large WWTPs as a by-product of sludge digestion. This approach is used because the sludge volume is decreased by about one-third to one-half, and a useful energy product is produced. Biogas can be converted to heat, electricity or biomethane (equivalent to natural gas) using various technologies and plant configurations. Biogas from digesters contains about 60-65% methane (CH_4), with the remaining being mostly CO_2, but also some siloxanes and H_2S, which can be corrosive to equipment and piping, and may require scrubbing for some uses.

2.3.1 Proposed Biogas Production Approach for CAWTP

Biogas production is planned to take place at the regional biosolids treatment and energy facility that could potentially be sited at either the Hartland Landfill or in the industrial park in the Township. Biogas will be recovered from the thermophillic anaerobic digesters and upgraded through the gas scrubbing system to create a high quality biomethane product. The combined gas compression and purification process will be capable of recovering over 90% of biogas as biomethane (CH_4) and producing a final gas product made up of 98% CH_4 and 2% CO_2[5].

The biosolids treatment and energy facility will require a significant amount of heat for the digesters, for drying of biosolids and for space heating. The facility will be equipped with a heat recovery system which will capture heat from raw sludge using sludge-to-water-to-sludge heat exchangers. Stantec has reported that the heat recycling from the sludge will provide 50% of the heat required for the digester system. The estimated demand for heat from the facility is about 12.8 GWh/year in 2016 and 15.4 GWh/year in 2031 according to Stantec, which is approximately 1/3 of the total biogas energy available.

Once cleaned and processed, the biogas produced at the Hartland site will be reused at the energy facility to supplement digester heating requirements and for biosolids drying by consuming the biogas in a combined heat and power (CHP) system, typically a reciprocating gas engine with heat recovery and an electrical generator. The remaining surplus gas will be upgraded and injected into the natural gas pipeline and distributed to local users.

The following table shows the overall potential output of heat, electricity and biomethane under the CAWTP.

[5] Core Area Wastewater Treatment Program Wastewater Treatment Plant Option 1A Prime 2. Stantec, June 2011.

Table 2-2: Summary of Biogas Energy Production under Current Plan

Biogas Use	Energy (in GWh/year)	
	2016	**2031**
Total Biogas Production	38.1	46.3
Potential Heat for Digesters/Biosolids Drying (40%)	12.8	15.4
Potential Electricity (35%)	11.2	13.5
Losses (25%)	8.0	9.6
Residual Biogas Available for Biomethane to Grid	**6.1**	**7.8**
Total Resources Recovered	**30.1**	**36.7**
Note: 1 GWh = 3,600 GJ		

The residual biomethane made available could be sufficient to run approximately 300-400 vehicles per year[6], and could offset approximately 1,400-1,900 tonnes of carbon dioxide equivalent (CO_2e).

2.3.2 100% Biogas Combined Heat and Power

One of the potential limitations of locating the proposed biosolids treatment facility at the Hartland Landfill is the amount of heat uptake from combined heat and power production. If the facility were to be located within the Township, there could be increased potential for local buildings to utilize heat generated on-site, or alternatively the heat could be transported to other neighbourhoods outside the Township using a district energy system.

The table below lists the estimated biogas production and residual availability for maximized heat and power production (i.e. 100% of biogas consumed by CHP) in 2016 and 2031.

Table 2-3: Summary of Maximum Potential Combined Heat and Power Production

Biogas Use	Energy (in GWh/year)	
	2016	**2031**
Total Biogas Production	38.1	46.3
Potential Heat (50%)	19	23
Potential Electricity (35%)	13	16
Losses (15%)	6	7
Digester and Biosolids Drying Demand	**12.8**	**15.4**
Residual Heat Available for District Heating	**6.3**	**7.8**
Total Energy Recovered	**32.4**	**39.4**

Under this scenario, a higher rate of heat capture from the CHP is assumed, which may require a more expensive CHP system. The resulting residual heat availability is equivalent to the use of 600-800 typical apartment units. This approach would generate about 20% more electricity than the currently-proposed approach and would offset 1,100-1,400 tonnes CO_2e.

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[6] Assuming an average fuel economy of 15 L/100 km and 25,000 km travelled per year.

2.3.3 100% Biogas Upgrading to Biomethane

A final consideration for biogas use may be to upgrade the full available amount to biomethane, and use recovered heat from treated effluent to heat the digesters and dry biosolids. This would require large heat pumps that consume electricity to provide the digester and biosolids drying heat, but would make a larger quantity of biomethane available, thus increasing the overall recovered resource availability. This is shown in the following table.

Table 2-4: 100% Biomethane Upgrading/Effluent Heat for Biosolids Treatment

Energy Use	Energy (in GWh/year)	
	2016	**2031**
Total Biomethane Production	38.1	46.3
Digester and Biosolids Drying	12.8	15.4
Electricity Required for Heat Pumps[1]	4.3	5.1
Recovered Heat from Effluent	8.5	10.3
Net Energy Recovery[2]	**42.4**	**51.4**

Notes:
1. Assumes heat pumps with coefficient of performance of 3.0.
2. Electricity subtracted from total energy output as it must be purchased from BC Hydro.

This approach would result in 40% more net energy recovery than the currently-proposed approach, and could yield avoided emissions of up to 2,100 – 2,600 tonnes CO_2e.

2.4 Biosolids

2.4.1 Dried Biosolids as Fuel

Following sludge digestion and dewatering, the biosolids are proposed to be dried for reuse as a fuel in cement kilns. This dried biosolid fuel product is a cleaner alternative to fossil fuels such as coal. With a heating value of approximately 18 GJ/dry tonne, the heat potential for dried biosolids is comparable to that of soft coal. A solid-fuel boiler or combustor would be required to use this as a fuel source. A total of 5,600 tonnes of dried biosolids per year would be produced by 2031, with a total energy equivalent value of 28 GWh (100,720 GJ).

2.4.2 Dried Biosolids as Fertilizer

The proposed biosolids treatment process at the biosolids treatment facility will involve heat drying to produce Class A quality biosolids. The nutrient contents of the dried biosolids will vary depending on the type of solids at the plant. An estimate of the potential phosphorous and nitrogen contents in the biosolids from the proposed biosolids treatment facility is presented in the table below.

Table 2-5: Estimated Nutrient Content of Dried Biosolids

Nutrient	Dry Tonnes Per Year	
	2016	**2031**
Nitrogen	280	340
Total Phosphorous	145	175
***Solids Process Design and Management, WEFPress.**		

The CAWTP planning process reviewed land application of dried biosolids, and it was determined there would be challenges associated with this approach. The provincial *Organic Matter Recycling Regulation (OMRR)* governs the land application of biosolids, which requires a permitting process for this activity.

2.5 Nutrient Recovery

One by-product of the anaerobic digestion process is phosphorus, which is mainly available in the sludge centrate. The phosphorus is released from the process and recycled back into the liquid stream where it can be captured for reuse. Technologies are available to capture the phosphorus as a crystalline product called struvite, often using an "upflow fluidized bed reactor" column with the addition of magnesium salts to cause a precipitate to form. Stantec estimated that approximately 272 tonnes of struvite would be recovered per year in the CAWTP, which is similar to the nutrient content of the biosolids.

Based on performance data from a similarly-sized project, the Rock Creek WWTP in Hillsboro, Oregon up to 1,185 tonnes per year could be captured as a maximum potential output.

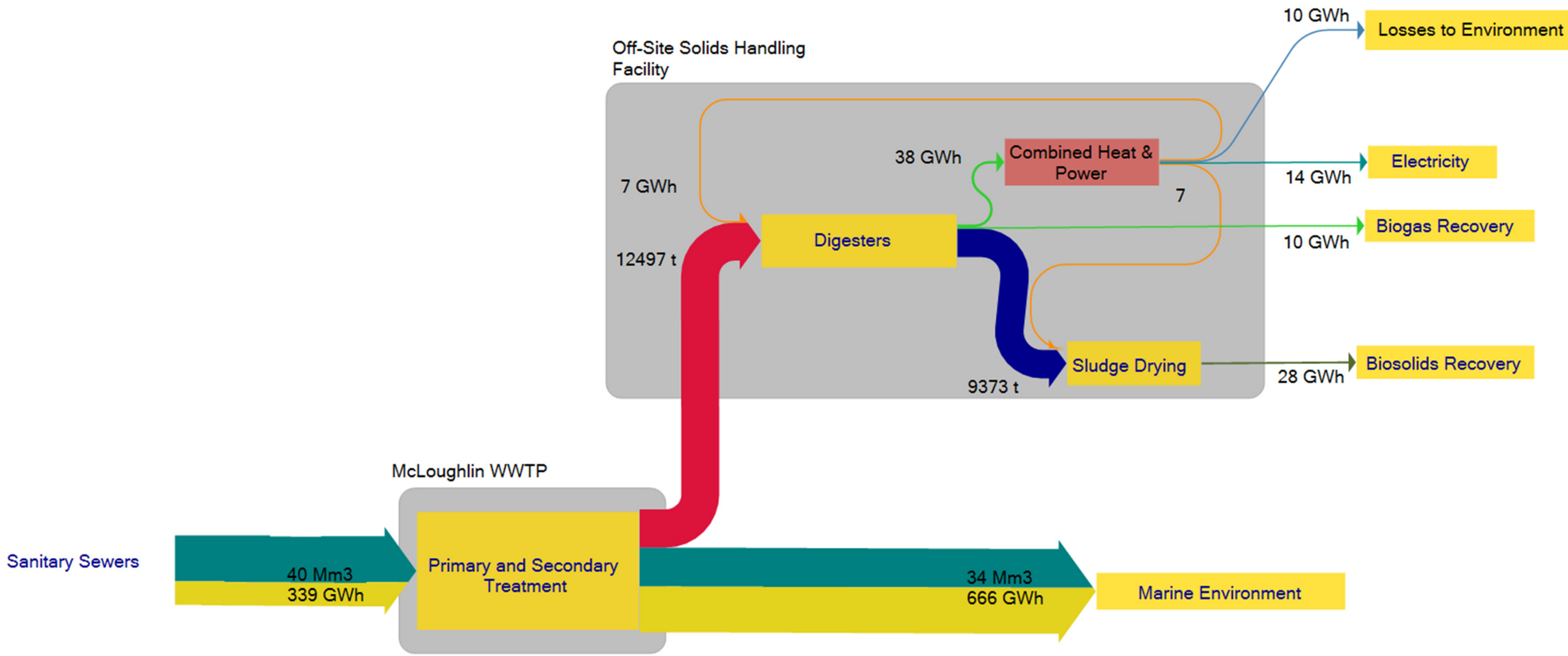
2.6 Summary of Resource Supplies

The following summary of potential recovered resource supplies is provided:

- Raw sewage up to 13 MW in 2016 and 21 MW in 2031 could be available, subject to the presence of potential upstream sewage heat recovery projects;
- The treated effluent stream could provide a further 44 MW in 2016 and 48 MW in 2031 in addition to any raw sewage heat recovery;
- Biogas production is estimated at 38 GWh per year, which could be converted to heat, electricity and/or biomethane;
- Use of treated effluent in the biosolids treatment facility would increase the potential biomethane supply and overall recovery of energy;
- Dried biosolids may yield up to 28 GWh per year as a solid fuel or 175 tonnes per year of phosphorus fertilizer by 2031; and
- Nutrient recovery from sludge centrate could yield up to 1,185 tonnes of struvite fertilizer per year.

The potential resource supplies are to be considered in the context of potential demand within the Township.

Township of Esquimalt
Potential Resource Recovery Opportunities
Desktop Study



Legend

- ADWF [Mm3]
- Recoverable Heat [GWh]
- Sludge [t]
- Biogas [GWh]
- Biosolids [t]
- Recoverable Solids Energy [GWh]
- Heat [GWh]
- Electricity [GWh]
- Losses [GWh]

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Project No.	Date
601.008	March, 2013

Baseline
2031

Figure 2-1

Notes:

1. Theoretical heat recovery from sanitary sewers assumes 7.1°C ΔT
2. Theoretical heat recovery from treated effluent assumes 14.2°C ΔT
3. Combined heat and power plant sized for biosolids facility heat load at 75% total efficiency

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3. Resource Utilization

3.1 Heat Use

Heat recovered from the proposed CAWTP projects can be utilized within new and existing buildings that would be connected to the potential heat sources by a district energy system (DES). A DES usually requires that connected buildings use “hydronic” heating systems, which means that hot water piped through the buildings is used as the heating medium. Buildings are considered hydronic if they have a heating boiler, which are indicated by the BC Safety Authority boiler database[7]. By contrast, new residential buildings are usually constructed with electric baseboard heating in suites and gas-fired makeup air and domestic hot water units.

For district energy, new buildings are generally preferable and less-expensive to connect than existing buildings, since they can be purpose-designed for hydronic heating, and additional retrofit costs are avoided. New buildings can also be built “DE-ready” to accept district energy from a future DES if not available at the time of building construction.

Heating demand can be estimated by using available energy consumption data (typical for existing buildings), or by using “energy use intensity” (EUI) factors for similar buildings if the floor area is known (used for planned buildings without energy data available). Using existing energy billing data requires an assumption about the efficiency of the existing heat plant.

KWL received energy consumption data from the Township, as well as projected floor area information for the Esquimalt Village Project and the Legion Rise project. The energy consumption data for the existing Township buildings was used to estimate an “end-use” demand (i.e. independent of energy supply) assuming a heating efficiency of 75%. The demands for the proposed buildings were estimated using the EUI method above. In addition, the other existing boilers noted from the BC Safety Authority database were used to project energy demand based on their size and expected utilization.

Table 3-1 summarizes the total amount of potential heating demand that could be met with heat recovered from the CAWTP infrastructure. As the table shows, the single largest demand is from the Esquimalt Recreation Centre. Figure 3-1 shows the locations of the potential heating demands. As will be discussed further in Section 4.2, not all of these potential heating demands would be considered in the context of a district energy system, and the preferred focus is to identify and screen for the most promising demands.

[7] KWL has developed a map of existing (2008) boiler units for the Capital Regional District using the BC Safety Authority database.

Table 3-1: Estimated Annual Heating Energy Demands

Demand Name	Total Floor Area	Energy Use Intensity	Annual Energy Demand (End Use)	
	m^2	$kWh/m^2/yr$	GWh	GJ
New Construction				
EVP Phase 1	17,000	100	1.7	6,120
EVP Phase 2	15,600	50	0.8	2,808
EVP Phase 3	41,400	50	2.1	7,452
Legion Rise	15,000	100	1.5	5,400
Subtotal New Construction	**89,000**	**300**	**6.1**	**21,780**
Municipal Buildings (Billed Data)				
Town Hall	2,094	52	0.1	392
Archie Browning Rec. Center	7,000	139	1.0	3,503
Esquimalt Rec. Center	4,400	606	2.7	9,599
Golf Course Works Yard	400	53	<0.1	77
DND Works Yard	1,400	54	0.1	274
Subtotal Municipal Buildings	**15,294**	**70**	**3.8**	**13,845**
Other Boilers	**unknown**	**-**	**10.0**	**23,795**
Total	**104,299**	**53**	**19.9**	**59,420**

3.2 Non-Potable Water Use

Treated effluent from the CAWTP could potentially be used in irrigation and non-potable indoor uses. The *Municipal Wastewater Regulation* and *BC Building Code* are the two primary regulations that govern the use of reclaimed treated wastewater. The following uses were considered in the context of this study:

- Spray irrigation of golf courses, playing fields and other non-food crop irrigated areas;
- Underground irrigation of landscaped areas; and
- Toilet flushing in new buildings equipped with ‘purple pipe’ systems.

Buildings using this non-potable water supply would require a separate “grey water” plumbing system to avoid cross-contamination. It is for this reason that the demands presented are for new buildings and not for existing structures. Re-plumbing existing buildings to make use of this treated effluent stream may not be viable due to the associated retrofit costs to complete the piping upgrades. The estimated non-potable water use areas and demands are shown in Table 3-2 below.

Table 3-2: Township Indoor Non-Potable Water and Irrigation Demands

Category	Area (ha)	Irrigation Area (%)	Annual Water Use (m^3/year)	Maximum Day Demand (ML/d)	Peak Hourly Flow (L/s)	Included in Proposed Reuse System
Indoor Non-Potable Demand						
Esquimalt Village Project Phase 1			0.001	0.00	0.04	Included
Legion Rise Residential Project			0.002	0.01	0.08	Included
Total Indoor Non-Potable Demand			0.004	0.01	0.12	
Potential Irrigation Demand						
Township Parks	27	80%	0.053	1.18	65	Included
Gorge Vale Golf Course[1]	60	90%	0.121	2.69	150	Included
Irrigable ICI	88	50%	0.099	2.21	123	
Residential	323	40%	0.338	7.51	417	
Total Potential Irrigation Demand			*0.394*	*6.08*	*338*	

Note:
1. Golf Course water meter record flows were 0.133 Mm^3/yr.

As discussed further in Section 4.3, the potential demands that are most likely to be met with reuse of treated effluent are the new residential developments (primarily indoor use) and the Township's parks and the Gorge Vale Golf Course. These demands are estimated at a total of 215 L/s (peak hour), with annual consumption of 181,000 m^3.

3.3 Biomethane Use

The two primary options for the Township to utilize biomethane are in its fleet vehicles or heating systems that use natural gas. The Township's Climate Action Revenue Incentive Public Report for 2012 provides information on current usage of fossil fuels in stationary (heating) and vehicle purposes. The following table summarizes the current use of natural gas, gasoline, diesel, biodiesel (B5) and propane, as well as the associated energy emissions.

Table 3-3: 2012 Township Fossil Fuel Usage and Emissions

Source	Usage	Energy Value (GJ)	Emissions (tonnes CO_2e)
Natural Gas	18,443 GJ	18,443	925
Gasoline	48,223 L	1,688	112
Diesel	2,701 L	103	7.7
B5 Biodiesel	49,615 L	1,900	132
Propane	8,205 L	208	13
Total	**18,443 GJ nat. gas 108,754 L vehicle fuel**	**22,243**	**1,189**

Of the above totals, fuel switching could be feasibly contemplated for all natural gas use, light duty trucks and heavy duty trucks. These uses account for approximately 22,100 GJ (99% of total) of switchable fuel usage, and 1,175 tonnes per year in CO_2e.

3.4 Dried Biosolids Use

The Township could potentially utilize dried biosolids in thermal energy applications or as a soil amendment. The Township does not currently own any solid-fuel boilers, and therefore this option is not considered to be particularly strong because of fuel handling requirements.

3.5 Nutrient Use

According to data supplied by the Township, 2.5 tonnes per year of fertilizer are used at a cost of $5,000. Should a regional-scale commercial fertilizer production facility be developed, the Township would have the opportunity to purchase a locally-recovered and processed fertilizer which would have better environmental than conventional fertilizers.

3.6 Summary of Potential Resource Use

The following summary of potential recovered resource demand was determined:

- Existing and future heating demands where recovered heat could be supplied from district energy systems totals to almost 20 GWh by 2031, however this is a maximum theoretical amount;
- Potential non-potable peak hour water use supplied from reclaimed effluent is estimated at 215 L/s, and an annual consumption of 181,000 m^3, and is meant to be used for irrigation purposes and for indoor non-potable water use (i.e. toilet flushing);
- By converting fleet vehicles to CNG fuel systems, the Township could make use of biomethane and replace 22,250 GJ of fossil fuels usage;
- The use of dried biosolids in thermal energy applications is currently not feasible from a business case perspective; and
- The Township can make use of the recovered nutrients from the biosolids treatment facility to replace the use of conventional fertilizer use on various parklands.

The potential resource supplies are to be considered in the context of potential demand within the Township.

Township of Esquimalt
Potential Resource Recovery
Opportunities
Desktop Study

Legend

Existing Boiler Demand Clusters

- Craigsflower
- Industrial Park
- Esquimalt Rd.
- Esquimalt Village
- Trunk Sewer
- Village Core
- Proposed WWTP
- Industrial Park
- Future Demands

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Project No.	Date
601-008	March 2013

Heat Demand by Area

Figure 3-1

Source: \\L\bra25.burnaby.kerrwoodleidal.org\0000-0999\0600-0699\601-008\430-GIS\MXD-Rpt\601008_Fig_404_Heat_Demand.mxd
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4. Resource Recovery Opportunities

4.1 Key Assumptions

The resource recovery opportunity analysis presented below reviews a selection of potential economic cases for resource recovery within the Township. These are indicative analyses based on Class D capital cost estimates and broad assumptions regarding lifecycle costs and forecast resource values. The following section describes the assumptions for this analysis.

4.1.1 Capital Cost Assumptions

Capital costs were estimated for various infrastructure components at a Class D level of detail and accuracy. This is an indicative analysis based on little or no detailed site information, and based on other experience with other projects. The following specific details are noted for the capital cost estimates:

- Underground piping costs include excavation, backfill, pipe installation and surface restoration;
- Facility costs (e.g. pump stations, district energy plants) are based on projects of a similar nature and scope, and were scaled according to project parameters;
- Costs do not include site-specific requirements such as utility relocations, geotechnical issues, contaminated site remediation or other similar issues not identified as part of the scope of work; and
- Estimates include 20% engineering and construction management, and 40% contingency allowances.

These estimates are considered appropriate for demonstrative purposes, and any further project decisions should include additional feasibility work to further define project scope and cost accuracy.

4.1.2 Operations and Maintenance Assumptions

Annual operations and maintenance (O&M) costs for most infrastructure projects entail labour, contracted maintenance, replacement of equipment, materials and energy consumption. At the level of detail required for this analysis, the following assumptions are included for annual O&M:

- Equipment labour and maintenance at 4% of capital cost;
- Structures and underground piping labour and maintenance at 2% of capital cost; and
- Energy and consumables estimated from annual throughput, and costed according to pricing assumptions listed in Section 4.1.4.

The annual O&M costs would be expected to increase with general inflation, assumed to be 2%. Energy and materials pricing are per Section 4.1.4.

4.1.3 Financial Assumptions

A lifecycle cost analysis with discounted cash flows was used to assess the various resource recovery options. The following assumptions were used in the financial analysis:

- All financial calculations in real dollars ($2013);
- Real discount rate of 4% assumed;

- District energy projects assumed to have a lifespan of 30 years;
- Water projects assumed to have a lifespan of 50 years;
- Biomethane and nutrient recovery assumed to have a lifespan of 15 years;
- Fleet vehicles assumed to have a lifespan of 5 years;
- 100% of capital costs assumed to be incurred in year 1, and projects assumed to operate at full capacity throughout lifespan; and
- Inflation assumed to be 2%.

All financial results are presented in net present value terms, or as normalized net present value.

4.1.4 Energy and Materials Pricing Assumptions

KWL has conducted a number of studies involving forecasting of future energy and materials pricing. This is a complex subject with many uncertainties involved, and energy and materials price forecasts are often determined to be incorrect, particularly when considering short-term price volatility. The energy and materials pricing assumptions in this study are based on typical assumptions for other similar projects. Table 4-1 shows the assumptions and source information for energy and materials price forecasts.

Table 4-1: Energy and Materials Pricing Assumptions

Commodity	2013 Price	Escalation Rate (Real)
Electricity, Large General Service	$0.045/kWh	2%
Electricity, Residential Blended Conservation Rate	$0.085/kWh	2%
Potable Water	$3.25/100 cu.ft. + flat rate connection charge	1%
Natural Gas (including $30/tonne carbon tax)	$14/GJ	0%
Biomethane (FortisBC Rate 11B)	$23/GJ	0%
Diesel	$1.50/L	0%
Fertilizer (based on Township costs)	$2,000/tonne	3%
Carbon Offsets	$25/tonne	0%

Notes:
1. Electricity rates based on current BC Hydro rate tariffs, escalation based on typically assumed values from recent district energy studies. Residential blended rate is the average between RIB Step 1 and Step 2. Rates do not include demand charges and actual costs may vary depending upon annual use profile.
2. Potable water rate as per City of Victoria's website. Escalation rate based on projected annual increase in water revenues.
3. Natural gas rate based on current FortisBC Vancouver Island rate tariff. Escalation rate based on Sproule gas price forecast for North America (predicts flat pricing).
4. Biomethane rate is approximated from differential between current commodity price for natural gas ($3/GJ) and delivered price for Vancouver Island (differential of $11/GJ). Current biomethane commodity rate for Lower Mainland and Inland service areas is $12/GJ.

4.2 District Energy Systems

Heat recovery from raw sewage and treated effluent were considered as potential heat sources for district energy systems (DES). An additional case using combined heat and power is considered in Section 4.4. The proposed DES could be developed in a number of technical configurations, however for this study, a DES with a central heating plant and hot water distribution piping is proposed. The DES would generally include the following components:

- Energy centre with boilers, heat pumps and heat exchangers and water pumps for handling and extracting heat from raw sewage or treated effluent;
- Distribution piping system, consisting of two parallel supply/return pipes that distribute hot water to connected buildings;
- Energy transfer stations, consisting of heat exchangers to separate the building heating systems from the DES distribution system, and energy meters; and
- Hydronic piping systems within connected buildings.

The DES would extract heat using heat pumps to 'lift' the temperature of the heat extracted from the raw sewage or treated effluent from approximately 15ºC to 65ºC. This process consumes approximately 1/3 of the total heat pump output as electricity to run the heat pump compressor. This system would be sized to approximately 30% of the peak building heating demand, and provide approximately 80% of the annual energy consumed. The remaining capacity and energy would be supplied by peaking boilers, which use natural gas to top up the heating system.

The conventional approach to providing heating would be to use a combination of electric baseboards and gas makeup air and domestic hot water in residential buildings, and standalone boilers in commercial buildings and the Township's recreation centres. It is understood the Township recently invested in some energy efficiency measures for the Esquimalt Recreation Centre, which are not included in this analysis.

For the purpose of this study, one example district energy system that is considered the most likely to be successful from an economic standpoint has been considered. This involves the Esquimalt Village area, including the following potential DES loads:

- Esquimalt Village Project Phase 1 (residential);
- "Legion Rise" 12-story residential tower development;
- Town Hall & Library;
- Archie Browning Recreation Centre; and
- Esquimalt Recreation Centre.

The combined load of these buildings is described in the following table. A concept called "load diversity" is applied, which assumes that not all of the buildings have concurrent peak heating demands, thereby allowing for a slight reduction in the sizing of the heating equipment. An 85% load diversity factor was assumed. The DES would use approximately the same amount of energy whether supplied with raw sewage or treated effluent, except that treated effluent would require slightly more pumping energy to move the effluent from the treatment plant to the DES.

Table 4-2: Estimated Design Loads for Esquimalt Village District Energy System

Loads & Sizing	Units	Quantity	Description
Undiversified Peak Heat Load	kW	2,641	Peak hour load for the buildings
Diversified Peak Heat Load	kW	2,245	Peak hour load seen by DES
Heat Pump Capacity	kW	700	Sizing for heat pumps
Gas Boiler Capacity	kW	2,400	Sizing for gas boilers, including backup redundancy (1 redundant unit)
Energy Balance	**Units**	**Quantity**	**Description**
Annual Heating Energy	MW.h	7,126	Annual heat delivered to connected buildings
% Annual Heating from Heat Pump	%	80%	% of annual heat from heat pumps
% Annual Heating from Boilers	%	20%	% of annual heat from boilers
DES Alternate Source Heating	MW.h	5,701	Annual heat from heat pumps delivered to buildings
DES Boilers	MW.h	1,425	Annual heat from boilers delivered to buildings
Gas Boiler Efficiency	%	82%	Efficiency of DES boiler plant
Heat Pump Heating COP		3.1	Ratio of heat pump output to electricity input (remaining 2.1 units from sewage)
Pumping Energy	MW.h	122 (205)	Pumping energy required to circulate hot water and raw sewage (effluent in parenthesis)
Distribution Losses	MW.h	200	Heat loss in distribution piping
DES Gas Use	MW.h	1,835	Total gas required by DES
DES Electricity Use	MW.h	2,110 (2,193)	Total electricity required by DES (effluent option in parenthesis)

By comparison a conventional heating approach would use approximately 7,600 MWh of gas and 1,100 MWh of electricity. The DES has the potential to offset approximately 1,000 tonnes of CO_2e.

The above information was used to develop a capital and operating cost estimate for the proposed DES. The proposed DES is detailed on Figure 4-1. The capital cost estimate includes the following assumptions:

- Raw sewage option assumes sewage is accessed from CRD Northwest Trunk Sewer – West at a manhole adjacent to Esquimalt Village;
- Treated effluent option includes an effluent pump station at McLoughlin WWTP, and 1,500 m of 150 mm dia. pipe to convey effluent to energy centre, with effluent return via the trunk sewer;
- Energy centre includes building, heating equipment, mechanical piping, electrical and site works;
- Raw sewage option requires specialized heat exchanger at premium cost compared with treated effluent;
- Distribution piping includes supply, installation, backfill and surface restoration, using insulated steel piping;

- Energy transfer stations include heat exchangers, piping and energy meter;
- Hydronic system costs for buildings not included; and
- Land for energy centre provided by Township.

The treated effluent and raw sewage options are essentially identical from points downstream of the heat exchanger.

Table 4-3 shows the resulting cost estimates for these options. Financial assumptions are per those described in Section 4.1.

Table 4-3: Lifecycle Cost Estimates for Raw Sewage and Treated Effluent DES Options

	DES Treated Effluent Option	DES Raw Sewage Option	Conventional Heating
Capital Cost	$5,300,000	$4,900,000	$1,300,000
Annual Non-Fuel O&M	$120,000	$140,000	60,000
Annual Fuel Costs	$270,000	$260,000	490,000
Net Present Value (rounded, 30-year)	**$12,000,000**	**$11,800,000**	**$10,900,000**

The options are very similar in terms of net present value. While the treated effluent option has a higher capital cost and higher fuel costs due to additional pumping, the raw sewage option requires more maintenance because of the use of raw sewage (fouling, clogging increased). The conventional heating approach includes full replacement costs of existing boilers, as well as the domestic hot water and makeup air systems for residential buildings. As indicated, there is potentially significant fuel cost savings associated with the DES options because of use of high efficiency heat pumps. An additional $500,000 in net present value carbon offsets could be realized, narrowing the lifecycle cost gap between the conventional approach and the raw sewage option to $400,000. The simple payback period is estimated to be between 19 and 25 years depending upon whether the carbon value is factored in. Based on the above analysis, it is recommended that district energy be given further consideration for more detailed feasibility analysis.

4.3 Non-Potable Water Systems

A non-potable water system fed from treated effluent to feed the potential non-potable demands described in Section 3.2 would involve constructing approximately 3.7 km of 300 mm dia. trunk piping with 2.1 km of 150 mm dia. branch piping to feed the 11 irrigation and other non-potable water demands identified. This system would be fed by a 200 Hp effluent pump station and 800 m^3 of storage at the end of the system would be used to maintain pressure and buffer peak demands. This system would be designed to meet a peak hour demand of 215 L/s, with the largest single consumer being the Gorge Vale Golf Course. Figure 4-2 shows the proposed non-potable water system.

The non-potable water system would offset use of potable water, primarily during irrigation season, and could provide benefits in terms of peak hour demand reduction on the potable water system, as well as reducing the annual volume of potable water consumed for irrigation and to a lesser degree, toilet flushing. The following table summarizes the economic evaluation for this project, which considers the capital cost, operating costs and avoided costs by providing non-potable water.

Table 4-4: Lifecycle Cost Analysis for Non-Potable Water Reclaim System

	Non-Potable System	Current
Capital Cost	$8,000,000	-
Annual O&M Cost	$160,000	-
Annual Pumping Cost	$1,700	-
Avoided Potable Water Cost	-	$204,000
Net Present Value (rounded, 30-year)	**$9,800,000**	**$4,000,000**

As indicated, the proposed non-potable water system would have significantly higher lifecycle costs than continuing with current servicing if only the avoided cost of potable water is included. Therefore, to make an economic case for this system, the additional benefits to the overall CRD and City of Victoria water systems would need to be further considered, as this system would reduce peak hour demand by 215 L/s. The forecast escalation in water rates is 1% on a real basis, which makes a simple payback analysis difficult, however on average the total operational cost savings would be on the order of $75,000. This would require a roughly 100-year payback period, which is likely too long to support this option on the basis of avoided water volumetric costs alone.

4.4 Biomethane

The two primary options for the Township to utilize biomethane are in its fleet vehicles or heating systems that use natural gas. To utilize biomethane in vehicular applications, the Township would need access to a compressed natural gas (CNG) fuelling station. A cursory review indicates there are no public CNG fuelling stations on Vancouver Island, so a new station would need to be constructed to facilitate this. No additional infrastructure would be needed to utilize biomethane *per se*, except that FortisBC does not appear to currently offer biomethane to its Vancouver Island customers. This may change once the CAWTP is complete, and the system is producing biomethane for distribution.

Three scenarios are considered for the Township to use recovered biomethane, assuming FortisBC or others have made biomethane available from the grid:

1. Construct a CNG fuelling station to enable Township vehicles to fill CNG-enabled vehicles;
2. Assuming a CNG fuelling station is provided by others, convert the Township truck fleet to CNG using biomethane; and
3. Purchase biomethane for use in existing Township boiler heating plants to reduce GHG emissions.

All of the above scenarios assume that there will be biomethane available for purchase within the Township, either directly from the solids facility, or through the gas distribution system.

4.4.1 Compressed Natural Gas Refuelling Station and Fleet Conversion

FortisBC Energy Inc. filed an application[8] with the BC Utilities Commission in February 2012 to construct and operate a CNG fuelling station for BFI Inc. in the Lower Mainland. This document indicates the approximate capital cost of a CNG fuelling station intended to provide 60,000 GJ/year at $2 million. As the Township does not appear to currently own any CNG-fuelled vehicles, additional

[8] Application for CPCN to BC Utilities Commission from Fortis BC Energy Inc, Exhibit B-1, Feb 29th, 2012

investment in the Township's fleet would be needed to utilize CNG. Westport Innovations, a Vancouver-based company specializing in CNG vehicle conversions, lists its "WiNG" CNG engine as a roughly $10,000 premium above typical diesel vehicles.

In assessing the potential for installing a CNG station for the Township's use, the following assumptions were developed:

- Light-duty and heavy-duty truck use requires approximately 3,600 GJ/year (based on 2012 fuel consumption data from Township);
- At an average fuel economy of 15 L/100 km, and 25,000 km travelled per year, approximately 15 vehicles would need to be replaced with CNG-fuelled units, assuming 3 cycles over a 15-year lifespan (total capital cost of $450,000); and
- The CNG station would cost approximately $100,000 per year to operate.

On this basis, a simple payback calculation was performed to evaluate this option, and detailed in the following table.

Table 4-5: Simple Payback Analysis for CNG Fuelling and Fleet Conversion

	CNG	Current
Capital Cost	$2,450,000	$0
Annual Operating Cost	$146,085	$78,474
Carbon Value	$3,197	$0
Net Annual Cost	$142,888	$78,474
Annual Savings		-$64,414
Payback Period		**-38**

As indicated, the CNG fuelling system would not result in a favourable payback. This is based on the Township being the only fuelling station customer, which does not generate sufficient fuel cost savings or carbon offsets to result in a favourable economic case. This is confirmed in that the FortisBC application assumed that 60,000 GJ/year in fuel demand would be needed, whilst the Township's vehicle fuel demand is only 3,600 GJ/year.

4.4.2 Township Fleet Conversion Only

As shown above, the CNG fuelling station dedicated to Township use would not result in a favourable business case, however, it may still be feasible for the Township to convert its fleet to CNG were a third party supplier to develop a fuelling station with sufficient demand (i.e. 60,000 GJ/year). The results of this calculation are shown in the following table.

Table 4-6: Simple Payback Analysis for CNG Fleet Conversion Only

	CNG	Current
Capital Cost	$150,000	$0
Annual Operating Cost	$46,085	$78,474
Carbon Value	$3,197	$0
Net Annual Cost	$42,888	$78,474
Annual Savings		$35,586
Payback Period		**4**

The payback analysis indicates a 4-year payback period, which is less than the anticipated lifespan of fleet vehicles (assumed to be 5 years), thus indicating the Township could benefit financially and environmentally were a CNG station with biomethane to be made available by others. Removing the carbon offset value would increase the payback to 5 years, which is still within tolerance.

4.4.3 Purchased Biomethane for Heating

The simplest approach for the Township to use biomethane would be to purchase it for use in its existing heating systems. The estimated premium cost for using biomethane over natural gas is $9/GJ, which would result in an annual cost increase of about $166,000 at current prices. The associated carbon offset value would be approximately $81,000, which leaves a financial gap of about $85,000. This option is not recommended.

4.5 Nutrients

There are a number of nutrient recovery systems entering commercial production, with the Ostara™ system being a commonly identified local example. KWL contacted Ostara™, which indicated a ‘full-scale’ system may cost in the range of $1 million to $5 million to construct. A full-scale system is currently in operation at the Rock Creek WWTP in Hillsboro, Oregon, which reportedly produces approximately 4,000 kg/day (~1,400 tonnes/year) of crystallized struvite.

In order to evaluate the viability of such a system for the Township, a critical value analysis was performed based on the current usage of fertilizer reported by the Parks Department. As per Section 3.4, the Township currently consumes about 2.5 tonnes of fertilizer per year at a cost of $2,000/tonne. Assuming an escalation factor of 3% (real), the 15-year net present value of this is about $125,000. Assuming O&M at 5%, including catalysts, the residual capital cost could not exceed $80,000 to construct a nutrient recovery facility dedicated to the Township’s fertilizer use. This is not considered to be sufficient for such a facility.

For a regional-scale facility producing 272 tonnes/year (~620 kg/day), per the CAWTP, the residual capital cost could be as high as $7 million, which does appear to be sufficient to support inclusion of this technology. Thus, if a regional-scale facility is constructed, the Township could purchase a locally-recovered fertilizer source, which would have better environmental qualities than conventional fertilizer, which is largely produced from fossil fuels and mined phosphates.

A nutrient recovery facility could be placed anywhere along the centrate line (the line returning the supernatant from the thickened digested sludge to the McLoughlin WWTP), but would be best-located at either of the treatment facilities to take advantage of a common site.

4.6 Integrated System

If the district energy and non-potable water options are both pursued, it may be possible to combine these to share some of the infrastructure costs. For instance, the cost of the pipe extension from the McLoughlin WWTP to Esquimalt Village is roughly $600,000, most of which is shared with the proposed non-potable piping route. The pumping station required for the non-potable system would also be shared. It is likely that the total capital cost savings would be enough to make the treated effluent DES option equivalent to the raw sewage and potentially even conventional heating on a life-cycle basis. Further study would be needed to understand the full economic implications of an integrated system. The proposed integrated system is detailed on Figure 4-3.

A further integration opportunity exists if there is sufficient interest to supply the Downtown Victoria neighbourhood with treated effluent for re-use and heating purposes. This was previously estimated to cost approximately $250-300 million as part of the CALWMP Resource Recovery and Use Plan[9].

4.7 Incremental Opportunities Related To Solids Facility Within Township

It is of interest in this study to examine the incremental changes to resource recovery potential in the event that a solids handling facility is located within the Township's industrial area.

4.7.1 Biogas Combined Heat and Power

As discussed in Section 2.3.2, there would be 8 GWh of residual heat from a potential biogas CHP available for district heating where the biosolids treatment facility to be located in the industrial area. Within 500 m of this location, there are 4,000 kW of existing boilers on 9 properties, which indicate potential to utilize heat generated at the biosolids treatment facility, at an approximate annual energy usage of 4.8 GWh, or half of the potentially available residual heat. Approximately 1,400 m of distribution piping would be needed to connect to these buildings at an estimated cost of $3 million. A business case to determine the feasibility of use of this heat would need to consider cost recovery of the CHP plant, distribution system, and any commodity valuation for use of the heat supply. This would require further coordination with the biosolids treatment facility proponents and the CRD.

4.7.2 Biomethane Fuelling Station

If, as per current plans, the residual biogas generated by the biosolids treatment facility is upgraded to biomethane, a CNG fuelling station could be placed at the facility, thus potentially eliminating the need to distribute to the natural gas grid. For consumers of the biomethane, it would potentially mean that midstream and delivery costs associated with natural gas could be avoided, though the costs of the upgrader and fuelling station would need to be added to the base biomethane commodity price. A reduction in biomethane costs, coupled with a local fuelling station would further improve the business case for converting the Township's vehicle fleet.

4.7.3 Dried Biosolids Processing

While the current plans for biosolids are to ship them to the Lower Mainland for consumption in cement kilns, there also remains a possibility for a local operation to create other products such as fertilizer or

[9] Capital Regional District Core Area Liquid Waste Management Plan, Resource Recovery and Use Plan, 2010.

engineered soil. The primary benefit to the Township related to biosolids is thus considered to be an economic development opportunity.

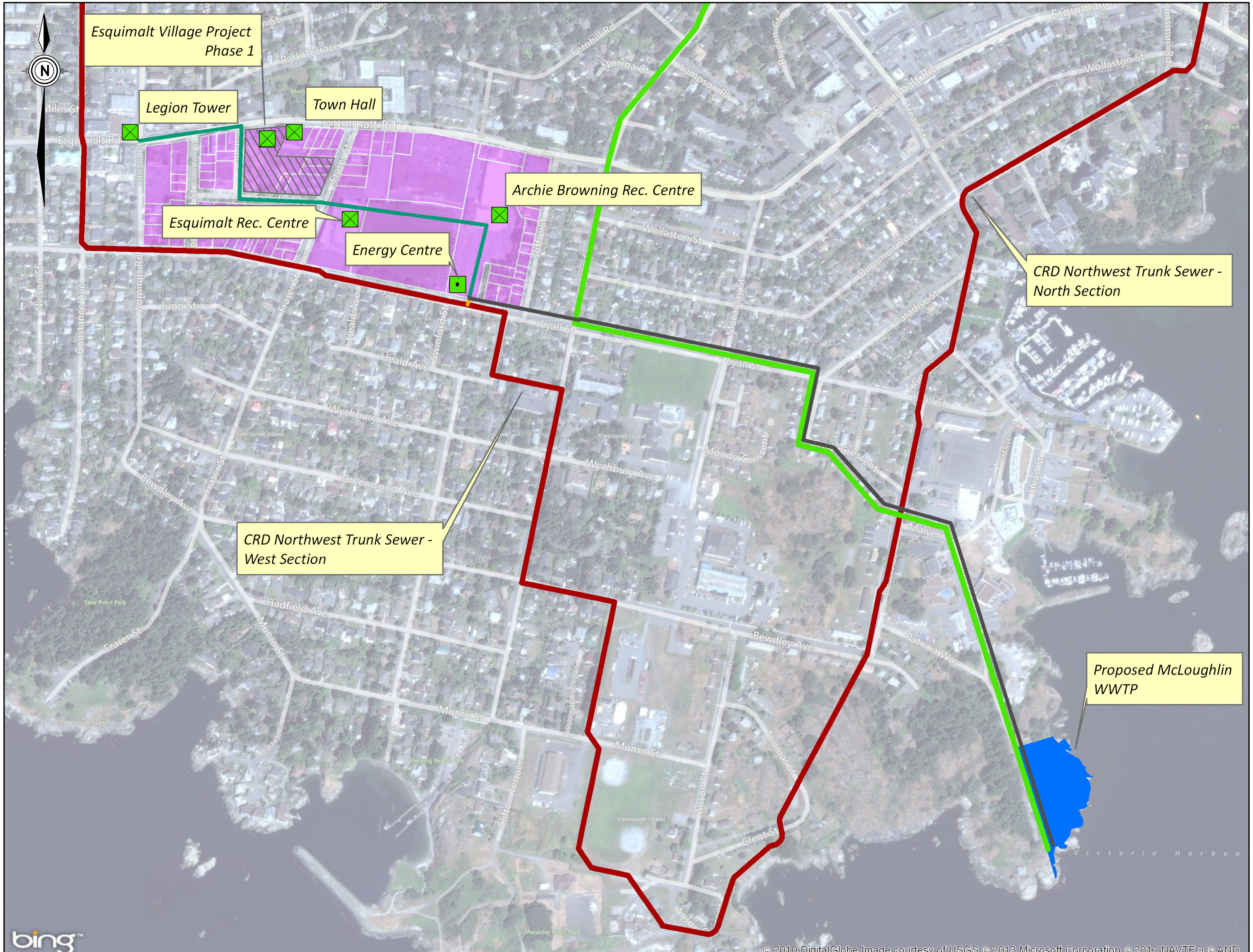
4.8 Summary of Resource Recovery Opportunities

Based on the work conducted, the following conclusions regarding potential resource recovery opportunities for the Township are provided:

- The Esquimalt Village Project and neighbouring Township buildings are considered as being good opportunities for implantation of district energy systems using treated effluent or raw sewage as a heat source. The DES options are about 10% more expensive on a life cycle basis, but this is close enough to warrant further study, and potentially investigate possibilities for capital grant assistance to close the gap.
- Using treated effluent for non-potable water uses within the Township is not economically viable if only the avoided cost of potable water use is accounted. The Township would need to work with the CRD and City of Victoria to determine whether there is a sufficient additional benefit from reducing peak hour irrigation demand (approximately $4 million in present value).
- The Township could benefit economically and environmentally from the provision of a third-party CNG fuelling station with biomethane available. The Township does not have sufficient demand to support its own fuelling station, but there is a positive economic case for fuel switching for its fleets should the biomethane resource become available at the approximate pricing shown.
- Purchasing biomethane to run in existing Township boilers is not considered to be a cost-effective measure for reducing GHG emissions compared with district energy.
- If the biosolids treatment facility is located in the Township's industrial area, the main additional opportunity would be to increase the amount of heat supplied from a combined heat and power system to feed local heat demands. Further analysis is needed to understand the potential for this, however a minimum capital cost of $3 million is anticipated for a DES to distribute heat.
- The Township's fertilizer demand is not sufficient to support a nutrient recovery system, however, it would appear feasible to develop a regionally-sized nutrient recovery system, which would allow the Township to source fertilizer from a local, sustainable supply.
- Dried biosolids are not considered to be a high priority for the Township due to limited opportunities for use.

The key resource priorities for the Township include district energy, vehicle fuel switching and nutrient sourcing. These should be subject to more detailed feasibility studies if the Township wishes to pursue these options.

Township of Esquimalt
Potential Resource Recovery Opportunities
Desktop Study



Legend

- Proposed Energy Transfer Station
- Proposed Energy Centre
- Potential Sludge Line Route
- Existing Trunk Sewer

Proposed District Energy Piping (2 pipes)

Pipe Type

- Hot Water
- Raw Sewage Option
- Treated Effluent Option
- Village Core
- Proposed WWTP

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Heat Recovery Options

Figure 4-1

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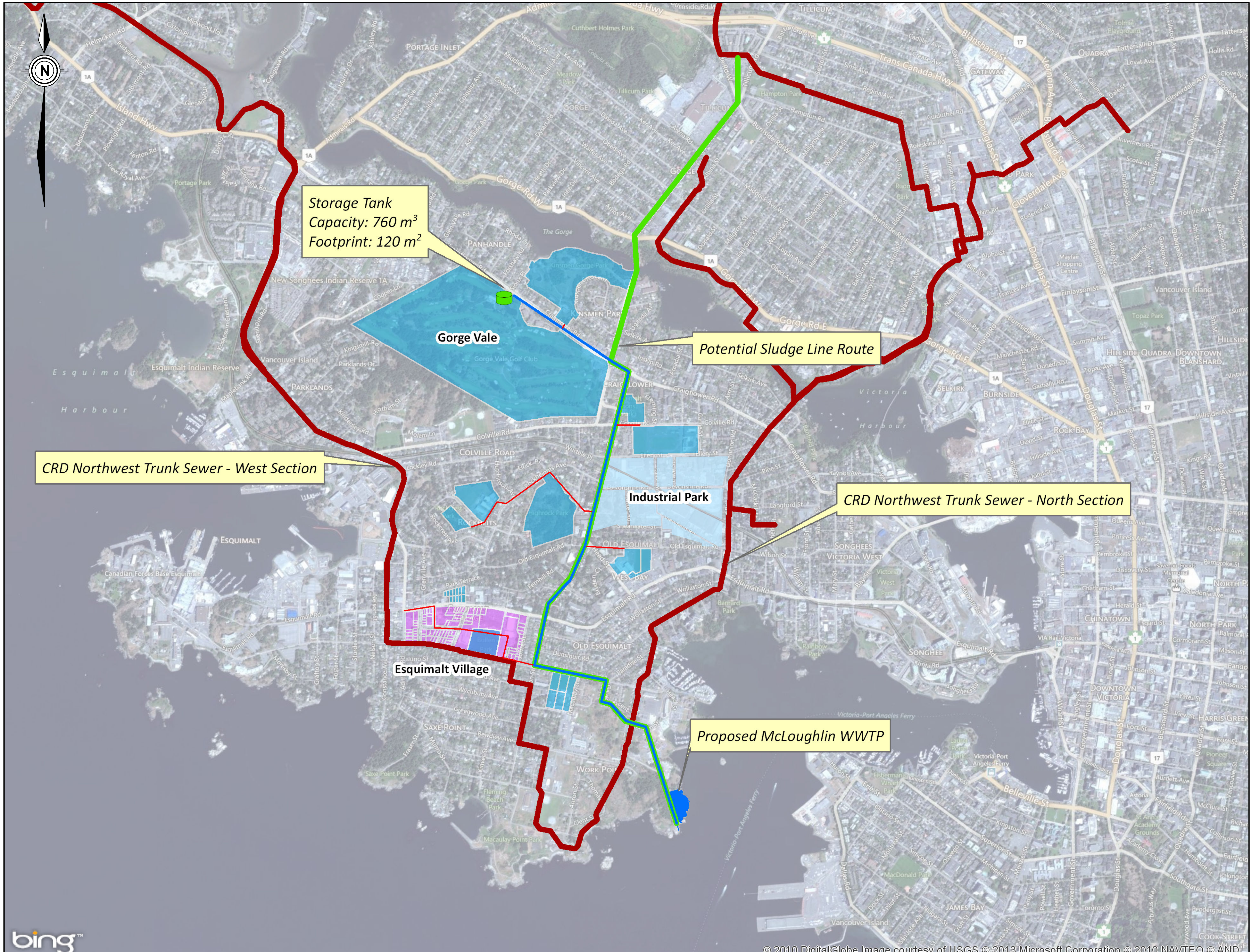
Township of Esquimalt
Potential Resource Recovery Opportunities Desktop Study



Legend

- Proposed Water Reuse Main
- Proposed Water Reuse Distribution
- Proposed Sludge Line Route
- Trunk Sewer
- Potential Water Re-Use Opportunities
- Village Core
- Proposed WWTP
- Industrial Park Parcel

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Project No.	Date
601-008	March 2013

Water Reuse

Figure 4-2

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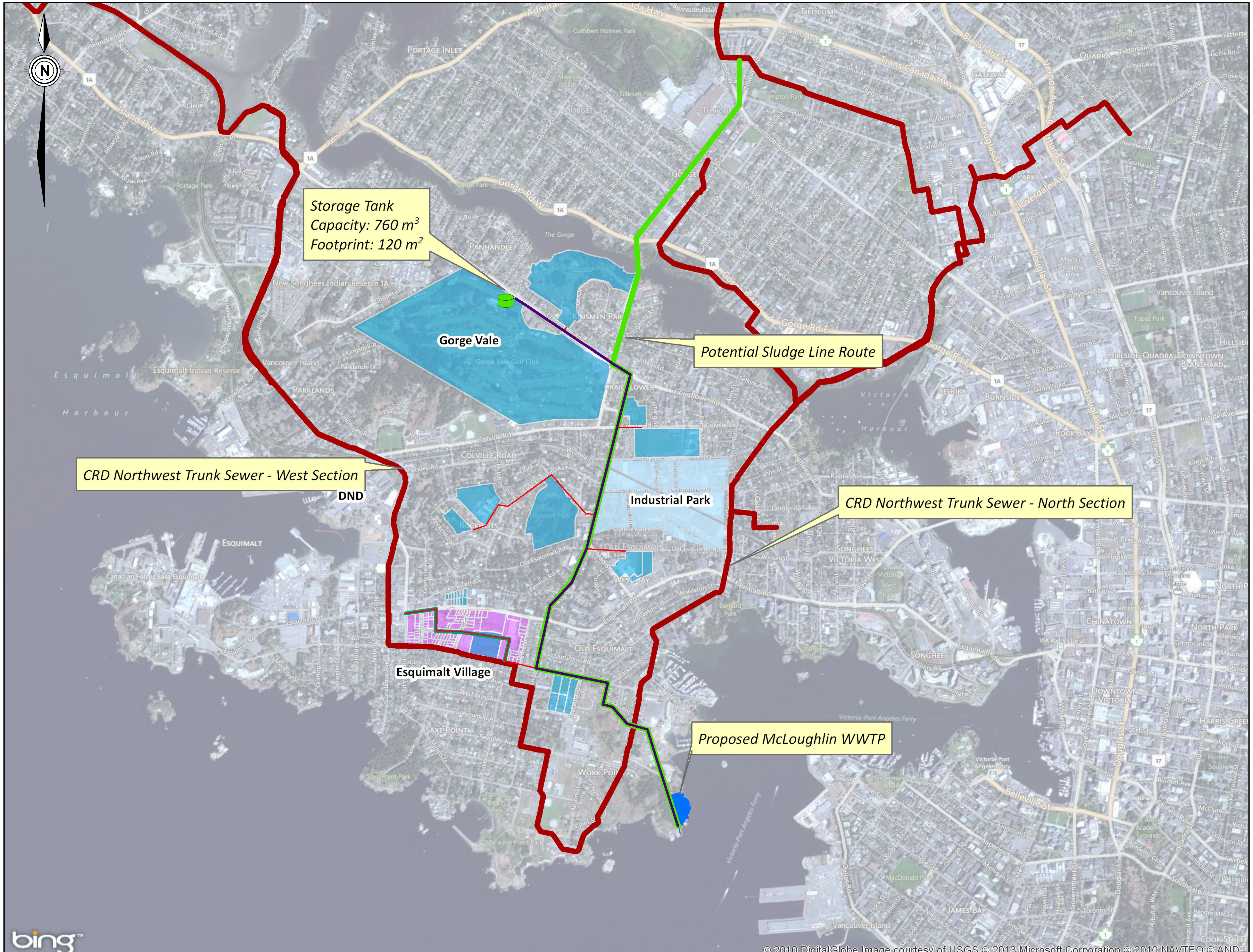
Township of Esquimalt
Potential Resource Recovery Opportunities
Desktop Study



Legend

- Proposed Integrated Reuse Main
- Proposed Water Reuse Distribution
- Proposed Sludge Line Route
- Proposed DE distribution
- Trunk Sewer
- Potential Water Re-Use Opportunities
- Village Core
- Proposed WWTP
- Industrial Park Parcel

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Project No.	Date
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Integrated System

Figure 4-3

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5. Conclusions and Recommendations

5.1 Conclusions

Due to the proximity of the McLoughlin WWTP, there is much potential for the Township to recover and utilize the various treatment plant resource streams. In general, the estimated demand within the Township is much lower than the potential supply of resources from the proposed McLoughlin WWTP. In general, the potential recovered resource supplies available as a result of the proposed CAWTP far outpace the potential demands within the Township.

The key conclusions from the study are summarized below.

Heat Recovery and District Energy Potential

- The most viable location for a district energy system is in the Esquimalt Village area;
- Total recoverable raw sewage heat is estimated to be 5.3 MW in 2016 and 12.6 MW in 2031;
- Effluent heat recovery for the McLoughlin WWTP is estimated at 44 MW in 2016 and 48 MW in 2031;
- The lifecycle cost for a raw sewage or treated effluent DES located in Esquimalt Village is within 10% of conventional heating systems, and with potential for GHG emissions avoidance and capital grant funding, the business case could be positive; and
- Raw sewage heat is also available for the industrial park area and is estimated at 7.6 MW in 2016 and 8.7 MW in 2031.

Purple Pipe Effluent Reuse System

- There is more than 12 ML/d of effluent from the McLoughlin WWTP which can be made available for irrigation and indoor non-potable water use within the Township;
- A non-potable ‘purple pipe’ water system used to supply water to 11 irrigation and other non-potable water demands would introduce a high capital cost though it would provide additional benefits to the CRD and City of Victoria water systems by decreasing peak hour water demand by approximately 215 L/s; and
- There is potential to combine the proposed effluent reuse system with the proposed DES to leverage common infrastructure for both projects, thereby reducing capital and O&M costs.

Biogas and Biomethane Production and Use

- An estimated production of biogas at the proposed biosolids treatment and energy facility is 38 GWh per year, which could be converted to heat, electricity and/or biomethane;
- The available energy from biogas will depend on the location of the biosolids treatment and energy facility – a location closer to the McLoughlin Point WWTP would allow enable the use of effluent heat for facility heating demands which would free up biogas energy for external use;
- The construction of a compressed natural gas refuelling station would not result in a favourable business case for the Township if it is the only user of the station;

- The Township may benefit financially and environmentally by converting their vehicle fleet to compressed natural gas, using biomethane as the fuel – the estimated payback period is less than 5 years; and
- Purchasing biomethane for use in existing heating systems is the simplest approach for the Township though would result in an estimated annual cost increase of up to $166,000.

Nutrient Recovery

- Land application of nutrient-rich biosolids would be challenging due to permitting requirements;
- Phosphorous recovered from the biosolids treatment and energy facility can produce an estimated 272 tonnes of struvite fertilizer material per year, which is significantly more than the Township's reported use of 2.5 tonnes per year; and
- A regional-scale commercial fertilizer production facility would provide the Township the opportunity to purchase a locally-recovered and processed fertilizer which would have better environmental than conventional fertilizers.

Biosolids Treatment Facility within the Township

- One of the possible locations for the proposed biosolids treatment facility is in the Township's industrial park; and
- The most likely additional opportunity associated with this is to increase the amount of heat recovered from a biogas combined heat and power system to supply local heating uses, up to 5 GWh per year.

5.2 Recommendations

With the implementation of the Core Area Wastewater Treatment Program comes the opportunity to recover various resources for reuse. Of the various resource streams and uses, there are a select few which are recommended for further investigation in more detailed studies. The Township should further pursue the following opportunities:

1. **District Energy System** – Development of a district energy system in the Esquimalt Village area using raw sewage or treated WWTP effluent to replace the need for conventional heating to the proposed Esquimalt Village Project, the Legion Rise residential tower development, Town Hall & Library, the Archie Browning Recreation Centre and the Esquimalt Recreation Centre.
2. **Integrated DES and Purple Pipe Treated Effluent Distribution System** – Construction of an effluent supply system that can provide treated effluent for DES heat recovery as well as for irrigation and non-potable water reuse. There is further opportunity for integration should the CRD be interested in supplying the Downtown Victoria neighbourhood with treated effluent heat.
3. **Biogas Combined Heat and Power** – Recovery of approximately 5 GWh per year of residual biogas heat energy from the proposed biosolids treatment facility. This energy could be used in a district energy system which would tie-in existing boilers in the vicinity of the proposed biosolids treatment facility site, should it be located within the Township's industrial area.
4. **CNG Refuelling Station and Fleet Conversion** – The addition of a CNG fuelling station at the proposed biosolids treatment facility and the conversion of the Township's fleet vehicles to operate using compressed natural gas should be investigated further to determine whether a business case is there.

5.3 Report Submission

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Apr 15, 2013

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Revision History

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0	March 28, 2013	DRAFT		KZ/MEH
1	April 15, 2013	FINAL	Final Revisions.	KZ/MEH