DISCUSSION PAPER 036-DP-2

Capital Regional District
Core Area Wastewater Management Program

Discussion Paper – Development of Distributed Wastewater Management Strategies
036-DP-2

Prepared by:	Dean Shiskowski / John Spencer / Rick Corbett
Issued:	March 9, 2009
Previous Issue:	None

1 Introduction

Building on the previous work completed under Activity 036, this Discussion Paper 036-DP-2 describes the development and details of the three distributed wastewater management Options presented to the CALWMC on February 25, 2009 and summarized in the accompanying February 19, 2009 Briefing Memorandum. The Discussion Paper also documents the capital cost, life cycle analysis and carbon footprint analysis information that has been developed to date for the three Options.

As noted in the Briefing Memorandum, the three Options provide reasonable "book ends" for an analysis that is intended to reveal trends associated with various extents of distributed wastewater management. Besides providing both detailed and summarized findings of the analyses, this Discussion Paper also provides the key assumptions that underpin the "base scenario" analysis completed to this point. In doing so, the CRD can solicit feedback from stakeholders on the analysis and results.

It is important to recognize that the findings have not yet provided the final answer to the most appropriate strategy for the CRD. Additional analyses will examine the sensitivity of various assumptions on the results presented in this Discussion Paper. These findings will be incorporated into an updated and re-issued 036-DP-02 document. Furthermore, the CRD will be using the information generated in the Sustainability Assessment Framework (SAF), which will analyze the Options from a triple-bottom-line perspective that considers environmental, social and economic elements, to holistically understand the attributes of the Options. The SAF analysis will utilize information contained in the 036-DP-02 document. This SAF analysis will be provided in Discussion Paper 036-DP-03.

2 Distributed Wastewater Management and Resource Recovery

2.1 The Concept of Distributed Wastewater Management

Distributed wastewater management, which involves the spatial distribution of treatment facilities across a geographic area, must meet the Core Area needs. It must ultimately provide secondary treatment for the dry weather wastewater flows. It must also incorporate wet weather flow management and opportunities for resource recovery – all in an affordable manner. A distributed approach allows the CRD to take best advantage of the existing sewerage infrastructure, while setting the direction for more localized wastewater management with potential water reuse and energy recovery opportunities.

The advantages of the distributed management approach are three fold. First, it reduces the size of the downstream facilities, as the upstream treatment plants reduce the flows reaching the downstream plants. Second, by strategically locating the upstream plants, local opportunities for water reuse and wastewater-derived heat recovery are created. Third, by reducing the existing wastewater flows in the lower portions of the sewerage system, capacity is freed up to handle a greater portion of the wet weather wastewater flow – greatly reducing the frequency and volumes of the current sanitary sewer overflows (SSO).

2.2 Resource Recovery Overview – Ideas and Opportunities

A considerable effort has been expended to identify potential resource recovery strategies that could be developed in conjunction with Core Area wastewater treatment facilities and associated infrastructure over a planning horizon that extends to Year 2065. Detailed information on the various topic areas is contained in a series of previously prepared Discussion Papers, but key points are noted below.

The topic areas / strategies contemplated are diverse. Some, like water reuse (Discussion Paper 031-DP-7) and heat recovery (031-DP-6), are relatively familiar within the wastewater industry and have long, albeit limited, histories around the world. As is discussed in Section 2.3, these topics are particularly important when assessing the spatial distribution of treatment facilities and were key considerations in developing the Options.

Others ideas, such as pressure energy recovery (031-DP-4), have seen some application elsewhere (i.e. potable water field) and are now being considered for wastewater systems. Energy and resource recovery from wastewater sludges and biosolids has a long-standing record, but newly up-and-coming variations include upgrading biogas to natural gas-grade biomethane, use of dried biosolids as a “green fuel” coal substitute, and co-digestion of solid waste organics with wastewater organics (031-DP-3, 031-DP-9). Phosphorus recovery (031-DP-5) from wastewater is considered an innovative technology, with few installations worldwide at this time, which is attracting increased intention given that phosphate is a finite resource. Finally, urine separation (031-DP-8) is a strategy of considerable complexity, since it extends beyond recovering a potential resource (nitrogen) from wastewater to include significant energy and micro-constituent removal implications for wastewater treatment. In this case technology and strategy development are still at an embryonic stage.

The question for the CRD is this – which of these resource recovery strategies are applicable to District given the context and time frame under consideration? Section 2.3 examines this question in detail, culminating in the development of a series of distributed wastewater management Options (Section 2.4) that meet the requirements of the secondary treatment program while capitalizing on the short- and long-term resource recovery opportunities.

2.3 Development of Distributed Wastewater Management Options – The Methodology

As noted in the previous Section, wastewater-derived heat recovery and water reuse potential are key drivers in developing increasingly distributed wastewater management options. In this context, a three-step process was employed to use these drivers to assist in developing the distributed wastewater management options:

1. Creation of Energy Resource Opportunity Areas (EROAs)
2. Rating and ranking of the EROAs
3. Screen and grouping the EROAs to form distributed wastewater management options.

1. Creation of Energy Resource Opportunity Areas: As described in Discussion Paper 036-DP-1, through a process of evaluating heating energy demand, energy supply via wastewater-derived heat, and water re-use demand, 38 areas were identified for wastewater treatment and resource recovery potential in these two contexts. These areas, defined as Energy Resource Opportunity Areas or EROAs, formed the basis to develop three distributed management Options.

2. Rating and ranking of the EROAs: Each EROA was rated and ranked on the basis of the EROA resource recovery attributes. The rating and ranking is defined in Discussion Paper 036-DP-1, where wastewater-derived heat energy recovery and water re-use criteria were used to asses the potential of each area to meet resource recovery objectives.

The rating and subsequent ranking took into account the varying attributes of each EROA. As an example; some areas represent excellent opportunities to match resource recovery with urban growth, while others offer opportunities to match resource recovery with urban redevelopment. Some EROAs are better suited for water re-use while others are better suited for energy recovery, while some offer combined attributes for both. Taken together, the EROAs offer a very complex set of choices to design a wastewater treatment and resource recovery strategy for the CRD.

3. Screen and grouping the EROAs to form distributed wastewater management options: With these ratings and rankings in-hand, the challenge was to define strategies to both serve the EROAs wastewater treatment needs and capture the resource recovery opportunities.

Accomplishing these two challenges required organizing the EROAs into logical wastewater management areas. This was done by assessing how:

- EROAs might be grouped based on their location and geography.

- Energy and water re-use demand time-frame or planning horizon for the EROAs would allow EROAs to be integrated or grouped.

- The need to achieve secondary treatment for existing flows within the EROAs, would allow for the grouping or integration of EROAs.

- Water would be conveyed to representative treatment sites and transmitted to re-use and energy recovery users.

- Wet weather flows would be conveyed and treated.

Using this assessment, a set of guidelines was used to create a range of strategic wastewater treatment and resource recovery options. The guidelines followed the CRD goals to:

Goal 1 – Protect Public Health and the Environment
Goal 2 – Manage Wastewater in a Sustainable Manner
Goal 3 – Provide Cost Effective Wastewater Management

The guidelines used were:

.1 Have the potential to utilize the wastewater-derived heat energy available within the wastewater system at 2065

.2 Enable water re-use in conjunction with energy recovery

.3 Enable future, public or privately funded development or redevelopment, to capture the energy and re-use opportunities

.4 Avoid discharge of treated wastewater to local fresh water bodies, and

.5 Manage wet weather flows.

Through an iterative process of matching of EROA groups to conveyance, transmission and representative facility sites and users, three distributed wastewater management Options were defined.

With the heat recovery and water reuse opportunities addressed in developing the Options, the obvious question is how the other resource recovery ideas discussed in Section 2.2 were incorporated into the three Options. The following points provide the answers:

- All Options include the same biosolids energy and resource recovery opportunities. These are further described in Section 2.4 and are based on the work documented in Discussion Paper 031-DP-9. The location of some of the infrastructure needed varies with each

Option, reflecting differences in material mass flow and potential opportunities to use biomethane in specific areas.

- All Options include phosphorus recovery that is implemented to the same extent. Phosphorus recovery systems are essentially “add-on” systems that the CRD could implement at any time. As is discussed in Section 2.4, for analysis purposes it is assumed that the CRD would implement such technology in the near-term.

- Pressure energy recovery has not been included in any of the Options given the limited benefit it may provide in the CRD situation (Discussion Paper 031-DP-4). However, this assumption does not preclude the CRD from installing these systems should more detailed future analysis reveal specific, favourable opportunities.

- Due to the present “embryonic” level of technology and strategy development, urine separation has not been explicitly included in any of the Options. Again, the CRD could implement urine separation in the future as industry developments allow. Furthermore, decisions the CRD needs to make in the near-term are essentially independent of the longer-term possibilities that may exist with urine separation. Therefore, all Options remain flexible in the future with respect to this topic.

2.4 Option Descriptions

The three distributed wastewater management Options are characterized by the spatial distribution of wastewater treatment facilities around the Core Area. Brief summaries of the three Options are provided below. **Tables 2-1**, **2-2** and **2-3** provide detailed descriptions of Options 1, 2, and 3, respectively. **Figures 2-1**, **2-2** and **2-3** illustrate the infrastructure elements for each of the three Options. **Appendix A** contains conceptual facility layout drawings.

Option 1: Resource Recovery on a Regional Basis. Option 1 provides wastewater management and treatment with resource recovery on a regional basis within the CRD Core Area service area. This reflects the use of the fewest wastewater treatment facilities (WWTFs) of the three Options developed. The facilities would be located in three areas: Macaulay/McLoughlin Point, Saanich East near the University of Victoria, and in the South Colwood area. A wet weather treatment facility would be provided at Clover Point.

Option 2: Resource Recovery on a Combined Regional-Local Basis. Option 2 provides a more distributed approach to wastewater management with the use of additional wastewater treatment facilities, representing a “middle ground” scenario relative to Option 1 and Option 3. Five WWTFs would be employed in Option 2 to provide secondary treatment. The additional facilities, relative to Option 1, include ones located in the Ogden Point and Juan de Fuca areas

Option 3: Resource Recovery on a Local Basis. Option 3 provides the most distributed approach to wastewater management of all three Options and, as a result, involves the most

Table 2-1. Option 1 Description

OPTION 1
Resource Recovery on a Regional Basis

1.0 DESCRIPTON

Option 1 provides wastewater management and treatment with what is described as resource recovery on a regional basis within the CRD Core Area service area. This terminology reflects the use of the fewest wastewater treatment facilities (WWTFs) of the three Options developed.

Three WWTFs would provide secondary treatment performance under all dry-weather and the majority of wet-weather flow conditions, the latter attained using a split-and-blend approach with specific technology application. The facilities would be located in three areas: Macaulay/McLoughlin Point, Saanich East near the University of Victoria, and South Colwood within the Colwood Gravel Pit. Effluent from these WWTFs would be suitable for reuse in landscape irrigation and toilet flushing applications. In addition, effluent from these facilities would be available for use as a heat source in adjacent district energy systems. These plants would be located along the existing conveyance system.

The wet-weather flows within each of the sewerage areas would be managed within the sewerage area, with the ultimate goal of treating the wet-weather flows at the treatment plants. The Clover Point facility would treat wet-weather flows only. The dry-weather flows would be pumped from the Clover Point sewerage area to the secondary treatment plant at Macaulay/McLoughlin Point.

The Macaulay/McLoughlin Point and South Colwood WWTFs include sludge processing operations. Dilute sludges produced at the Saanich East and Clover Point plants will be discharged to the collection system for processing at the downstream Macaulay/McLoughlin Point WWTF. Biogas generated by anaerobic sludge digestion would be upgraded to natural-gas quality biomethane and injected into the utility pipeline. Phosphorus released during sludge processing operations will be recovered as magnesium-ammonium-phosphate (MAP, i.e. struvite) using a crystallization reactor system, in turn producing a commercial-grade, slow-release fertilizer product.

One-half of the stabilized biosolids would be hauled to a biosolids drying facility located in the Hartland landfill area where, following drying, the product would be transported to the Lower Mainland to a cement kiln for use as a coal-substitute fuel. The other one-half of stabilized biosolids would be directed to an “industrial” land application / willow coppice program. The harvested willow biomass would be converted into woodchips and used in the CRD’s solid waste composting program and sold for other typical applications, and could potentially be used as biofuel as markets may develop in the future.

2.0 WASTEWATER TREATMENT AND RESOURCE RECOVERY

Macaulay/McLoughlin Point WWTF

Additional property would be acquired to construct a treatment facility at McLoughlin Point, which would include the land currently occupied by the Imperial Oil tank farm and the DND lands to the north of the tank farm. In addition, the site would require some in-fill expansion to the east into the harbour.

Wastewater would be intercepted upstream of the existing Macaulay Point pumping station using a new tunnel system, which would convey the wastewater to the McLoughlin Point site.

As noted in Section 1, this WWTF would handle all of the solids from the Saanich East and Clover Point plants and any future flow from the Macaulay sewerage area not handled by the South Colwood WWTF. Representative liquid-stream technologies used at the Macaulay/McLoughlin Point WWTF include:

- Influent pumping
- Screening and grit removal
- Lamella-based primary clarification, with chemically-enhance primary treatment (CEPT) capability for wet-weather flows
- Membrane bioreactor (MBR)-based secondary treatment
- Effluent pumping

The WWTF would use a primary effluent split-and-blend approach to accommodate the majority of wastewater flows. Primary treatment, with CEPT capability, would be provided for up to 4.0 times the ultimate (Year 2065) average dry-weather flow (ADWF) or 350 ML/d. Secondary treatment capacity would be provided for up to 1.5 times the ultimate ADWF or 131 ML/d. Wastewater flow rates in excess of 350 ML/d would bypass primary treatment and receiving screening. All flows would be blended prior to discharge.

Effluent requiring disposal would be returned to the marine environment via a new outfall constructed along the approximate alignment of the existing Macaulay Point outfall, but more to the east. As the site is only a few meters above sea level, it is expected that the effluent discharge will be pumped from a new station at the McLoughlin site. The existing Macaulay pumping station would be decommissioned. Given the treatment process, discharge location and environment, effluent disinfection would not be required.

Beyond directing effluent to marine disposal, effluent will be managed in two other ways. First, the effluent pumping station will have the capability of pumping effluent (i.e. ADWF-type magnitude) across the harbour to and from a third-party district energy system (DES) located in Victoria. Effluent would also be available for heat recovery in an area to the north of the site. The DES would recover heat from the effluent.

Second, the effluent could be used for non-potable applications. The WWTF layout includes a clearwell for reclaimed effluent storage, with space provided to accommodate a reclaimed water ultra-violet effluent disinfection system (primary disinfection) and a chlorine-based system (residual disinfectant). Effluent would be pumped out of the clearwell and made available to a nearby third-party reclaimed water system.

Representative solids-stream technologies used at the Macaulay/McLoughlin Point WWTF include:

- Mechanical sludge thickening
- Anaerobic sludge digestion
- Biogas cleaning and upgrading to biomethane
- Centrifuge sludge dewatering
- Crystallization phosphorus recovery

Primary and secondary sludge would be blended in a blend tank prior to mechanical thickening. Subsequently, the thickened sludge would be pumped to anaerobic digesters for stabilization. The anaerobic digesters would also accept truck-hauled, locally generated solid waste organics for co-digestion with wastewater sludges. The organic material would include fats, oils and grease (FOG) that require minimal preprocessing prior to digestion. Other solid waste organics could be accepted that received the required preprocessing at a solid waste transfer station. After digestion, the biosolids would be dewatered using centrifuges and then hauled to the willow coppice program lands or dryer facility located in the Hartland area (Section 4.0).

The biogas generated from the digesters would be upgraded to natural-gas grade biomethane and injected into the utility natural gas pipeline for use off-site as an energy source. Biogas upgrading would involve carbon dioxide removal (pressure swing adsorption), as well as siloxane (activated carbon) and

hydrogen sulphide (iron sponge) removal. Phosphorus would be recovered from the digester supernatant and dewatering recycle streams using a crystallization reactor system with magnesium addition and pH control. The MAP product would be bagged and made available for sale. The recycle streams would be returned to the main liquid-stream process for treatment. Facility odour control would be provided by two systems. A 3-stage chemical scrubber/activated carbon system would be used for the most odourous air streams, such as those originating from headworks areas. A single-stage activated carbon system would be used for less odourous air streams such as those withdrawn from the headspace above bioreactors. The technologies selected provide a compact facility footprint. Surface structures will be attractively designed buildings or will be blended into the surrounding land features. The majority of the liquid-treatment tankage will be constructed below grade; the top of the tankage will be level with or just above ground level. The top of the primary clarifiers and bioreactors will be covered flush with the top of the tankage and structurally designed such that the surface would be available for controlled-access storage or vehicle parking. Tank access would be provided via removable, structural covers. While the MBR membrane tanks will also finish at grade, the tanks will be enclosed in a single story building. The digesters will be partially buried and partially above grade. Most of the Macaulay / McLouglin WWTF will be constructed in a single, initial stage with minor works constructed in a second stage in around Year 2030.
South Colwood WWTF The concept and representative liquid-stream and solids-stream technology would be the same for the South Colwood WWTF as the Macaulay/McLoughlin WWTF. The South Colwood WWTF primary and secondary treatment capacities would be 109 ML/d (2.9 x ADWF) and 58 ML/d (1.5 x ADWF) for Year 2065, respectively. At this time wet-weather flows in excess of 109 ML/d are not anticipated and thus planned bypassing, except under emergency conditions, is not part of the concept. Effluent would be returned to the marine environment via a new outfall extending into Juan de Fuca Strait. Effluent pumping will not be required as the site elevation is significantly higher than sea level. Effluent disinfection will not be required. Similar infrastructure as that used at the Macaulay / McLoughling WWTF would be provided to deliver effluent for heat recovery and reclaimed water reuse purposes. Architecture will be a similar style and profile to that used at the Macaulay / McLoughlin WWTF but tankage surface area would not be available for use. Odour control works would be similar to those of the Macaulay / McLoughling WWTF. The facility would be constructed in two stages, with the second stage being constructed in approximately Year 2030.
Saanich East WWTF This facility will function as a “liquids stream only” facility, reducing the downstream wastewater flows and providing a high quality effluent for water reuse and a source of heat. Sludges generated by the facility will be discharged to the sewer system for transport to and processing at the Macaulay / McLoughlin WWTF.

The Saanich East WWTF concept uses the same liquid-stream processes as described for the other two facilities. Secondary treatment capacity would be provided for up to 1.5 times the ADWF for the Year 2065 scenario or 26 ML/d. Primary treatment only would be provided for flows between 1.5 and 4 times the ADWF, up to 69 ML/d. Any flow above 4 times the ADWF would receive screening only and be blended with the primary and secondary effluent for discharge to the outfall.

Effluent requiring disposal would be discharged by gravity via a new outfall constructed out into Haro Strait.

Similar infrastructure as that used at the Macaulay / McLoughlin WWTF would be provided to deliver effluent for heat recovery and reclaimed water reuse purposes.

The facility design would be low profile and architecturally designed to fit with the surrounding neighborhood. The liquid-stream tankage for this facility will follow a similar profile to those at Macaulay/McLoughlin WWTP, but the surface area would not be available for use. Odour control works would be similar to those of the Macaulay / McLoughling WWTF.

The facility would be constructed in two stages, with the second stage in approximately Year 2030.

Clover Point Wet-Weather Treatment Facility

The process works at this location would consist of the following:

- Pump station and forcemain to pump the dry-weather wastewater flow to the Macaulay/McLoughlin Point WWTF
- Influent pump station for wet-weather flows
- Screening and grit removal for wet-weather flows
- High-rate, chemically-enhanced primary clarification for wet-weather flows
- Effluent pumping for wet-weather flows

For most days of the year, the pump station and forcemain system would pump the wastewater arriving at this location to the Macaulay/McLoughlin Point plant. This pump system would be sized for 2.0 x ADWF or about 74 ML/d. On the days where the flow arriving at this site exceeds this capacity, the surplus flow, up to 403 ML/d, would be routed through the wet-weather flow treatment system. This system would have an chemically-enhanced primary treatment capacity of 254 ML/d. On days with extremely high wet-weather flows, flows in excess of this capacity would receive screening only and be blended with other effluent prior to being discharged out the Clover Point outfall. The expected peak screened only flow is estimated at 149 ML/d.

The residual sludge from the wet-weather treatment process would be returned to the dry-weather pump station for transport to the Macaulay/McLoughlin Point WWTF for processing. This eliminates the need to truck-haul sludge from the Clover Point site.

The new dry-weather pump station and the wet-weather treatment facility can be located underground in a similar manner to the existing works. Some disruption of public access will be required during the construction period, as it will be necessary to employ a “cut and cover” construction process. Once in operation, truck traffic to deliver chemicals to the site will be minimal as the wet-weather system will only operate during limited periods.

Odour control works would be similar to those of the Macaulay / McLoughling WWTF.
The plant would be constructed in a single stage.

3.0 WET-WEATHER FLOW MANAGEMENT

The wet-weather flows within each of the sewerage areas would be managed within the sewerage area, with the ultimate goal of treating the wet weather flows at the treatment plants. The Clover Point site will be a dedicated wet weather treatment facility. All flows arriving at Clover Point under 2.0 x ADWF will be pumped to the Macaulay/McLoughlin Point WWTF.

The wet-weather flows reaching the Clover Point site will be treated and discharged at that point. This is more efficient than pumping the infrequent but high volume of dilute wastewater to another location. In addition, use of the South Colwood and Saanich East WWTFs reduces the amount of wet-weather flow continuing downstream.

The wet weather flow management strategy would still be combined with a continued program of combined sewer separation and I/I reduction.

4.0 BIOSOLIDS MANAGEMENT AND RESOURCE RECOVERY

The biosolids management strategy would see 50% of the digested and dewatered biosolids truck-hauled to a new solids drying facility (gas-fired indirect dryer system) located in the Hartland area. The dried biosolids would then be truck-hauled to the Lower Mainland for use in a cement kiln(s) as a coal-substitute fuel.

The other 50% of digested and dewatered biosolids would be truck-hauled to “industrial” land application sites where willow trees are grown and harvested, with the tree biomass subsequently reused. The purposeful (i.e. “industrialized”) growing and harvesting of trees in this manner is termed “coppice”. The harvested trees will be chipped and sold in the form of woodchips as a saleable, revenue generating product. The woodchips would be used in CRD solid waste and other composting operations, as well as other typical uses of woodchip products in the near-term. However, the potential exists to sell the woodchips as a green fuel as such markets develop over time. The strategy assumes that the CRD would lease the land required for willow coppice from private landowners. The land leases would be for a fixed time, allowing the CRD to rotate through land plots as dictated by planting / harvesting cycles.

5.0 CONVEYANCE SYSTEM MODIFICATIONS

Option 1 would require several modifications to the wastewater collection / conveyance system beyond treatment facility-specific changes discussed previously , including:

- Direct wastewater flow from the Penhryn pumping station (PS) to the Saanich East WWTF
- Extend the Trent PS forcemain to Clover Point
- Increase capacity of the Currie Road PS
- Various modifications in the NWT sewer area (NWTN twinning, NWTW wet-weather flow upgrades, diverting wastewater flows to the South Colwood WWTF).

Table 2-2. Option 2 Description

OPTION 2 Resource Recovery based on a Combined Regional – Local Basis
1.0 DESCRIPTON
Option 2 provides a more distributed approach to wastewater management with the use of additional wastewater treatment facilities, representing a "middle ground" scenario relative to the other Options. Five WWTFs would be employed in Option 2 to provide secondary treatment. The additional facilities, relative to Option 1, include ones located in the Ogden Point and Juan de Fuca areas. Like the other facilities described in Option 1, the Ogden Point WWTF will use a split-and-blend approach to provide secondary treatment performance under all dry-weather and the majority of wet-weather flow conditions. Alternately, because of the effluent discharge to the more sensitive Esquimalt Harbour, the Juan de Fuca WWTF will provide secondary treatment for all wastewater flows entering the facility. Option 2 also employs a change in the Macaulay Point sewerage area boundary, which will divert wastewater from the Marigold pumping station to the west. This change, along with the addition of the two WWTFs, substantially reduces the dry-weather flows reaching the Macaulay/McLoughlin WWTF. However, a comparable amount of wet-weather flow will still require treatment at the facility. To this end, the Macaulay/McLoughlin WWTF includes a separate wet-weather treatment system, similar to that used at Clover Point, to process these flows. Similar to Option 1, effluent from these WWTFs would be suitable for reuse in landscape irrigation and toilet flushing applications and as a heat source in adjacent district energy systems. Option 2 uses the same wet-weather flow management approach as Option 1, including the same size Clover Point wet-weather flow treatment facility. Solids processing operations will be located exclusively at the Macaulay/McLoughlin WWTF in Option 2, which differs from Option 1 where the South Colwood WWTF also processed solids. This change results from the South Colwood facility being of a much smaller size in Option 2. Because of its location, solids generated at the South Colwood WWTF will be truck-hauled to the Macaulay/McLoughlin WWTF for processing. Solids from the Juan de Fuca facility will be discharged to the sewer system for conveyance to the Macaulay/McLoughlin site. The Odgen Point WWTF will pump its solids directly to the Macaulay/McLoughlin WWTF via a dedicated forcemain across the harbour. The Macaulay/ McLoughlin WWTF will use the same solids processing and resource recovery systems as those described in Option 1. Furthermore, Option 2 utilizes the same biosolids management strategy as that of Option 1.
2.0 WASTEWATER TREATMENT AND RESOURCE RECOVERY
Macaulay/McLoughlin Point WWTF From a land requirement perspective, the site will be of a comparable size as that in Option 1 but with a marginally smaller in-fill area into the harbour. The larger solids processing facilities required in Option 2 partially off-set the reduced secondary treatment requirements. Similarly, the substantial wet-weather flows arriving at the site, and the treatment needed, also impacts land requirements. As in Option 1, the WWTF would use a primary effluent split-and-blend approach to accommodate the majority of wastewater flows. Primary treatment, with CEPT capability, would be provided for up to 4.0 x

ADWF or 93 ML/d. Secondary treatment capacity would be provided for up to 1.5 x ADWF or 35 ML/d. Wastewater flow rates in excess 4.0 x ADWF and up to an additional 154 ML/d would be directed to a dedicated wet-weather treatment facility using the same process technology (i.e. high-rate CEPT) as that of the Clover Point Facility. Flows in excess of about 250 ML/d would bypass primary treatment and receive screening. All flows would be blended prior to discharge.

Option 2 would not pump effluent across the harbour to Victoria for use in a DES. Instead, effluent would be available for heat recovery for areas to the north of the site.

The other main difference for the facility in Option 2, relative to Option 1, is the use of a side-stream treatment system for the digester supernatant and solids dewatering recycling streams. The need for this system results from the combined effect of having a smaller main liquid-stream treatment system and a larger solids-stream system. The side-stream treatment system would use a biological SHARON-ANAMMOX system to provide nitrogen removal through a largely anaerobic process, which reduces the overall energy requirements for treatment. In addition, external alkalinity addition, and associated costs, would likely not be required for SHARON-ANAMMOX system operation.

The facility would be constructed in a single initial stage.

South Colwood WWTF

The Option 2 South Colwood WWTF is substantially down-sized relative to the Option 1 facility. The primary and secondary treatment capacities would be 27 ML/d (2.8 x ADWF) and 15 ML/d (1.5 x ADWF) for Year 2065, respectively.

As noted in Section 1.0, the Option 2 South Colwood WWTF will provide no solids processing. However, since the solids generated will be truck-hauled to the Macaulay/McLoughlin WWTF for processing, the South Colwood solids will be centrifuge-thickened to reduce the volume and trucking requirements.

The facility would be constructed in three stages, with the latter two stages constructed in around Year 2030 and 2045.

Saanich East WWTF

The Option 2 facility is identical to that in Option 1.

Ogden Point WWTF

Like the South Colwood and Saanich East facilities, the Ogden Point WWTF will be a liquid-stream only facility that uses the same treatment technologies. Since the Ogden Point facility is receiving wastewater pumped from Clover Point, the primary treatment capacity will be the same 2.0 x ADWF of 74 ML/d. Again, this facility will use a primary effluent split-and-blend approach where the secondary treatment capacity will be capped at 1.5 x ADWF or 56 ML/d.

Effluent requiring disposal will be pumped to a new outfall extending into the Juan de Fuca Strait. Given the high level of treatment and receiving environment, effluent disinfection is not required.

Similar infrastructure as that used at the other WWTFs would be provided to deliver effluent for heat recovery and reclaimed water reuse purposes.

As noted in Section 1.0, the Odgen Point WWTF will pump its solids directly to the

Macaulay/McLoughlin WWTF for processing via a dedicated forcemain across the harbour.

Ogden Point is a light industrial use area, surface structures will be blended into the surrounding architecture. The majority of the liquid-treatment tankage will be a buried-enclosed configuration with at grade roof structures to allow for continued use of the existing site infrastructure. Odour control works would be similar to those described previously for the Macaulay / McLoughling WWTF.

The facility would be constructed in a single initial stage.

Juan de Fuca WWTF

The Juan de Fuca WWTF will also be a liquid-only facility that uses the same treatment technologies as described for the other facilities. This facility has the largest treatment capacity of any WWTF in Option 2. The Year 2065 primary and secondary treatment capacities are both 2.0 x ADWF or 112 ML/d. This approach, where all wastewater receives secondary treatment, was adopted given the more sensitive nature of the effluent receiving environment at Esquimalt Harbour. Wet-weather flows in excess of 112 ML/d continue down the collection system to the Macaulay / McLoughlin site for treatment.

Effluent requiring disposal will be pumped to a new outfall extending into Esquimalt Harbour. The embayed nature of the discharge location requires the effluent to be disinfected, accomplished using ultra violet irradiation.

This facility will be located near existing sport facilities. The technologies selected provide a compact facility footprint. Surface structures will be attractively designed buildings and will have added architectural features to enhance the existing recreational amenities. The majority of the liquid-treatment tankage will be constructed below grade; the top of the tankage will be level with or just above ground level. The top of the primary clarifiers and bioreactors will be covered flush with the top of the tankage, with access hatches at appropriate locations. The MBR membrane tanks will also finish at grade and the tanks will be enclosed in a single story building.

Odour control works would be similar to those described previously for other facilities.

The facility would be constructed in two stages, with the second stage in about Year 2030.

Clover Point Wet-Weather Treatment Facility

The Option 2 facility is identical to that in Option 1.

3.0 WET-WEATHER FLOW MANAGEMENT

The wet-weather flow management approach is identical to Option 1.

4.0 BIOSOLIDS MANAGEMENT AND RESOURCE RECOVERY

The biosolids management approach is identical to Option 1.

5.0 CONVEYANCE SYSTEM MODIFICATIONS

Option 2 would require the same conveyance system modifications as described previously for Option 1, but would include diverting the 2.0 x ADWF flow from the Marigold pump station to the Juan de Fuca WWTF. Diverting wastewater flows to the South Colwood WWTF would still be required, but the works

would be smaller given the overall flow reduction in Option 2.

Table 2-3. Option 3 Description

OPTION 3 **Resource Recovery on a Local Scale**
1.0 DESCRIPTON
Option 3 provides the most distributed approach to wastewater management of all three Options and, as a result, involves the most wastewater treatment facilities. The extent of facility distribution was based on an extensive analysis of approximately forty potential energy recovery opportunity areas (EROAs) located throughout the Core Area. Option 3 employs a total of ten WWTFs to provide secondary treatment. The additional facilities, relative to Option 2, include ones located in the Windsor Park, Westhills, Florence Lake, Lang Cove and Roderick areas. Like the other facilities described in other Options, the Windsor Park WWTF will use a split-and-blend approach to provide secondary treatment performance under all dry-weather and the majority of wet-weather flow conditions. Alternately, because of effluent discharge to more sensitive water bodies or for wet-weather flow management reasons, the other WWTFs provide secondary treatment for all wastewater flows entering the facility. In addition, the Roderick WWTF has phosphorus removal capability, again in consideration of the receiving water conditions. Relative to Option 2, the addition of more WWTFs further and significantly reduces the dry-weather flows reaching the Macaulay/McLoughlin WWTF. However, a comparable amount of wet-weather flow will still require treatment at the facility. Option 3 differs notably from Options 1 and 2 with respect to water reclamation and reuse. First, reclaimed water from the Westhills and Florence Lake WWTFs will be pumped to the existing Humpback Reservoir for use in a non-potable water system. This water could be used for landscape irrigation and toilet flushing purposes. Returning all of the excess effluent to local creeks is not practical given the extremely low dilution ratios and the effluent-dominated nature of stream flow in this scenario. In addition, effluent discharge to these creeks during some wet-weather periods could cause undesirable hydraulic impacts. Therefore, surplus effluent will be returned to the ocean via the South Colwood WWTF outfall. In addition, Option 3 includes more aggressive water conservation measures beyond those assumed to exist in Options 1 and 2. Specifically, Option 3 envisions the use of household- and development-level "internal recycling systems" (IRS) that would collect bathtub and shower water, provide suitable treatment, and recycle the water for toilet flushing. As a result, IRS use off-sets potable water consumption and wastewater generation. Similar to the other Options, Option 3 provides the opportunity to use effluent from the WWTFs for landscape irrigation. However, the use of IRS systems reduces the opportunity for using WWTF effluent for toilet flushing purposes. Similar to Options 1 and 2, effluent from the Option 3 WWTFs would be suitable for use as a heat source in adjacent district energy systems. In addition, to fully utilize the heat available, a third-party could extract heat directly from raw wastewater in a location near the Royal Jubilee Hospital. Option 3 uses the same wet-weather flow management approach as Option 1, including a comparably sized Clover Point wet-weather flow treatment facility. The Option 3 facility is slightly smaller due to the reduction in ADWF provided by IRS use. The other area where Option 3 departs from the other Options is in solids processing operations. The Macaulay/McLoughlin WWTF provides solids processing per Option 2, but at a reduced scale since it receives external solids generated only by the Windsor Park, Lang Cove and Roderick facilities. Solids produced by the Saanich East, South Colwood, Westhills, Florence Lake and Juan de Fuca WWTFs will be thickened and truck-hauled to a dedicated organics processing facility located near Royal Roads

University. The Royal Roads organics facility will use the same solids processing and resource recovery systems as those used at the Macaulay/McLoughlin WWTF and described elsewhere. Option 3 utilizes the same biosolids management strategy as that of Options 1 and 2.

2.0 WASTEWATER TREATMENT AND RESOURCE RECOVERY

Macaulay/McLoughlin Point WWTF

The Option 3 facility is smaller than the Option 2 facility from a dry-weather treatment perspective. However, in Option 3 the wet-weather flow rate requiring treatment increases because the reduced primary treatment ADWF capacity "multipliers" at upstream facilities means conveying a greater portion of the wet-weather flow downstream to Macaulay/McLoughlin.

Primary treatment, with CEPT capability, would be provided for up to 4.0 x ADWF or 48 ML/d. Secondary treatment capacity would be provided for up to 1.5 x ADWF or 18 ML/d. Wastewater flow rates in excess 4.0 x ADWF and up to an additional 185 ML/d would be directed to a dedicated wet-weather treatment facility using the same process technology (i.e. high-rate CEPT) as that of the Clover Point Facility. Flows in excess of about 235 ML/d would bypass primary treatment and receive screening. All flows would be blended prior to discharge.

The Option 3 facility also uses a SHARON-ANAMMOX system for solids processing recycle stream treatment, as described for the Option 2 facility.

The facility would be constructed in a single, initial stage.

South Colwood WWTF

The Option 3 South Colwood WWTF is slightly smaller than the Option 2 facility, owing to the reduced flow rates from use of IRS in Option 3. The primary and secondary treatment capacities would be 24 ML/d (3.0 x ADWF) and 12 ML/d (1.5 x ADWF) for Year 2065, respectively.

Solids generated will be truck-hauled to the Royal Roads Organics Facility for processing, following centrifuge thickening to reduce the volume and trucking requirements.

The facility would be constructed in three stages, with the latter two stages constructed in around Year 2030 and 2045.

Saanich East WWTF

The Option 2 facility is comparable to those of Options 1 and 2, but slightly smaller because of the IRS impacts on wastewater flow rates. The primary and secondary treatment capacities would be 61 ML/d (4.0 x ADWF) and 23 ML/d (1.5 x ADWF) for Year 2065, respectively.

Solids generated would be centrifuge thickened and truck-hauled to the Royal Roads Organics Facility for processing.

Ogden Point WWTF

The Option 3 facility serves a substantially smaller population (i.e. 2/3 in Year 2065) relative to the Option 2 WWTF. This artifact, combined with Option 3 IRS use, reduces the primary and secondary treatment sizes. The primary and secondary treatment capacities would be 40 ML/d (2.0 x ADWF) and

30 ML/d (1.5 x ADWF) for Year 2065, respectively.

The facility would be constructed in a single, initial stage.

Juan de Fuca WWTF

This facility is substantially smaller in Option 3, relative to Option 2, since the service population is less than 1/3 the size. The Year 2065 primary and secondary treatment capacities are both 2.0 x ADWF or 27 ML/d. Wet-weather flows in excess of 27 ML/d will continue down the collection system to the Macaulay / McLoughlin site for treatment.

In this option the facility design and architecture would be as such to preserve the use of tennis courts and other recreational facilities above the process tankage. As a result, the majority of the liquid-treatment tankage will be a buried-enclosed configuration with just-below grade roof structures. Building structures will be blended into the surrounding architecture.

The facility would be constructed in two stages, the latter around Year 2030.

Windsor Park WWTF

The Windsor Park WWTF is a liquid-only treatment facility using the same process technologies used elsewhere. Wet-weather flows in excess of 2.0 x ADWF will continue down the collection system towards Clover Point. The facility will use a split-and-blend treatment approach where up to 2.0 x ADWF (24 ML/d, in Year 2065) receives primary treatment and 1.5 x ADWF (18 ML/d, in Year 2065) receives secondary treatment.

Effluent requiring disposal will be pumped to a new outfall extending into Juan de Fuca Strait. Given the high level of treatment and receiving environment, effluent disinfection is not required.

Similar infrastructure as that used at the other WWTFs would be provided to deliver effluent for heat recovery and reclaimed water reuse purposes.

Solids produced at the Windsor WWTF would be discharged to the collection system for transport to the Macaulay / McLoughlin WWTF for processing.

As Windsor Park is an residential area, building structures will be blended into the surrounding architecture. It is expected the majority of the liquid-treatment tankage will be a buried-enclosed configuration with just-below grade roof structures that will allow for continued use of the existing park on top of these structures.

Odour control works would be similar to those described previously for other facilities.

The facility would be constructed in a single, initial stage.

Westhills WWTF

The Westhills WWTF is also a liquid-only facility, again incorporating the same technologies used elsewhere. Both the Year 2065 primary and secondary treatment capacities are 2.0 x ADWF or 16 ML/d. Wet-weather flows in excess of 2.0 x ADWF will continue down the collection system towards Macaulay / McLoughlin Point.

UV disinfected effluent will be pumped to the Humpback Reservoir, for non-potable reuse, via a new forcemain that will be partially shared by the Florence Lake WWTF. During these periods chemical phosphorous removal will be used at the WWTF to limit the P loading to the reservoir. Surplus effluent will be pumped through a non-potable water distribution system with a connection point to the South Colwood WWTF outfall. Effluent disinfection would not be required in this latter scenario. A similar non-potable waster distribution system would also be used by the Florence Lake WWTF.

For heat recovery purposes, the pumped effluent could pass through the heat exchanger / heat pump of a third party DES prior to entering the gravity sewer.

Solids generated at the Westhills WWTF would be centrifuge-thickened and truck-hauled to the Royal Roads Organics Facility for processing.

This facility will be part of a future residential development. The facility design would be low profile and architecturally designed to fit with the surrounding neighborhood. The liquid-stream tankage for this facility will follow a similar profile to the other facilities where the top of the tankage is level with or just above ground level.

Odour control works would be similar to those described previously for other facilities.

The facility would be constructed in two stages, the latter in around Year 2030.

Florence Lake WWTF

All elements of the Westhills WWTF, effluent disposal, effluent reuse and heat recovery systems apply to the Florence Lake WWTF. The only notable difference between the facilities is their size, where the Florence Lake WWTF serves a population approximately ½ that of the Westhills WWTF. Both the Year 2065 primary and secondary treatment capacities are 2.0 x ADWF or 8 ML/d.

The facility would be constructed in three stages, the latter in around Year 2030 and 2045.

Lang Cove WWTF

The Lang Cove WWTF is also a liquid-only treatment facility using the same process technologies used elsewhere. Wet-weather flows in excess of 2.0 x ADWF will continue down the collection system towards Macaulay / McLoughlin Point. The Year 2065 primary and secondary treatment capacities are both 2.0 x ADWF or 16 ML/d. This approach, where all wastewater receives secondary treatment, was adopted given the more sensitive nature of the effluent receiving environment in Esquimalt Harbour.

Effluent requiring disposal will be pumped to a new outfall extending into Esquimalt Harbour Effluent disinfection will be required for this discharge location.

Similar infrastructure as that used at the other WWTFs would be provided to deliver effluent for heat recovery and reclaimed water reuse purposes.

Solids produced at the Lang Cove WWTF would be discharged to the collection system for transport to the Macaulay / McLoughlin WWTF for processing.

This facility will be located in a residential area. The facility design would be low profile and architecturally designed to fit with the surrounding neighborhood. The liquid-stream tankage for this facility will follow a similar profile to the other facilities where the top of the tankage is level with or just above ground level.

Odour control works would be similar to those described previously for other facilities.

The facility would be constructed in two stages, the second around Year 2030.

Roderick WWTF

The Roderick WWTF has the distinction of being the largest treatment facility in Option 3, reflecting the size of the service population. This facility is also a liquid-only facility and will be discharging to The Gorge waters. To preserve the water quality of this particularly sensitive body, the Roderick facility will provide secondary treatment to all wastewater entering the facility. In addition, phosphorus removal will be provided via enhanced biological phosphorus removal (EBPR). Both the Year 2065 primary and secondary treatment capacities are 2.0 x ADWF or 42 ML/d. Wet-weather flows in excess of 2.0 x ADWF will continue down the collection system towards Macaulay / McLoughlin Point.

Effluent requiring disposal will be pumped to a new outfall extending into The Gorge waters. Effluent disinfection will be required for this discharge location.

Similar infrastructure as that used at the other WWTFs would be provided to deliver effluent for heat recovery and reclaimed water reuse purposes.

Solids produced at the Roderick WWTF would be discharged to the collection system for transport to the Macaulay / McLoughlin WWTF for processing.

As Roderick is a light industrial use area, surface structures will be blended into the surrounding architecture. The liquid-stream tankage for this facility will follow a similar profile to the other facilities where the top of the tankage is level with or just above ground level.

Odour control works would be similar to those described previously for other facilities.

The facility would be constructed in a single, initial stage.

Clover Point Wet-Weather Treatment Facility

The Option 3 facility is identical to that in Option 1.

Royal Roads Organics Facility

This facility will be a stand-alone operation that processes truck-hauled sludges received from the aforementioned WWTFs. Like the Macaulay/McLoughling WWTF, the Royal Roads facility will include anaerobic digestion, dewatering, biogas upgrading to biomethane and phosphorus recovery. A SHARON-ANAMMOX system will treat the digester supernatant and dewatering recycle streams, with effluent from this system returned to the sewer system for eventual discharge to the ocean via the South Colwood WWTF outfall.

This facility will be located at an existing gravel pit within a wooded area. The surface structures will be architectural features to reflect the wooded surroundings and the digesters will be partially buried and partially above grade to ensure a low profile.

Odour control works would be similar to those described previously for other facilities.

The facility would be constructed in a single, initial stage.

3.0 WET-WEATHER FLOW MANAGEMENT

The wet-weather flow management approach is identical to Option 1.

4.0 BIOSOLIDS MANAGEMENT AND RESOURCE RECOVERY

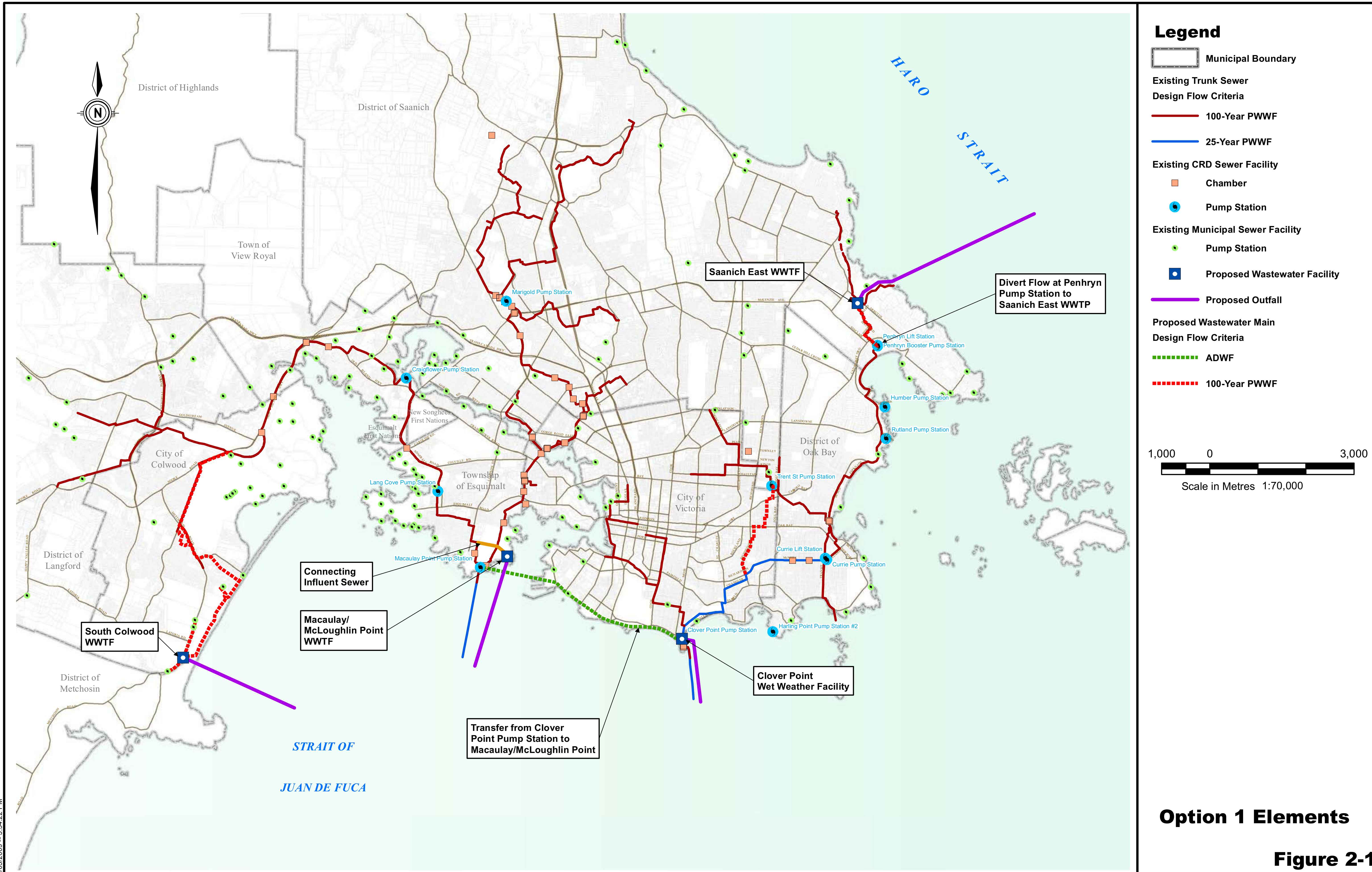
The biosolids management approach is identical to Option 1.

5.0 CONVEYANCE SYSTEM MODIFICATIONS

Option 3 would require the same conveyance system modifications as described previously for Option 1. Again, diverting wastewater flows to the South Colwood WWTF would still be required, but the works would be smaller given the overall flow reduction in Option 3.

In addition, the following works are required:

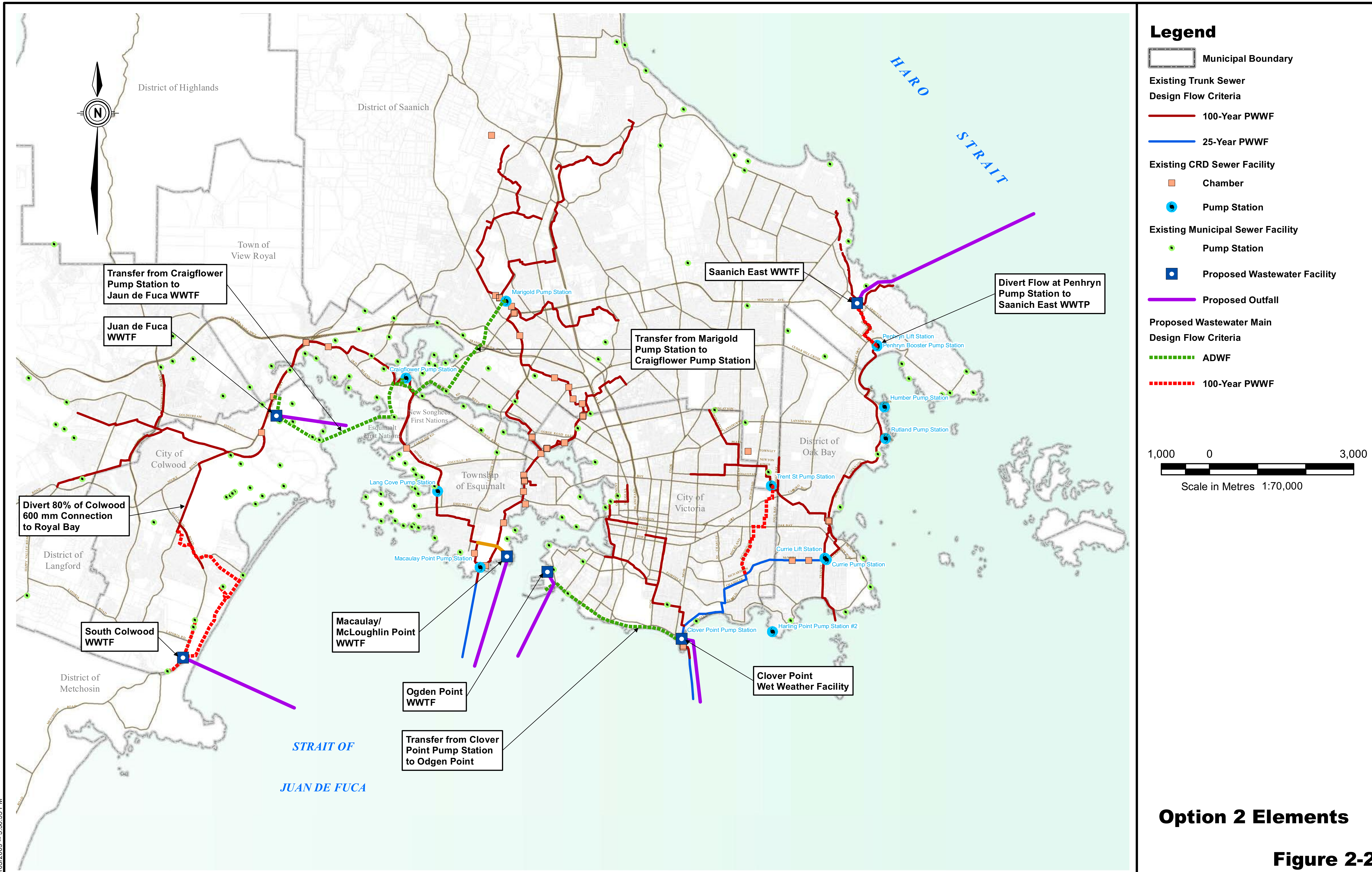
- 2 x ADWF Diversion X pump station and forcemain to Florence Lake
- 2 x ADWF Diversion Y pump station and forcemain to Westhills
- Craigflower pump station forcemain/siphon upgrade to Lang Cove



Option 1 Elements

Figure 2-1

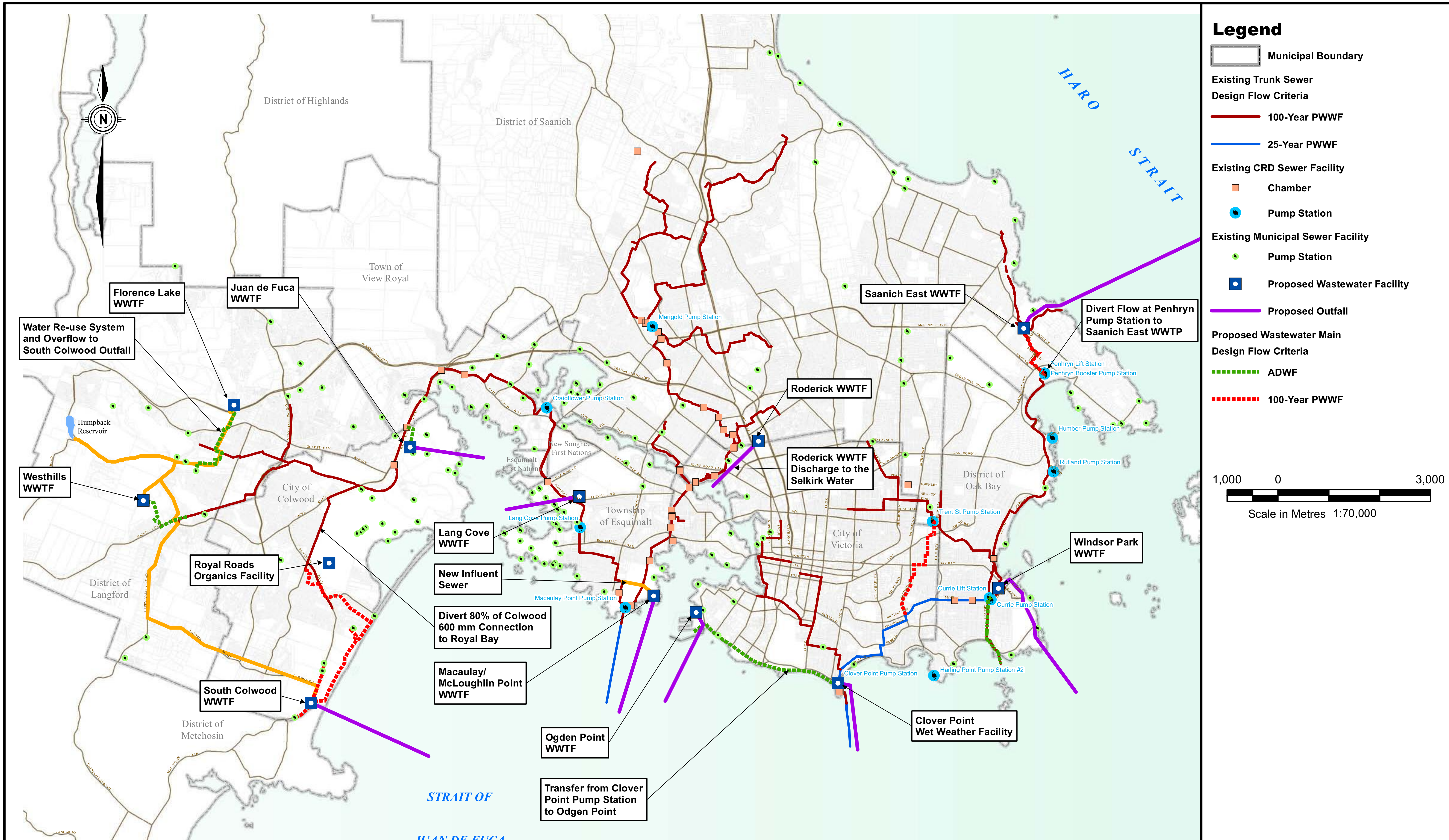
Map Document: (O:\0700-0799\764-014\430-GIS\MXD-Rp\036-DP-2\764014Fig2-1.mxd)
06/03/2009 -- 3:34:22 PM



Option 2 Elements

Figure 2-2

Map Document: (O:\0700-0799\764-014\430-GIS\MXD-Rp\036-DP-2\764014Fig2-2.mxd)
06/03/2009 -- 3:36:53 PM



Option 3 Elements

Figure 2-3

Map Document: (O:\0700-0799\764-014\430-GIS\MXD-Rp\036-DP-21764014Fig2-3.mxd)
06/03/2009 -- 3:41:12 PM

wastewater treatment facilities. Option 3 employs a total of ten WWTFs to provide secondary treatment. The additional facilities, relative to Option 2, include ones located in the Windsor Park, Westhills, Florence Lake, Lang Cove and Roderick areas.

3 Analysis Methodology

3.1 Overview

The analyses presented in this Discussion Paper include the carbon footprint analysis, the capital cost analysis, and the life cycle analysis. The findings of the carbon footprint and capital cost analyzes are incorporated into the life cycle analysis, which also includes operations and maintenance costs and potential revenues.

Sections 3.2, 3.3 and 3.4 provide information and key assumptions on the carbon footprint analysis, capital cost analysis, and life cycle analysis, respectively.

3.2 Carbon Footprint

The carbon footprint analysis (CFA) for each Option was conducted in accordance with the general methodology and rationale described in Discussion Paper 032-DP-1, to which the reader is directed for additional information. The CFA extended from Year 2015 to Year 2065, where the net greenhouse gas (GHG) emissions where calculated for each year in the analysis period and summed over this period. The GHG emissions are presented in units of carbon dioxide equivalents (i.e. t CO2e).

As noted in 032-DP-1, any CFA faces the challenge of establishing analysis boundaries and balancing complexity against the value of incremental information. The approach taken for the current analysis was to focus on understanding the major relative differences between the three Options while at the same time taking into account the key and reasonably defined commonalities between Options. As presented in Discussion Paper 032-DP-1, once the CRD selects a final strategy a more comprehensive CFA analysis will be conducted that more comprehensively approximates the total “absolute” carbon footprint for that strategy. In addition, the CFA included GHG off-sets as well as GHG sources. Thus the Option carbon footprints are presented in “net” terms that consider both emissions and off-sets.

Table 3-1 summarizes the various GHG sources and off-sets included in the CFA. The CFA worksheets contained in **Appendix B** document the assumptions used in the CFA, including GHG emission factors and related items. Specific biosolids management related assumptions are documented in Discussion Paper 031-DP-9.

Table 3-1. Greenhouse Gas Source and Off-Set Summary

GHG Sources
Scope 1 - Direct GHG Emissions
Diesel fuel consumed in transport of raw thickened sludges, dewatered biosolids, land application of biosolids and willow harvesting
Biogas lost from anaerobic digestion and biogas/biomethane systems
Scope 2 - Indirect GHG Emissions via Purchased Energy
Electricity consumed in wastewater conveyance, treatment, effluent pumping, and biosolids drying
Natural gas consumed for biosolids drying
Scope 3 - All Other Indirect Emissions
Embedded emissions in sludge thickening polymer (only for truck transport of thickened raw sludges)
GHG Off-Sets
Avoided natural gas / electricity use via wastewater-derived heat
Avoided natural gas use via biomethane
Avoided coal use via dried biosolids

3.3 Capital Costs

Each of the three Options involves a considerable amount of new infrastructure elements and modification of some existing elements. The approach taken to develop the capital costs was as follows:

- Develop a conceptual layout for each wastewater and wet-weather treatment facility, as well as solids processing and biosolids management facilities, required in each Option using an assumed site location and the technologies described in Section 2.4. The ultimate facility layouts reflect the Year 2065 scenario. Base construction costs in 2008 dollars were then prepared for the ultimate facility. Other direct and indirect costs, reflecting various allowances and contingencies, and land purchase costs were then added to the base construction cost.

  Beyond the base construction cost, the other direct costs included design contingency (10%) and construction contingency (15%) allowances. Indirect cost allowances included engineering (15%), administration (3%), miscellaneous costs (2%) and interim financing (4%). These additional factors result in a multiplier of 1.56 on the base construction costs.

- Determine the required upgrading of the linear conveyance systems (interceptor sewers, pumping stations, outfalls, etc.) required to accommodate the wastewater treatment and wet-weather flow strategy. Costs were then developed for this infrastructure in a manner similar to that described above.

- Determine the staging of the various works, based on the current and future service populations and wastewater flows. For the purpose of Option development, three stages were considered: Stage 1 (initial to Year 2030), Stage 2 (Year 2030 to 2045) and Stage 3 (Year 2045 to 2065).

The developed capital costs do not include all of the costs that will be incurred by the CRD over the next six decades. Items that are not included are local sewer costs incurred due to growth or replacement / rehabilitation of aging infrastructure, including programs for combined sewer separation or inflow/infiltration reduction.

In addition, the capital costs do not include most of the infrastructure needed for heat recovery or effluent reuse, as these costs would be borne by a third-party entity. Costs for the transport of effluent “across the street” for subsequent heat recovery by a third-party business entity are included in the estimates. In the case of the Macaulay / McLoughlin WWTF, a supply/return effluent pipeline across the harbour to Victoria is included in the WWTF cost estimates.

3.4 Life Cycle Analysis

Each of the Options was subjected to an economic life cycle analysis. The LCA included all capital expenditures, operations (e.g. labour, energy, chemicals, administration) and maintenance costs, revenue generated from saleable products, and costs of greenhouse gas (GHG) emissions incurred in each year during an analysis horizon that extended from Year 2015 to Year 2065, which was the end of the planning horizon. The costs of all future expenditures were brought back to a present value (i.e. Year 2008 dollars), with the total net present value (TNPV) being the summation of all these present values.

The LCA analysis details and assumptions are documented in the LCA worksheets contained in Appendix B. The following discussion describes several important items in more detail, primarily focused on revenue potential, to provide additional clarity on current assumptions. As noted in Section 1, future sensitivity analyses will examine the impact of key assumptions on the relative differences in Option TNPV.

Discount Rate

The life cycle and TNPV information presented in this Discussion Paper are from what is termed the “discount rate base scenario”. This scenario assumed a 4% discount rate.

Price of Saleable Products – Biomethane, Dried Biosolids, Woodchips, Recovered Phosphorous

These products all originate from wastewater solids processing and biosolids management activities, as discussed in Section 2.4. Since all are common to each of the three Options, the revenue potential for each Option for these products is the same.

Biomethane was priced as a natural gas-grade commodity using an assumed value of $10/GJ in 2008 dollars. This price was based on local natural gas prices while allowing room for a natural gas utility to mark-up the CRD’s “wholesale” selling price to a “retail” price.

Dried wastewater biosolids, to be used as a coal substitute fuel for cement kilns, were priced at $40/dry t in 2008 dollars. This value reflects the market rate for low-grade coal on an energy-equivalent basis.

Woodchips from the willow coppice program, which involves land application of biosolids, were priced at $100/dry t 2008 dollars based on the market rate for woodchips.

For reasons discussed in detail in Discussion Paper 031-DP-5, recovered phosphorus, in the form of magnesium-ammonium-phosphate or struvite, was assumed to be a revenue neutral commodity where its selling price off-sets the costs to operate the system.

Price of Saleable Products – Wastewater-Derived Heat
As discussed in Section 2.4, all three Options provide the potential for third-party energy utilities to use wastewater-derived heat in district energy systems (DES). In the assumed scenario, the CRD would be the whole-saler of this energy to the third-party utility, who would act as the retailer to the public. The third-party utility would be responsible for constructing, operating, maintaining and financing the DES.

The analysis assumes that the current energy market price (i.e. retail price) is $16.10/GJ in 2008 dollars. This value reflects the typical mix of natural gas and electricity consumed in the Core area and the current retail prices of these commodities. The analysis also assumes a 15% profit and overhead allowance for the third-party utility that would retail heat provided by CRD wastewater / effluent. Therefore, the *maximum* wholesale price the third-party utility would be willing to pay the CRD for the heat would be $14.00/GJ.

However, the *actual* wholesale price the third-party utility would be willing to pay the CRD for the heat will depend on the costs it incurred to build, operate, maintain and finance the DES that take the heat to the end users “doorstep”. For example, if this cost was $12.00/GJ, then the wholesale price the utility would be willing to pay the CRD would be $2.00/GJ.

For each WWTF in each of the Options, as well as the one raw wastewater heat recovery opportunity in Option 3, the LCA includes an assumed value for this actual wholesale price. These values were based on an analysis of the potential DES costs in each specific situation. Appendix D provides the background information on the DES costs.

Similarly, the amount of potentially saleable heat for each situation in each Option was estimated and is contained in the LCA sheets. The **Appendix D** material documents the derivation of these values.

Value of Reclaimed Water – Irrigation, Toilet Flushing
While included as a “revenue” source for the purposes of the analysis, reclaimed water used for large-scale, non-residential irrigation and toilet flushing is more a commodity of value to the CRD rather than a revenue source since the CRD is the provider of potable water in the Core Area. Reclaimed water used for these purposes was valued at 80% of the current CRD potable water consumption charge (i.e. average of $\$0.90/m^3$) or $\$0.72/m^3$ in 2008 dollars. The 80% factor reflects the discount used in some other jurisdictions, owing to public perception of the value of reclaimed water relative to potable water. This value does not include the cost of infrastructure needed to distribute the water for end use.

For each WWTF in each Option, the LCA sheets contain the assumed mean fraction of annual wastewater/effluent volume that could potentially be used for non-residential landscape irrigation. This assumed fraction was used to estimate the annual volume for re-use. The values were based on available CRD data for park and golf course irrigation and in consideration of the growth in future re-use opportunities in each Option. Appendix E contains the information used to develop the assumptions.

The annual volume of effluent that could be used for toilet flushing was based on an assumed turnover and retrofitting of existing properties and construction of new properties that provide the infrastructure to capitalize on this opportunity. The volumes for Option 1 and 2 were assumed identical to those for Option 3, where Option 3 uses internal recycling of bath/shower water to off-set potable water for toilet flushing (i.e. policy of aggressive water conservation; Table 2-3) rather than reclaimed water. Discussion Paper 033-DP-2 provides information on assumptions used to calculate the annual volumes. The LCA sheets contain the predicted annual volumes.

Finally, through internal recycling of wastewater, Option 3 also provides an off-set to potable water use. The value of this off-set was priced at the current CRD potable water consumption charge of $\$0.90/m^3$ in 2008 dollars.

Unit GHG Price

The CFA provides information on the net GHG emissions or carbon footprint for each Option. From an economic perspective, the LCA assumes that the CRD would claim the GHG credits for its saleable products that provide the following carbon off-sets:

- Avoided natural gas / electricity use via wastewater-derived heat
- Avoided natural gas use via biomethane
- Avoided coal use via dried biosolids

Based on the information contained in Discussion Paper 032-DP-1, the initial “price” of carbon (i.e. carbon dioxide equivalents, CO2e) was set at $15/t CO2e in 2008 dollars. Under the assumed 3% annual inflation rate used in the discount rate base scenario described previously, the carbon price is escalated to about $80/t CO2e in Year 2065. As noted in 032-DP-1, there is considerable uncertainty in the long-term price of carbon. However, the values used in this base scenario are consistent with mid-range values presented in 032-DP-1.

4 Results and Discussion

4.1 Carbon Footprint Analysis

Figure 4-1 illustrates the total carbon footprint, which is the sum of all emissions between Years 2015 and 2065, for each Option. Appendix B contains the detailed CFA results for each Option. The numerically negative values are an environmentally positive outcome, since they indicate that the GHG emissions are more than countered by the GHG off-sets achieved through the saleable products, given the analysis boundaries. Options 2 and 3 are distinctly more favourable from a GHG perspective than Option 1.

Option	Carbon Footprint (t CO2e)
Option 1	-483,000
Option 2	-2,350,000
Option 3	-2,870,000

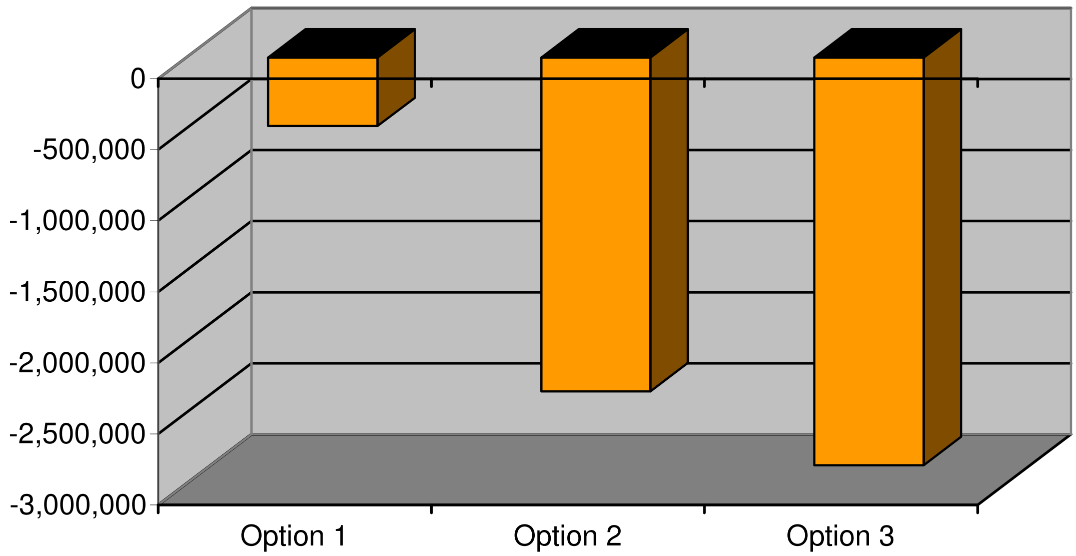


Figure 4-1. Total Carbon Footprint Summary (sum of all emissions between Year 2015 and 2065)

Figure 4-2 shows the same information broken down into the various GHG source and off-set categories. Clearly, recovering heat from wastewater / effluent, and off-setting natural gas and electricity use to provide heating, has a significant and positive impact on the carbon footprint. As will be discussed in Section 4.2, the amount of wastewater-derived heat assumed to be sold and thus utilized in Option 1 is substantially lower than that for Options 2 and 3, with Option 3 utilizing more heat than Option 2. This situation explains the majority of difference in carbon footprints between the Options.

Again, as discussed in Section 3.2, it is important to reiterate that the current CFA analysis focused on identifying differences between the Options rather than attempting to establish "absolute" values for each of the Options. As presented in Discussion Paper 032-DP-1, once the CRD selects a final strategy a more comprehensive CFA analysis will be conducted that more comprehensively approximates the total carbon footprint for that strategy.

4.2 Capital Cost and Life Cycle Analysis

Capital Costs

Figure 4-3 summarizes the total capital cost for each Option, in 2008 dollars, which includes all CRD elements constructed through Year 2065. Appendix C contains detailed capital cost tables that break down the capital costs for each of the Options.

Figure 4-4 summarizes the Stage 1 capital costs for each Option. Stage 1 reflects the elements constructed by 2017. In this figure the capital costs were escalated from 2008 dollars to the expected mid-point of construction using an inflation allowance of 2.0% per year. This value is slightly lower than the 2.5% value used previously in *The Path Forward* document to reflect the current and anticipated construction and economic conditions over the next few years. The Figure 4-4 values are directly comparable to the Stage 1 values presented in *The Path Forward* report.

The Figure 4-3 and 4-4 data show that as the number of wastewater treatment facilities increase the overall capital costs increase significantly. Escalated Stage 1 capital costs (Figure 4-3) range from approximately $1.2 billion for Option 1 with the fewest plants to $2.0 billion for Option 3 with the most plants. This difference is primarily due to the loss of scale – larger facilities are less expensive to build on a unit cost basis compared to smaller facilities. It is also due to the fact that many of the wastewater plants, regardless of size, are expensive to build due to the urban setting. They require more extensive structural work due to the need to keep the surface footprint as small as possible, as well as more extensive odour control and architectural treatment to fit into the surrounding land use.

Operations and Maintenance Costs, Revenues and Greenhouse Gas Costs

Figure 4-5 provides a snapshot for Year 2030 that shows annual operations and maintenance costs alongside revenues and greenhouse gas costs, all in 2008 dollars. The revenues are shown as negative values to differentiate them from costs. As can be seen from the graph, the potential annual revenue from resource recovery increases with the number of facilities, although the relative

Option	GHG Sources					GHG Off-Sets			Total
	Electricity (t CO2e)	Diesel Fuel (t CO2e)	Sludge Polymer (t CO2e)	Biogas Lost (t CO2e)	Natural Gas (t CO2e)	Avoided Natural Gas / Electricty via Wastewater-Derived Heat (t CO2e)	Avoided Natural Gas use via Biomethane (t CO2e)	Avoided Coal Use via Dried Biosolids (t CO2e)	(t CO2e)
Option 1	135,000	13,000	0	26,500	79,500	-358,000	-149,000	-229,000	-482,000
Option 2	142,000	14,400	310	26,500	79,500	-2,240,000	-149,000	-229,000	-2,360,000
Option 3	143,000	17,300	2,050	26,500	79,500	-2,760,000	-149,000	-229,000	-2,870,000

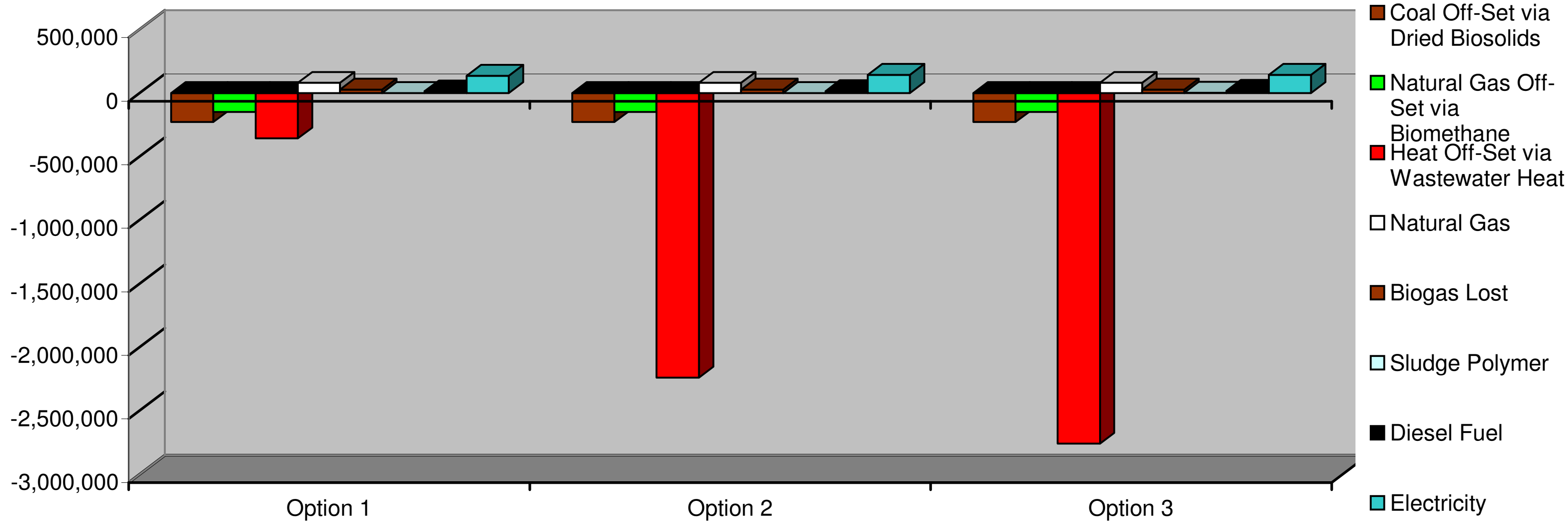


Figure 4-2. Total Carbon Footprint Breakdown (sum of all emissions between Year 2015 and 2065)

Option	Total Capital Cost
Option 1	$1,100,000,000
Option 2	$1,540,000,000
Option 3	$1,850,000,000

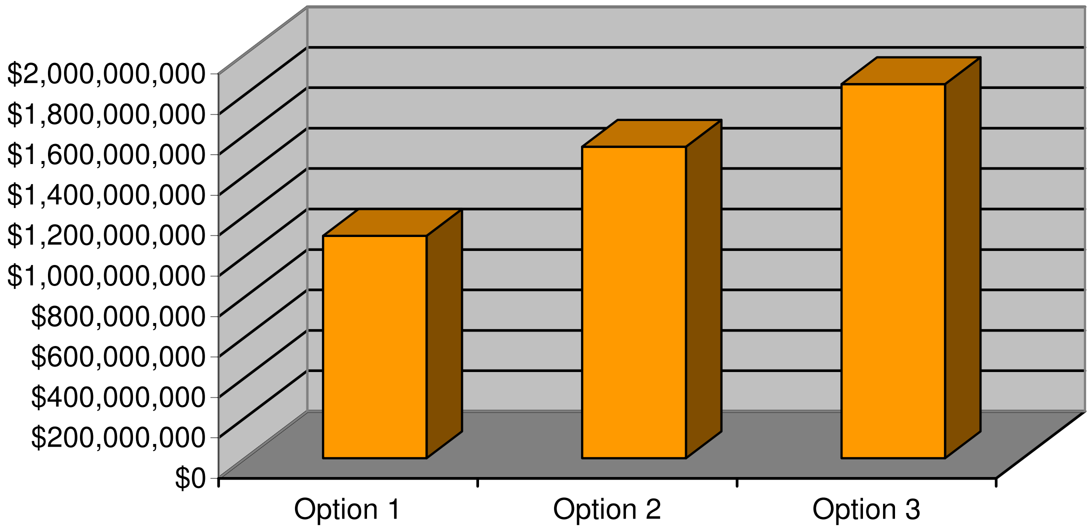


Figure 4-3. Total Capital Cost Summary (Year 2008 dollars)

Option	Stage 1 Capital Cost
Option 1	$1,170,000,000
Option 2	$1,630,000,000
Option 3	$1,990,000,000

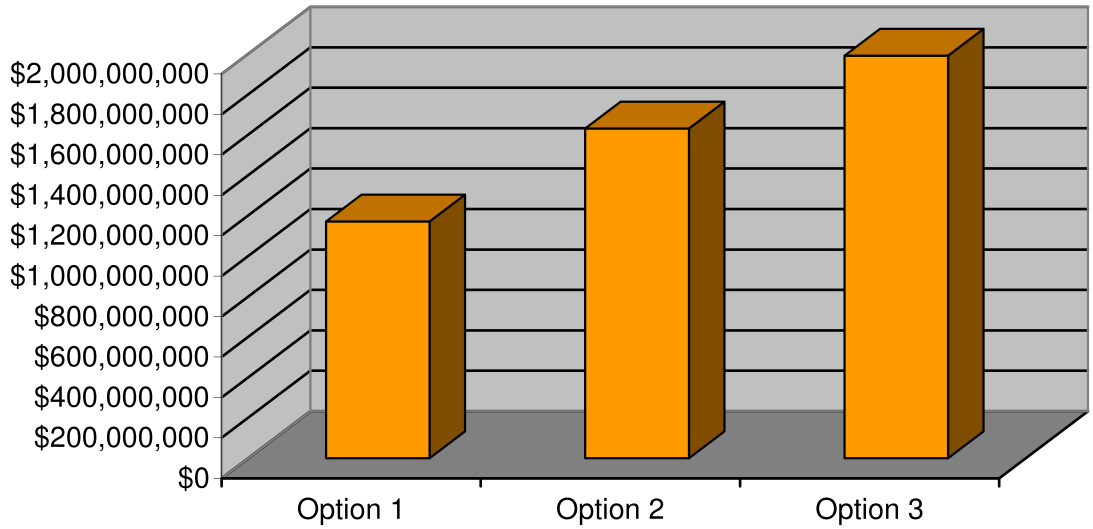


Figure 4-4. Stage 1 Capital Cost Summary (costs escalated to mid-point of construction)

Option	O&M Costs	Revenues	GHG Costs
Option 1	$23,500,000	-$3,600,000	-$125,000
Option 2	$29,000,000	-$7,300,000	-$674,000
Option 3	$33,400,000	-$8,300,000	-$741,000

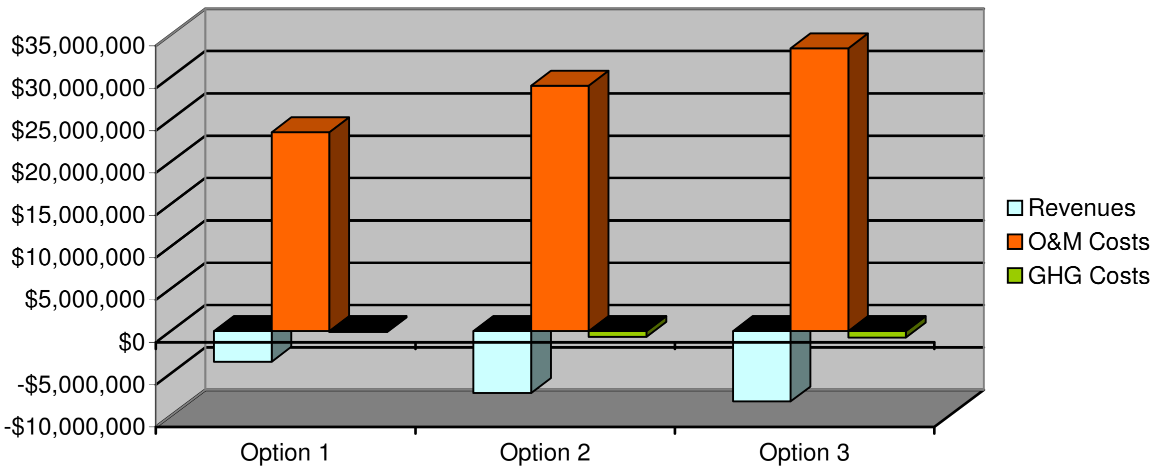


Figure 4-5. Year 2030 Operation and Maintenance Costs, Revenues and Greenhouse Gas Costs (Year 2008 dollars)

increase significantly slows with additional facilities. Annual (Year 2030) revenues are $3.6 million in Option 1; $7.3 million in Option 2 and $8.3 million in Option 3. The initial increase in revenue with the larger number of plants (Option 2) is primarily due to the improved proximity and economies of heat supply to the end user, as compared to fewer, larger plants. Option 3 continues to benefit from this factor, but the relative incremental gain is smaller. Further discussion on the revenue potential is provided later in the content of the net present value of future revenues.

The data show that the operations and maintenance costs in all Options are significantly larger than the potential revenues. Annual (Year 2030) operations and maintenance costs are $23.5 million in Option 1; $29.0 million in Option 2 and $33.4 million in Option 3. Like the capital costs, reduced economies-of-scale impact operations & maintenance costs and result in increased costs with additional infrastructure.

Finally, Options 2 and 3 benefit from additional greenhouse gas “credits” (i.e. numerically negative values), relative to Option 1, due to the off-setting effect of using additional wastewater-derived heat for heating purposes. As shown the figure, these credits are relatively small and range from a low of $125,000 in Option 1 to $670,000 on Option 2 and $740,000 in Option 3 for year 2030.

Total Net Present Value

As discussed in Section 3.4, the LCA included all capital expenditures, operations (e.g. labour, energy, chemicals, administration) and maintenance costs, revenue generated from saleable products, and costs of greenhouse gas (GHG) emissions incurred in each year during an analysis horizon that extended from Year 2015 to Year 2065, which was the end of the planning horizon. The costs of all future expenditures were brought back to a present value (i.e. Year 2008 dollars), with the total net present value (TNPV) being the summation of all these present values.

Figure 4-6 presents a total net present value (TNPV) summary for each of the Options. The TNPV data reflect the conclusions drawn for other data shown in previous figures – with an increasing number of facilities (Option 1 to Option 3) comes an increasing capital and operations and maintenance cost that far outweighs the present value of future revenues and GHG credits.

Finally**, Figure 4-7** provides a breakdown of the revenue NPV for each of the Options. Clearly, wastewater-derived heat is a potentially significant source of revenues, assuming the wholesale price that the CRD could sell this heat to a third-party energy utility is sufficiently high. By locating treatment facilities nearer to potential suitable users of this heat, Options 2 and 3 provided a marked advantage in revenue relative to Option 1.

Water used for toilet flushing purposes has significant value, either through reclaimed water use (Options 1 and 2) or off-setting potable water use (Option 3). Alternatively, water used for irrigation purposes has a relatively low value given the assumptions used in the analysis – primarily that reclaimed water would be used only for non-residential irrigation of parks and golf courses. Residential irrigation might be implemented in the future, but public acceptance of this practice and the costs to retrofit home systems could restrict its use. So too may changing attitudes about water

Option	GHG NPV	O & M NPV	Revenue NPV	Capital NPV	Total NPV
Option 1	-$1,900,000	$395,200,000	-$61,100,000	$842,300,000	$1,174,500,000
Option 2	-$10,100,000	$488,600,000	-$115,800,000	$1,175,000,000	$1,537,700,000
Option 3	-$27,800,000	$565,600,000	-$136,500,000	$1,264,900,000	$1,666,200,000

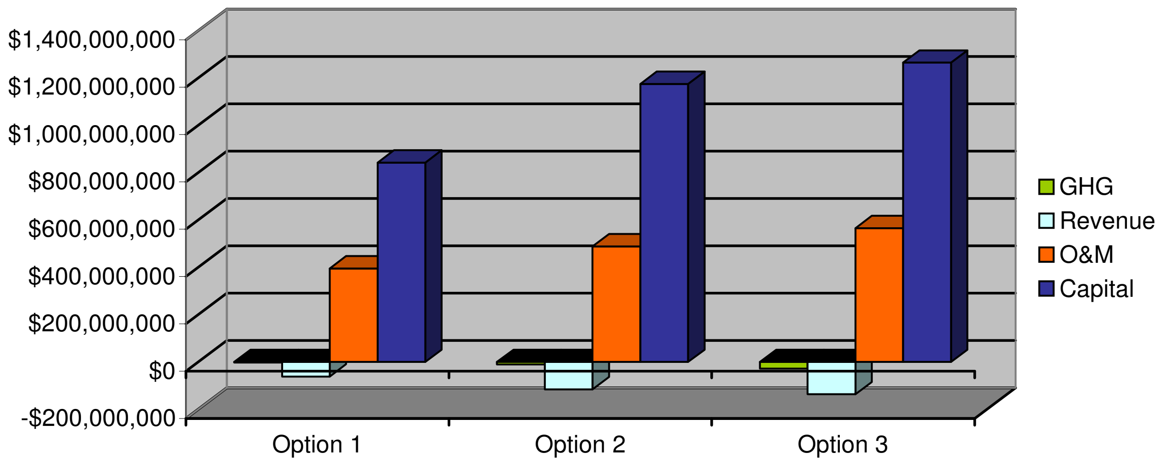


Figure 4-6. Total Net Present Value Summary (discount rate base scenario)

Option	Effluent / Wastewater Heat NPV	Water (Irrigation) NPV	Water (Toilet) NPV	Dried Sludges NPV	Biomethane NPV	Woodchips NPV	Total NPV
Option 1	-$13,200,000	-$2,500,000	-$30,100,000	-$1,300,000	-$8,000,000	-$6,000,000	-$61,100,000
Option 2	-$67,400,000	-$3,000,000	-$30,100,000	-$1,300,000	-$8,000,000	-$6,000,000	-$115,800,000
Option 3	-$80,200,000	-$3,400,000	-$37,700,000	-$1,300,000	-$8,000,000	-$6,000,000	-$136,600,000

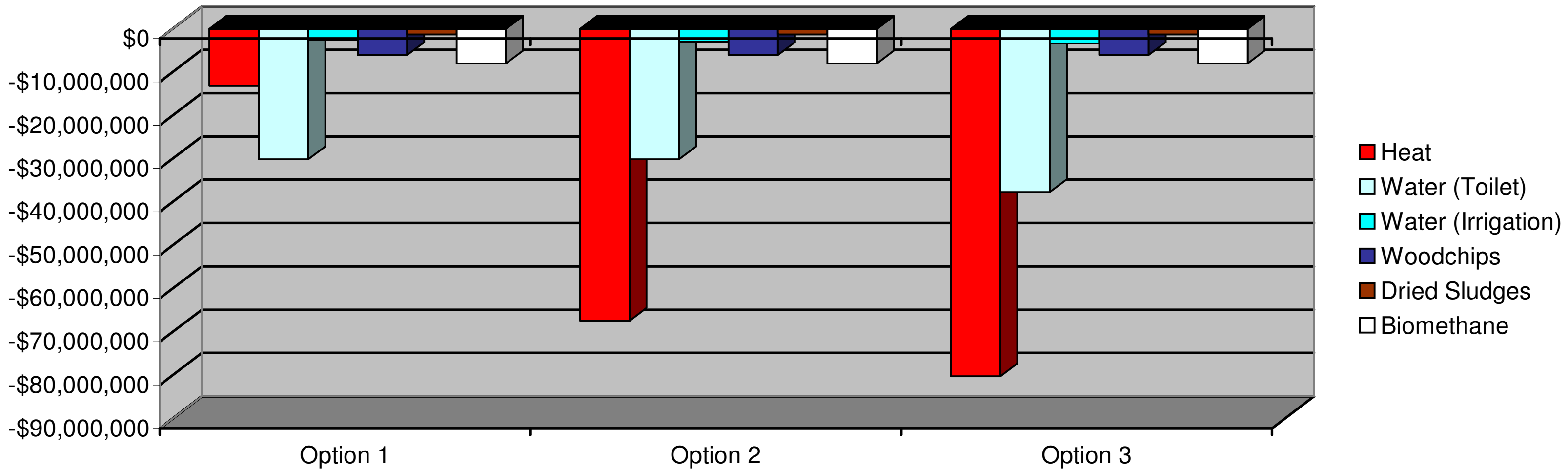


Figure 4-7. Revenue Net Present Value Breakdown (discount rate base scenario)

– just because more is available does not necessarily mean more would be used for decorative irrigation.

The revenues from biosolids-related products comprise about 10% (Option 3) to 25% (Option 1) of the Option revenue NPV. While these revenues are potentially much lower than that of heat, or the value of off-set potable water, in practice they may be realized more easily in the near-term and thus are an important part of the revenue stream.

5 Next Steps

Additional analyses will examine the sensitivity of various assumptions on the results presented in this Discussion Paper. These findings will be incorporated into an updated and re-issued 036-DP-02 document.

In addition, the CRD will be using the information generated in the Sustainability Assessment Framework (SAF), which will analyze the Options from a triple-bottom-line perspective that considers environmental, social and economic elements, to holistically understand the attributes of the Options. The SAF analysis will utilize information contained in the 036-DP-02 document. This SAF analysis will be provided in Discussion Paper 036-DP-03.

APPENDIX D - Heat Recovery Technical Memoranda

Technical Memo

KERR WOOD LEIDAL associates limited CONSULTING ENGINEERS

Capital Regional District
Core Area Wastewater Management Program
Distributed Wastewater Management Task 036

Estimation of Saleable Recovered Heat Energy for Distributed Treatment Options
February 10, 2009

Prepared For: Dean Shiskowski, Ph.D., PEng
Prepared By: Mike Homenuke, PEng

Objective

The Capital Regional District (CRD) is implementing a wastewater management strategy that will involve wastewater conveyance, treatment, reuse and disposal. Alternatives for wastewater treatment options and preliminary sizing of liquid and solids treatment facilities have been discussed in previous discussion papers. Potential locations for placement of new facilities have also been identified.

This technical memorandum is a supplement to Discussion Paper 036-DP-2. This document provides the methodology used to determine the amount of saleable recovered heat from wastewater.

Distributed Wastewater Management Scenarios

Three distributed wastewater management scenarios have been developed for 036-DP-2, and are described briefly as follows:

- **Option 1 – Regional Resource Recovery**: Liquid stream treatment and heat recovery at Macaulay/McLoughlin, East Saanich and Royal Bay;
- **Option 2 – Regional/Local Resource Recovery**: Liquid stream treatment and heat recovery at Macaulay/McLoughlin, Ogden Point, East Saanich, Juan de Fuca and Royal Bay; and
- **Option 3 – Local Resource Recovery**: Liquid stream treatment and heat recovery at Macaulay/McLoughlin, Ogden Point, East Saanich, Roderick, Westhills, Florence Lake, Juan de Fuca Lang Cove, and Royal Bay; heat recovery without treatment at Royal Jubilee.

Options 1 and 2 have assumed a gradual implementation of indoor water conservation such that base sanitary flow (BSF) rates reach 160 L/PE/d over time through usage of reduced-flow fixtures beginning in 2015. Option 3 includes an additional measure to ultimately reduce BSF to 130 L/cap/d by re-using bath water for toilet flushing beginning in 2020. Discussion Paper 036-DP-2 discusses the water conservation measures.

Table 1

Base Sanitary Flow Rates and Dry Weather Flow Design Temperature

Year	**Aggregate BSF Rate (L/PE/d)**		**Aggregate ADWF Temperature (ºC)**	
	Options 1& 2	Option 3	Options 1& 2	Option 3
2008	225	225	14.2	14.2
2015	223	223	14.8	14.8
2030	206	193	15.8	15.8
2045	195	173	16.4	16.5
2065	184	152	17.2	17.5

As shown in the above table, the temperature of wastewater under ADWF conditions is expected to increase over time. This is due to two factors: decreased dilution of sanitary flow with groundwater infiltration as BSF increases in both volume and proportion of flow; and reduced amounts of cold water being discharged to the sanitary sewer, primarily by replacing 12 L/flush toilets with 6 L/flush models.

Wastewater Treatment Facility Heat Supply Estimate

Heat supply is estimated according to the following equation:

$$HES\ [GJ/d] = ADWF\ [m^3/d] \times UHER_{ww}\ [GJ/ºC/m^3] \times (T_{inlet} - T_{outlet})\ [ºC]$$

where,

HES = Heat Energy Supply

$UHER_{ww}$ = Unit Heat Energy of Wastewater = 4,187 kJ/ºC/m^3

T_{inlet} = Influent (to heat exchanger) Wastewater Temperature

T_{outlet} = Outlet Wastewater Temperature (6ºC for treated effluent[1], 8ºC for raw wastewater)

As noted in Table 1, while the wastewater volume per capita is expected to decrease over time based on changes to in-home fixtures, the temperature of the wastewater is expected to increase as a result of the fixture changes. In locations where upstream populations will see minimal growth (Victoria, Saanich, Oak Bay), the decreasing wastewater flow roughly balances with the increased heat content of the wastewater. Areas seeing significant growth (Western Communities) will see increased heat supply over time.

---

1 Associated Engineering. Discussion Paper 031-DP-6, "Heat Recovery", July 2008.

Table 2 shows the calculation of wastewater heat supply at key analysis dates.

Option 3 has a slight reduction in overall heat supply compared with Options 1 & 2.

Wastewater Treatment Facility Heat Demand Estimate

Discussion Paper 036-DP-1 presented heat demands for the Energy Recovery Opportunities[2]. The annual demands are total space and water heating use within an Opportunity polygon, and have been used to estimate saleable heat.

Westlands Resource Group has provided KWL with estimates of potential adoption rates[3] at 2020 and 2065 for use of recovered heat energy with the following factors being considered:

- The eastern core customers will primarily consist of retrofits after wastewater treatment has been constructed, and therefore will have low connection rates in 2020;
- Some West Shore developments (Olympic View, Westhills expansion) will not be built out until the 2020-2065 period, so they have a substantial growth in adoption in 2065;
- Some areas (Spectrum School, Vic General Hospital) are "all or nothing" areas, with one major energy user;
- In large areas, even 15% or 20% represents substantial use of recovered energy;
- In Royal Bay, Olympic View, and Westhills, development is new and can be built to use recovered energy, so the 2065 values are high; and
- In areas with boilers, the replacement schedule will influence the adoption rate.

Table 3 shows the calculation of demands for recovered wastewater heat for each Opportunity at 2020 and 2065.

The proposed WWTFs have been paired with one or more Opportunities presented in Discussion Paper 036-DP-1. This provides the basis for determining the demand for recovered heat energy for each Option. The adoption rates have been applied to the annual demands to determine the demand for recovered heat. Table 4 shows the estimated heat demands at the proposed treatment plants at 2015, 2030, 2045 and 2065.

Saleable Heat Estimate

Saleable heat is determined as the lesser of either supplied or demanded heat for each year in the analysis. Heat supply and demand has been estimated at key years in the analysis (2015, 2020, 2030, 2045, 2065) and interpolated linearly between the key years.

---

[2] Kerr Wood Leidal Associates Ltd. Technical memorandum for Discussion Paper 036-DP-1 entitled "Utilization of Recovered Heat Energy from Municipal Wastewater".

[3] Personal Communication. Westlands Resource Group. October 15, 2008.

Tables 5-7 (attached) show the projected annual supply, demand and recovery of heat energy from wastewater for the Options.

In nearly all cases, the annual demand for recovered heat exceeds the supply by 2065. In some cases, low early adoption rates will result in reduced energy recovery in early years of the treatment program. It is likely seasonal demand fluctuations will reduce the amount of heat recovery during the summer months and exceed the amount of available heat in the winter months.

References

Associated Engineering. Discussion Paper 031-DP-6, "Heat Recovery", July 2008.

Kerr Wood Leidal Associates Ltd. Discussion Paper 036-DP-1, Appendix E, "Utilization of Recovered Heat from Municipal Wastewater". October 2008.

Personal Communication. Westlands Resource Group. October 15, 2008.

Table 2
Estimated Heat Energy Supply

Heat Parameters	
Unit Heat Content of Wastewater	4,187 kJ/m3/ºC
Treated Effluent Discharge Temperature	6 ºC
Raw Sewage Discharge Temperature	8 ºC

	ADWF (m^3/d)					Recovered Heat Supply (GJ/d)					
	2005	2015	2030	2045	2065	2005	2015	2020	2030	2045	2065
Design ADWF Wastewater Temperature (ºC)						14.2	14.8	15.2	15.8	16.4	17.2
Treated Effluent Heat Extraction Rate						34,400	37,000	38,300	40,900	43,700	47,000
Raw Sewage Heat Extraction Rate						26,000	28,600	30,000	32,500	35,300	38,600
Option 1 - Regional Resource Recovery											
Saanich East WWTF	15,816	16,125	16,605	17,624	17,179	544	597	624	679	770	807
Royal Bay WWTF	4,419	11,750	23,143	29,772	38,340	152	435	595	947	1,301	1,802
Macaulay Point WWTF	77,371	83,326	84,149	86,740	87,483	2,662	3,083	3,202	3,442	3,791	4,112
Total	*97,606*	*111,202*	*123,898*	*134,136*	*143,002*	*3,358*	*4,114*	*4,421*	*5,067*	*5,862*	*6,721*
Option 2 - Regional/Local Resource Recovery											
Saanich East WWTF	15,816	16,125	16,605	17,624	17,179	544	597	624	679	770	807
Ogden Point WWTF	36,598	38,561	37,792	38,137	37,051	1,259	1,427	1,467	1,546	1,667	1,741
Royal Bay WWTF	722	1,582	4,577	7,382	9,842	25	59	99	187	323	463
Juan de Fuca WWTF	24,578	33,259	43,100	48,717	55,780	845	1,231	1,399	1,763	2,129	2,622
Macaulay/McLoughlin WWTF	19,891	21,675	21,824	22,276	23,149	684	802	832	893	973	1,088
Total	*97,606*	*111,202*	*123,898*	*134,136*	*143,002*	*3,358*	*4,114*	*4,421*	*5,067*	*5,862*	*6,721*

	ADWF (m^3/d)					Recovered Heat Supply (GJ/d)					
	2005	2015	2030	2045	2065	2005	2015	2020	2030	2045	2065
Design ADWF Wastewater Temperature (ºC)						14.2	14.8	15.2	15.8	16.5	17.5
Treated Effluent Heat Extraction Rate						34,400	37,000	38,300	40,900	44,100	48,100
Raw Sewage Heat Extraction Rate						26,000	28,600	30,000	32,600	35,700	39,700
Option 3 - Local Resource Recovery											
Saanich East WWTF	15,816	16,125	15,904	16,256	15,147	544	597	615	650	717	729
Royal Jubilee Heat Recovery Facility[1]	4,954	5,182	5,441	5,792	5,881	129	148	202	177	207	233
Windsor Park WWTF[2,3]	14,662	14,433	13,490	13,004	12,144	376	386	339	374	367	351
Ogden Point WWTF	21,937	24,128	22,506	21,884	20,089	755	893	903	921	965	966
Royal Bay WWTF	722	1,582	4,308	6,608	8,253	25	59	95	176	291	397
Westhills WWTF	647	2,410	7,009	7,260	7,829	22	89	151	287	320	377
Florence Lake WWTF	534	1,430	2,374	3,060	4,066	18	53	67	97	135	196
Juan de Fuca WWTF	3,239	7,802	9,429	10,979	13,573	111	289	320	386	484	653
Lang Cove WWTF	4,892	5,483	6,723	7,847	8,244	168	203	226	275	346	397
Roderick WWTF	23,221	24,604	23,405	22,819	20,791	799	910	927	957	1,006	1,000
Macaulay/McLaughlin WWTF	11,937	13,205	12,334	11,866	12,105	411	489	495	504	523	582
Total	*102,560*	*116,384*	*122,924*	*127,375*	*128,123*	*3,358*	*4,114*	*4,339*	*4,805*	*5,362*	*5,880*

Notes:

(1) Royal Jubilee Heat Recovery Facility assumes raw sewage heat extraction (8ºC outlet)

(2) Windsor Park heat recovery is based on total ADWF with treated effluent, less the amount extracted at Royal Jubilee

(3) Estimated inlet temperature to Windsor Park WWTF is 11.9ºC during normal DWF conditions.

Table 3
Summary of Estimated Demand for Recovered Heat

Opportunities No.	Name	Heating Season Average Energy Demand[1] (GJ/day)		Annual Average Heat Energy Demand (GJ/d)		Adoption Rate[2] for Usage of Recovered Heat (%)		Average Annual Demand for Recovered Heat Energy (GJ/d)	
		2020	2065	2020	2065	2020	2065	2020	2065
1	James Bay	4,198	5,390	1,679	2,156	15	30	252	647
2	Old Town	2,212	3,317	885	1,327	10	30	88	398
3	Downtown Victoria	11,944	16,722	4,778	6,689	15	45	717	3,010
4	Fairfield	2,798	3,946	1,119	1,579	15	25	168	395
5	Hillside	2,230	3,744	892	1,498	15	25	134	374
6	Shellbourne and MacKenzie	2,874	4,773	1,149	1,909	15	25	172	477
7	University of Victoria	7,541	7,860	3,017	3,144	10	30	302	943
8	Royal Oak	1,525	3,831	610	1,532	15	30	92	460
9	Lower Mackenzie	777	2,303	311	921	15	30	47	276
10	Douglas Corridor	6,950	13,901	2,780	5,560	15	35	417	1,946
11	Rock Bay/West Douglas	3,372	4,789	1,349	1,916	15	35	202	670
12	Esquimalt Harbour	2,119	2,733	848	1,093	15	35	127	383
13	Esquimalt Centre	2,166	3,161	866	1,264	15	35	130	442
14	Tillicum Mall	1,459	2,918	584	1,167	25	35	146	409
15	View Royal Town Centre	453	680	181	272	15	45	27	122
16	Colwood Corners	4,178	6,318	1,671	2,527	35	45	585	1,137
17	Royal Roads	2,377	3,507	951	1,403	35	45	333	631
18	Langford City Centre	7,688	12,814	3,075	5,126	25	35	769	1,794
19	Colwood Employment Centre	1,942	2,819	777	1,128	25	45	194	507
20	Royal Bay	3,863	5,311	1,545	2,125	35	45	541	956
21	Olympic View	463	1,847	185	739	45	55	83	406
22	Glen Lake Neighborhood Centre	489	733	195	293	25	35	49	103
23	Westhills Tower 1	588	882	235	353	20	55	47	194
24	Westhills Main	2,470	3,088	988	1,235	35	55	346	679
25	Westhills Tower 2	596	894	238	358	20	55	48	197
26	Bear Mountain Expansion 1	571	856	228	342	20	30	46	103
27	Bear Mountain Expansion 2	615	922	246	369	20	30	49	111
28	Bear Mountain Main	2,924	3,655	1,170	1,462	25	35	292	512
29	Langford North Millstream	491	736	196	295	25	35	49	103
30	Camosun College	5,105	6,381	2,042	2,552	-	-	-	-
31	Fort Street	2,074	2,904	830	1,162	15	30	124	348
32	DND West Esquimalt	231	277	92	111	10	35	9	39
33	Jubillee Hospital	719	1,429	288	571	20	35	58	200
34	Victoria General Hospital	239	328	95	131	25	35	24	46
35	Spectrum High School	430	507	172	203	35	35	60	71
36	Oak Bay Marina area	461	548	184	219	10	30	18	66
37	Oak Bay High School-Cadboro Bay Road	605	592	242	237	15	30	36	71
38	Queen Alexandra	485	732	194	293	20	45	39	132
39	Vanalman	1,659	2,073	664	829	10	35	66	290

Notes:
(1) Heating season average energy demand is based on use of heat pumps, not including electrical power input. This represents the demand using 100% recovered wastewater heat energy.
(2) Adoption rates provided by Westlands Resource Group. October 2008.

Table 4
Estimated Average Annual Heat Demand at WWTFs

Wastewater Treatment Facility	**Paired Opportunities**	**Average Annual Heat Demand at WWTF (GJ/d)**			
Option 1 - Regional Resource Recovery		**2015**	**2030**	**2045**	**2065**
Saanich East	7	100	444	515	943
Royal Bay	20	120	633	679	956
Macaulay Point	1, 3, 13	918	1,993	2,294	4,099
Total - Option 1		*1,138*	*3,070*	*3,489*	*5,998*
Option 2 - Regional/Local Resource Recovery		**2015**	**2030**	**2045**	**2065**
Saanich East	7	100	444	515	943
Ogden Point	1, 3	824	1,566	1,865	3,657
Royal Bay	20	120	633	679	956
Juan de Fuca	16, 17	238	1,107	1,201	1,769
Macaulay/McLoughlin	12, 13	172	383	446	825
Total - Option 2		*1,454*	*4,133*	*4,707*	*8,150*
Option 3 - Local Resource Recovery		**2015**	**2030**	**2045**	**2065**
Saanich East	7	100	444	515	943
Royal Jubilee Heat Recovery Facility	33	17	89	105	200
Windsor Park	36	134	159	165	196
Ogden Point	1, 3	824	1,566	1,865	3,657
Royal Bay	20	120	633	679	956
Westhills	23, 24	87	500	553	873
Florence Lake	18, 26	193	1,055	1,175	1,897
Juan de Fuca	16, 17	238	1,107	1,201	1,769
Lang Cove	13, 32	75	215	253	481
Roderick	10	156	757	927	1,946
Macaulay/McLaughlin	12, 13	172	383	446	825
Total - Option 3		*2,116*	*6,908*	*7,885*	*13,743*

Table 5
Annual Wastewater Heat Supply 2015-2065

Annual Supply GJ/year

Year	Option 1 Mac/McL	Option 1 Saanich East	Option 1 Royal Bay	Option 1 Total
2015	1,125,324	217,768	158,689	1,501,781
2016	1,134,050	219,776	171,143	1,524,969
2017	1,142,777	221,784	183,597	1,548,158
2018	1,151,504	223,792	196,050	1,571,346
2019	1,160,230	225,800	208,504	1,594,535
2020	1,168,957	227,808	220,958	1,617,723
2021	1,177,684	229,816	233,412	1,640,912
2022	1,186,410	231,824	245,866	1,664,100
2023	1,195,137	233,832	258,320	1,687,289
2024	1,203,863	235,840	270,774	1,710,477
2025	1,212,590	237,848	283,228	1,733,666
2026	1,221,317	239,856	295,682	1,756,855
2027	1,230,043	241,864	308,136	1,780,043
2028	1,238,770	243,872	320,590	1,803,232
2029	1,247,497	245,880	333,043	1,826,420
2030	1,256,223	247,888	345,497	1,849,609
2031	1,264,711	250,103	354,122	1,868,937
2032	1,273,199	252,318	362,747	1,888,265
2033	1,281,687	254,533	371,373	1,907,593
2034	1,290,175	256,748	379,998	1,926,922
2035	1,298,664	258,964	388,623	1,946,250
2036	1,307,152	261,179	397,248	1,965,578
2037	1,315,640	263,394	405,873	1,984,906
2038	1,324,128	265,609	414,498	2,004,234
2039	1,332,616	267,824	423,123	2,023,563
2040	1,341,104	270,039	431,748	2,042,891
2041	1,349,592	272,254	440,373	2,062,219
2042	1,358,080	274,469	448,998	2,081,547
2043	1,366,568	276,684	457,623	2,100,875
2044	1,375,056	278,899	466,248	2,120,204
2045	1,383,544	281,114	474,873	2,139,532
2046	1,389,405	281,794	484,016	2,155,215
2047	1,395,267	282,473	493,159	2,170,899
2048	1,401,128	283,153	502,301	2,186,582
2049	1,406,989	283,832	511,444	2,202,265
2050	1,412,850	284,512	520,587	2,217,949
2051	1,418,711	285,192	529,730	2,233,632
2052	1,424,572	285,871	538,872	2,249,315
2053	1,430,433	286,551	548,015	2,264,999
2054	1,436,294	287,230	557,158	2,280,682
2055	1,442,155	287,910	566,300	2,296,365
2056	1,448,016	288,589	575,443	2,312,049
2057	1,453,878	289,269	584,586	2,327,732
2058	1,459,739	289,948	593,728	2,343,415
2059	1,465,600	290,628	602,871	2,359,099
2060	1,471,461	291,307	612,014	2,374,782
2061	1,477,322	291,987	621,157	2,390,465
2062	1,483,183	292,666	630,299	2,406,149
2063	1,489,044	293,346	639,442	2,421,832
2064	1,494,905	294,025	648,585	2,437,515
2065	1,500,766	294,705	657,727	2,453,199
Total (GJ/year)	**67,816,011**	**13,474,369**	**21,668,390**	**102,958,770**

Year	Option 2 Mac/McL	Option 2 Saanich East	Option 2 Royal Bay	Option 2 JDF	Option 2 Ogden Point	Option 2 Total
2015	292,720	217,768	21,361	449,163	520,769	1,501,781
2016	294,925	219,776	24,492	462,113	523,663	1,524,969
2017	297,130	221,784	27,623	475,063	526,557	1,548,158
2018	299,336	223,792	30,754	488,014	529,450	1,571,346
2019	301,541	225,800	33,886	500,964	532,344	1,594,535
2020	303,746	227,808	37,017	513,914	535,238	1,617,723
2021	305,951	229,816	40,148	526,865	538,132	1,640,912
2022	308,157	231,824	43,279	539,815	541,026	1,664,100
2023	310,362	233,832	46,410	552,766	543,919	1,687,289
2024	312,567	235,840	49,541	565,716	546,813	1,710,477
2025	314,773	237,848	52,672	578,666	549,707	1,733,666
2026	316,978	239,856	55,803	591,617	552,601	1,756,855
2027	319,183	241,864	58,934	604,567	555,495	1,780,043
2028	321,389	243,872	62,065	617,517	558,388	1,803,232
2029	323,594	245,880	65,196	630,468	561,282	1,826,420
2030	325,799	247,888	68,327	643,418	564,176	1,849,609
2031	327,766	250,103	71,622	652,328	567,117	1,868,937
2032	329,734	252,318	74,917	661,237	570,059	1,888,265
2033	331,701	254,533	78,212	670,146	573,000	1,907,593
2034	333,669	256,748	81,507	679,056	575,942	1,926,922
2035	335,636	258,964	84,802	687,965	578,883	1,946,250
2036	337,603	261,179	88,097	696,875	581,824	1,965,578
2037	339,571	263,394	91,392	705,784	584,766	1,984,906
2038	341,538	265,609	94,687	714,694	587,707	2,004,234
2039	343,506	267,824	97,982	723,603	590,649	2,023,563
2040	345,473	270,039	101,276	732,513	593,590	2,042,891
2041	347,440	272,254	104,571	741,422	596,531	2,062,219
2042	349,408	274,469	107,866	750,331	599,473	2,081,547
2043	351,375	276,684	111,161	759,241	602,414	2,100,875
2044	353,342	278,899	114,456	768,150	605,356	2,120,204
2045	355,310	281,114	117,751	777,060	608,297	2,139,532
2046	357,400	281,794	120,306	786,053	609,663	2,155,215
2047	359,491	282,473	122,860	795,045	611,029	2,170,899
2048	361,582	283,153	125,415	804,038	612,395	2,186,582
2049	363,672	283,832	127,969	813,030	613,761	2,202,265
2050	365,763	284,512	130,524	822,023	615,127	2,217,949
2051	367,853	285,192	133,079	831,016	616,493	2,233,632
2052	369,944	285,871	135,633	840,008	617,859	2,249,315
2053	372,035	286,551	138,188	849,001	619,224	2,264,999
2054	374,125	287,230	140,742	857,994	620,590	2,280,682
2055	376,216	287,910	143,297	866,986	621,956	2,296,365
2056	378,307	288,589	145,852	875,979	623,322	2,312,049
2057	380,397	289,269	148,406	884,972	624,688	2,327,732
2058	382,488	289,948	150,961	893,964	626,054	2,343,415
2059	384,578	290,628	153,515	902,957	627,420	2,359,099
2060	386,669	291,307	156,070	911,950	628,786	2,374,782
2061	388,760	291,987	158,625	920,942	630,152	2,390,465
2062	390,850	292,666	161,179	929,935	631,518	2,406,149
2063	392,941	293,346	163,734	938,928	632,884	2,421,832
2064	395,032	294,025	166,289	947,920	634,250	2,437,515
2065	397,122	294,705	168,843	956,913	635,616	2,453,199
Total (GJ/year)	**17,616,449**	**13,474,369**	**5,029,296**	**36,890,704**	**29,947,952**	**102,958,770**

Year	Option 3 Mac/McL	Saanich East	Royal Bay	JDF	Ogden Point	Westhills	Florence Lake	Roderick	Windsor Park	Lang Cove	Royal Jubilee	Total
2015	178,328	217,768	21,361	105,359	325,848	32,552	19,308	332,283	140,822	74,052	54,098	1,501,781
2016	178,715	219,078	24,225	107,720	326,524	37,357	20,383	333,425	140,544	75,806	54,808	1,518,585
2017	179,101	220,389	27,088	110,080	327,199	42,163	21,458	334,566	140,266	77,561	55,518	1,535,389
2018	179,488	221,699	29,951	112,440	327,875	46,968	22,533	335,708	139,988	79,315	56,227	1,552,192
2019	179,874	223,010	32,815	114,800	328,551	51,773	23,608	336,849	139,710	81,070	56,937	1,568,996
2020	180,261	224,320	35,678	117,161	329,227	56,579	24,683	337,991	139,431	82,824	57,647	1,585,800
2021	180,647	225,630	38,541	119,521	329,902	61,384	25,758	339,132	139,153	84,578	58,356	1,602,604
2022	181,034	226,941	41,405	121,881	330,578	66,190	26,833	340,274	138,875	86,333	59,066	1,619,408
2023	181,420	228,251	44,268	124,241	331,254	70,995	27,908	341,415	138,597	88,087	59,776	1,636,212
2024	181,807	229,562	47,131	126,602	331,929	75,800	28,983	342,557	138,319	89,842	60,485	1,653,016
2025	182,193	230,872	49,995	128,962	332,605	80,606	30,058	343,698	138,040	91,596	61,195	1,669,820
2026	182,580	232,182	52,858	131,322	333,281	85,411	31,133	344,839	137,762	93,351	61,905	1,686,624
2027	182,966	233,493	55,721	133,682	333,956	90,217	32,208	345,981	137,484	95,105	62,614	1,703,428
2028	183,353	234,803	58,585	136,043	334,632	95,022	33,283	347,122	137,206	96,859	63,324	1,720,232
2029	183,739	236,114	61,448	138,403	335,308	99,828	34,358	348,264	136,928	98,614	64,034	1,737,036
2030	184,126	237,424	64,311	140,763	335,983	104,633	35,433	349,405	136,649	100,368	64,743	1,753,840
2031	184,584	239,040	67,114	143,160	337,069	105,448	36,355	350,599	136,462	102,098	65,459	1,767,388
2032	185,042	240,656	69,918	145,557	338,154	106,264	37,276	351,793	136,275	103,828	66,174	1,780,936
2033	185,499	242,272	72,721	147,954	339,239	107,079	38,198	352,987	136,088	105,557	66,889	1,794,484
2034	185,957	243,889	75,524	150,351	340,325	107,895	39,120	354,180	135,901	107,287	67,604	1,808,032
2035	186,415	245,505	78,327	152,748	341,410	108,710	40,041	355,374	135,714	109,017	68,320	1,821,581
2036	186,873	247,121	81,130	155,145	342,496	109,526	40,963	356,568	135,526	110,747	69,035	1,835,129
2037	187,331	248,737	83,933	157,542	343,581	110,341	41,884	357,761	135,339	112,476	69,750	1,848,677
2038	187,789	250,353	86,737	159,938	344,666	111,157	42,806	358,955	135,152	114,206	70,466	1,862,225
2039	188,247	251,969	89,540	162,335	345,752	111,972	43,728	360,149	134,965	115,936	71,181	1,875,773
2040	188,705	253,585	92,343	164,732	346,837	112,788	44,649	361,343	134,778	117,665	71,896	1,889,321
2041	189,163	255,201	95,146	167,129	347,922	113,603	45,571	362,536	134,591	119,395	72,611	1,902,869
2042	189,621	256,817	97,949	169,526	349,008	114,419	46,492	363,730	134,403	121,125	73,327	1,916,417
2043	190,079	258,433	100,752	171,923	350,093	115,234	47,414	364,924	134,216	122,855	74,042	1,929,965
2044	190,536	260,050	103,555	174,320	351,178	116,049	48,336	366,118	134,029	124,584	74,757	1,943,513
2045	190,994	261,666	106,359	176,717	352,264	116,865	49,257	367,311	133,842	126,314	75,473	1,957,062
2046	192,071	261,879	108,286	179,796	352,285	117,894	50,364	367,196	133,549	127,235	75,960	1,966,515
2047	193,147	262,093	110,213	182,874	352,306	118,923	51,470	367,082	133,256	128,157	76,448	1,975,969
2048	194,223	262,306	112,140	185,953	352,327	119,953	52,577	366,967	132,964	129,078	76,935	1,985,423
2049	195,300	262,520	114,067	189,032	352,348	120,982	53,683	366,852	132,671	130,000	77,423	1,994,877
2050	196,376	262,733	115,994	192,111	352,369	122,011	54,790	366,737	132,378	130,921	77,910	2,004,331
2051	197,452	262,947	117,921	195,189	352,390	123,040	55,896	366,623	132,085	131,843	78,398	2,013,784
2052	198,528	263,160	119,848	198,268	352,411	124,070	57,003	366,508	131,792	132,764	78,886	2,023,238
2053	199,605	263,374	121,775	201,347	352,432	125,099	58,109	366,393	131,499	133,686	79,373	2,032,692
2054	200,681	263,587	123,702	204,426	352,453	126,128	59,216	366,278	131,207	134,607	79,861	2,042,146
2055	201,757	263,801	125,629	207,504	352,475	127,158	60,322	366,164	130,914	135,528	80,348	2,051,600
2056	202,834	264,014	127,556	210,583	352,496	128,187	61,429	366,049	130,621	136,450	80,836	2,061,054
2057	203,910	264,228	129,483	213,662	352,517	129,216	62,535	365,934	130,328	137,371	81,323	2,070,507
2058	204,986	264,441	131,410	216,740	352,538	130,245	63,642	365,819	130,035	138,293	81,811	2,079,961
2059	206,062	264,655	133,337	219,819	352,559	131,275	64,748	365,704	129,743	139,214	82,299	2,089,415
2060	207,139	264,868	135,265	222,898	352,580	132,304	65,855	365,590	129,450	140,136	82,786	2,098,869
2061	208,215	265,082	137,192	225,977	352,601	133,333	66,961	365,475	129,157	141,057	83,274	2,108,323
2062	209,291	265,295	139,119	229,055	352,622	134,362	68,068	365,360	128,864	141,978	83,761	2,117,776
2063	210,368	265,509	141,046	232,134	352,643	135,392	69,174	365,245	128,571	142,900	84,249	2,127,230
2064	211,444	265,722	142,973	235,213	352,664	136,421	70,281	365,131	128,278	143,821	84,736	2,136,684
2065	212,520	265,936	144,900	238,291	352,685	137,450	71,387	365,016	127,986	144,743	85,224	2,146,138
Total (GJ/year)	**9,762,377**	**12,674,981**	**4,518,283**	**8,548,928**	**17,514,348**	**5,318,271**	**2,297,526**	**18,159,960**	**6,862,403**	**5,828,234**	**3,619,559**	**95,104,871**

KERR WOOD LEIDAL ASSOCIATES LTD.
C:\Projects\764.014\[DES_SaleableHeatEnergy.xls]Supply

Table 6
Annual Wastewater Heat Demand 2015-2065

Annual Demand (GJ/year)

	Option 1			
	Mac/McL	Saanich East	Royal Bay	Total
2015	334,921	36,488	43,861	415,269
2016	361,090	44,864	56,341	462,295
2017	387,260	53,241	68,821	509,321
2018	413,430	61,617	81,301	556,348
2019	439,599	69,994	93,781	603,374
2020	465,769	78,371	106,260	650,400
2021	491,938	86,747	118,740	697,426
2022	518,108	95,124	131,220	744,452
2023	544,278	103,500	143,700	791,478
2024	570,447	111,877	156,180	838,504
2025	596,617	120,253	168,660	885,530
2026	622,786	128,630	181,140	932,556
2027	648,956	137,007	193,620	979,582
2028	675,125	145,383	206,100	1,026,608
2029	701,295	153,760	218,580	1,073,635
2030	727,465	162,136	231,060	1,120,661
2031	734,786	163,871	232,183	1,130,839
2032	742,108	165,605	233,305	1,141,018
2033	749,429	167,339	234,428	1,151,197
2034	756,751	169,074	235,551	1,161,376
2035	764,072	170,808	236,674	1,171,555
2036	771,394	172,543	237,797	1,181,733
2037	778,715	174,277	238,920	1,191,912
2038	786,037	176,011	240,043	1,202,091
2039	793,359	177,746	241,165	1,212,270
2040	800,680	179,480	242,288	1,222,449
2041	808,002	181,215	243,411	1,232,627
2042	815,323	182,949	244,534	1,242,806
2043	822,645	184,683	245,657	1,252,985
2044	829,966	186,418	246,780	1,263,164
2045	837,288	188,152	247,903	1,273,343
2046	870,235	195,957	252,956	1,319,147
2047	903,182	203,762	258,008	1,364,952
2048	936,129	211,566	263,061	1,410,756
2049	969,076	219,371	268,114	1,456,561
2050	1,002,022	227,176	273,167	1,502,365
2051	1,034,969	234,981	278,220	1,548,170
2052	1,067,916	242,785	283,273	1,593,975
2053	1,100,863	250,590	288,326	1,639,779
2054	1,133,810	258,395	293,379	1,685,584
2055	1,166,757	266,200	298,431	1,731,388
2056	1,199,704	274,004	303,484	1,777,193
2057	1,232,651	281,809	308,537	1,822,997
2058	1,265,598	289,614	313,590	1,868,802
2059	1,298,545	297,419	318,643	1,914,607
2060	1,331,492	305,224	323,696	1,960,411
2061	1,364,439	313,028	328,749	2,006,216
2062	1,397,386	320,833	333,802	2,052,020
2063	1,430,333	328,638	338,854	2,097,825
2064	1,463,280	336,443	343,907	2,143,629
2065	1,496,227	344,247	348,960	2,189,434
Total	**43,954,251**	**9,631,204**	**11,819,162**	**65,404,616**

	Option 2					
	Mac/McL	Saanich East	Royal Bay	JDF	Ogden Point	Total
2015	62,838	36,488	43,861	86,833	300,632	530,652
2016	67,976	44,864	56,341	107,976	318,694	595,851
2017	73,114	53,241	68,821	129,119	336,756	661,050
2018	78,251	61,617	81,301	150,262	354,818	726,249
2019	83,389	69,994	93,781	171,405	372,880	791,449
2020	88,527	78,371	106,260	192,548	390,942	856,648
2021	93,665	86,747	118,740	213,691	409,004	921,847
2022	98,803	95,124	131,220	234,834	427,066	987,046
2023	103,940	103,500	143,700	255,977	445,128	1,052,246
2024	109,078	111,877	156,180	277,120	463,190	1,117,445
2025	114,216	120,253	168,660	298,263	481,252	1,182,644
2026	119,354	128,630	181,140	319,405	499,314	1,247,844
2027	124,492	137,007	193,620	340,548	517,376	1,313,043
2028	129,629	145,383	206,100	361,691	535,438	1,378,242
2029	134,767	153,760	218,580	382,834	553,500	1,443,441
2030	139,905	162,136	231,060	403,977	571,562	1,508,641
2031	141,441	163,871	232,183	406,278	578,831	1,522,602
2032	142,976	165,605	233,305	408,579	586,099	1,536,564
2033	144,512	167,339	234,428	410,879	593,367	1,550,526
2034	146,048	169,074	235,551	413,180	600,635	1,564,488
2035	147,583	170,808	236,674	415,481	607,903	1,578,449
2036	149,119	172,543	237,797	417,781	615,172	1,592,411
2037	150,654	174,277	238,920	420,082	622,440	1,606,373
2038	152,190	176,011	240,043	422,383	629,708	1,620,335
2039	153,726	177,746	241,165	424,683	636,976	1,634,296
2040	155,261	179,480	242,288	426,984	644,244	1,648,258
2041	156,797	181,215	243,411	429,285	651,512	1,662,220
2042	158,333	182,949	244,534	431,586	658,781	1,676,182
2043	159,868	184,683	245,657	433,886	666,049	1,690,144
2044	161,404	186,418	246,780	436,187	673,317	1,704,105
2045	162,940	188,152	247,903	438,488	680,585	1,718,067
2046	169,850	195,957	252,956	448,841	713,292	1,780,895
2047	176,760	203,762	258,008	459,194	745,999	1,843,723
2048	183,671	211,566	263,061	469,547	778,705	1,906,551
2049	190,581	219,371	268,114	479,900	811,412	1,969,379
2050	197,491	227,176	273,167	490,254	844,119	2,032,207
2051	204,402	234,981	278,220	500,607	876,826	2,095,035
2052	211,312	242,785	283,273	510,960	909,533	2,157,863
2053	218,222	250,590	288,326	521,313	942,239	2,220,691
2054	225,133	258,395	293,379	531,666	974,946	2,283,519
2055	232,043	266,200	298,431	542,019	1,007,653	2,346,347
2056	238,953	274,004	303,484	552,373	1,040,360	2,409,175
2057	245,864	281,809	308,537	562,726	1,073,067	2,472,002
2058	252,774	289,614	313,590	573,079	1,105,773	2,534,830
2059	259,685	297,419	318,643	583,432	1,138,480	2,597,658
2060	266,595	305,224	323,696	593,785	1,171,187	2,660,486
2061	273,505	313,028	328,749	604,138	1,203,894	2,723,314
2062	280,416	320,833	333,802	614,491	1,236,601	2,786,142
2063	287,326	328,638	338,854	624,845	1,269,307	2,848,970
2064	294,236	336,443	343,907	635,198	1,302,014	2,911,798
2065	301,147	344,247	348,960	645,551	1,334,721	2,974,626
Total	**8,614,762**	**9,631,204**	**11,819,162**	**21,206,144**	**36,903,298**	**88,174,569**

	Option 3											
	Mac/McL	Saanich East	Royal Bay	JDF	Ogden Point	Westhills	Florence Lake	Roderick	Windsor Park	Lang Cove	Royal Jubilee	Total
2015	62,838	36,488	43,861	86,833	300,632	31,865	70,318	56,806	49,059	27,553	6,252	772,505
2016	67,976	44,864	56,341	107,976	318,694	41,898	91,301	71,435	49,664	30,952	8,005	889,106
2017	73,114	53,241	68,821	129,119	336,756	51,931	112,283	86,064	50,269	34,352	9,758	1,005,707
2018	78,251	61,617	81,301	150,262	354,818	61,964	133,265	100,693	50,873	37,751	11,512	1,122,307
2019	83,389	69,994	93,781	171,405	372,880	71,997	154,247	115,322	51,478	41,150	13,265	1,238,908
2020	88,527	78,371	106,260	192,548	390,942	82,030	175,230	129,951	52,083	44,549	15,018	1,355,509
2021	93,665	86,747	118,740	213,691	409,004	92,063	196,212	144,580	52,688	47,948	16,771	1,472,109
2022	98,803	95,124	131,220	234,834	427,066	102,096	217,194	159,209	53,292	51,348	18,524	1,588,710
2023	103,940	103,500	143,700	255,977	445,128	112,129	238,176	173,838	53,897	54,747	20,278	1,705,311
2024	109,078	111,877	156,180	277,120	463,190	122,162	259,159	188,467	54,502	58,146	22,031	1,821,911
2025	114,216	120,253	168,660	298,263	481,252	132,195	280,141	203,096	55,107	61,545	23,784	1,938,512
2026	119,354	128,630	181,140	319,405	499,314	142,228	301,123	217,725	55,712	64,944	25,537	2,055,113
2027	124,492	137,007	193,620	340,548	517,376	152,261	322,105	232,354	56,316	68,344	27,290	2,171,713
2028	129,629	145,383	206,100	361,691	535,438	162,294	343,088	246,983	56,921	71,743	29,043	2,288,314
2029	134,767	153,760	218,580	382,834	553,500	172,327	364,070	261,612	57,526	75,142	30,797	2,404,915
2030	139,905	162,136	231,060	403,977	571,562	182,360	385,052	276,241	58,131	78,541	32,550	2,521,515
2031	141,441	163,871	232,183	406,278	578,831	183,659	387,978	280,375	58,259	79,466	32,935	2,545,274
2032	142,976	165,605	233,305	408,579	586,099	184,958	390,904	284,509	58,387	80,391	33,320	2,569,034
2033	144,512	167,339	234,428	410,879	593,367	186,257	393,830	288,644	58,514	81,316	33,706	2,592,793
2034	146,048	169,074	235,551	413,180	600,635	187,556	396,756	292,778	58,642	82,241	34,091	2,616,552
2035	147,583	170,808	236,674	415,481	607,903	188,855	399,682	296,912	58,770	83,165	34,476	2,640,311
2036	149,119	172,543	237,797	417,781	615,172	190,154	402,608	301,047	58,898	84,090	34,861	2,664,070
2037	150,654	174,277	238,920	420,082	622,440	191,453	405,534	305,181	59,026	85,015	35,247	2,687,829
2038	152,190	176,011	240,043	422,383	629,708	192,752	408,460	309,315	59,154	85,940	35,632	2,711,588
2039	153,726	177,746	241,165	424,683	636,976	194,051	411,386	313,450	59,282	86,865	36,017	2,735,347
2040	155,261	179,480	242,288	426,984	644,244	195,350	414,311	317,584	59,410	87,790	36,402	2,759,106
2041	156,797	181,215	243,411	429,285	651,512	196,649	417,237	321,719	59,538	88,714	36,788	2,782,865
2042	158,333	182,949	244,534	431,586	658,781	197,948	420,163	325,853	59,666	89,639	37,173	2,806,624
2043	159,868	184,683	245,657	433,886	666,049	199,247	423,089	329,987	59,794	90,564	37,558	2,830,383
2044	161,404	186,418	246,780	436,187	673,317	200,546	426,015	334,122	59,922	91,489	37,943	2,854,142
2045	162,940	188,152	247,903	438,488	680,585	201,845	428,941	338,256	60,050	92,414	38,329	2,877,901
2046	169,850	195,957	252,956	448,841	713,292	207,690	442,108	356,861	60,626	96,576	40,062	2,984,817
2047	176,760	203,762	258,008	459,194	745,999	213,536	455,275	375,465	61,201	100,737	41,796	3,091,733
2048	183,671	211,566	263,061	469,547	778,705	219,381	468,441	394,070	61,777	104,899	43,530	3,198,649
2049	190,581	219,371	268,114	479,900	811,412	225,226	481,608	412,675	62,353	109,061	45,263	3,305,565
2050	197,491	227,176	273,167	490,254	844,119	231,072	494,775	431,279	62,929	113,222	46,997	3,412,480
2051	204,402	234,981	278,220	500,607	876,826	236,917	507,941	449,884	63,504	117,384	48,731	3,519,396
2052	211,312	242,785	283,273	510,960	909,533	242,762	521,108	468,488	64,080	121,546	50,464	3,626,312
2053	218,222	250,590	288,326	521,313	942,239	248,608	534,275	487,093	64,656	125,708	52,198	3,733,228
2054	225,133	258,395	293,379	531,666	974,946	254,453	547,442	505,698	65,232	129,869	53,932	3,840,144
2055	232,043	266,200	298,431	542,019	1,007,653	260,298	560,608	524,302	65,808	134,031	55,665	3,947,060
2056	238,953	274,004	303,484	552,373	1,040,360	266,144	573,775	542,907	66,383	138,193	57,399	4,053,975
2057	245,864	281,809	308,537	562,726	1,073,067	271,989	586,942	561,512	66,959	142,355	59,133	4,160,891
2058	252,774	289,614	313,590	573,079	1,105,773	277,835	600,108	580,116	67,535	146,516	60,866	4,267,807
2059	259,685	297,419	318,643	583,432	1,138,480	283,680	613,275	598,721	68,111	150,678	62,600	4,374,723
2060	266,595	305,224	323,696	593,785	1,171,187	289,525	626,442	617,325	68,686	154,840	64,334	4,481,639
2061	273,505	313,028	328,749	604,138	1,203,894	295,371	639,609	635,930	69,262	159,001	66,067	4,588,554
2062	280,416	320,833	333,802	614,491	1,236,601	301,216	652,775	654,535	69,838	163,163	67,801	4,695,470
2063	287,326	328,638	338,854	624,845	1,269,307	307,061	665,942	673,139	70,414	167,325	69,535	4,802,386
2064	294,236	336,443	343,907	635,198	1,302,014	312,907	679,109	691,744	70,989	171,487	71,268	4,909,302
2065	301,147	344,247	348,960	645,551	1,334,721	318,752	692,275	710,349	71,565	175,648	73,002	5,016,218
Total	**8,614,762**	**9,631,204**	**11,819,162**	**21,206,144**	**36,903,298**	**9,869,507**	**21,113,690**	**17,976,199**	**3,066,739**	**4,860,094**	**1,975,535**	**147,036,332**

Table 7
Saleable Heat 2015-2065

Option 1

Year	Mac/McL	Saanich East	Royal Bay	Total
2015	334,921	36,488	43,861	415,269
2016	361,090	44,864	56,341	462,295
2017	387,260	53,241	68,821	509,321
2018	413,430	61,617	81,301	556,348
2019	439,599	69,994	93,781	603,374
2020	465,769	78,371	106,260	650,400
2021	491,938	86,747	118,740	697,426
2022	518,108	95,124	131,220	744,452
2023	544,278	103,500	143,700	791,478
2024	570,447	111,877	156,180	838,504
2025	596,617	120,253	168,660	885,530
2026	622,786	128,630	181,140	932,556
2027	648,956	137,007	193,620	979,582
2028	675,125	145,383	206,100	1,026,608
2029	701,295	153,760	218,580	1,073,635
2030	727,465	162,136	231,060	1,120,661
2031	734,786	163,871	232,183	1,130,839
2032	742,108	165,605	233,305	1,141,018
2033	749,429	167,339	234,428	1,151,197
2034	756,751	169,074	235,551	1,161,376
2035	764,072	170,808	236,674	1,171,555
2036	771,394	172,543	237,797	1,181,733
2037	778,715	174,277	238,920	1,191,912
2038	786,037	176,011	240,043	1,202,091
2039	793,359	177,746	241,165	1,212,270
2040	800,680	179,480	242,288	1,222,449
2041	808,002	181,215	243,411	1,232,627
2042	815,323	182,949	244,534	1,242,806
2043	822,645	184,683	245,657	1,252,985
2044	829,966	186,418	246,780	1,263,164
2045	837,288	188,152	247,903	1,273,343
2046	870,235	195,957	252,956	1,319,147
2047	903,182	203,762	258,008	1,364,952
2048	936,129	211,566	263,061	1,410,756
2049	969,076	219,371	268,114	1,456,561
2050	1,002,022	227,176	273,167	1,502,365
2051	1,034,969	234,981	278,220	1,548,170
2052	1,067,916	242,785	283,273	1,593,975
2053	1,100,863	250,590	288,326	1,639,779
2054	1,133,810	258,395	293,379	1,685,584
2055	1,166,757	266,200	298,431	1,731,388
2056	1,199,704	274,004	303,484	1,777,193
2057	1,232,651	281,809	308,537	1,822,997
2058	1,265,598	289,614	313,590	1,868,802
2059	1,298,545	290,628	318,643	1,907,815
2060	1,331,492	291,307	323,696	1,946,495
2061	1,364,439	291,987	328,749	1,985,174
2062	1,397,386	292,666	333,802	2,023,853
2063	1,430,333	293,346	338,854	2,062,533
2064	1,463,280	294,025	343,907	2,101,212
2065	1,496,227	294,705	348,960	2,139,891
Total Saleable (GJ/year)	**43,954,251**	**9,434,036**	**11,819,162**	**65,207,448**
Total Demand (GJ/year)	**43,954,251**	**9,631,204**	**11,819,162**	**65,404,616**
Total Supply (GJ/year)	**67,816,011**	**13,474,369**	**21,668,390**	**102,958,770**
% of Supply Recovered	**65%**	**70%**	**55%**	**63%**
2065 Heat Supply	**1,500,766**	**294,705**	**657,727**	**2,453,199**
2065 Heat Demand	**1,496,227**	**344,247**	**348,960**	**2,189,434**
2065 Demand/Supply %	**100%**	**117%**	**53%**	**89%**
Demand > Supply in Year	**2065**	**2058**	**2065+**	**2065+**

Option 2

Year	Mac/McL	Saanich East	Royal Bay	JDF	Ogden Point	Total
2015	62,838	36,488	21,361	86,833	300,632	508,152
2016	67,976	44,864	24,492	107,976	318,694	564,002
2017	73,114	53,241	27,623	129,119	336,756	619,853
2018	78,251	61,617	30,754	150,262	354,818	675,703
2019	83,389	69,994	33,886	171,405	372,880	731,554
2020	88,527	78,371	37,017	192,548	390,942	787,404
2021	93,665	86,747	40,148	213,691	409,004	843,254
2022	98,803	95,124	43,279	234,834	427,066	899,105
2023	103,940	103,500	46,410	255,977	445,128	954,955
2024	109,078	111,877	49,541	277,120	463,190	1,010,806
2025	114,216	120,253	52,672	298,263	481,252	1,066,656
2026	119,354	128,630	55,803	319,405	499,314	1,122,507
2027	124,492	137,007	58,934	340,548	517,376	1,178,357
2028	129,629	145,383	62,065	361,691	535,438	1,234,207
2029	134,767	153,760	65,196	382,834	553,500	1,290,058
2030	139,905	162,136	68,327	403,977	564,176	1,338,522
2031	141,441	163,871	71,622	406,278	567,117	1,350,329
2032	142,976	165,605	74,917	408,579	570,059	1,362,136
2033	144,512	167,339	78,212	410,879	573,000	1,373,943
2034	146,048	169,074	81,507	413,180	575,942	1,385,750
2035	147,583	170,808	84,802	415,481	578,883	1,397,557
2036	149,119	172,543	88,097	417,781	581,824	1,409,364
2037	150,654	174,277	91,392	420,082	584,766	1,421,171
2038	152,190	176,011	94,687	422,383	587,707	1,432,978
2039	153,726	177,746	97,982	424,683	590,649	1,444,785
2040	155,261	179,480	101,276	426,984	593,590	1,456,592
2041	156,797	181,215	104,571	429,285	596,531	1,468,399
2042	158,333	182,949	107,866	431,586	599,473	1,480,206
2043	159,868	184,683	111,161	433,886	602,414	1,492,013
2044	161,404	186,418	114,456	436,187	605,356	1,503,820
2045	162,940	188,152	117,751	438,488	608,297	1,515,627
2046	169,850	195,957	120,306	448,841	609,663	1,544,616
2047	176,760	203,762	122,860	459,194	611,029	1,573,605
2048	183,671	211,566	125,415	469,547	612,395	1,602,594
2049	190,581	219,371	127,969	479,900	613,761	1,631,583
2050	197,491	227,176	130,524	490,254	615,127	1,660,571
2051	204,402	234,981	133,079	500,607	616,493	1,689,560
2052	211,312	242,785	135,633	510,960	617,859	1,718,549
2053	218,222	250,590	138,188	521,313	619,224	1,747,538
2054	225,133	258,395	140,742	531,666	620,590	1,776,527
2055	232,043	266,200	143,297	542,019	621,956	1,805,516
2056	238,953	274,004	145,852	552,373	623,322	1,834,504
2057	245,864	281,809	148,406	562,726	624,688	1,863,493
2058	252,774	289,614	150,961	573,079	626,054	1,892,482
2059	259,685	290,628	153,515	583,432	627,420	1,914,680
2060	266,595	291,307	156,070	593,785	628,786	1,936,543
2061	273,505	291,987	158,625	604,138	630,152	1,958,407
2062	280,416	292,666	161,179	614,491	631,518	1,980,271
2063	287,326	293,346	163,734	624,845	632,884	2,002,134
2064	294,236	294,025	166,289	635,198	634,250	2,023,998
2065	301,147	294,705	168,843	645,551	635,616	2,045,861
Total Saleable (GJ/year)	**8,614,762**	**9,434,036**	**5,029,296**	**21,206,144**	**28,238,560**	**72,522,797**
Total Demand (GJ/year)	**8,614,762**	**9,631,204**	**11,819,162**	**21,206,144**	**36,903,298**	**88,174,569**
Total Supply (GJ/year)	**17,616,449**	**13,474,369**	**5,029,296**	**36,890,704**	**29,947,952**	**102,958,770**
% of Supply Recovered	**49%**	**70%**	**100%**	**57%**	**94%**	**70%**
2065 Heat Supply	**397,122**	**294,705**	**168,843**	**956,913**	**635,616**	**2,453,199**
2065 Heat Demand	**301,147**	**344,247**	**348,960**	**645,551**	**1,334,721**	**2,974,626**
2065 Demand/Supply %	**76%**	**117%**	**207%**	**67%**	**210%**	**121%**
Demand > Supply in Year	**2065+**	**2058**	**2015**	**2065+**	**2029**	**2053**

Option 3

Year	Mac/McL	Saanich East	Royal Bay	JDF	Ogden Point	Westhills	Florence Lake	Roderick	Windsor Park	Lang Cove	Royal Jubilee	Total
2015	62,838	36,488	21,361	86,833	300,632	31,865	19,308	56,806	49,059	27,553	6,252	698,995
2016	67,976	44,864	24,225	107,720	318,694	37,357	20,383	71,435	49,664	30,952	8,005	781,274
2017	73,114	53,241	27,088	110,080	327,199	42,163	21,458	86,064	50,269	34,352	9,758	834,785
2018	78,251	61,617	29,951	112,440	327,875	46,968	22,533	100,693	50,873	37,751	11,512	880,465
2019	83,389	69,994	32,815	114,800	328,551	51,773	23,608	115,322	51,478	41,150	13,265	926,145
2020	88,527	78,371	35,678	117,161	329,227	56,579	24,683	129,951	52,083	44,549	15,018	971,825
2021	93,665	86,747	38,541	119,521	329,902	61,384	25,758	144,580	52,688	47,948	16,771	1,017,506
2022	98,803	95,124	41,405	121,881	330,578	66,190	26,833	159,209	53,292	51,348	18,524	1,063,186
2023	103,940	103,500	44,268	124,241	331,254	70,995	27,908	173,838	53,897	54,747	20,278	1,108,866
2024	109,078	111,877	47,131	126,602	331,929	75,800	28,983	188,467	54,502	58,146	22,031	1,154,546
2025	114,216	120,253	49,995	128,962	332,605	80,606	30,058	203,096	55,107	61,545	23,784	1,200,226
2026	119,354	128,630	52,858	131,322	333,281	85,411	31,133	217,725	55,712	64,944	25,537	1,245,907
2027	124,492	137,007	55,721	133,682	333,956	90,217	32,208	232,354	56,316	68,344	27,290	1,291,587
2028	129,629	145,383	58,585	136,043	334,632	95,022	33,283	246,983	56,921	71,743	29,043	1,337,267
2029	134,767	153,760	61,448	138,403	335,308	99,828	34,358	261,612	57,526	75,142	30,797	1,382,947
2030	139,905	162,136	64,311	140,763	335,983	104,633	35,433	276,241	58,131	78,541	32,550	1,428,627
2031	141,441	163,871	67,114	143,160	337,069	105,448	36,355	280,375	58,259	79,466	32,935	1,445,492
2032	142,976	165,605	69,918	145,557	338,154	106,264	37,276	284,509	58,387	80,391	33,320	1,462,357
2033	144,512	167,339	72,721	147,954	339,239	107,079	38,198	288,644	58,514	81,316	33,706	1,479,222
2034	146,048	169,074	75,524	150,351	340,325	107,895	39,120	292,778	58,642	82,241	34,091	1,496,087
2035	147,583	170,808	78,327	152,748	341,410	108,710	40,041	296,912	58,770	83,165	34,476	1,512,952
2036	149,119	172,543	81,130	155,145	342,496	109,526	40,963	301,047	58,898	84,090	34,861	1,529,817
2037	150,654	174,277	83,933	157,542	343,581	110,341	41,884	305,181	59,026	85,015	35,247	1,546,682
2038	152,190	176,011	86,737	159,938	344,666	111,157	42,806	309,315	59,154	85,940	35,632	1,563,547
2039	153,726	177,746	89,540	162,335	345,752	111,972	43,728	313,450	59,282	86,865	36,017	1,580,412
2040	155,261	179,480	92,343	164,732	346,837	112,788	44,649	317,584	59,410	87,790	36,402	1,597,277
2041	156,797	181,215	95,146	167,129	347,922	113,603	45,571	321,719	59,538	88,714	36,788	1,614,142
2042	158,333	182,949	97,949	169,526	349,008	114,419	46,492	325,853	59,666	89,639	37,173	1,631,007
2043	159,868	184,683	100,752	171,923	350,093	115,234	47,414	329,987	59,794	90,564	37,558	1,647,872
2044	161,404	186,418	103,555	174,320	351,178	116,049	48,336	334,122	59,922	91,489	37,943	1,664,737
2045	162,940	188,152	106,359	176,717	352,264	116,865	49,257	338,256	60,050	92,414	38,329	1,681,601
2046	169,850	195,957	108,286	179,796	352,285	117,894	50,364	356,861	60,626	96,576	40,062	1,728,555
2047	176,760	203,762	110,213	182,874	352,306	118,923	51,470	367,082	61,201	100,737	41,796	1,767,125
2048	183,671	211,566	112,140	185,953	352,327	119,953	52,577	366,967	61,777	104,899	43,530	1,795,359
2049	190,581	219,371	114,067	189,032	352,348	120,982	53,683	366,852	62,353	109,061	45,263	1,823,593
2050	196,376	227,176	115,994	192,111	352,369	122,011	54,790	366,737	62,929	113,222	46,997	1,850,712
2051	197,452	234,981	117,921	195,189	352,390	123,040	55,896	366,623	63,504	117,384	48,731	1,873,112
2052	198,528	242,785	119,848	198,268	352,411	124,070	57,003	366,508	64,080	121,546	50,464	1,895,512
2053	199,605	250,590	121,775	201,347	352,432	125,099	58,109	366,393	64,656	125,708	52,198	1,917,912
2054	200,681	258,395	123,702	204,426	352,453	126,128	59,216	366,278	65,232	129,869	53,932	1,940,312
2055	201,757	263,801	125,629	207,504	352,475	127,158	60,322	366,164	65,808	134,031	55,665	1,960,313
2056	202,834	264,014	127,556	210,583	352,496	128,187	61,429	366,049	66,383	136,450	57,399	1,973,379
2057	203,910	264,228	129,483	213,662	352,517	129,216	62,535	365,934	66,959	137,371	59,133	1,984,947
2058	204,986	264,441	131,410	216,740	352,538	130,245	63,642	365,819	67,535	138,293	60,866	1,996,516
2059	206,062	264,655	133,337	219,819	352,559	131,275	64,748	365,704	68,111	139,214	62,600	2,008,084
2060	207,139	264,868	135,265	222,898	352,580	132,304	65,855	365,590	68,686	140,136	64,334	2,019,653
2061	208,215	265,082	137,192	225,977	352,601	133,333	66,961	365,475	69,262	141,057	66,067	2,031,221
2062	209,291	265,295	139,119	229,055	352,622	134,362	68,068	365,360	69,838	141,978	67,801	2,042,790
2063	210,368	265,509	141,046	232,134	352,643	135,392	69,174	365,245	70,414	142,900	69,535	2,054,358
2064	211,444	265,722	142,973	235,213	352,664	136,421	70,281	365,131	70,989	143,821	71,268	2,065,927
2065	212,520	265,936	144,900	238,291	352,685	137,450	71,387	365,016	71,565	144,743	73,002	2,077,495
Total Saleable (GJ/year)	**7,896,826**	**9,187,296**	**4,518,283**	**8,530,402**	**17,481,301**	**5,317,584**	**2,297,526**	**14,615,894**	**3,066,739**	**4,696,851**	**1,975,535**	**79,584,237**
Total Demand (GJ/year)	**8,614,762**	**9,631,204**	**11,819,162**	**21,206,144**	**36,903,298**	**9,869,507**	**21,113,690**	**17,976,199**	**3,066,739**	**4,860,094**	**1,975,535**	**147,036,332**
Total Supply (GJ/year)	**9,762,377**	**12,674,981**	**4,518,283**	**8,548,928**	**17,514,348**	**5,318,271**	**2,297,526**	**18,159,960**	**6,862,403**	**5,828,234**	**3,619,559**	**95,104,871**
% of Supply Recovered	**81%**	**72%**	**100%**	**100%**	**100%**	**100%**	**100%**	**80%**	**45%**	**81%**	**55%**	**84%**
2065 Heat Supply	**212,520**	**265,936**	**144,900**	**238,291**	**352,685**	**137,450**	**71,387**	**365,016**	**127,986**	**144,743**	**85,224**	**2,146,138**
2065 Heat Demand	**301,147**	**344,247**	**348,960**	**645,551**	**1,334,721**	**318,752**	**692,275**	**710,349**	**71,565**	**175,648**	**73,002**	**5,016,218**
2065 Demand/Supply %	**142%**	**129%**	**241%**	**271%**	**378%**	**232%**	**970%**	**195%**	**56%**	**121%**	**86%**	**234%**
Demand > Supply in Year	**2049**	**2054**	**2015**	**2016**	**2017**	**2016**	**2015**	**2046**	**2065+**	**2055**	**2065+**	**2022**

KERR WOOD LEIDAL ASSOCIATES LTD.
O:\0700-0799\764-014\402-Work_036DP2\DES_Sizing\[DES_SaleableHeatEnergy.xls]Saleable

Technical Memo

KERR WOOD LEIDAL associates limited CONSULTING ENGINEERS

Capital Regional District
Core Area Wastewater Management Program
Distributed Wastewater Management Task 036

Heat Recovery for Distributed Wastewater Management Options with District Energy Systems
February 10, 2009

Prepared For: Dean Shiskowski, Ph.D., PEng
Prepared By: Mike Homenuke, PEng

Objective

The Capital Regional District (CRD) is implementing a wastewater management strategy that will involve wastewater conveyance, treatment, reuse and disposal. Alternatives for wastewater treatment options and preliminary sizing of liquid and solids treatment facilities have been discussed in previous discussion papers. Potential locations for placement of new facilities have also been identified.

This technical memorandum is a supplement to Discussion Paper 036-DP-2. This document provides the technical process for estimating the potential cost of heat recovery using a District Energy System (DES). The DES would convey heat energy recovered from wastewater to potential customers through a pipe network. Conceptual design parameters, heat energy supply and demand, and costing are discussed. A number of specific technical issues have been identified and will warrant further investigations as the wastewater management program proceeds.

Distributed Wastewater Management Scenarios

Three distributed wastewater management scenarios have been developed for 036-DP-2, and are described briefly as follows:

- **Option 1 – Regional Resource Recovery**: Liquid stream treatment and heat recovery at Macaulay/McLoughlin, East Saanich and Royal Bay;
- **Option 2 – Regional/Local Resource Recovery**: Liquid stream treatment and heat recovery at Macaulay/McLoughlin, Ogden Point, East Saanich, Juan de Fuca and Royal Bay; and
- **Option 3 – Local Resource Recovery**: Liquid stream treatment and heat recovery at Macaulay/McLoughlin, Ogden Point, East Saanich, Roderick, Westhills, Florence Lake, Juan de Fuca Lang Cove, and Royal Bay; heat recovery without treatment at Royal Jubilee.

Recoverable Heat Estimate

Recoverable heat is determined as the lesser of either supplied or demanded heat for each year in the analysis. Heat supply and demand has been estimated at key years in the analysis (2015, 2030, 2045, 2065) and interpolated linearly between the key years. All analyses in this document are based on average dry weather flow conditions.

A technical memorandum developed by KWL[1] details the calculation of recoverable heat. The maximum amount of saleable heat in 2065 has been identified as the key parameter for sizing the DESs. Table 1 shows the estimated heat supply and demand for each Option.

District Energy System Concept

The proposed arrangement for the DES is a low-temperature two-pipe closed branch system with treated effluent as the primary heat source in all cases except the proposed Royal Jubilee Heat Recovery Facility (HRF). A low-temperature system provides flexibility such that various users could use the DES network for cooling and heating simultaneously (energy sharing). Secondary heat sources such as geoexchange or biogas-fired boilers could also be added to the system. At this stage of analysis, cooling and secondary heat sources have not been considered as the scope of this study is limited to evaluating potential heat recovery from wastewater.

The proposed DES concept is based on "Technique 2" from Technical Memorandum 3, Appendix A, Discussion Paper 036-DP-1[2]. Effluent pumps would transfer treated effluent to the HRF, where heat exchangers would transfer the heat from the effluent to the DES carrier fluid. The carrier fluid (water) would be circulated through the network with variable-speed pumps. A heat pump system for each DES customer would be used to boost the heat from the DES to the required temperature for space and water heating. Figure 1 shows a schematic layout of the proposed DES concept.

DES systems have been sized for the 2065 condition for costing and heat recovery estimate purposes. Design temperatures for the DES system in 2065 are as follows:

- Effluent winter inlet temperature in 2065: 17.2ºC – 17.6ºC
- Effluent outlet temperature: 6ºC (treated), 8ºC (raw)[3]
- Heat exchanger temperature differential: 2ºC between effluent and loop
- DES supply loop temperature: 15ºC
- DES return loop temperature: 4ºC

---

[1] Kerr Wood Leidal Associates Ltd. Technical Memorandum for Discussion Paper 036-DP-2 entitled "Estimation of Saleable Recovered Heat Energy for Distributed Treatment Options". February 2009.

[2] CH2M Hill, October 28, 2008

[3] p.10, Discussion Paper 031-DP-6: Heat Recovery, AE. July 21, 2008.

Table 1

Estimated Recovered Heat Energy Supply and Demand

Heat Parameters	
Unit Heat Content of Wastewater	4,187 kJ/m3/ºC
Treated Effluent Discharge Temperature	6 ºC
Raw Sewage Discharge Temperature	8 ºC

	ADWF (m³/d)					**Recovered Heat Supply (GJ/d)**						**Heat Recovery**	**Estimated Winter Demand for Recovered Heat (GJ/d)**			**Demand/Supply Ratio**		
	2005	**2015**	**2030**	**2045**	**2065**	**2005**	**2015**	**2020**	**2030**	**2045**	**2065**	**Opportunities**	**2005[1]**	**2020[2]**	**2065[2]**	**2005**	**2020**	**2065**
Design ADWF Wastewater Temperature (ºC)						14.2	14.8	15.2	15.8	16.4	17.2							
Treated Effluent Heat Extraction Rate						34,400	37,000	38,300	40,900	43,700	47,000							
Raw Sewage Heat Extraction Rate						26,000	28,600	30,000	32,500	35,300	38,600							
Option 1 - Regional Resource Recovery																		
Saanich East WWTF	15,816	16,125	16,605	17,624	17,179	544	597	624	679	770	807	7	106	754	2,358	19%	121%	292%
Royal Bay WWTF	4,419	11,750	23,143	29,772	38,340	152	435	595	947	1,301	1,802	20	0	1,352	2,390	0%	227%	133%
Macaulay Point WWTF	77,371	83,326	84,149	86,740	87,483	2,662	3,083	3,202	3,442	3,791	4,112	1, 3, 13	1,956	3,478	10,248	73%	109%	249%
Total	*97,606*	*111,202*	*123,898*	*134,136*	*143,002*	*3,358*	*4,114*	*4,421*	*5,067*	*5,862*	*6,721*		*2,061*	*5,584*	*14,996*	*61%*	*126%*	*223%*
Option 2 - Regional/Local Resource Recovery																		
Saanich East WWTF	15,816	16,125	16,605	17,624	17,179	544	597	624	679	770	807	7	106	754	2,358	19%	121%	292%
Ogden Point WWTF	36,598	38,561	37,792	38,137	37,051	1,259	1,427	1,467	1,546	1,667	1,741	1, 3	1,956	2,421	9,142	155%	165%	525%
Royal Bay WWTF	722	1,582	4,577	7,382	9,842	25	59	99	187	323	463	20	0	1,352	2,390	0%	1368%	517%
Juan de Fuca WWTF	24,578	33,259	43,100	48,717	55,780	845	1,231	1,399	1,763	2,129	2,622	16, 17	109	2,294	4,422	13%	164%	169%
Macaulay/McLoughlin WWTF	19,891	21,675	21,824	22,276	23,149	684	802	832	893	973	1,088	12, 13	370	643	2,063	54%	77%	190%
Total	*97,606*	*111,202*	*123,898*	*134,136*	*143,002*	*3,358*	*4,114*	*4,421*	*5,067*	*5,862*	*6,721*		*2,540*	*7,464*	*20,374*	*76%*	*169%*	*303%*

	ADWF (m³/d)					**Recovered Heat Supply (GJ/d)**						**Heat Recovery**	**Estimated Winter Demand for Recovered Heat (GJ/d)**			**Demand/Supply Ratio**		
	2005	**2015**	**2030**	**2045**	**2065**	**2005**	**2015**	**2020**	**2030**	**2045**	**2065**	**Opportunities**	**2005[1]**	**2020[2]**	**2065[2]**	**2005**	**2020**	**2065**
Design ADWF Wastewater Temperature (ºC)						14.2	14.8	15.2	15.8	16.5	17.5							
Treated Effluent Heat Extraction Rate						34,400	37,000	38,300	40,900	44,100	48,100							
Raw Sewage Heat Extraction Rate						26,000	28,600	30,000	32,600	35,700	39,700							
Option 3 - Local Resource Recovery																		
Saanich East WWTF	15,816	16,125	15,904	16,256	15,147	544	597	615	650	717	729	7	106	754	2,358	19%	123%	324%
Royal Jubilee Heat Recovery Facility[3]	4,954	5,182	5,441	5,792	5,881	129	148	202	177	207	233	33	14	144	500	11%	71%	214%
Windsor Park WWTF[4,5]	14,662	14,433	13,490	13,004	12,144	504	534	541	552	573	584	36	326	372	490	65%	69%	84%
Ogden Point WWTF	21,937	24,128	22,506	21,884	20,089	755	893	903	921	965	966	1, 3	1,956	2,421	9,142	259%	268%	946%
Royal Bay WWTF	722	1,582	4,308	6,608	8,253	25	59	95	176	291	397	20	0	1,352	2,390	0%	1417%	602%
Westhills WWTF	647	2,410	7,009	7,260	7,829	22	89	151	287	320	377	23, 24	0	982	2,183	0%	650%	580%
Florence Lake WWTF	534	1,430	2,374	3,060	4,066	18	53	67	97	135	196	18, 26	37	2,036	4,742	204%	3048%	2424%
Juan de Fuca WWTF	3,239	7,802	9,429	10,979	13,573	111	289	320	386	484	653	16, 17	109	2,294	4,422	98%	718%	677%
Lang Cove WWTF	4,892	5,483	6,723	7,847	8,244	168	203	226	275	346	397	13, 32	143	348	1,203	85%	154%	303%
Roderick WWTF	23,221	24,604	23,405	22,819	20,791	799	910	927	957	1,006	1,000	10	202	1,043	4,865	25%	112%	487%
Macaulay/McLaughlin WWTF	11,937	13,205	12,334	11,866	12,105	411	489	495	504	523	582	12, 13	370	643	2,063	90%	130%	354%
Total	*102,560*	*116,384*	*122,924*	*127,375*	*128,123*	*3,486*	*4,263*	*4,541*	*4,982*	*5,569*	*6,113*		*3,263*	*12,389*	*34,358*	*94%*	*273%*	*562%*

Notes:

(1) 2005 heat demands are based on top percentile of existing boiler demands. Top percentile is based on 2020 % recovery estimate by Westlands Resource Group

(2) 2020 and 2065 heat demands are based on future demand projections by Westlands Resource Group, including % recovery estimates for 2020 and 2065

(3) Royal Jubilee Heat Recovery Facility assumes raw sewage heat extraction (8ºC outlet)

(4) Windsor Park heat recovery is based on total ADWF with treated effluent, less the amount extracted at Royal Jubilee

(5) Estimated inlet temperature to Windsor Park WWTF is 11.9ºC during normal DWF conditions.

KERR WOOD LEIDAL ASSOCIATES LTD.

O:\0700-0799\764-014\402-Work_036DP2\[WWTP_FlowCalcs_DP_2_Option3_20081217.xls]HeatSupplyEstimate

It is recognized that existing commercial heat pumps typically provide a 5°C temperature drop between the supply and return loops[4]. This is not considered to be problematic in terms of providing building heat, however to maximize the amount of heat recovery through heat exchange a drop of about 11°C is needed between the supply and return loops. This is considered to be technically achievable, however this is also contingent upon the timing of treated effluent exiting the treatment plant relative to demand periods. This case was identified in Stockholm, Sweden, in which the solution was to construct large storage tanks to balance loads with supplies[5]. In any case, many of the proposed plants would not require this until the later stages of the heat recovery program because in the early stages the wastewater temperature will be lower and demands will not fully utilize the potentially recoverable heat energy. Further, the timing of peak effluent flow versus peak heat demand has not been quantified at this stage of analysis, and would require consideration of peak attenuation and travel time through both the sewer collection system and proposed treatment facilities.

A GIS model was developed to estimate the extent of DES pipe networks for each HRF in the scenarios. DES pipe networks were generated between the proposed HRFs by setting an alignment for a transmission 'backbone', then determining the shortest pathway along existing roads to the potential opportunities. This provided the basis for estimating the quantity of DES piping for cost estimating and sizing of loop pumps.

Figures 2-4 (attached) present the conceptual arrangement of the DESs for each option.

The following table presents the sizing and estimate of recoverable heat for each plant and option.

---

[4] Personal Communication – William Vaughan, PEng, DEC Design Mechanical Consultants Ltd.

[5] p. 8, Associated Engineering. Discussion Paper 031-DP-6, "Heat Recovery", July 2008.

Table 2

DES Sizing and Energy Production

Plant	Recoverable Energy Rate 2065 (GJ/d)	Design HRF Capacity 2065 (MW)	Total Recoverable Energy 2015-2065 (GJ x 10^6)	Capacity Factor
Option 1 – Regional Resource Recovery				
Macaulay/McLoughlin	4,112	48	44.0	0.59
Saanich East	807	9.3	9.4	0.64
Royal Bay	956	11	11.8	0.68
Option 2 – Regional/Local Resource Recovery				
Macaulay/McLoughlin	825	9.5	8.6	0.57
Juan de Fuca	1,800	21	21.2	0.65
Royal Bay	463	5.4	5.0	0.60
Saanich East	807	9.3	9.4	0.64
Ogden Point	1,741	20	28.2	0.89
Option 3 – Local Resource Recovery				
Macaulay/McLoughlin	582	6.7	7.9	0.74
Roderick	1,000	12	14.6	0.80
Lang Cove	397	4.6	4.7	0.65
Juan de Fuca	653	7.6	8.5	0.72
Royal Bay	397	4.6	4.5	0.62
Westhills	377	4.4	5.3	0.77
Florence Lake	196	2.3	2.3	0.64
Ogden Point	966	11	17.5	0.99
Windsor Park[1]	200	2.3	3.1	0.84
Saanich East	729	8.4	9.2	0.69
Royal Jubilee	200	2.3	2.0	0.54
Saanich East	729	8.4	44.0	0.59
Notes: (1) Windsor Park has been identified as the only plant where energy demand does not exceed energy supply.				

The 'capacity factor' shown in the above table is the ratio of saleable energy to the design capacity of the HRF operating 100% of the time over the project life cycle. As shown this ranges from 0.54 up to 0.99. Plants with lower capacity factors indicate low demand during the earlier portion of the project life cycle, in which case the system could be constructed in phases.

District Energy System End Users

The Opportunities identified in 036-DP-1 represent a number of different types of potential end users of a DES. The following table describes the end user characteristics of the opportunities that have been linked to the treatment plant locations in the proposed Options.

Table 3

DES End Users

Opportunity	Potential End Users	Distribution Type
#1 – James Bay	Retrofit, Redevelopment	Distributed
#3 – Downtown	Retrofit, Redevelopment	Distributed
#7 – UVic	Institutional	Single User
#10 – Upper Douglas	Retrofit, Redevelopment	Distributed
#12 – Vic West	Retrofit, Redevelopment	Distributed
#13 – Esquimalt Centre	Retrofit, Redevelopment	Distributed
#16 – Colwood Corners	Redevelopment	Distributed
#17 – Royal Roads	Institutional	Single User
#18 – Langford City Centre	Retrofit, Redevelopment	Distributed
#20 – Royal Bay	New Development	Distributed
#23 – Westhills Tower 1	New Development	Distributed
#24 – Westhills Main	New Development	Distributed
#26 – Bear Mountain Expansion 1	New Development	Distributed
#32 – DND West Esquimalt	Institutional	Single User
#33 – Royal Jubilee	Institutional	Single User
#36 – Oak Bay Marina	Retrofit, Redevelopment	Distributed

The various end users and distribution types are described as follows:

- Retrofit: Larger buildings with existing hot water boilers using a heat pump to displace boiler usage, requires distribution pipe to be provided;
- Redevelopment: New buildings within existing developed areas with DES incorporated into design, requires distribution pipe to be provided;
- Institutional: Existing institutions that have hot water boiler systems, assumed to be compatible with heat pump;

- New Development: Greenfield development, assumed to have a distribution network in place as part of the development, as opposed to provision of additional DES piping;
- Distributed: DES loop piping extends to frontage of property, with heat pump located within property; and
- Single User: DES utility would provide a heat exchange facility to user, at which point the end user would take responsibility for the distribution of heat energy.

Cost Estimate

The proposed DESs can be considered in three segments for cost analysis: the effluent stream heat supply (CRD), transmission and distribution of heat energy to potential consumers (Energy Utility) and the energy consumers (Customers). The Energy Utility is assumed to be a fully privatized or P3 commercial venture, although a municipal-owned company such as Lonsdale Energy Corporation (City of North Vancouver) would present another possibility. The following table describes the cost allocation for this analysis.

Table 4

District Energy System Cost Elements

Element	Capital Cost Units	Operating Cost Units	Allocation
Heat Recovery Plant			
Effluent Pumps	each	kWh/year	CRD
Effluent Piping	m	-	CRD
Heat Exchanger	kW	-	Utility
Distribution Loop Pumps	each	kWh/year	Utility
Electrical Supply	kW	-	Utility
Controls	kW	-	Utility
Building	kW	-	Utility
Land	N/A	N/A	N/A
Transmission/Distribution System			
Piping	m	-	Utility
Fittings	10% of Piping	-	Utility
Customer-Side Works			
Connection Pipes	m	N/A	Utility
Heat Pump(s) & Control Equipment	kW	kWh	Utility (Capital)/ Customer (Operating)

The primary basis for the capital cost estimates is the Whistler Athletes' Village District Energy System (WAVDES) project, which is the first known application of a low-temperature DES using effluent heat as a primary energy source in North America.

Capital cost estimates are considered to be of Class 'D' detail and accuracy, which means that general project requirements are known, but detailed site condition information is limited. Allowances of 20% for engineering and construction management, and 45% for contingencies have been added to the estimated costs. All costs are presented in 2008 dollars.

Capital and life cycle cost estimates were prepared for six plants: Macaulay/McLoughlin Option 1; East Saanich Option 1/2; Ogden Point Option 2; Juan de Fuca Option 2; Windsor Park Option 3 and Florence Lake Option 3. These examples cover the complete range of potential DES system sizes and configurations expected to be encountered in this study. These costs were plotted as a regression against the design capacity of the HRFs, which is shown as Figure 5. The remaining DESs were costed using these curves. Customer connection costs were estimated at either $700/kW for an on-site heat pump connection, or as a flat $2,000,000 for a heat exchange facility for institutional users.

Life cycle costs were estimated as follows:

- Capital: Assumed financing at 10% net discount rate for 40 year amortization term, all capital costs up-front;
- Electrical Consumption: $0.07/kWh for operation of effluent and loop water pumps, and heat pumps assuming a COP of 3.0[6];
- Asset Amortization/Equipment Replacement: 2% of capital as annual expense; and
- Administration/Labour: $50,000/year for small plant (< 20 MW) and $100,000/year for large plant (> 20 MW).

The 2015-2065 net present value of O&M costs were determined to amount to approximately 20% of capital based on an annual inflation rate of 3% applied to electrical and administrative costs.

Table 5 (attached) summarizes the estimated capital costs and unit energy costs for each plant. The unit energy costs presented do not include a commodity price for heat energy, which is one of the subjects of Discussion Paper 036-DP-2.

CRD Costs

As mentioned above, the CRD direct costs are assumed to include provision of effluent pumps and piping from the WWTF to the HRF. As shown in Table 6, estimated costs for effluent pump stations typically range between $400,000 and $800,000, with the notable exception of the $18,000,000 Macaulay/McLoughlin Option 1 system that would require an additional crossing of the Inner Harbour. The capital cost makes up approximately $0.05-

---

[6] Low end of COP range, p.3, Discussion Paper 036-DP-1, Appendix A Tech Memo No. 5 "Wastewater Heat Recovery – Heating Options in Non-Plant Uses", CH2M Hill, June 27, 2008.

Table 5
Summary of Estimated Heat Recovery Costs

DWM Option	Plant	Total HRF Cost[1]	CRD Share of HRF Cost[2]	DES Pipe Cost	Connection Cost	Total Capital Cost	Amortized Financing Cost	Total Saleable Energy	Unit Capital Cost	Unit O&M Cost[3]	Heat Pump Electricity Cost	Total Unit Energy Cost
		($)	($)	($)	($)	($)	($)	(GJ)	($/GJ)	($/GJ)	($/GJ)	($/GJ)
1	Saanich East	4,100,000	550,000	2,400,000	2,000,000	8,500,000	34,900,000	9,434,036	3.70	0.74	4.86	9.30
1	Royal Bay	5,000,000	650,000	10,700,000	7,700,000	23,400,000	95,700,000	11,819,162	8.10	1.62	4.86	14.58
1	Macaulay/McLoughlin	38,100,000	18,000,000	41,500,000	33,300,000	112,900,000	461,900,000	43,954,251	10.51	2.10	4.86	17.47
Total - Option 1		**47,200,000**	**19,200,000**	**54,600,000**	**43,000,000**	**144,800,000**	**592,500,000**	**65,207,448**	**9.09**	**1.82**	**4.86**	**15.76**
2	Saanich East	4,100,000	600,000	2,400,000	2,000,000	8,500,000	34,900,000	9,631,204	3.63	0.73	4.86	9.21
2	Ogden Point	8,800,000	800,000	6,100,000	14,100,000	29,000,000	118,700,000	29,947,952	3.96	0.79	4.86	9.62
2	Juan de Fuca	8,200,000	750,000	7,600,000	14,600,000	30,400,000	124,400,000	21,206,144	5.87	1.17	4.86	11.90
2	Macaulay/McLoughlin	4,400,000	600,000	6,300,000	6,700,000	17,400,000	71,200,000	8,614,762	8.26	1.65	4.86	14.78
2	Royal Bay	2,700,000	500,000	5,100,000	3,800,000	11,600,000	47,300,000	5,029,296	9.41	1.88	4.86	16.16
Total - Option 2		**28,200,000**	**3,250,000**	**27,500,000**	**41,200,000**	**96,900,000**	**396,500,000**	**74,429,358**	**5.33**	**1.07**	**4.86**	**11.25**
3	Saanich East	4,000,000	600,000	2,400,000	2,000,000	8,400,000	34,200,000	9,631,204	3.55	0.71	4.86	9.12
3	Roderick	5,200,000	650,000	4,200,000	8,100,000	17,500,000	71,400,000	17,976,199	3.97	0.79	4.86	9.63
3	Ogden Point	5,000,000	650,000	5,700,000	7,800,000	18,500,000	75,800,000	17,514,348	4.33	0.87	4.86	10.06
3	Royal Jubilee	1,300,000	400,000	500,000	500,000	2,300,000	9,400,000	1,975,535	4.74	0.95	4.86	10.55
3	Lang Cove	2,400,000	450,000	2,000,000	2,000,000	6,400,000	26,300,000	4,860,094	5.40	1.08	4.86	11.34
3	Juan de Fuca	3,600,000	550,000	3,900,000	5,300,000	12,800,000	52,400,000	8,548,928	6.12	1.22	4.86	12.21
3	Westhills	2,300,000	450,000	2,700,000	3,000,000	8,000,000	33,000,000	5,318,271	6.20	1.24	4.86	12.30
3	Windsor Park	1,400,000	400,000	1,800,000	1,600,000	4,800,000	19,500,000	3,066,739	6.34	1.27	4.86	12.47
3	Macaulay/McLoughlin	3,300,000	550,000	6,000,000	4,700,000	14,000,000	57,100,000	8,614,762	6.63	1.33	4.86	12.81
3	Royal Bay	2,400,000	450,000	4,400,000	3,200,000	10,000,000	41,000,000	4,518,283	9.08	1.82	4.86	15.76
3	Florence Lake	1,300,000	350,000	2,200,000	1,600,000	5,100,000	20,900,000	2,297,526	9.08	1.82	4.86	15.76
Total - Option 3		**32,200,000**	**5,500,000**	**35,800,000**	**39,800,000**	**107,800,000**	**441,000,000**	**84,321,888**	**5.23**	**1.05**	**4.86**	**11.14**

Notes:

(1) Heat recovery facility costs include effluent pump stations and piping from the proposed WWTFs to the HRFs.

(2) CRD costs include effluent pump station and piping to HRF

(3) Unit O&M cost estimated as 20% of capital cost.

KERR WOOD LEIDAL ASSOCIATES LTD.

O:\0700-0799\764-014\312-TechMemo_036DP2\DES\[Table6.xls]Sheet1

0.10/GJ in unit energy costs, with the exception of Macaulay/McLoughlin Option 1 at $0.37/GJ.

Electrical costs for operating the effluent pump stations typically amount to less than 1% of the energy recovered from the DES. The CRD would also be required to report the amortization expense of its capital assets (2% of capital cost/year). This equates to a unit energy cost of approximately $0.04-$0.10/GJ, with the exception of Macaulay/McLoughlin Option 1 at $0.28/GJ.

The total CRD cost to recover heat is therefore estimated at between $0.10/GJ and $0.20/GJ for Options 2 and 3, and upwards of $0.65/GJ for Option 1.

Analysis Results

Based on the analysis conducted, Option 1 is anticipated to have a significantly higher cost of energy recovery than Options 2 or 3. At approximately $16/GJ for Option 1, it may not be possible to provide a commercially viable opportunity for heat recovery with the proposed arrangement. This is attributable to the Macaulay/McLoughlin DES, which would involve transferring a large amount of treated effluent across the harbour to the James Bay/Downtown area at a significant expense. Because two-thirds of the heat energy would be concentrated at this facility, it has a dominant effect upon the energy cost for this option.

An alternative arrangement for Option 1 would be to only provide recovered heat to Esquimalt, and/or add raw wastewater heat recovery to the Clover Point sewer area. While this would likely permit a commercial energy opportunity, significantly less energy would be available for sale.

Options 2 and 3 present very similar unit energy costs at approximately $11/GJ, which is lower than natural gas and electricity costs for the Vancouver Island region. Notwithstanding the high cost of energy recovery for the Macaulay/McLoughlin Option 1 plant, Options 2 and 3 are expected to increase the amount of total heat energy that can be recovered. Of these, Option 3 is expected to provide largest amount of recovered heat at the lowest average unit cost.

The Saanich East DES was determined to have the lowest cost in all scenarios, primarily because the cost of integrating the recovered heat supply into UVic on the customer side has been omitted. UVic's heating systems are assumed to be complex, and integration of recovered wastewater heat into these systems goes beyond the level of detail required for this analysis, however the estimated energy costs could be compared with other sources in future feasibility studies.

The Macaulay/McLoughlin plant was estimated to consistently have higher energy costs as compared to other similar DES arrangements. This is at least partially attributable to the distance between the demand centres and the proposed WWTF location(s). The Royal Bay and Florence Lake DESs are noted to have similar unit energy costs and have similar distances between proposed plant locations and demand centres.

Sensitivity to Analysis Parameters

A detailed sensitivity analysis has not been performed at this stage of project planning. There are however, several key parameters in the analysis that could be adjusted to affect the cost of heat recovery:

- The temperature drop (8ºC to 11ºC) selected for this analysis is the maximum theoretical amount, however commercial heat pumps can generally only produce a 5ºC drop. The timing of treated effluent heat supply versus demands also needs consideration. The technical solutions to these specific issues could affect the cost of heat recovery, and should be explored further as more details of the treatment program are determined.
- The proposed financing model uses a relatively high discount rate, assuming this would be considered a high-risk commercial venture, and would transfer risk to potential customers/ratepayers through higher energy costs. Were the CRD or municipalities to provide financing, a municipal borrowing rates would reduce overall capital costs, albeit taxpayers would assume the ultimate risk burden. Assuming a 5% borrowing rate (2% net discount rate), the resulting unit energy costs are estimated to be approximately $3-4/GJ lower with municipal versus private financing.
- Phased construction of plants with low energy demand in the early stages of the project may reduce operating costs and would extend the life of the plants. A statistical relationship between capacity factor and energy cost could not be established in this analysis.
- Seasonal variations in heating demands and wastewater temperature will change the COP of the heat pump, and therefore the amount of electrical input required (refer to 036-DP-1, Technical Memorandum No. 3). The current analysis has assumed a COP of 3, which is conservative. A seasonal analysis would likely yield lower heat pump electricity costs than those estimated in this analysis.

Summary of Key Findings

The key findings of this analysis are summarized as follows:

- Option 1 (Regional Resource Recovery) is forecast to result in the lowest amount of recovered heat (65 million GJ), at the highest unit energy cost ($15.76/GJ) and highest capital cost for the CRD (est. $19.2 million). This option is considered to be the poorest choice for heat energy recovery.
- Option 2 (Regional/Local Resource Recovery) is forecast to recover 75 million GJ at a cost of $11.25/GJ, with a $3.25 million capital cost to the CRD.
- Option 3 (Local Resource Recovery) is forecast to recover 85 million GJ at a cost of $11.14/GJ, with a $5.5 million capital cost to the CRD.
- Options 2 and 3 are expected to provide a much higher likelihood of successful resource recovery than Option 1.

- The CRD's direct costs in heat recovery are estimated to be between $0.10/GJ and $0.20/GJ with the exception of the Macaulay/McLoughlin Option 1 plant.
- Individual plants with longer transmission distances have higher energy costs than those with short transmission distances.
- Additional costs will be associated with institutional customers in order to integrate the recovered heat energy into existing systems. These cannot be quantified without specific knowledge of the existing heating systems.
- A number of factors should be considered in further detail as plans progress, including but not limited to:
    - Design effluent and loop temperatures with respect to peak loading timing and optimization of the extraction of heat energy;
    - District cooling, energy sharing and secondary heat sources/sinks;
    - Financing models for future energy utilities;
    - Phasing of the construction of DES systems; and
    - Annual temperature variations and the effect upon heat production and electricity costs.

References

Associated Engineering. Discussion Paper 031-DP-6, "Heat Recovery", July 2008.

CH2M Hill. Discussion Paper 036-DP-1, Appendix A, Technical Memorandum No. 3 "Wastewater Heat Recovery – Options for Effluent Heat Recovery at Treatment Plants". October 2008.

CH2M Hill. Discussion Paper 036-DP-1, Appendix A, Technical Memorandum No. 5 "Wastewater Heat Recovery – Heating Options in Non-Plant Uses". October 2008.

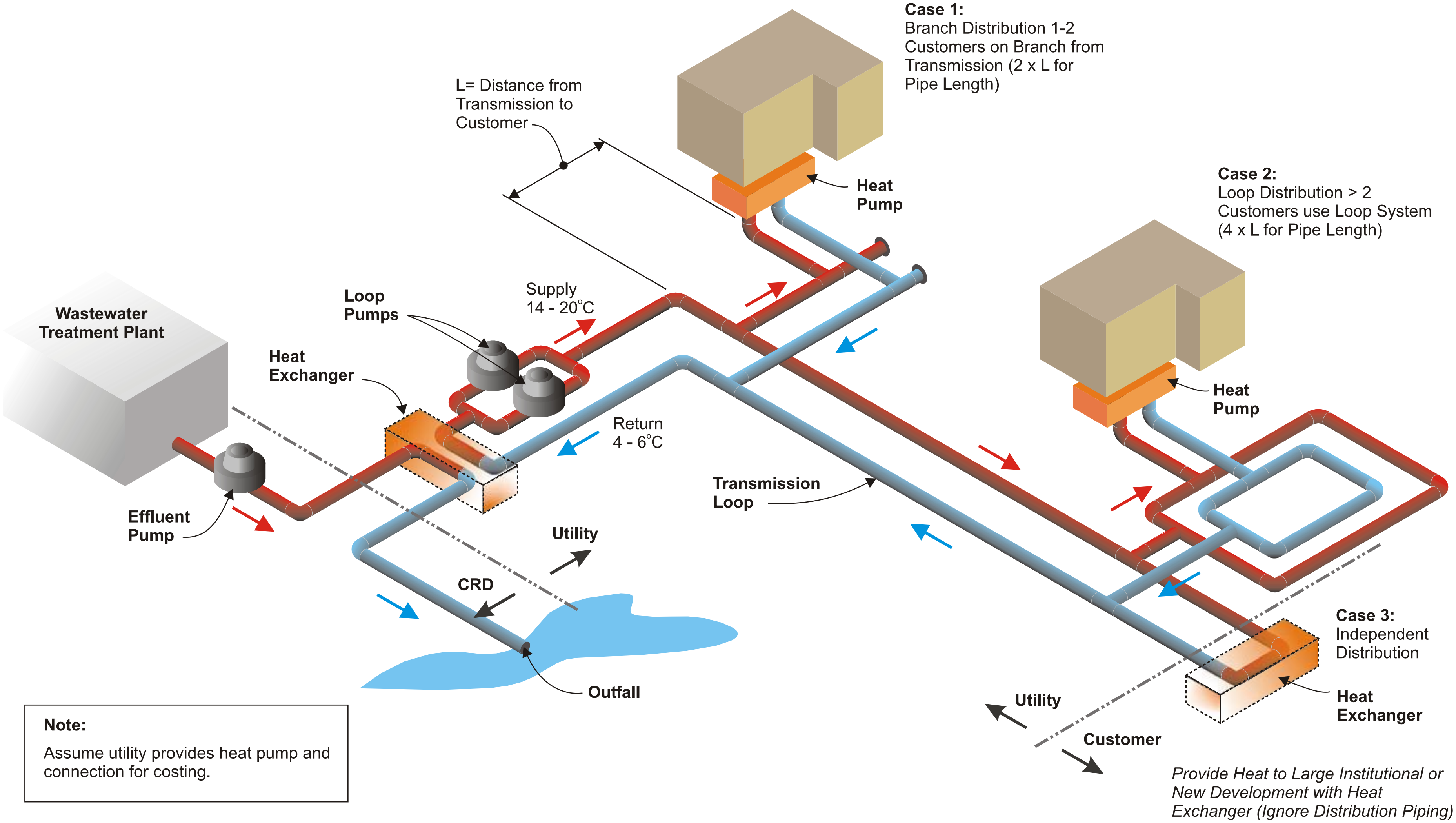
Kerr Wood Leidal Associates Ltd. Discussion Paper 036-DP-1, Appendix E, "Utilization of Recovered Heat from Municipal Wastewater". October 2008.

Kerr Wood Leidal Associates Ltd. Technical Memorandum for Discussion Paper 036-DP-2 entitled "Estimation of Saleable Recovered Heat Energy for Distributed Treatment Options". February 2009.

Personal Communication. Westlands Resource Group. October 15, 2008.

Personal Communication. William Vaughan, PEng, DEC Design Mechanical Consultants Ltd. February 6, 2009.

764-014\500-Drawings\764014Fig1.CDR



Note:

Assume utility provides heat pump and connection for costing.

KERR WOOD LEIDAL
associates limited
CONSULTING ENGINEERS

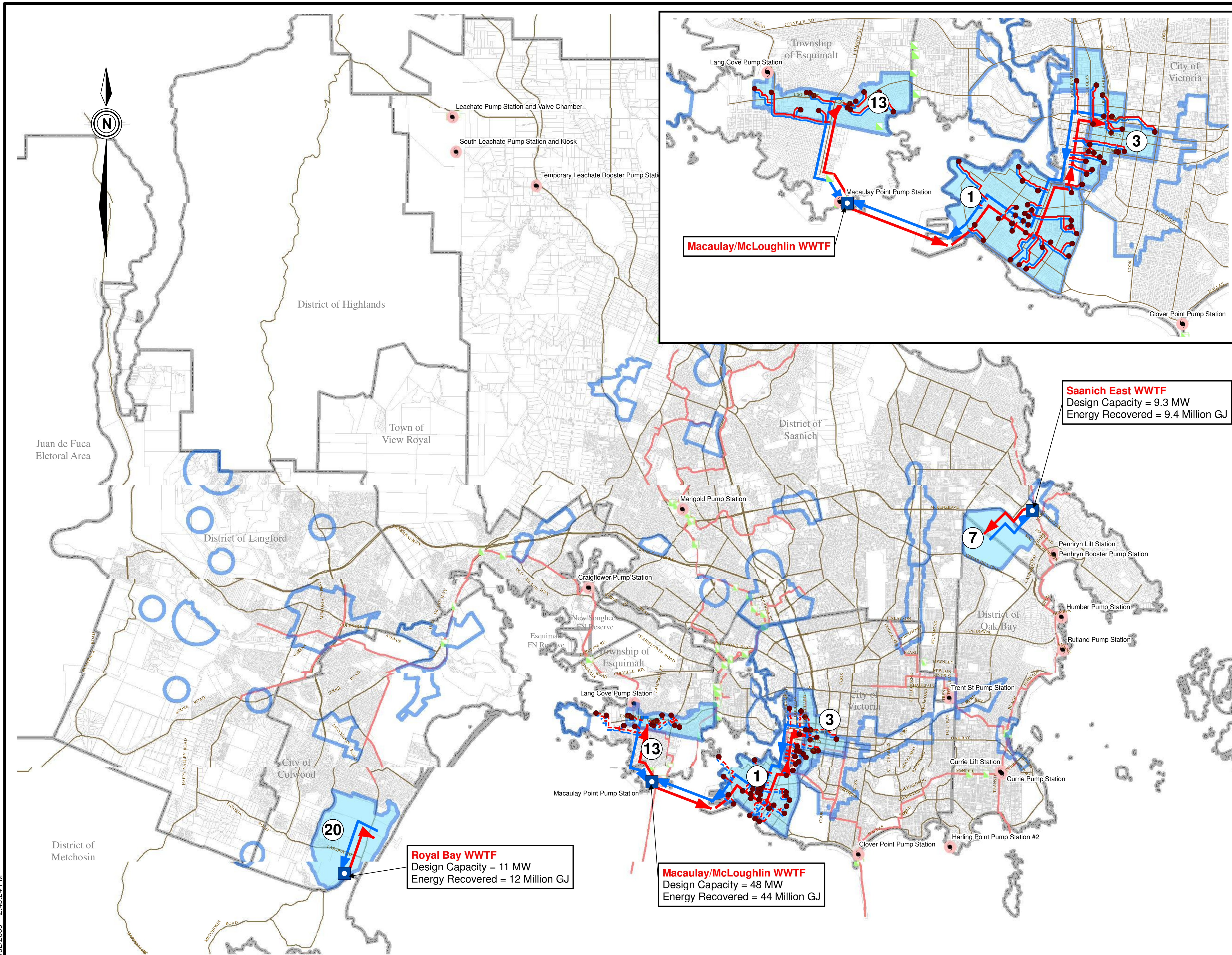
Core Area Wastewater Management Strategy

Project No.	Date
764-014	February 2009

N.T.S.

036-DP-2 District Energy System Concept

Figure 1



Capital Regional District
Core Area Wastewater Management Strategy

Legend

- Municipal Boundary
- Existing CRD Sewer Facility
  - Chamber
  - Pump Station
- Existing Trunk Sewer
- Proposed Boiler Connection
- Proposed Wastewater Facility
- Heat Demand Opportunity
  - Not Available for Option 1
  - Available for Option 1
- District Energy Distribution Main
- District Energy Transmission Main

KERR WOOD LEIDAL associates limited
CONSULTING ENGINEERS

2,000 0 2,000

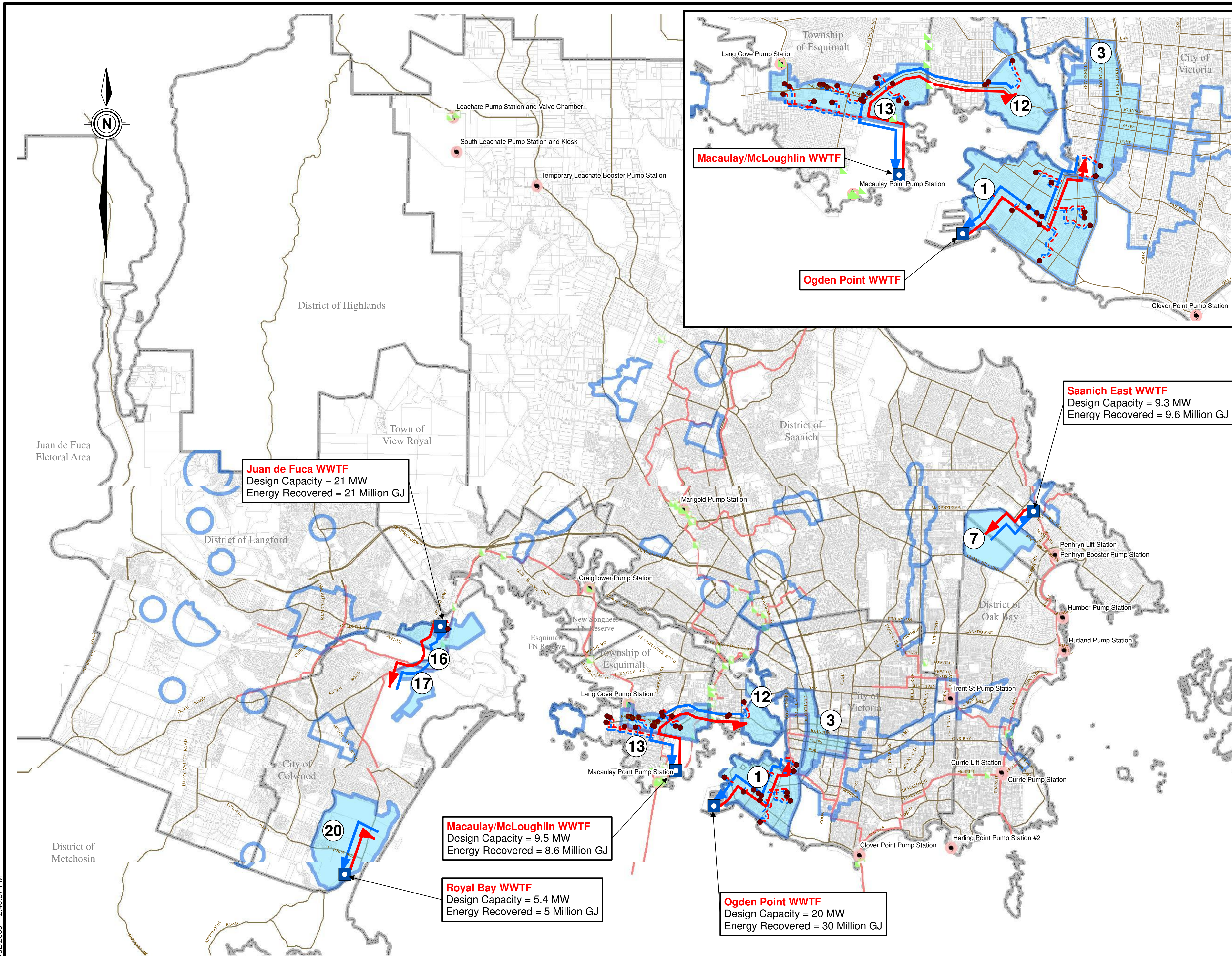
Scale in Metres 1:75,000

Project No.	Date
764-014	February 2009

Heat Recovery Concept Option 1

Figure 2

Map Document: (O:\0700-0799\764-014\430-GIS\MXD-Rp\036-DP-2\HeatRecoveryOption1_20090127.mxd)
04/02/2009 -- 2:49:24 PM



Map Document: (O:\0700-0799\764-014\430-GIS\MXD-Rp\036-DP-2\HeatRecoveryOption2_20090127.mxd)
04/02/2009 -- 2:49:37 PM

Capital Regional District
Core Area Wastewater
Management Strategy

Legend

- Municipal Boundary
- Existing CRD Sewer Facility
  - Chamber
  - Pump Station
- Existing Trunk Sewer
- Proposed Boiler Connection
- Proposed Wastewater Facility
- Heat Demand Opportunity
  - Not Available for Option 2
  - Available for Option 2
- District Energy Distribution Main
- District Energy Transmission Main

KERR WOOD LEIDAL
associates limited
CONSULTING ENGINEERS

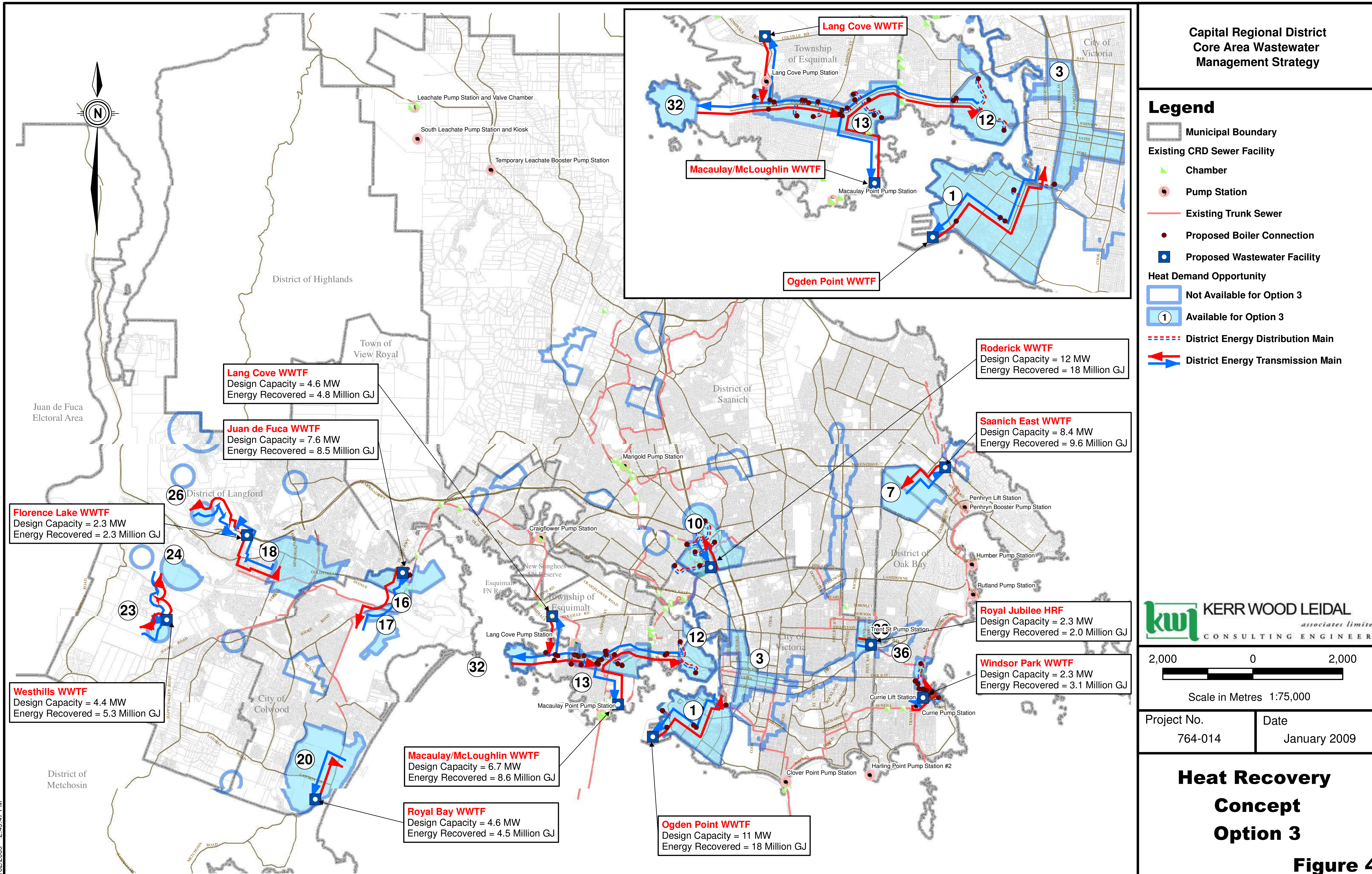
2,000 0 2,000

Scale in Metres 1:75,000

Project No.	Date
764-014	February 2009

Heat Recovery Concept Option 2

Figure 3



Capital Regional District Core Area Wastewater Management Strategy

KERR WOOD LEIDAL associates limited CONSULTING ENGINEERS

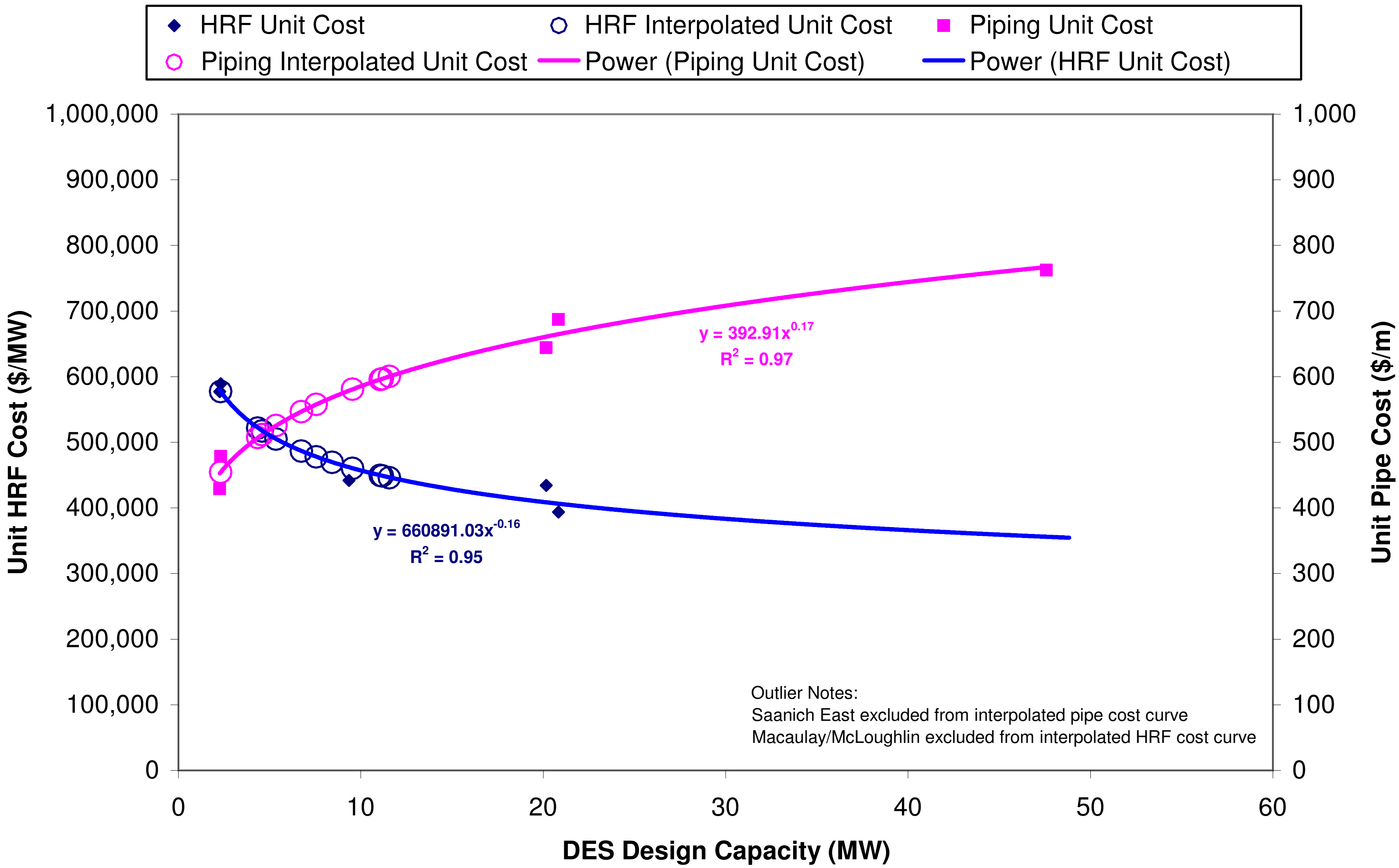
Project No.	Date
764-014	January 2009

Heat Recovery Concept Option 3

Figure 4

Map Document: (O:\0700-0799\764-014\430-GIS\MXD-Rp\036-DP-2\HeatRecoveryOption3_20090127.mxd)
04/02/2009 -- 2:49:47 PM

Figure 5
Unit Cost Curves for District Energy Systems



APPENDIX E - Reclaimed Water For Landscape Irrigation Table

Yellow-shaded cell denotes assumed/input value

Question: What fraction of ADWF generated by a WWTF could be used in the future for park and golf course irrigation?

Background Information: S. Young provided the following data for CRD Core area potable water use, as contained in leve1_study_area_water_use_summary_280109.xls, provided in his Jan 28/09 e-mail.

	Victoria / Esquimalt	Oak Bay	Saanich	Western Communities	Total
Golf courses (m3 in 2007) =	126,263	129,624	12,151	30,769	298,807
Parks (m3 in 2007) =	280,768	0	195,063	27,880	503,711
	407,031	129,624	207,214	58,649	**802,518**
2007 total potable water =	16,128,748	2,462,267	12,982,239	4,237,696	35,810,950
Fraction used for irrigation =	2.52%	5.26%	1.60%	1.38%	**2.24%**

Discussion: The first question is why would the 802,000 m3/yr number increase over time? This could happen only by the addition of new parks and golfcourses, plus the possible "conversion" of some entities from using non-CRD water (e.g. groundwater) to reclaimed effluent in the future. As shown in dnt_WW_load_analysis_ds.xls, KWL Projections (2), the total residential population is expected to grow from 271,000 people in 2005 to 438,00 people in 2065, which is a 62% increase. With higher density development in the future, the relative growth of parks and golf courses would not be expected to be proportional with the population growth. For the purposes of this analysis, assume they grow at a rate of 20% over this time frame. This value is consistent with the "outdoor watering projection" in the CRD's Water Use and Conservation Update 2008 (Figure 5). Thus the Year 2065 irrigation water demand would be 1.2 x 803,000 = 964,000 m3/yr. Including a climate-change allowance on irrigation demand, say **1,000,000 m3/yr**. Assume the Year 2015 value remains at about **800,000 m3/yr**.

The second question is how much of this irrigation demand would reclaimed water realistically satisfy? Proximity of WWTFs with parks and golf courses is a key consideration. Aerial photos indicate that much of the "green space" is well away from the coastal areas where the treatment facilities would typically be located. For Year **2015**, assume the following irrigation demands for the Options:

Option 1 = 800,000 m3/yr x 25% = 200,000 m3/yr
Option 2 = 20% more than Option 1 = 200,000 m3/yr x 1.20 = 240,000 m3/yr
Option 3 = 25% more than Option 1 = 200,000 m3/yr x 1.25 = 250,000 m3/yr

Now look to **Year 2065**. It would be reasonable to assume that there would be more future golf courses and parks in the Western Communities as this area is currently relatively undeveloped. In addition, some of the wastewater Options will have more practical opportunity to use reclaimed water given their proximity to reuse areas. Therefore, for Year 2065, assume the following irrigation demands for the Options:

Option 1 = 200,000 m3/yr x 10% = 220,000 m3/yr
Option 2 = 30% more than Option 1 = 220,000 m3/yr x 1.30 = 286,000 m3/yr
Option 3 = 40% more than Option 1 = 220,000 m3/yr x 1.40 = 308,000 m3/yr

OPTION AND WWTF

Option 1	**Year 2015 ADWF** (m3/d)	(m3/yr)	**Assumed Reuse Fraction**	**Annual Reuse Volume**	**Year 2065 ADWF** (m3/d)	(m3/yr)	**Assumed Reuse Fraction**	**Annual Reuse Volume**
Saanich East	16,125	5,885,625	0.50%	29,428	17,179	6,270,335	0.50%	31,352
South Colwood	11,750	4,288,750	0.50%	21,444	38,340	13,994,100	0.25%	34,985
Macaulay / McLoughlin	83,326	30,413,990	0.50%	152,070	87,483	31,931,295	0.48%	153,270
	111,201	40,588,365	0.50%	**202,942**	143,002	52,195,730	0.41%	**219,607**

Recommendations: Based on the above numbers, assume that the annual average relative fraction of ADWF used for irrigation is 0.50% for Saanich East, 0.25% for South Colwood, and 0.49% for Macaulay / McLouglin

Option 2	**Year 2015 ADWF** (m3/d)	(m3/yr)	**Assumed Reuse Fraction**	**Annual Reuse Volume**	**Year 2065 ADWF** (m3/d)	(m3/yr)	**Assumed Reuse Fraction**	**Annual Reuse Volume**
Saanich East	16,125	5,885,625	0.50%	29,428	17,179	6,270,335	0.50%	31,352
Ogden Point	38,561	14,074,765	0.69%	97,116	37,051	13,523,615	0.69%	93,313
South Colwood	1,582	577,430	3.80%	21,942	9,842	3,592,330	1.00%	35,923
Juan de Fuca	33,259	12,139,535	0.30%	36,419	55,780	20,359,700	0.20%	40,719
Macaulay / McLoughlin	21,675	7,911,375	0.70%	55,380	23,149	8,449,385	1.00%	84,494
	111,202	40,588,730	1.20%	**240,285**	143,001	52,195,365	0.68%	**285,801**

Recommendations: Based on the above numbers, assume that the annual average relative fraction of ADWF used for irrigation is 0.50% for Saanich East, 0.69% for Ogden Point, 1.00% for South Colwood, 0.20% for Juan de Fuca and and 0.85% for Macaulay / McLouglin.

Option 3	**Year 2015 ADWF** (m3/d)	(m3/yr)	**Assumed Reuse Fraction**	**Annual Reuse Volume**	**Year 2065 ADWF** (m3/d)	(m3/yr)	**Assumed Reuse Fraction**	**Annual Reuse Volume**
Saanich East	16,125	5,885,625	0.50%	29,428	15,147	5,528,655	0.57%	31,513
Windsor Park	14,433	5,268,045	0.10%	5,268	12,144	4,432,560	0.12%	5,319
Ogden Point	24,128	8,806,720	1.10%	96,874	20,089	7,332,485	1.30%	95,322
South Colwood	1,582	577,430	3.80%	21,942	8,253	3,012,345	1.20%	36,148
Westhills	2,410	879,650	0.20%	1,759	7,829	2,857,585	0.30%	8,573
Florence Lake	1,430	521,950	0.20%	1,044	4,066	1,484,090	0.30%	4,452
Juan de Fuca	7,802	2,847,730	1.20%	34,173	13,573	4,954,145	0.80%	39,633
Lang Cove	5,483	2,001,295	0.20%	4,003	8,244	3,009,060	0.60%	18,054
Roderick	24,604	8,980,460	0.10%	8,980	20,791	7,588,715	0.30%	22,766
Macaulay / McLoughlin	13,205	4,819,825	1.00%	48,198	12,105	4,418,325	1.05%	46,392
	111,202	40,588,730	0.84%	**251,670**	122,241	44,617,965	0.65%	**308,174**

Recommendations: Based on the above numbers, assume that the annual average relative fraction of ADWF used for irrigation is 0.53% for Saanich East, 0.11% for Windsor Park, 1.20% for Ogden Point, 1.30% for South Colwood, 0.30% for Westhills, 0.30% for Florence Lake, 0.90% for Juan de Fuca, 0.50% for Lang Cove, 0.20% for Roderick and and 1.05% for Macaulay / McLouglin.