# Final Report

## PEER REVIEW TEAM

***Capital Regional Districts***
***Core Area Wastewater Management Program***

***May 6, 2009***

# FINAL REPORT
# PEER REVIEW TEAM
# CAPITAL REGIONAL DISTRICTS CORE AREA
# WASTEWATER MANAGEMENT PROGRAM
**May 6, 2009**

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# SUMMARY

The Capital Regional District (CRD) in Victoria, BC is currently in the process of developing a ***Core Area Wastewater Management Program***. At the request of the Core Area Liquid Waste Management Committee (CALWMC) an external Peer Review Team (PRT) was formed. The purpose of the PRT and its principal observations and findings are summarized below. Additional details may be found in the body of this final report and in the attached appendices.

## PURPOSE OF PEER REVIEW TEAM

The purpose of the PRT was to:

1. Ensure that the planning process is comprehensive and consistent with the needs of the CRD and member municipalities.
2. Review the technical evaluations prepared by the consultants to the CRD.
3. Answer specific questions posed by CALWMC.

The PRT's observations and findings are derived from a review of the reports prepared by the consultants to the CRD, three review meetings held in Victoria with the consultants and the CRD staff, site visits to potential treatment plant sites and meetings with the CALWMC and the CRD Technical and Community Advisory Committee.

## PRT GUIDING PRINCIPLES

The PRT developed a set of guiding principles to assist in its evaluation of the programs and projects recommended by the consultants to the CRD:

1. Meet current and Future Regulatory Requirements
2. Maximize Potential Opportunities for Integrated Resource Recovery
3. Strive for Sustainability
4. Maintain Greater Flexibility for Future Options
5. Develop Facilities that Minimize Construction and Operating Costs
6. Encourage Upstream (Distributed) Water Reuse
7. Maximize Wastewater and Sludge Management Opportunities
8. Provide for Training and Education Opportunities
9. Avoid Sites that are Difficult to Permit
10. Strive to Eliminate Intermittently Operated Wet Weather Plants
11. Evaluate Programs and Projects Using Triple Bottom Line Analysis
12. Maximize Benefit to Ratepayer

## SERVICE AREA AND WASTEWATER CHARACTERISTICS

Population projections show the total connected equivalent population in the Core Area increasing from a current level of about 320,000 to about 420,000 by 2030, and to 600,000 by 2065. The expected rate of growth in the Macaulay catchment is much greater than that in the Clover Point catchment. The growth potential in the Clover Point catchment is through infill and densification while there is room for expansion in the Macaulay catchment.

The currently available wastewater quality data can be used for general process design but further data gathering and analysis should be undertaken before pre-design reports are commissioned for any of the new treatment plants.

## REGULATORY REQUIREMENTS

The treatment technology incorporated in the system options will meet the current Provincial and Federal effluent discharge and biosolids standards. Plant sites and plant layouts and hydraulic grade lines should be selected that allow flexibility for treatment plant modifications to incorporate improved technology and to meet potential future requirements such as limits on greenhouse gas emissions, removal of microconstituents such as endocrine disruptors, removal of phosphorus and nitrogen, and quantitative odour limits.

## IMPLEMENTATION CONSIDERATIONS

Some important implementation issues that must also be considered in the selection and implementation of the preferred option include resource recovery, staging of construction, siting of treatment plants, operability of wastewater management facilities, and greenhouse gas emissions.

### Resource Recovery

Wastewater is a potential resource for energy, nutrients for plant growth, and usable water.  Methane is a biofuel that can be generated from organic materials found in wastewater. The other major source of energy in wastewater is the heat energy of the water itself.  The principal nutrients in wastewater are nitrogen, phosphorus, and iron.  Capturing the potential resources in wastewater to help meet resource limitations and to enhance environmental goals such as reduction of greenhouse gas emissions should be an integral consideration in any wastewater management plan   However, a significant expenditure of funds and other resources such as energy are often needed to capture these resources. Thus, the environmental costs as well as benefits must be evaluated in assessing the feasibility of resource recovery from wastewater to determine which of the resources in wastewater provide environmental as well as economic benefit.

### Staging of Construction

Staging of construction for treatment facilities involves building treatment capacity in phases. Typically each phase of a major wastewater treatment plant is designed to provide capacity for the population growth projected to occur over the next 10 to 15 years. If the initial treatment plant is constructed with a capacity for a population projected for say 40 years, the result will be an acceleration of cash flow for construction and costs of maintaining facilities for many years before they are needed. Another disadvantage of not staging construction is the lack of flexibility to incorporate future improvements in treatment or resource recovery technology. If the required treatment capacity is achieved in appropriate stages, the initial capital investment and related interest payments will be reduced, maintenance of unused facilities will be eliminated, flexibility to use improved technology in the later stages of construction will be provided and future construction can be adjusted to match actual population growth.

### Siting Treatment Plants

The implementation plans for each of the Options should consider that the complexity and time to obtain public acceptance, obtain needed permits and acquire the sites will increase as the number of sites increases.

### Operability Considerations

The complexity of O&M increases significantly as the number of plants increases in a wastewater system. The number of potential failure points increases as the number of treatment plants and the number of pieces of equipment in the system increases. The complexity of maintenance and cost of maintaining an adequate inventory of spare parts increases substantially if there are a large number of plants with varying sizes of equipment. If the type of equipment differs from plant to plant, another layer of maintenance complexity is added. Adequately monitoring and controlling the treatment processes also becomes more complex as the number of plants increases.

### Greenhouse Gas Considerations

The PRT considered whether greenhouse gas production is an issue that should be considered in present treatment plant design or might in the future affect decisions on treatment, operation and maintenance costs. Information on this issue is still insufficient to reach definitive conclusions. Septic tank usage may come under greater control in the future because of greenhouse gas impacts. Any expansion of the use of septic tank systems should be questioned. Also, at centralized facilities, use of anaerobic digestion for biosolids treatment has favourable aspects for greenhouse gas reduction over biosolids incineration. Of course there are many other factors that must be involved in comparing options but greenhouse gas emissions and impacts need to be among the many factors considered in the Triple Bottom Line analysis.

## EVALUATION OF CONSULTANTS' PROPOSED ALTERNATIVES

The principal elements of the proposed alternatives are: (1) the wastewater treatment processes, (2) the solids management program and (3) costs and revenues from recovery and sale of resources.

### Wastewater Treatment Process

In their comparison of wastewater system options, the consultants used the membrane bioreactor (MBR) process as a representative wastewater treatment process for all treatment plants. The MBR process offers a small footprint needed for some plant sites. Although MBR will produce an excellent effluent quality for reuse, the MBR process will produce an effluent quality far superior to that needed for marine discharge. A conventional activated sludge plant (CAS) would meet marine discharge standards at lower cost and less energy usage. The portion of effluent from a CAS plant to be reused for irrigation or toilet flushing can be treated in a tertiary membrane or filter sized for only the reuse flow.

Using the MBR system to treat all of the flow requires 2.4 times the energy needed for the CAS alternative when considering the added energy associated with nitrification and with the operation of the membranes. In addition, the MBR process will likely require chemical addition to maintain an adequate alkalinity in the biological treatment portion of the process. The high energy demand of the membrane system and the consumption of chemicals to meet alkalinity needs are contrary to the interest in resource recovery and minimizing the carbon footprint of the CRD project. The PRT recommends that in subsequent pre-design work, MBR technology should not be used indiscriminately in all cases for wastewater treatment. It will be better from a greenhouse gas effect and operating costs to use the MBR technology where the only sites available have very limited space and where a high percentage of the plant effluent will be reclaimed water for reuse.

The PRT supports the approach and process design for the Saanich East facility. It will provide an example of technology and resource recovery methods for future satellite plants that fit into trends in market demand. Treating flow at a Saanich East plant will remove flow thus relieving downstream sewers whose capacity is sometimes exceeded in wet weather. It will also eliminate two steps of downstream pumping of the Saanich East flows.

### Biosolids Management

Both the PRT (see the earlier PRT report of preliminary findings) and the consultants do not recommend anaerobic digestion of combined organic solid wastes and wastewater sludge. Separation of treatment and resource recovery for these two different waste materials minimizes problems with transporting materials to the same site, allows for independent operation and optimization of the separate treatment systems, and allows flexibility for the use of different technologies for each type of waste and easier response to future technology improvements in each area.

In the consultants' recommended strategy, sludges would be anaerobically digested with 50% of the digested biosolids dried and used as a fuel supplement at a cement kiln in the Lower Mainland. The other 50% would be applied to a dedicated willow coppice created on an industrial land application site for the periodic harvesting of wood chips as a saleable product.

Anaerobic digestion is an appropriate choice for sludge processing as it is an efficient way to produce energy from wet sludge, to reduce solids mass, and to provide pathogen destruction. However, the PRT suggests that the choice of thermophilic digestion be reconsidered. Mesophilic digestion has a lower capital cost, and results in more net energy recovery. If the ultimate disposal options are controlled-access forest land or forest tree farming, combustion or drying/cement kilns, mesophilic digestion is adequate. Thermophilic digestion was suggested by the consultants primarily because it was thought it would ease public acceptance of land application of biosolids. However, thermophilic digestion will be more costly. A public education effort on the acceptability of mesophilic digestion for controlled-access land application should be considered.

The PRT agrees that upgrading biogas for use as pipeline biomethane or as a motor fuel is a reasonable option for consideration but this should be compared to the economics of its use in a cogeneration facility for directly satisfying the energy needs at the treatment plant.

The practice of applying biosolids to a willow coppice is by no means widespread. The PRT recommends a pilot-scale program to verify the feasibility of this disposal option. The proposed willow coppice program would require 600 hectares of dedicated land for biosolids application over a 21-year period. If property owners are not willing to lease their land to the CRD then the CRD may have to purchase sufficient suitable land. No allowance for land costs has been included in the consultants' estimates. Assuming a cost of $100,000 per hectare, the acquisition cost for the 21-year supply of land for the willow coppice would be $60 million. The availability of suitable land of this area reasonably close to the Core Area is doubtful. As greater travel times are needed to reach suitable sites, both the cost and the process carbon footprint will increase. Also as distance from the Core Area increases, the relatively moderate rainfall experienced in the Core Area approximately doubles. Such conditions may severely hamper the ability to access land for application of biosolids, particularly during the wettest period from October to March.

In view of the uncertainties associated with a long term cement kiln option and a willow coppice program to be managed by the CRD, the PRT recommends that a back-up alternative also be included in the biosolids management plan. Such an alternative would likely include a landfill for the near term and possibly a future thermal energy recovery system for biosolids and solid wastes.

The PRT also recommends a risk analysis of the cement kiln fuel supplement option be conducted in regard to worker and public health.

**Costs**

The PRT agrees with the consultants' conclusion that treatment and overall system costs will increase as the number of treatment facilities increases from the three secondary treatment plants included in Option 1 to a greater number of smaller plants included in Options 2 and 3.

The estimates developed by the consultants for the treatment plants in each option generally fall within the range of costs experienced at other similar treatment facilities and are reasonable for purposes of comparing system options. The CRD and the public should be aware that the consultants' estimate of cost will be refined and will change during pre-design and design. These changes may result in either an increase or decrease in the estimated cost. Cost will remain an estimate until the actual bids are received. Estimates made during this preliminary planning phase of this project are generally considered to have an accuracy range of –15% to +30%.

**Revenue from Recovery and Sale of Resources**

The PRT agrees with the consultants' conclusion that the value of the resources potentially recovered from wastewater handing and treatment is far less than the cost of the collection and treatment systems used to produce those resources. That is, wastewater collection and treatment will not be a profit making venture.

The consultants are commended for their thorough analysis of the technology for heat recovery and markets for the potential use of the thermal energy. However, the PRT believes that the projected revenues for the sale of heat are optimistic with respect to: (1) efficiency of existing commercially available heat pumps (2) the willingness of purchasers to provide the necessary infrastructure to utilize the heat effectively (3) the price buyers will be willing to pay for heat given infrastructure costs for making use of that heat compared with that for alternative energy sources including heat pumps using air as a source of heat and (4) the cost to provide a standby source of heat to account for anticipated service interruptions, which are unavoidable.

Similarly, the assumed value for the sale of reclaimed water is optimistic with respect to: (1) the purchase of reclaimed water that is only needed seasonally and would require storage to utilize effectively; (2) the willingness of purchasers to provide the necessary infrastructure to utilize the reclaimed water, especially to convey the reclaimed water through property they may not own; and (3) the price they are willing to pay for reclaimed water given that a separate distribution system and storage facilities to utilize the reclaimed water effectively would be needed.

### Staging

The staging of construction in Options 1, 2 and 3 is limited to about 4-6% of the total treatment plant construction required to serve the area until 2065. Since 42% of the population growth is projected to occur after year 2030, this staging would result in facilities being built before they are needed. Also, there is no proposed staging of the Hartland biosolids facility. The PRT recommends that the subsequent predesign effort develop a staging approach that better matches the growth in population served.

## FINDING ON REVENUES AND BASIS FOR COMPARING COSTS OF OPTIONS

In Options 2 and 3 the wastewater treatment and resource recovery facilities are distributed over a larger portion of the service area to provide greater revenues from resource recovery. Even using optimistic estimates of revenues, the incremental cost of using the more distributed wastewater treatment systems in Options 2 and 3 are 5-6 times greater than the incremental revenue generated when compared to Option 1. That is, the CRD would spend $5-$6 dollars in a more distributed system to generate $1 in resource recovery revenues. Also there is no assurance that revenues from resource recovery will materialize. Potential revenues will not become assured revenues until signed contracts with purchasers are in hand. On the other hand, costs for wastewater conveyance and treatment will assuredly be incurred. Therefore, the PRT strongly recommends that the cost of the proposed wastewater alternatives be compared on the basis of wastewater conveyance and treatment costs without the inclusion of potential revenues. The potential for resource recovery could be included as a factor in the scoring of social benefits in the Triple Bottom Line analysis.

## BUILDING BLOCKS TO COMPARE ALTERNATIVES

Decision making by the Core Area Liquid Waste Management Committee (CALWMC) may be eased if the information on the current system options were supplemented with comparable information on a wastewater treatment system capable of meeting the essential requirements of the BC Municipal Sewage Regulation irrespective of providing opportunities for resource recovery. With such information in hand, the options for providing wastewater treatment and resource recovery could be presented in a hypothetical “building block” fashion to facilitate comparisons and enable value judgments based on costs, revenues and non-economic benefits. Material already developed on capital and operating and maintenance costs, potential revenues, and corresponding social and environmental benefits could be assembled to create hypothetical “building blocks” for water reclamation and reuse, recovery and sale of thermal energy, generation and sale of biomethane and recovery and sale of magnesium ammonium phosphate.

## PEER REVIEW TEAM SUGGESTED ALTERNATIVES

Based on a review of materials provided by the CRD and the consultants, the PRT has developed two suggested alternative versions of Option 1 for consideration by the consultants and the CALWMC. PRT concerns about the McLoughlin site led to the development of these alternatives. The variations of Option 1 described in this section are offered as examples. There are no doubt other variations potentially involving conveyance system modifications and other treatment plant locations that should be considered as refinements of Option 1 are further developed.

### McLoughlin Site Concerns

The McLoughlin site is extremely small for the size of the recommended treatment plant to be located there. It will require the use of compact and more expensive MBR treatment technology. The site will require full buildout to the fence line limiting options for the future installation of other treatment or resource recovery facilities. Part of the plant must be excavated into rock and then covered further adding cost. It requires filling in a portion of Victoria Harbour. Part of the site has been used as a bulk oil terminal and there likely will be issues relating to contaminated soil and near shore sediments. The site is prominently visible from the entrance to the harbour, from cruise ship wharves and the heliport terminal. Negotiations with property owners and other agencies must be successfully completed.

The PRT has other serious reservations about the McLoughlin site that are enumerated in Section 6. Resolving these issues will entail a major and possibly prolonged effort. Before proceeding too far down the path of trying to resolve these issues, it would be prudent to ensure that the facilities currently proposed for the McLoughlin site can be accommodated on the site in a reasonable and satisfactory manner. The PRT recommends that further development of the conceptual engineering work be done to confirm the feasibility of the site for the intended purpose.

### Wastewater System Alternatives

A larger, adequately sized treatment plant site would provide more flexibility in choice of the treatment process, for easier staging of treatment facilities, more flexibility for future resource recovery and more flexibility for compliance with future treatment regulations. Because of concerns the PRT has about the McLoughlin site, the PRT considered two variations of Option 1 involving other possible locations for the major centralized treatment facility in Option 1.

### Potential Alternatives to McLoughlin Site

Should it become available, the Macaulay site should be evaluated. However, the PRT understands the focus has been on the McLoughlin site because it is believed that the Macaulay site cannot assuredly be available in time to meet the regulatory deadlines. Another possible site for the centralized treatment plant is located at the gravel pit area in the western portion of the CRD. Adequate land is available at this site for other more economical treatment options than are compatible with the McLoughlin site and to provide greater flexibility for future modifications. The PRT suggested two additional variations of Option 1, Options 1B and 1C. The original Option 1 is now called Option 1A.

**PRT Option 1B**

In Option 1B, the major secondary treatment plant for the first stage of the project would be located at the gravel pit site on the western shore rather than at McLoughlin Point. The gravel pit site is much larger than the McLoughlin site. The West Shore plant could be a conventional, high rate non-nitrifying activated sludge plant rather than a plant at McLoughlin using the more energy intensive and more costly MBR technology. The small footprint of the MBR process is necessary to fit a plant on the McLoughlin site. The plant at the gravel pit site could also incorporate conventional primary clarification rather than chemically-enhanced primary clarification. An underwater pipeline would be used to convey two times average dry weather flow from the east service area to the gravel pit site.

**PRT Option 1C**

In Option 1C, the major secondary treatment plant for the first stage of the project would also be located at the West Shore gravel pit site rather than at McLoughlin Point. The West Shore plant would use the same treatment processes as in Option 1B. All treatment facilities for wet weather flows of two to four times dry weather flow would be located at the West Shore gravel pit site and the intermittently operated treatment facilities for these wet weather flows at Macaulay and Clover Point would be eliminated. An underwater pipeline would be used to convey four times average dry weather flow to the West Shore gravel pit site from Macaulay Point.

**Analysis of Options 1B and 1C**

The PRT identified several potential advantages for Options 1B and 1C that are enumerated in Section 6 of this report. The consultant team has estimated that the capital costs of 1B and 1C are 6-9% more than 1A and the present worth costs are 5% to 8.5% more than 1A. At this preliminary planning phase of the project, cost differences of less than 10% are not significant. Options 1A, 1B and 1C should be considered equivalent in cost. The opportunity for staging treatment plant construction in Options 1B and 1C offers the potential to reduce the initial capital cost of the project by $180 to $200 million. The PRT recommends that the analysis of economic, social and environmental aspects of Options 1A, 1B and 1C be continued through the Triple Bottom Line Analysis.

## Biosolids Alternative

The PRT is concerned that there is no back-up strategy if and when either or both of the willow coppice and cement kiln markets become unavailable due to reasons beyond the control of the CRD. The PRT recommends that the CRD develop a third backup biosolids alternative designed to process 100% of the biosolids. This backup method should not rely wholly on external markets. Candidate processing technologies for consideration for this third option could include anaerobically digested sludge dewatering and ultimate disposal in dedicated monofill cells at Hartland, fluidized bed incineration of the sludge with electricity generation and landfilling of the incinerator ash residue, and a combined solid wastes/biosolids thermal energy recovery system.

Because of the larger West Shore plant site in Options 1A and 1B, all of the biosolids processing could occur at the West Shore site. This provides an opportunity to ship dried biosolids via barge to the cement kilns in the lower mainland rather than hauling the biosolids to Hartland for drying and trans-shipment by truck. The only dewatered biosolids hauled by truck would be those to be applied to the willow coppice lands. The barging and direct hauling to land application may provide opportunities for reduced operating costs.

## Staging

Options 1B and 1C have the potential to achieve a greater degree of staging of construction of wastewater treatment capacity than Option 1A. Also, about 25% of the biosolids processing capacity could be deferred until about 2035.

## METHODS FOR PROJECT ALTERNATIVE ANALYSIS

The Triple Bottom Line (TBL) analysis is an accepted approach for assessing the relative merits of several competing development paths for a project and many jurisdictions have adopted it for broad use. The three principal elements of a TBL analysis are: (1) environmental, (2) social/community, and (3) economic issues. For municipal infrastructure projects which usually do not have a net payback, it is possible to separate the economic aspects from the non-economic issues and arrive at a quotient that is a measure of the "value" of an alternative development path by dividing scores for the non-economic criteria by the cost for a given development path. The value quotient is computed using the following expression:

$$\text{Value} = \frac{\text{Environmental Issues Score} + \text{Social \& Community Issues Score}}{\text{Cost}}$$

At the time of this report, the TBL had not been completed by the CRD and its consultants. A workshop to begin work on the TBL was held with the CRD in late March and other TBL workshops are scheduled for late April and May. The results of these workshops will be used to select one of the system approaches represented by Options 1, 2 and 3. If Option 1 is selected, the PRT recommends that another TBL be conducted for Options 1A, 1B and 1C and another for the biosolids management options. The PRT suggests some evaluation criteria that could be used for comparing Options 1A, 1B and 1C and recommends that an independent, neutral facilitator lead the TBL workshops.

## ANSWERS TO CRD QUESTIONS

At the initiation of the PRT effort, the CRD provided a list of questions for the PRT to address. The PRT responses are found in Appendix D of this report.

## PRT RECOMMENDATION

Based upon consideration of the relative costs, system operability, system reliability, probable resource recovery and the preliminary TBL Analysis conducted by the consultants and the CRD, the PRT recommends that Option 1 be carried forward for further development and more detailed evaluation including consideration of the alternative configurations of Option 1A, 1B and 1C. Other variations of Option 1 may arise during this subsequent evaluation.

# 1
# INTRODUCTION

The Capital Regional District (CRD) in Victoria, BC is currently in the process of developing a ***Core Area Wastewater Management Program.*** At the request of the Core Area Liquid Waste Management Committee (CALWMC) an external Peer Review Team (PRT) was formed. This final report contains the PRT observations, analyses and findings. Supporting information is included in several appendices.

## PURPOSE OF PEER REVIEW TEAM

The purpose of the PRT was to:

1. Ensure that the planning process is comprehensive and consistent with the needs of the CRD and member municipalities.
2. Review the technical evaluations prepared by the consultants to the CRD.
3. Answer specific questions posed by CALWMC.

The PRT's observations and findings are derived from a review of the reports prepared by the consultants to the CRD, three review meetings held in Victoria with the consultants and the CRD staff, site visits to potential treatment plant sites and meetings with the CALWMC and the CRD Technical and Community Advisory Committee.

## PRT MEMBERSHIP

The PRT is comprised of seven members:

Gordon Culp (Chair)
Perry McCarty
Bill Oldham
Norbert Schmidtke
David Stensel
George Tchobanoglous
Warren Wilson

The PRT members were selected to represent a broad range of disciplines and experience. Brief biographies of the PRT members may be found in Appendix A. Because of scheduling conflicts, Dr. Schmidtke participated in only the initial phases of the PRT work that preceded the preparation of this report.

## MEETING SCHEDULE

The first PRT meeting was held on February 12 and 13, 2009 at the offices of the CRD in Victoria. The second PRT meeting was held on March 11, 12, and 13, 2009, also at the offices of the CRD in Victoria. The third meeting of the PRT was held on April 22, 23, and 24, 2009 at which time further discussions with CRD and the consultants about the options under consideration were held and work began to finalize this report.

## MEETING AGENDAS AND SUMMARIES

The agenda and summary notes for the first PRT meeting may be found in Appendix B. The first meeting included presentations by the consulting team and by the authors of the Integrated Resource Management (IRM) Report and discussions with the presenters. The PRT also toured portions of the service area. Based on the supporting material reviewed by the team members and the presentations, the PRT prepared and submitted a report titled ***Peer Review Panel Preliminary Findings,*** dated February 27, 2009***.***

The agenda and summary notes for the second PRT meeting may be found in Appendix C. The second meeting involved meeting with CALWMC on March 11, 2009, to discuss and answer questions related to the PRT's preliminary findings. The PRT also toured portions of the western service area in the afternoon of the first day. The PRT met with the consulting team in the morning of the second day. The afternoon of the second day and the morning of the third day were spent discussing and reviewing elements of the program. Based on the discussion and review of the program, the PRT developed the outline for this draft report and prepared and submitted to the CRD an ***Interim Report,*** dated March 16, 2009. The ***Interim Report*** was developed to suggest additional system options and to request that the consulting team provide answers to specific questions.

The agenda and summary notes for the third PRT meeting may be found in Appendix I. The third meeting involved meeting with CALWMC on April 22, 2009 to present and discuss a draft of this report. The PRT also met with the Technical and Community Advisory Committee to present and discuss the draft of this report. The PRT met with the consulting team and the CRD staff to discuss the draft report, to discuss a list of questions that the PRT had forwarded to the CRD and to review ongoing work by the consultant team. The PRT also toured the industrial area that has been suggested by the consultant team as a potential location for anaerobic digesters to process biosolids should a treatment plant be located at the McLoughlin Point site. The balance of the third meeting was spent in work sessions in which material for this final report was discussed and prepared.

## REPORT ORGANIZATION

This report of the PRT has been organized into the following sections:

1. Introduction
2. Goals and Guiding Principles
3. Service Area Characteristics
4. Implementation Considerations
5. Evaluation of Proposed Alternatives
6. Peer Review Suggested Alternative
7. Methods for Project Alternative Analysis

The organization of the report is designed to meet the terms of engagement for the PRT. The goals and guiding principles (Section 2) define the basis for evaluating the proposed and recommended plans. The service area characteristics (Section 3) are briefly described to define the demographic, topographic, environmental, and economic issues that must be dealt with in any of the proposed plans and to provide background to some of the recommendations that arise later in this report. Considerations related to implementation of the wastewater management plan are examined in Section 4. The alternatives proposed by the CRD's consultants are reviewed in Section 5. The PRT's suggested system alternatives are described in Section 6. The PRT review of the Triple Bottom Line analysis in which the social and environmental benefits for each alternative are balanced against the economic performance and impacts to ratepayers is presented in Section 7.

# 2
# GOALS AND GUIDING PRINCIPLES

The ***Core Area Wastewater Management Program*** (CAWMP) involves: (1) the plan for the immediate measures and projects that must be implemented to meet the Provincial government's mandate that secondary treatment be provided for the seven core municipalities service area by the end of 2016, and (2) a vision of the future that will sustain the vital services of wastewater management in the context of integrated resource management. In developing a management program plan, it is of critical importance to define the overall goals of the program and the guiding principles that will be used to evaluate the implementation of specific projects designed to meet the management program goals

## GOALS FOR THE CORE AREA WASTEWATER MANAGEMENT PROGRAM

The goals for the CAWMP established by the CRD Board are:

1. Protect public health and the environment
2. Manage wastewater in a sustainable manner
3. Provide cost effective wastewater management

## GUIDING PRINCIPLES FOR PEER REVIEW OF THE CORE AREA WASTEWATER MANAGEMENT PROGRAM

Complementary to the management program goals, a series of guiding principles is needed to ensure that specific programs and projects, developed during the planning process, are consistent with the program goals. The guiding principles must reflect the vision that the public (ratepayers) and the CRD have for the wastewater collection, treatment, and dispersal facilities. The PRT developed a set of guiding principles to assist in its technical evaluation of the programs and projects recommended by the consultants to the CRD.

### 1. Meet Current and Future Regulatory Requirements

The proposed wastewater treatment facilities must meet current and proposed regulations, and strive to improve the quality and reduce the quantity of minimally treated stormwater so that adverse effects are diminished.

### 2. Maximize Potential Opportunities for Integrated Resource Recovery

Wastewater treatment plants should be designed and located to the degree practical so as to be compatible with potential resource recovery.

### 3. Strive for Sustainability

The program should promote environmental stewardship that includes the sustainable use of natural resources and the application of integrated resource management principles.

### 4. Maintain Greater Flexibility for Future Options

Treatment plants sites should provide flexibility for meeting potential future as well as present regulatory requirements regarding ocean disposal, as well as future resource recovery facilities needs.

### 5. Develop Facilities that Minimize Construction and Operating Costs

Wastewater treatment processes should be selected that will meet the present, but with flexibility to address potential future Provincial and Federal treatment requirements and that are compatible with resource recovery while minimizing construction and operating costs.

### 6. Encourage Upstream (Distributed) Water Reuse

Larger regional treatment plants should be located so that the opportunity to implement satellite (distributed) plants in various parts of the service area for better resource recovery is preserved. Excess biosolids from such satellite water reclamation plants might then be transmitted through the collection system to the regional plant for sludge processing. Unused reclaimed water could similarly be conveyed to the regional plant in case of satellite system failure or other needs.

### 7. Maximize Wastewater and Sludge Management Opportunities

Treatment plant sites should preferably be large enough to allow for expansion and modification to better meet future liquid and sludge management opportunities and requirements.

### 8. Provide for Training and Education Opportunities

To the extent possible, treatment plants should be designed to allow for training and research opportunities.

### 9. Avoid Sites that are Difficult to Permit

Sites that involve especially difficult permitting and implementation issues should be avoided because such sites may delay the implementation of the mandated secondary treatment facilities.

### 10. Strive to Eliminate Intermittently Operated Wet Weather Plants

Seek to find solutions that will eliminate wet weather treatment facilities that will only be operated a few days per year. Often times, immediately placing such facilities into service when a storm occurs is problematic.

### 11. Evaluate Programs and Projects Based on the Triple Bottom Line

Use the triple bottom line concept in which social and environmental impacts are balanced against economic performance and impacts to ratepayers in evaluating the value of proposed programs and projects.

### 12. Maximize Benefit to Ratepayer

Every effort and means should be made to apply the Guiding Principles in a manner that provides the highest value to the ratepayer.

# 3

# SERVICE AREA CHARACTERISTICS

This short review of the service area characteristics is included to provide background to some of the recommendations that arise in later sections of this report. The discussion includes aspects of the physical development of the existing collection and disposal system, an overview of possible candidate sites for construction of wastewater treatment facilities, some of the more important wastewater characteristics, plus a brief review of Provincial and Federal regulatory activities.

## EXISTING INFRASTRUCTURE

As outlined by the District's consultant in the report entitled "The Path Forward", the Core Area program involves the geopolitical entities of Langford, Colwood, View Royal, Esquimalt, Saanich, Oak Bay, and Victoria. The serviced portions of this Core Area have the dry weather wastewater flows directed to either the Clover Point outfall or the Macaulay Point outfall. At both locations, the wastewater is screened prior to ocean discharge. During stormflow events there are numerous overflow points (predominantly in the Clover catchment) in the collection system that allow the flows in excess of the system capacity to be discharged directly to the ocean or to Gorge waterway through a number of relief outfalls. In general, Victoria, Oak Bay and the eastern third of Saanich discharge dry weather wastewater flows to the Clover point outfall, while the rest of the developed part of the Core Area is potentially tributary to the Macaulay Point outfall. In the Path Forward report it was noted that the current (2005) connected equivalent population of about 320,000 is split 50:50 between the two major outfalls.

## POPULATION PROJECTIONS

In the same report (The Path Forward), the total connected equivalent population in the Core Area is projected to increase to about 420,000 by 2030, and to 600,000 by 2065. The expected rate of growth in the Macaulay catchment is much greater than that in the Clover Point catchment, as the only growth potential in the Clover Point catchment is through infill and densification, whereas there is room for expansion in the Macaulay catchment. Because these projections originate from planning exercises in each of the member municipalities, there is no apparent justification for questioning them.

## POTENTIAL WWTP SITES

The CRD is currently considering 12 potential sites for the construction of new wastewater treatment facilities in addition to the installation of new treatment processes to augment the existing preliminary treatment systems at Macaulay Point and Clover Point and the disposal facilities at the Hartland Landfill.

## WASTEWATER CHARACTERISTICS

It is important to have good information on existing wastewater characteristics so that a reasonable assessment can be made about what treatment processes can be expected to produce satisfactory effluent quality for any of the possible dispersal/reuse options considered. Wastewater data provided the CRD have been reviewed to provide that assessment.

### Wastewater Quality

The wastewater quality data mentioned above have been analyzed in two groupings: dry-weather and wet weather flow rates. The wastewater characteristics, considered important to the PRT's assignment, are presented in the following two tables. The only constituent that appears somewhat abnormal is the ratio of dissolved BOD to total BOD, which is above 33% for both dry weather flow (DWF) and wet weather flow (WWF). However, the difference is marginal when compared to the general North American experience.

**Table 3-1 Clover Point Wastewater Constituent Concentrations[a]**

| | Average (mg/L) | | Std Deviation (mg/L) | |
|---|---|---|---|---|
| | DWF | WWF | DWF | WWF |
| TSS | 159 | 149 | 52.6 | 92.8 |
| VSS | 142 | 139 | 43.8 | 44.1 |
| BOD tot | 205 | 157 | 58.6 | 59.3 |
| BOD diss | 74.0 | 54.8 | 34.2 | 23.9 |
| TKN tot | 38.6 | 27.6 | 5.8 | 6.8 |
| TKN diss | 30.8 | 21.4 | 4.3 | 4.9 |
| NH3-N tot | 25.4 | 21.2 | 3.5 | 4.6 |
| NH3-N diss | na | 14.8 | na | 4.5 |
| Alk-as CaCO3 | 144 | 151 | 37.1 | 28.8 |
| P tot | 5.71 | 3.64 | 1.34 | 1.15 |
| P diss | na | 2.08 | na | 0.82 |

[a] Constituent concentration data obtained between August 21 and September 6 2008 for the DWFs, and between January 4 and February 16, 2008 for WWFs

**Table 3-2 Macaulay Point Wastewater Constituent Concentrations[a]**

| | Average (mg/L) | | Std Deviation (mg/L) | |
|---|---|---|---|---|
| | DWF | WWF | DWF | WWF |
| TSS | 194 | 186 | 52.3 | 113 |
| VSS | 166 | 175 | 52.1 | 101 |
| BOD tot | 239 | 160 | 64.2 | 42.5 |
| BOD diss | 82.8 | 53.8 | 40.7 | 20.1 |
| TKN tot | 47.1 | 42.0 | 6.49 | 9.68 |
| TKN diss | 36.4 | 33.8 | 4.82 | 6.75 |
| NH3-N tot | 32.0 | 33.3 | 4.32 | 6.15 |
| NH3-N diss | na | 27.1 | na | 7.04 |
| Alk-as CaCO3 | 174 | 245 | 20.0 | 63.0 |
| P tot | 6.97 | 4.33 | 1.22 | 1.30 |
| P diss | na | 2.28 | na | 0.91 |

[a] Constituent concentration data obtained between August 21 and September 6 2008 for the DWFs, and between January 4 and February 16, 2008 for WWFs

## Wastewater Flow Rates and Variations

Flowrate data for the same periods of time as covered in Tables 3-1 and 3-2 are summarized in Table 3-3. As expected, the measured WWF at both outfall locations is higher than the measured DWF. It is somewhat surprising to note that the increase in average wet weather flow as compared to average dry weather flow is greater for Macaulay than for Clover (30% vs. 10%). This finding is somewhat unexpected in light of the information provided with respect to the PRT's understanding of the condition of the wastewater collection system and the presence of a combined sewer area within the Clover Point collection area. However, such conditions may have a reduced effect on wet weather flow rates because of the added opportunities for direct ocean discharges at overflow points in the collection system at high flows in the Clover Point collection system.

**Table 3-3 Macaulay and Clover Point Flow Rates[a]**

| Flowrate | Unit | Macaulay | Clover Point |
|---|---|---|---|
| DWF | | | |
| Avg | ML/d | 40.3 | 53.3 |
| Std dev | ML/d | 1.35 | 2.19 |
| WWF | | | |
| Avg | ML/d | 52.6 | 58.8 |
| Std dev | ML/d | 6.78 | 8.00 |

[a] Flow rate data obtained between August 21 and September 6 2008 for the DWFs, and between January 4 and February 16, 2008 for WWFs

### Wastewater Constituent Loadings

Using the data presented in Tables 3-1 to 3-3, Table 3-4 has been developed to provide some insight into the variation in constituent mass loadings (kg/d) arriving at the two main outfall sites. There appears to be very good agreement between the dry-weather loads calculated for the two outfalls, given that the tributary populations of each drainage area are very close to equal. The dry weather loads for all constituents shown in Table 3-4 are some 10% to 20% higher at Clover point, which can possibly be explained by the higher commercial development in the Clover Point drainage area. The wet weather loads calculated for both drainage areas are more difficult to explain, as the change from DWF to WWF varies from a 70% increase for alkalinity at Macaulay to a 20% reduction for dissolved BOD at Clover Point. If the plan remains to treat two times average dry weather flow (ADWF) to secondary treatment levels, then the data to date can be used for general process design to meet secondary standards, but further data gathering and analysis should be undertaken before pre-design reports are commissioned for any new treatment plants.

**Table 3-4 Constituent Mass Loading Rates at Macaulay and Clover Points[a]**

| | Macaulay Point (kg/d) | | Clover Point (kg/d) | |
|---|---|---|---|---|
| | DWF | WWF | DWF | WWF |
| TSS | 7820 | 9780 | 8470 | 8760 |
| VSS | 6690 | 9210 | 7570 | 8170 |
| BOD tot | 9630 | 8420 | 10930 | 9230 |
| BOD diss | 3340 | 2830 | 3940 | 3220 |
| TKN tot | 1900 | 2210 | 2060 | 1622 |
| Alk-as CaCO3 | 7010 | 12890 | 7680 | 8880 |

[a] Constituent mass data obtained between August 21 and September 6, 2008 for the DWFs, and between January 4 and February 16, 2008 for WWFs.

## WASTEWATER QUALITY REGULATIONS

Both the Province of BC and the Government of Canada have regulations and/or guidelines that must be considered for receiving water discharge of treated wastewater. Various reuse scenarios also require adherence to stipulated regulations. The CRD's consultants are proposing a wastewater management system that consists of ocean discharge of treated effluent plus an increasing amount of effluent reuse. Because of the time constraints imposed by the Province, the equivalent of secondary treatment prior to discharge is required by the end of 2016. Additionally, there are some aspects of the effluent quality requirements that have recently been approved by the Canadian Council of Ministers of the Environment (CCME) that will also have to be satisfied.

## Provincial Regulations

In a document entitled “Municipal Sewage Regulations” under the Provincial Environmental Management Act, specific requirements for treated effluent quality are listed. If the treated effluent is to be discharged to the “open marine” environment, the regulations stipulate that secondary treatment (defined as effluent containing no more than 45 mg/L each of BOD and TSS at any time) must be provided for all flows up to 2 x ADWF. The limiting concentration values may be interpreted as values that are never to be exceeded, regardless of the type of sample taken.

If flows in excess of two times ADWF occur more than once every five years, a waste management plan or specific study must be undertaken to determine what treatment level is recommended for such occurrences. If the high flow does not occur more frequently than once every five years, then the equivalent of primary treatment is acceptable for that high flow period. In the CRD system, flows in excess of 2 x ADWF do occur more frequently than once every five years.

In Schedule 2 of those regulations there are listed both “treatment requirements” and “effluent quality requirements” for treated wastewater that is intended to be used as reclaimed water for a variety of end uses, including irrigation of various crops, landscape irrigation, outside wash water, outside fountains, and toilet flushing. The specific treated effluent constituents listed are pH, BOD, turbidity, and coliform organisms. Any such uses being contemplated by the CRD will have to comply with Schedule 2.

Biosolids regulations called “Organic Matter Recycling Regulation” have been issued under the Environmental Management Act and the Health Act. The regulations provide for two classes of biosolids, Class A and Class B, whose characteristics are summarized in Table 3-5. Class A biosolids are processed to a higher degree than Class B biosolids, thus having a much lower pathogen concentration in the finished product and therefore have much less restrictive handling and land application requirements. In some respects, the regulation is similar to the US EPA Regulation 503 for biosolids.

The Organic Matter Recycling Regulation also specifies requirements for Classes A and B compost as well as the maximum allowable metal concentrations in biosolids, compost and soils following land application.

**Table 3-5 Summary of Biosolids Classification Requirements in BC's Organic Matter Recycling Regulation**

| Characteristic | Class A Biosolids | Class B Biosolids |
|---|---|---|
| Pathogen Reduction Requirements | <1,000 MPN per gm (dry solids basis) to be produced by one of the pathogen reduction processes listed below | <2,000,000 MPN per gm (dry solids basis) or one of the pathogen reduction processes listed below |
| Acceptable Processes for Pathogen Reduction | Thermophilic aerobic digestion at ≥55ºC for at least 30 min | Aerobic digestion with mean cell retention time between 40 days at 20ºC and 60 days at 15ºC |
| | Thermophilic anaerobic digestion at ≥50ºC for at least 10 days | Anaerobic digestion with a mean cell retention time between 15 days at 35ºC and 60 days at 20ºC |
| | Exposure to time-temperature processing requirements according to arithmetical formulae given in the regulation depending on the total solids concentration of the biosolids | Air drying for >3 months, during which the ambient temperature must be >0ºC for at least 2 months |
| | Alkaline stabilization by maintaining the pH within the biosolids >12 for 72 hours during which T > 52ºC for 12 hours, followed by air drying to >50% total solids concentration | Lime stabilization such that the pH of the biosolids is raised to ≥12 after 2 hours of contact |
| Vector Attraction Reduction Requirements | Aerobic or anaerobic digestion resulting in >38% destruction of volatile solids mass or another acceptable criterion specified in the Regulation | Aerobic or anaerobic digestion resulting in >38% destruction of volatile solids mass or another acceptable criterion specified in the Regulation |

## Federal Initiatives

The Canadian Council of Ministers of the Environment (CCME) is comprised of the environment ministers of the federal, provincial and territorial governments. The Council meets at least once per year and focuses on issues that are national in scope and that require collective action by a number of governments. The purpose of the CCME is to assist its members to meet their mandate of protecting Canada's environment. While the CCME is a collaborative effort, each minister remains accountable to his/her government according to the laws and statutes governing their jurisdiction.

Over the past five years, the CCME has been developing the Canada-Wide Strategy for the Management of Municipal Wastewater Effluent, known as "the CCME Strategy" recently endorsed by the CCME Council of Ministers on

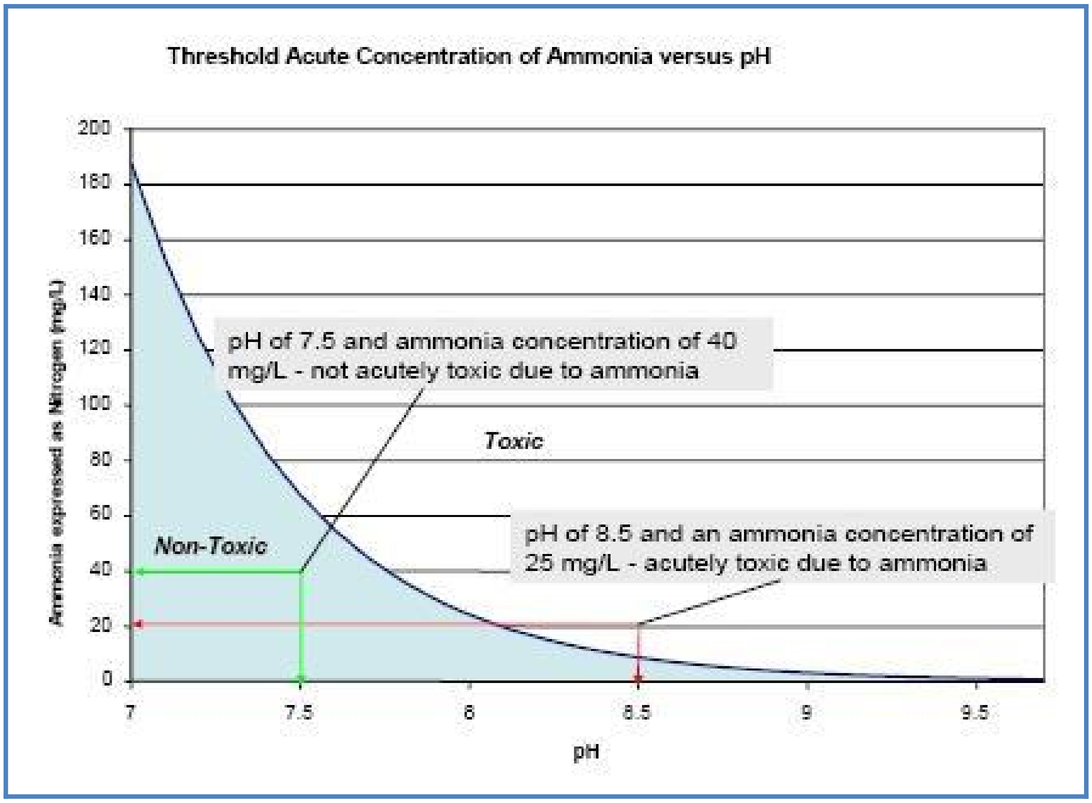
February 17, 2009. Environment Canada has taken the lead in coordinating this effort. Among other things, the CCME Strategy establishes National Performance Standards to be considered minimum performance requirements for effluent quality from all municipal, community and government wastewater facilities that discharge municipal wastewater effluent to surface water. The National Performance Standards for wastewater treatment facilities of a size likely to be installed in Victoria are:

- $cBOD_5$ ≤25 mg/L (monthly average of at least five samples per week)
- TSS ≤25 mg/L (monthly average of at least five samples per week)
- Total residual chlorine ≤0.02 mg/L (testing is required only if chorine is used as a disinfectant in the treatment facility; testing to be done three times per day if required)

The monthly average $cBOD_5$/TSS concentration limits of 25/25 mg/L contained in the CCME National Performance Standards generally are equivalent to the Provincial not-to-exceed concentration limits of 45/45 mg/L for the same parameters.

Wastewater facilities with flow rates in excess of 2,500 $m^3$/d, are also required to conduct whole effluent acute toxicity testing and evaluate chronic toxicity at the edge of a specified mixing zone. Given the likely size of the future Victoria wastewater treatment facilities, toxicity testing will probably be a monthly requirement. If a facility fails an acute toxicity test, a toxicity reduction and evaluation process is used to identify and correct the cause of the toxicity. If the whole effluent acute toxicity test failure is due to ammonia, then the need for ammonia reduction must be determined on the basis of the assimilative capacity of the receiving environment. Given the $BOD_5$ and TKN concentrations indicated in Tables 3-2 and 3-3 for Macaulay Point and Clover Point respectively, and making a simplistic assumption that 0.5 grams of biosolids containing 8% nitrogen will be produced for every gram of $BOD_5$ removed, the conservatively high estimates for the treated effluent ammonia-nitrogen concentrations from treatment plants located at Macaulay and Clover Points would be in the order of 38 mg/L and 31 mg/L respectively. From an examination of the plot given in Figure 3-1, it is unlikely that the future ammonia-nitrogen concentrations in Victoria's treated effluent will be an issue, presuming that the pH is less than about 7.8.

**Figure 3-1 Acute Toxicity Relationship Between pH and Ammonia-Nitrogen Concentration** (after Environment Canada, 2007)




## POSSIBLE FUTURE REGULATORY INITIATIVES

Possible future regulatory initiatives may include (1) greenhouse gas emissions, (2) microconstituents, (3) nitrogen and phosphorus limits and (4) odour emissions. Each of these is considered briefly in the following discussion.

### Greenhouse Gas (GHG) Emissions

The Federal Government has implemented a mandatory reporting requirement for all facilities that emit the equivalent of 100,000 tonnes per year or more of greenhouse gases (in $CO_2$ equivalent units). It is not likely that the future wastewater treatment facilities at the CRD will exceed this threshold, either individually or in combination and therefore the CRD would not be required to submit a GHG emission report to the Federal Government. However if the threshold reporting limit is lowered in future, the CRD may be required to submit such a report, depending on the new threshold value. The GHG and global warming debate is still very much an unsettled issue; therefore it is difficult to predict what regulations pertaining to GHG controls may be enacted in future.

**Microconstituents**

Microconstituents include hundreds of compounds, which encompass endocrine disrupting compounds (EDC's), pharmaceutically-active compounds (PhAC's) and Personal Care Products (PCP's). These compounds are typically present in raw wastewater at ng/L to ug/L concentrations, 5 to 6 orders of magnitude less than the concentration of conventional pollutants. Such compounds are of special concern because of their potential to cause toxicity and other adverse impacts on the endocrine systems of aquatic species inhabiting a receiving waterbody. A substantial body of research has accumulated over the last decade to quantify the amount of these substances in wastewater and to determine mechanisms for their removal. It is possible that regulatory initiatives will be introduced for the control of these substances in the foreseeable future.

**Nitrogen and Phosphorus Limits of Treatment**

More stringent effluent limits are being placed on Wastewater treatment plants discharging to fresh water environments whose ecosystems are especially sensitive to stressed DO conditions due to the addition of nitrogen and/or phosphorus. Such limits sometimes require very low treated effluent nutrient concentrations in the order of 3 mg/L total nitrogen and 0.1 mg/L total phosphorus. These limits are at the current level of technology achievable by advanced biological treatment systems and require very conservative process design practices. To go beyond these limits will require implementation of advanced and expensive treatment technologies such as reverse osmosis, activated carbon, or ion exchange. While such technologies would not be required to satisfy the requirements for a marine discharge, they may be mandated by the regulatory authority in future to preserve the ecosystem of a freshwater receiving stream should it be decided to construct a wastewater treatment facility on an inland site. Already the BC Municipal Sewage Regulation makes provision for more stringent treated effluent quality limits for discharge to the nutrient sensitive waters of the Okanagan Valley and other similar areas of the Province. It is quite possible that as the pressures of population growth in these areas place more stress on the aquatic ecosystem, more stringent nutrient regulations will be mandated in the future.

**Odour Emissions**

Odour emissions from wastewater collection and treatment systems are certainly nothing new. Regardless, neither the BC Municipal Sewage Regulation nor the Organic Matter Recycling Regulation include specific requirements for odour control. It is reasonable to assume that the public will be intolerant of offensive odours from the new wastewater facilities and thus state of the art odour control equipment should be installed. It is possible that future regulations could be promulgated employing quantitative odour monitoring such as dilutions to threshold (D/T) at the plant fence line or at the nearest downwind receptor. However such regulations are not on the immediate horizon.

# 4

# IMPLEMENTATION CONSIDERATIONS

In addition to treatment performance and costs, there are a number of other technical implementation issues that must be considered in the selection of the preferred option including resource recovery, staging of construction, siting of treatment plants, operability of wastewater management facilities, impact of global climate change, and carbon footprint.

## RESOURCE RECOVERY

Wastewater is a potential resource for energy, nutrients for plant growth, and usable water. The organic materials found in wastewater and the heat energy of the water itself are the two major sources of energy in wastewater. The principal nutrients in wastewater are nitrogen, phosphorus, and iron. The use of treated wastewater for a variety of beneficial uses is common, especially in water short areas. Capturing the potential resources in wastewater to help meet resource limitations in an area and to enhance environmental goals, such as reduction of greenhouse gas emissions, should be an integral consideration in any wastewater management plan. However, a significant expenditure of funds and other resources such as energy are often needed to capture these resources. Thus, the environmental costs as well as benefits must be evaluated when assessing the feasibility of resource recovery from wastewater in any given situation to determine which of the resources might provide environmental as well as economic benefit. The answer is very situation dependent. General considerations related to resource recovery are discussed in this section while specific considerations related to the CRD wastewater system are discussed in Section 5 of this report.

### Recovery of Energy from Organic Matter

A significant portion of the energy content of organic material in wastewater can be captured in the form of methane from the anaerobic treatment of biosolids resulting from the biological treatment of wastewater. Methane is a biofuel that can help offset fossil fuel usage and, thus, is of significant benefit for reduction of carbon emissions. In addition, the in-plant use of the energy in methane often offsets as much as 50% of the total energy requirements for operating a biological wastewater treatment process. This percentage may increase significantly in the future as more energy-efficient treatment plants are designed. Whether treatment systems can become a net energy producer from this source is questionable, but the percentage may increase in the future. In any event, capture of this form of energy through wastewater treatment is economically feasible and environmentally desirable.

Anaerobic treatment does not convert all the biosolids to methane, perhaps no more than about 50% conversion results. The remaining organics, such as lignins from plants, are only poorly biodegradable. Energy recovery from these remaining materials might be possible through combustion, but the water content of biosolids is generally too high to obtain net benefit from combustion unless the biosolids are first dried in some energy efficient manner. The removal of moisture may be accomplished through placing the biosolids in drying beds using air drying for moisture removal, or by drying using waste energy from a manufacturing process, such as from a cement-kiln.

**Recovery of Heat Energy from Wastewater**

The heat energy in wastewater is being captured in some cold regions, such as in Sweden, through use of heat pumps that transfer the heat in wastewater for normal heating in buildings. However, it is highly questionable whether this heat energy can be captured from wastewater economically in a much milder climate such as in Victoria. The use of heat pumps to capture either heat from air or from geological formations is common in the CRD; indeed homeowners are currently subsidized to install heat pumps for this purpose. The question is whether wastewater is the most economical source of heat for this purpose. Would a home, apartment, or building owner select to use the heat in wastewater when that in air is free and can be captured directly by an owner just outside of his/her own building? The answer will determine what building owners would pay, if anything, for the opportunity to use wastewater heat. The potential for heat recovery from a source is measured in terms of the Coefficient of Performance (COP), which may be a value as high as four or so. A COP of four means that for every unit of energy input to the heat pump, four units of heat energy can be transferred from the heat source to the building. The significance to the CRD of the relative COP when using air versus wastewater effluent is discussed in Section 5 of this report.

**Recovery of Nutrients**

Wastewater contains nutrients that are important for growth of crops, including nitrogen, phosphorus, and iron. Nitrogen for agriculture is produced primarily by fixation of atmospheric nitrogen, a process that is highly energy intensive. Use of wastewater nitrogen could help offset the energy cost of commercial fertilizer nitrogen. Phosphorus is also an important plant nutrient that is of some concern because, unlike nitrogen, its worldwide availability is much more limited. Phosphorus limitation may in the future increase its cost significantly, making the recovery of phosphorus from wastewater more economically feasible.

There are two streams resulting from wastewater treatment that contain these nutrients, the treated water itself and the associated waste biosolids. Nutrients in the wastewater can be captured if the wastewater is used for irrigation. It is a potential benefit that deserves some consideration when evaluating the value of wastewater reuse, but probably will not be a major driver in decision making for wastewater treatment for the CRD. Digested wastewater biosolids are often considered to be a useful resource through land application in agricultural areas, and use for this purpose is common. Biosolids added to soil provide a good soil conditioner to hold and conserve water as needed for good crop growth. The nitrogen and phosphorus are in a slow release form that is most desirable for agriculture. The main environmental concern with biosolids relates to the potential toxic materials such as heavy metals and trace organic contaminants that they may contain. Current biosolids regulations recognize and adequately address how to deal with pathogens and heavy metal contaminants. Current studies are concerned with potentially hazardous trace organic contaminants. The comparison here when considering land application is between the environmental benefits of land application versus the potential environmental harm. The environmental tradeoffs with use of biosolids for land application deserves broader discussion.

**Wastewater Reuse**

The use of treated wastewater for irrigation or indirect potable reuse is common, especially in water short areas. Water quality criteria for irrigation of food crops can be achieved through biological treatment, filtration, and disinfection. The criteria can be met through the disinfection of an effluent from a membrane bioreactor or that from conventional activated sludge treatment system followed by filtration. The price of water needs to be quite low for agricultural usage, well below that for domestic use. For example, about 15 $m^3$ water is required to grow the grain needed to produce one kg beef. Wastewater treatment costs about \$0.25 per $m^3$. At this price, the cost of the water to produce one kg beef would be \$3.75, a significant portion of the retail cost for beef. There would be little incentive for a farmer to pay such a price for reclaimed water as it would add too much to the cost of beef. For domestic and commercial purposes, water can be and is priced higher. If a fresh water supply is not available, a ready market for reclaimed water for landscape irrigation and non-potable industrial and commercial purposes is likely to be available, especially if the need extends over a substantial portion of the year. This does not appear now to be the case in Victoria, but may be in the future with population growth as well as the possible redistribution of water that may result in the future from climate change. The cost of delivery of the reclaimed water to the irrigation, industrial or commercial user must then be balanced against potential revenues from sale of the reclaimed water.

Use of reclaimed water for potable purposes is likely to be economical and environmentally sound only after active efforts for water conservation are made and when water availability is limited 12 months of the year. Water shortage for limited periods during summer months is perhaps better met through freshwater storage during times of sufficiency. Use for potable purposes requires expensive reverse osmosis membrane treatment and long-term storage or slow percolation through soil into a groundwater aquifer. For example, in water short areas such as in Southern California or Singapore, membrane filtration and reverse osmosis of wastewater following normal biological treatment is being used to help meet significant water deficiencies. Here again, such advanced treatment is associated with significant capital and energy costs, but is justified when water is in very short supply. However, in areas where water is plentiful, reuse of wastewater for potable purposes would not be justified and should not be done.

## STAGING OF CONSTRUCTION

The staging of construction for treatment facilities involves building treatment capacity in stages so that each stage (or phase) of a project follows in a reasonable timeframe, typically dictated by population growth, other capacity needs such as industrial requirements, or the need to meet enhanced regulations, General considerations related to staging of construction are discussed in this section. Specific considerations related to staging of the CRD wastewater system are discussed in the Section 5 of this report.

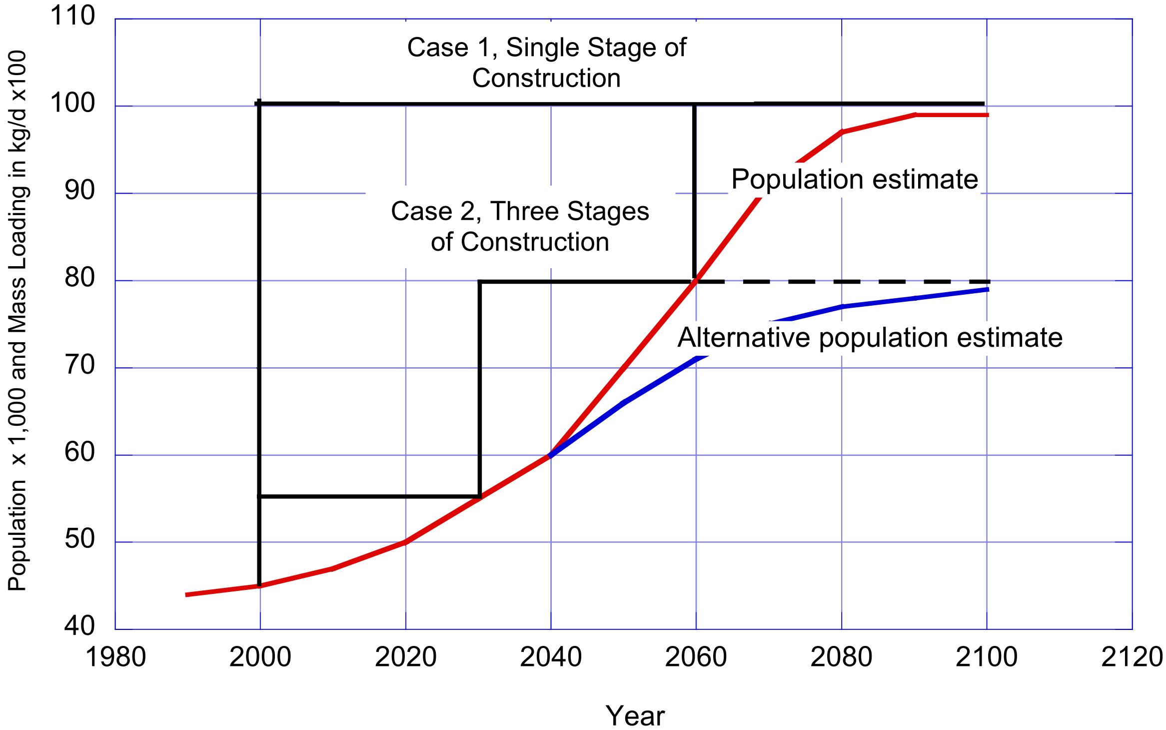
### Definition of Staging

The basic concept involved in staging can be illustrated by referring to Figure 4-1 which illustrates the growth of population with time and the corresponding constituent mass loading rates. In this example the saturation population is reached in 2100. Superimposed on the population curve are typical staging options. In Case 1, the ultimate capacity of the treatment facility is constructed initially. In Case 2, the required capacity for the ultimate saturation population is achieved in three stages. The population curve extending from the year 2040 represents an alternative population projection.

### Analysis of Staging

In the case of Case 1, the available treatment capacity will be under utilized until the saturation population is reached. In Case 2, the required treatment capacity is constructed in three stages to match the increase in the population. If a treatment plant is built in one stage (as proposed for Case 1), it may be possible to take advantage of the economies of scale in construction, but this approach will result in an acceleration of cash flow for construction and in the costs of maintaining facilities for several years before they are needed. Another disadvantage of a single stage of construction is that there is no flexibility to economically incorporate improved treatment or resource recovery technology in the future. If the required treatment capacity is achieved in three stages, for example, some economies of scale may be sacrificed, but gains will be made by delaying the initial capital investment and avoiding interest payments and by eliminating maintenance of unused facilities. It is also preserves the flexibility to use improved technology in the later stages of construction. Another advantage of staging as illustrated on Figure 4-1 occurs if the actual population growth is less than originally estimated. This lower growth rate is shown by the lower population curve extending from the year 2040. In this situation, the second stage of construction is sufficient for the saturation population.

**Figure 4-1 Illustration of Alternative Staging Options for Wastewater Treatment Facilities**




## Other Staging Opportunities

In the above discussion of staging, the primary focus has been on the increase in population and the corresponding increase in mass loadings. As noted previously, staging can be implemented to meet population growth, other capacity needs, or the need to meet new regulations. With respect to new regulations, often a timetable will be established which will also drive staging decisions. For example, the removal of a given constituent may necessitate the addition of new process equipment such as the inclusion of membranes or other filter types in or after existing secondary clarifiers for enhanced solids removal. Thus, it is important that as much flexibility as possible be incorporated in the design and staging of new wastewater treatment facilities.

## Time Between Stages

Typical staging practice for major wastewater treatment plants is to provide capacity for 10 to 15 years between plant expansions. It is also important to note that a considerable time period is needed for the planning, design, construction and commissioning of a new or expanded facility prior to the time when it must be operating in compliance with regulatory permits. Typical time requirements for implementing a wastewater treatment facility serving a population equivalent of about 300,000 using two project delivery methods: design/bid/build and design/build are summarized in Table 4-1. The time allotments in this table should be taken as approximate allocations only as they can vary considerably given the specifics of the project under consideration. It is also important to note that the time estimates shown in Table 4-1 occur **after** policy makers have made a firm commitment to the wastewater system strategy and **after** all of the related land for plant sites has been acquired. It would be premature to start treatment plant design without knowing the specifics of the plant site(s). The overall project time requirements may also be extended by the time required to obtain permits, obtain financing and to deal with any bid protests or legal actions that may arise.

**Table 4-1 Approximate Time Requirements to Implement Wastewater Treatment Plant Project to Serve and Equivalent Population of 300,000**

| Design/Bid/Build Project Delivery | | Design/Build Project Delivery | |
|---|---|---|---|
| | **Duration (months)** | | **Duration (months)** |
| Planning | 3 | Planning | 3 |
| Concept Design | 3 | Preparation of D/B Tender Package | 6 |
| Prelim. Eng./Functional Design | 6 | Tendering, Evaluation & Award | 6 |
| Detailed Design (including equipment pre-purchasing) | 12 | Design Completion & Construction | 36 |
| Tendering, Evaluation & Award | 3 | Commissioning, turnover, warranty and permit compliance | 12 |
| Construction | 36 | | |
| Commissioning, turnover, warranty and permit compliance period | 12 | | |
| **Approximate Total Elapsed Time** | **75** | **Approximate Total Elapsed Time** | **63** |

While the design/bid/build approach may require an additional 12 months to complete the project, it usually offers the owner more input and control over the design of the facility, the selection of the process configuration and processing components and appurtenances. The PRT understands that a subsequent business case study will evaluate the many other factors to consider when selecting a project delivery system and developing a detailed implementation schedule.

## SITING TREATMENT PLANTS

The implementation plans for wastewater system options should consider that the complexity and time to obtain public acceptance, needed permits and acquire the sites will increase as the number of treatment plants in system options under consideration increases.

## OPERABILITY OF WASTEWATER MANAGEMENT SYSTEM

Operability is a very important consideration in selection of the system configuration and in the wastewater/biosolids treatment process design. The ability to operate wastewater management facilities efficiently will depend on the number and type of facilities, the design of the individual components that comprise a given facility, and the availability of skilled labour resources. The impact of the number of facilities and example of the impact of a design consideration is presented below.

### Number of Facilities

With respect to the number of facilities, the complexity of O&M increases as the number of plants in a wastewater system increases. The number of potential failure points increases as the number of treatment plants and the number of pieces of equipment in the system increases. The complexity of maintenance and cost of maintaining an adequate inventory of spare parts increases substantially if there are a large number of plants with varying sizes of equipment. If the type of equipment differs from plant to plant, another layer of maintenance complexity is added. Adequately monitoring and controlling the treatment processes also becomes more complex as the number of plants increases.

### Impacts of Design Decisions on Operability

During design, many decisions will be made that ultimately affect operability of the system such as the degree of conservatism used in establishing design criteria for each treatment process, the amount of equipment and process redundancy, the physical layout of the plant, the degree of instrumentation and automation, etc. For example, in the consultants report it is assumed that sufficient alkalinity is present in the wastewater to support the nitrification/

denitrification process in the MBR process. Based on the analysis presented in Appendix E of this PRT report, the PRT concludes that facilities should be provided for the addition of alkalinity to assure the operability of the MBR treatment process. During pre-design and design, there will be many decisions about how close to the edge to go to balance costs with operability. It appears that a consistent design philosophy has been followed in each of the three system options so the comparison of system options is not affected by differences in design decisions that affect operability. However, the PRT recommends that an independent operability analysis be conducted during pre-design.

## IMPACT OF CLIMATE CHANGE

There is current worldwide concern over the climate change impacts of carbon dioxide ($CO_2$) emissions from fossil fuel usage, as well as that from other greenhouse gases such as methane ($CH_4$) and nitrous oxide ($N_2O$). One aspect of importance in making decisions about wastewater treatment in Victoria is changes that may occur in sea level rise and freshwater availability for domestic, industrial, and agricultural purposes. Current models suggest seawater rise on the order of 1 metre during the coming century and that rainfall in the western part of North America will decrease. Projected seawater rise needs consideration in structures to be built near the coast, as do estimates of future energy costs for pumping and disposal of treated wastewater to the sea. Projected less rainfall means that areas having sufficient fresh water now may have a deficiency in the future. Thus, while there may be little need at the present for advanced treatment of wastewater as required for its reuse now, the significantly greater cost such treatment entails may be more justified in the future. Designs today should have sufficiently flexibility to successfully meet these potential future impacts.

## CARBON FOOTPRINT

The other aspect that deserves consideration in treatment system design is the carbon footprint of the treatment system itself. There is growing concern that greenhouse gases need to be controlled now to reduce the rate of the changes anticipated from global warming, and regulations in this direction have already been enacted or are under active consideration. For example, the United States Environmental Protection Agency (U.S. EPA) has been directed to consider greenhouse gases as pollutants and to regulate their production. Toward this end, the U.S. EPA has already prepared various reports, some of which consider greenhouse gas emissions from waste handing and treatment. The gases here of concern are primarily methane and $N_2O$, gases produced during wastewater transport, treatment, and disposal. The impact of wastewater treatment on carbon emissions, the role of carbon trading, the situation in Victoria with respect to carbon footprint, and a summary assessment are presented below. Supplemental information on carbon footprints and related references are presented in Appendix H.

### Wastewater Treatment and Carbon Emissions

Organic oxidation such as occurs during biological wastewater treatment does produce $CO_2$, but this $CO_2$ is not considered adverse to the environment as it is considered part of the normal carbon cycle of plant growth and decay that otherwise would occur in the environment. The greenhouse gas production that may be of some concern is that associated with fossil-fuel derived energy utilization such as to power the various facilities associated with a wastewater treatment plant. More important is the possible escape to the atmosphere of methane and $N_2O$, gases that may be produced through waste handling and treatment. Interesting here is that methane, if captured and used, is a biofuel that is generally considered a "green" fuel that can offset fossil-fuel usage. One might even be able to obtain carbon credit for its production and use as is now being done for solid municipal and agricultural wastes. However, if methane escapes to the atmosphere, then it becomes a powerful greenhouse gas, having a heat-trapping potential 23 times that of $CO_2$ (IPCC 2001). The other greenhouse gas of concern in wastewater treatment is $N_2O$, a gas that is produced during oxidation of wastewater ammonia to nitrate (nitrification), as well as through the reduction of nitrate to $N_2$ gas (denitrification). While the amounts produced are likely to be small, the heat-trapping potential is 296 times that of $CO_2$ and thus worthy of concern (IPCC 2001).

### Carbon Trading

The financial aspects associated with the potential use of carbon trading or carbon taxation as methods to encourage overall reduction of greenhouse gas emissions suggests that a treatment system may in the future be rewarded financially for production of a biofuel such as methane, or may be penalized for use of fossil fuel energy (perhaps indirectly through rise in purchase price) or the release of methane or $N_2O$ to the atmosphere. How beneficial biofuel production may be or how severe these penalties may become in the future is currently unknown. Current trading suggests carbon equivalent penalties or costs in offset trading of $10 per metric ton $CO_2$ equivalents may be at the low end, with values at the high end of $200 per metric ton $CO_2$ equivalents or more that are mentioned by some as necessary to adequately encourage alternative energy production and use. One ton of methane if it escapes to the atmosphere would be equivalent to 23 tons of $CO_2$.

### Impact of Wastewater Treatment in Victoria

To place some perspective on the potential for greenhouse gas production from wastewater and its treatment in the Victoria area, estimates of $CO_2$ equivalent discharges from fossil fuel energy usage for aeration, from methane emissions, and from $N_2O$ production were calculated on a per capita basis and compared with the average total per capita $CO_2$ emissions for Canada. The results of this analysis are presented in Table 4-2. Emissions from small decentralized anaerobic treatment systems such as septic tanks where methane is not captured are likely to be of greatest concern. Not only would the methane produced represent a significant portion of annual per capita production (in the range of 1%), but potential $N_2O$ production from the ammonia released to the soil would add to this concern. Currently, the IPCC assumes 50% of the methane produced in septic tanks reaches the atmosphere, but their default value per unit of wastewater treated is about twice the PRT's estimates, which are believed to have a better scientific basis and are the values shown in the table. Collectively, these results show that use of septic tanks may come under closer control in the future.

**Table 4-2 Estimated Annual Per Capita Emissions of Equivalent Carbon Dioxide from Wastewater Handling and Treatment**

| Treatment Process | Carbon Dioxide Equivalents Emitted (tons/cap/year) | Percentage of Average Annual Per Capita Total Emissions |
|---|---|---|
| Septic Tank | | |
| Methane | | |
| 100% formation | 0.230 | 1.38 |
| 50% formation | 0.120 | 0.69 |
| Centralized Treatment | | |
| Carbon Dioxide from energy Use | | |
| Conventional | 0.006 | 0.04 |
| Membrane bioreactor | 0.009 | 0.05 |
| Discharge to Ocean | | |
| $N_2O$ Formation | | |
| 0.5% $NH_3$-$N_2O$ | 0.010 | 0.06 |
| 1.0% $NH_3$-$N_2O$ | 0.021 | 0.12 |
| 4.0% $NH_3$-$N_2O$ | 0.082 | 0.49 |

US DOE Carbon Dioxide Information Analysis Center gives estimate of total annual per capita carbon emission for Canada of 4.54 metric tons (16.6 tons $CO_2$/cap/yr), (http://cdiac.ornl.gov/trends/emis/meth_reg.html).

## Carbon Footprint Summary

This analysis and discussion related to carbon footprint has been carried out by the PRT to help evaluate whether greenhouse gas production is an issue that should be considered in present treatment plant design or might in the future affect decisions on treatment, operation and maintenance costs. Adequate scientific information on this issue is still insufficient to reach definitive conclusions on current treatment design. The conclusions that can be made are that sufficient flexibility is desirable to meet and address potential future adverse impacts that could pose significant possible financial impacts. At this point, the analysis suggests that septic tank usage may come under greater control in the future because of greenhouse impacts. Expansion of the use of such systems should be questioned. Also, at centralized facilities, use of anaerobic digestion for biosolids treatment has favourable aspects for greenhouse gas reduction over biosolids incineration. Of course there are many other factors to consider when making decisions over the best treatment option to use, but greenhouse gas emissions and related impacts should be among the many important factors considered in the Triple Bottom Line analysis of options.

# 5

# EVALUATION OF CRD CONSULTANTS PROPOSED ALTERNATIVES

The Consultants to the CRD have conducted extensive investigations of the wastewater situation in Victoria and of treatment systems to meet federal and provincial regulations as well to utilize wastewater as a resource for energy, water, and nutrients. Numerous reports on alternative methods of treatment and resource recovery have been produced. The purpose of this section is to review the proposed system options in terms of the recommended wastewater treatment processes, biosolids management and resource recovery alternatives, capital costs, operation and maintenance costs, potential revenues, and flexibility for the future.

## SYSTEM OPTIONS

Based on their investigations, the Consultants have developed three different options for a regional wastewater handling and treatment system to meet current and future (year 2065) requirements while capturing the resource potential from wastewater. The options were developed to aid in the selection of a final strategy for wastewater handling and treatment for the CRD service area. Details of the three options are outlined in the Consultants' reports. Taken from Discussion Paper 036-DP-2 Development of Distributed Wastewater Management Strategies (March 9, 2009), they are summarized below:

**Option 1**

A. Three treatment plants for up to 2.0 times average dry weather flow (ADWF) located at:
   1. Saanich East
   2. Macaulay Point/McLoughlin Point
   3. West Shore
B. Heat energy recovery from effluent of all three plants
C. Wet weather flow plant for between 2.0 times and 4.0 times ADWF located at:
   1. Clover Point
   2. Macaulay/McLoughlin Point
D. Wastewater solids processing and phosphorus recovery at two plants:
   1. Macaulay/McLoughlin
   2. West Shore

**Option 2**

A. Five treatment plants for up to 2.0 times ADWF located at:
   1. Saanich East
   2. Macaulay Point/McLoughlin Point
   3. Ogden Point
   4. West Shore
   5. Juan de Fuca
B. Heat energy recovery from effluent of all five plants
C. Wet weather flow plants at Clover Point and Macaulay/McLoughlin Point for between 2.0 times and 4.0 times ADWF
D. Wastewater solids processing and phosphorus recovery at Macaulay/McLoughlin

**Option 3**

A. Eleven treatment plants
B. Heat energy recovery from effluent of all 11 plants
C. Wet weather flow plants at Clover Point and Macaulay/McLoughlin Point for between 2.0 times and 4.0 times ADWF
D. Wastewater solids processing and phosphorus recovery at:
   1. Macaulay/McLoughlin
   2. Royal Roads
E. Aggressive water recycling at individual buildings

Common to all three options is a central biosolids resource recovery site to which anaerobically digested and dewatered sludge would be trucked for (a) drying and subsequent transport to the Lower Mainland for use as a fuel supplement in cement kilns, and (b) land application to a willow coppice area(s) for the production of a saleable wood chip biofuel.

All three options meet regulatory requirements for discharge and permit utilization of the resource potential in wastewater. The presentation of three potential options allows analysis of the value of many distributed treatment systems that may enhance resource recovery versus that of more centralized facilities that may offer better economies of scale. Such a comparison is necessary to aid in decision making about the most desired option by the communities served by the CRD within the constraints of regulatory requirements.

The PRT commends the consultants for the extensive and detailed studies that they have conducted on resources that might be recovered from wastewater and the economic analysis of the treatment system costs required to make these resources available.

The PRT agrees with two significant conclusions that arise from the Consultants' evaluations.

First, the value of the resources possibly recovered from wastewater handing and treatment is far less on an annualized basis than the cost of the collection and treatment systems used to produce those resources. That is, wastewater collection and treatment is not a profit making venture. The extent of resource recovery and related revenue generation that might be practically achieved is quite problematic at this point. Even if recovered to the maximum extent indicated in the Consultants' report, the revenue generated by resource recovery is far less than the cost of recovering the resources, as discussed later (see Finding on Revenue, page 5-18).

Second, increasing the number of treatment systems to provide more distributed opportunities for resource recovery does increase the potential revenue from sale of the resources, but the utilization of resources comes at a much greater cost for the treatment systems, negating the increased economic value of the resources. The conclusion from this analysis is that the most economical alternative of the three system alternatives evaluated by the Consultants is Option 1, which features the smallest number of treatment plants.

**Number of Treatment Plants**

Option 1 with the fewest number of treatment plants does not preclude the eventual construction of small decentralized treatment/resource recovery systems throughout the CRD service area as the need for more capacity develops and if the future value of energy, water, and/or nutrients provides incentive to develop such decentralized systems. Then, a more centralized system built now would still provide an important service. Excess biosolids from decentralized treatment systems could be discharged to the trunk sewer for treatment at the centralized plant. Also, the trunk system would provide a vehicle for discharge of excess reclaimed wastewater when not reused or for emergency discharge of wastewater in the event of failure at a decentralized system. Having the central system available would provide system redundancy and improve system reliability. It would avoid the increased construction and operating costs of providing this redundancy at each decentralized system. These considerations are important when selecting an option. Additionally, the three options evaluated by the consultants do not represent the only options. Another option may in fact be found to be more desirable by the community. However, the options provided do help to understand the relative benefits, costs, and flexibility for meeting future needs as necessary for making rational decisions about an overall wastewater treatment system.

## WASTEWATER TREATMENT PROCESS

The effluent quality required from the liquid treatment system is a function of the discharge location or intended use of the treated water. If the treated effluent is to be reused, the wastewater must be treated to low coliform bacteria concentrations and low turbidity of less than 2.2 NTU, which can be accomplished by a membrane bioreactor (MBR) treatment process or by using granular media filtration or polishing membranes after secondary clarifiers in a conventional activated sludge plant. For discharge to the marine environment the required treatment goal is a secondary effluent quality, which is primarily BOD and TSS removal to average and daily maximum effluent concentrations of 25 mg/L and 45 mg/L, respectively. Wastewater System Options 1, 2, and 3 use the MBR treatment process that will produce an effluent quality (less than 2 mg/L BOD and TSS) much better than required for marine discharge. It is important to note that the MBR technology has been used by the consultant for all treatment plants in the three wastewater system options as a representative treatment technology for the purpose of comparing the cost of system options.

### Biological Treatment Processes

The type of biological treatment process selected has a specific impact on site space requirements and capital and operating costs. MBR systems have been used in other locations where the process selection was driven by space limitations and/or aesthetics, as the MBR process may require only one-third to one-half the space of a conventional activated sludge (CAS) system with clarifiers for liquid-solids separation. It should be noted that in the “Liquid Process Alternatives Evaluation” (Discussion Paper 034-DP-1), a fixed film Biological Aerated Filter (BAF) process was considered but eliminated. This process also uses less space than the CAS process; about one-half. The reasons for eliminating the BAF process were based on assuming the process would be designed for nitrification, that there would be an adverse impact due to the addition of waste sludge from other treatment plants and that the process has a high energy demand. The PRT does not agree with those assumptions and this process could be evaluated further, although it does have a higher capital cost and higher operational complexity than the CAS system.

In the case of Option 1, the MBR system but not the CAS system can fit the McLoughlin Point site for the Year 2065 average dry weather flow (87.5 ML/d). For the Saanich East facility in Option 1 (Year 2065 design flow of 17.3 ML/d), there is space for a CAS system but the MBR system was selected to meet reclaimed water plans. For the third facility in Option 1 at South Colwood (38.7 ML/d) there is no overriding issue forcing MBR process selection such as producing reclaimed water for reuse from a high percentage of the treated flow or space restrictions. In Section 5 of this report the PRT suggests an alternative site to the McLoughlin site where it is possible to consider CAS versus MBR treatment technology. Appendix G evaluates and compares CAS treatment to

MBR treatment to meet the marine discharge BOD removal limits. If some portion of the CAS effluent is to be used for reclaimed water irrigation, which will only be for a few months each year, or for toilet flushing, membrane polishing systems can be used to treat only the reclaimed portion of the CAS effluent. The hydraulic application rate per unit of membrane area in a CAS effluent polishing application can be at least three times higher than that for membranes immersed in activated sludge in the MBR systems.

### Comparison of Processes

Based upon the analysis presented in Appendix G, the MBR system requires about 2.4 times the energy needed for the CAS alternative when considering the added energy associated with nitrification and with the operation of the membranes. In addition as discussed in Appendix E, the MBR process will likely require alkalinity addition to maintain an adequate pH to provide activated sludge characteristics that minimize the potential for membrane fouling. Additional alkalinity will also be needed during the chemical enhanced primary treatment and blending operation proposed for the MBR system during high wet weather flows, as alum or ferric addition consumes alkalinity. Regardless of capital cost considerations, the high energy demand of the MBR system and the consumption of chemicals to meet alkalinity needs run contrary to the interest in resource recovery and minimizing the carbon footprint of the CRD project. The PRT recommends that when implementing the full-scale system, MBR technology should not be applied indiscriminately in all cases for wastewater treatment. It will be better from a greenhouse gas effect and operating costs to consider the MBR technology where the only sites available have very limited space and where there is opportunity to reclaim a high percentage of the treatment plant effluent for reuse.

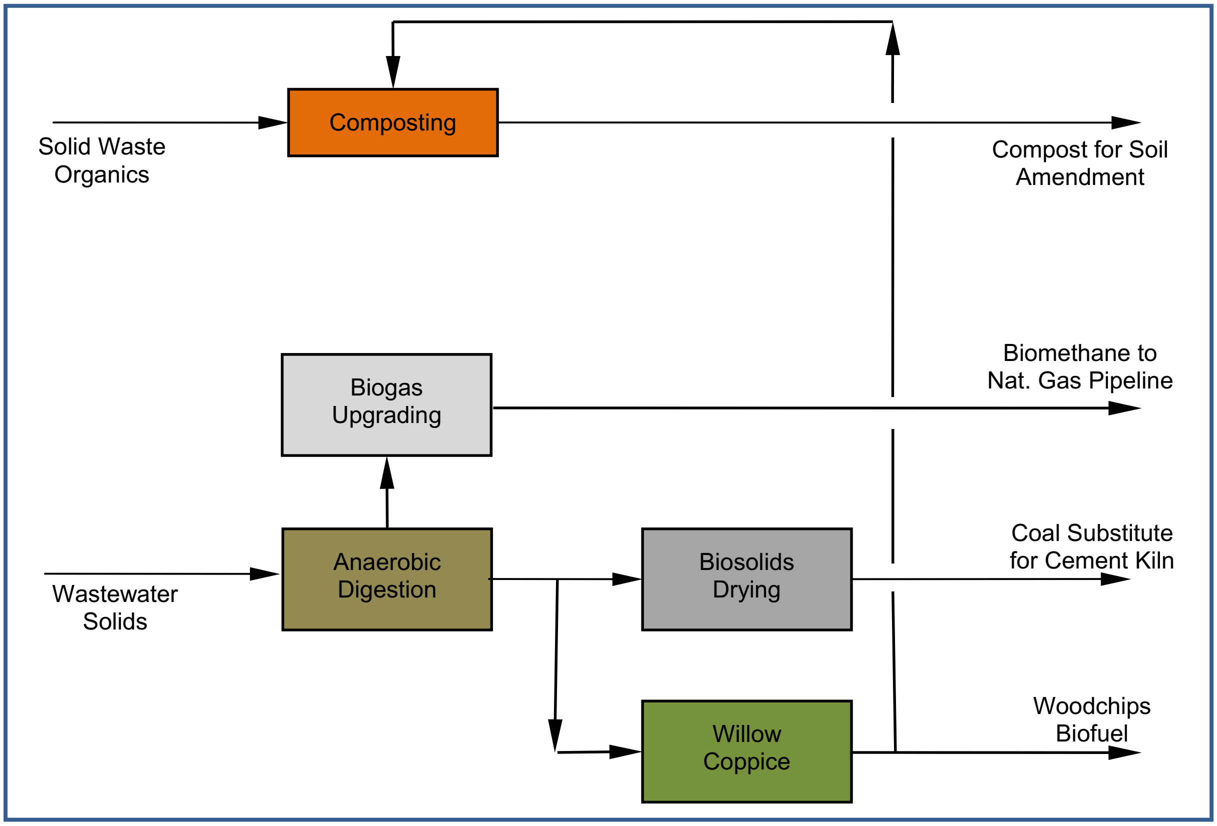
## BIOSOLIDS MANAGEMENT AND RESOURCE RECOVERY

When implementing a wastewater sludge processing and ultimate disposal system, many complex issues must be addressed that encompass a broad variety of technical, economic and social considerations. Such issues pose significant challenges for many municipalities and the CRD is no exception. To develop an understanding of the CRD sludge management options, the PRT reviewed the evolution of the approach to resolving these issues over the two years that have elapsed from the initial work in early 2007 through to the most recent discussion paper Development of Distributed Wastewater Management Strategies 036-DP-2 (March 9, 2009). Information gleaned from this review is summarized in Appendix F and provides the background for the PRT's comments.

### Consultants' Recommended Biosolids Management Strategy

The studies summarized in Appendix F and a recent Multiple-Objective Alternative Analysis (MOAA) resulted in the consultants' recommended biosolids management strategy that would be used for wastewater system Options 1, 2 and 3. A schematic for this strategy is sketched in Figure 5-1.

**Figure 5-1 Consultants Recommended Biosolids Management Strategy**




In the consultants' recommended strategy, 50% of the anaerobically digested wastewater biosolids would be dried and used as a fuel supplement at a cement kiln in the Lower Mainland. The other 50% would be applied to a dedicated willow coppice created on an industrial land application site for the periodic harvesting of wood chips as a saleable product.

Co-digestion of the waste sludge with local organic wastes, such as fats, oils and grease (FOG) and food wastes was recommended. In addition biogas cleaning and production of biomethane for vehicles or utility pipeline gas was recommended.

Further details of the sludge handling plan for Options 1, 2, and 3 are summarized in Tables 5-1, 5-2 and 5-3 respectively. For Option 1, the sludge handling will be done at the two main treatment plants: Macaulay/McLoughlin Point and South Colwood. The sludge produced in the smaller Saanich East facility will be discharged into the sewer system for removal and processing at the Macaulay/McLoughlin Point facility. In this option about 60% of the sludge produced will be handled at the Macaulay/McLoughlin Point facility, which has significant space constraints. The Macaulay/McLoughlin facility will also handle about 60% of the dry weather wastewater flow.

**Table 5-1 Option 1 Sludge Handling Plan**

| | | | Sludge Processing Location | |
|---|---|---|---|---|
| Macaulay/McLoughlin Point (MMP) | 87.5 | 25.7 | On site | |
| Saanich East | 17.3 | 5.1 | Mac/McL | Sewer System |
| South Colwood | 38.7 | 11.4 | On site | |
| Clover Point (Wet Weather Treatment) | (403) | | Mac/McL | Sewer System |

[1] Based on Year 2065

For Option 2 (Table 5-2), all of the sludge will be processed at the Macaulay/ McLoughlin facility with sludge transported from the other facilities by the sewer system, pumping across the harbour, and by centrifugation and truck hauling. This approach continues with the space constraints at the Macaulay/ McLoughlin facility. The liquid process space requirements at Macaulay/ McLoughlin (treating about 16% of the design flow) are less but the sludge handling processing space is increased with treatment of 100% of the waste sludge.

**Table 5-2 Option 2 Sludge Handling Plan**

| | | Dry Solids (tonnes/d) | Sludge Processing Location | |
|---|---|---|---|---|
| Macaulay/McLoughlin Point (Wet Weather Treatment) | 23.3 (154) | 6.9 | On site | |
| Saanich East | 17.3 | 5.1 | Mac/McL | Sewer System |
| South Colwood | 9.6 | 2.8 | Mac/McL | Centrifuge Truck Haul |
| Ogden Point | 37.0 | 10.9 | Mac/McL | Pump Across Harbour |
| Juan de Fuca | 56.0 | 16.5 | Mac/McL | Not Defined |
| Clover Point (Wet Weather Treatment) | (403) | | Mac/McL | Sewer System |

[1] Based on Year 2065

For Option 3 (Table 5-3), sludge processing is proposed for two sites; the Macaulay/McLoughlin facility and a sludge-processing only facility at Royal Roads. Note that the total ADWF wastewater treatment flow is reduced to 121.8 ML/d by an aggressive water conservation plan incorporated in Option 3 as compared to the Year 2065 ADWF of 143.2 ML/d in Options 1 and 2. Forty percent of the sludge produced is truck hauled to the Royal Roads site from 5 smaller facilities after centrifuge thickening. The remaining sludge is processed at the Macaulay/McLoughlin facility, with most of the sludge processed at that site delivered from other plants via the sewage collection system. The sludge processing location and method of delivery from the Ogden site was not stated specifically under this option, but presumably it would be pumped across the harbour to the Macaulay/McLoughlin facility as in Option 2. The Macaulay/ McLoughlin site processes only about 10% of the Year 2065 design wastewater flow in this scenario.

**Table 5-3 Option 3 Sludge Handling Plan**

| | | | Sludge Processing Location | |
|---|---|---|---|---|
| Macaulay/McLoughlin Point (MMP) (Wet Weather Treatment) | 12.0 (185) | 4.2 | On site | |
| Saanich East | 15.3 | 5.3 | Royal Roads | Centrifuge Truck Haul |
| South Colwood | 8.0 | 2.8 | Royal Roads | Centrifuge Truck Haul |
| Ogden Point | 20.0 | 6.9 | MMP | Pump Across Harbour |
| Juan de Fuca | 13.5 | 4.7 | Royal Roads | Centrifuge Truck Haul |
| Windsor Park | 12.0 | 4.2 | MMP | Sewer System |
| Westhills | 8.0 | 2.8 | Royal Roads | Centrifuge Truck Haul |
| Florence Lake | 4.0 | 1.4 | Royal Roads | Centrifuge Truck Haul |
| Lang Cove | 8.0 | 2.8 | MMP | Sewer System |
| Roderick | 21.0 | 7.3 | MMP | Sewer System |
| Clover Point (Wet Weather Treatment) | (403) | | MMP | Sewer System |

[1] Based on Year 2065

For Options 2 and 3, the SHARON-ANAMMOX process was proposed for the treatment of the centrate derived from the dewatering (by centrifugation) of the anaerobically digested biosolids. The SHARON Process uses an aerated low solids retention time process at high temperature and low dissolved oxygen to nitrify ammonia nitrogen ($NH_3$-N) to only nitrite nitrogen ($NO_2$-N), which reduces aeration costs. The ANAMMOX process is the second stage of the combined process and it has had limited full-scale operation experience and its major benefit is the removal of $NO_2$-N without a carbon source due to the ability of special autotrophic organisms that are able to oxidize $NH_3$-N with nitrite $NO_2$-N. The appropriate process and economical application for these processes are for systems that must produce low effluent total nitrogen concentration, well below 10 mg/L. As nitrogen removal is not needed or expected in the future for the CRD facilities due to the ocean discharge, these processes do not appear to be warranted.

**Peer Review Team Comments on Biosolids Strategy**

Both the PRT (see the PRT report of preliminary findings) and the consultants have recommended against anaerobic digestion of combined organic solid wastes and wastewater sludge. Separation of treatment and resource recovery for these two different waste materials minimizes problems with transporting materials to the same site, allows for separate operation and optimization of the separate treatment systems, and allows flexibility for the use of different technologies for each type of waste and easier response to future technology improvements in each area.

The Multiple-Objective Alternative Analysis done by the consultants illustrates the complexity of sludge processing and the many options for processing and ultimate reuse/disposal. The PRT notes that there is no universal trend for sludge processing and disposal. The trends tend to be noticeable on more local and regional basis rather than a national or international basis depending on land availability, population density, public concerns, reuse opportunities, landfill availability, and hauling distance for reuse or disposal. In the consultants' sludge processing analysis, the key pathways for sludge processing and reuse/disposal considered included its ultimate fate in land application, in combustion, or drying prior to combustion in cement kilns.

The use of anaerobic digestion is an appropriate choice for sludge processing at the wastewater treatment facilities as it is an efficient way to produce energy from wet sludge, to reduce solids mass, and to provide pathogen destruction. However, the PRT suggests the choice of thermophilic digestion be reconsidered. If the ultimate disposal options are controlled-access forest land or forest tree farming, combustion or drying/cement kilns, mesophilic digestion is adequate. Mesophilic digestion has a lower capital cost, and results in more net energy recovery. The PRT agrees that upgrading biogas for use as pipeline biomethane or as a motor fuel is a reasonable option for consideration but this should be compared to the economics of its use in a cogeneration facility for directly satisfying the energy needs at the treatment plant.

The PRT's review of the material presented in the various Discussion Papers and in the presentations to the PRT certainly indicates that many options have been considered for wastewater sludge processing and ultimate disposal. The preferred alternative strategy illustrated in Figure 5-1 has several merits, not the least of which is a relatively high degree of beneficial reuse of the wastewater biosolids for:

- Biogas production and upgrading to a fuel.
- Woodchips for use as a biofuel and as a bulking agent for composting the organic fraction of municipal solids wastes.
- Stabilized and dried biosolids for use as a fuel supplement in cement kiln or elsewhere.

However the PRT has a number concerns about the strategy illustrated in Figure 5-1:

1. The practice of applying biosolids to a willow coppice is by no means widespread. The PRT is not aware of North American experience for applying biosolids to willow coppices on a scale that would be required for the CRD. Before committing to full-scale implementation, it would be prudent to conduct a pilot-scale program to verify the technical feasibility of this disposal option for the topographic, geologic, hydrogeologic, climatic and soil conditions in the CRD area. Biosolids produced at the CRD's North Saanich wastewater treatment facility could be used for the pilot-scale program.
2. The PRT was advised during the March 12-14 Victoria meetings that the proposed willow coppice program would require 600 hectares (6 square kilometers or about 2.5 square miles) of dedicated land for biosolids application over a 21-year period. The amount of area that must be managed is significant. The willingness of property owners to lease their land to the CRD for purposes of biosolids application is open to question. If the required land cannot be leased, then the CRD may have to purchase sufficient suitable land itself for the purpose. No allowance for land costs has been included in the consultant's estimates. Assuming a cost of $100,000 per hectare, the acquisition cost for the 21-year supply of land for the willow coppice would be $60 million.
3. The availability of suitable land of this area reasonably close to the Core Area is doubtful. As sites further away are considered, travel costs increase along with the carbon footprint of the operation.
4. As one travels greater distances from the Core Area, the relatively moderate rainfall experienced in the Core Area approximately doubles as indicated in Table 5-4 and Figure 5-2. While the driest months of the year are still from May to September (Figure 5-2) greater precipitation occurs further afield from the Core Area. Such conditions may severely hamper the ability to access

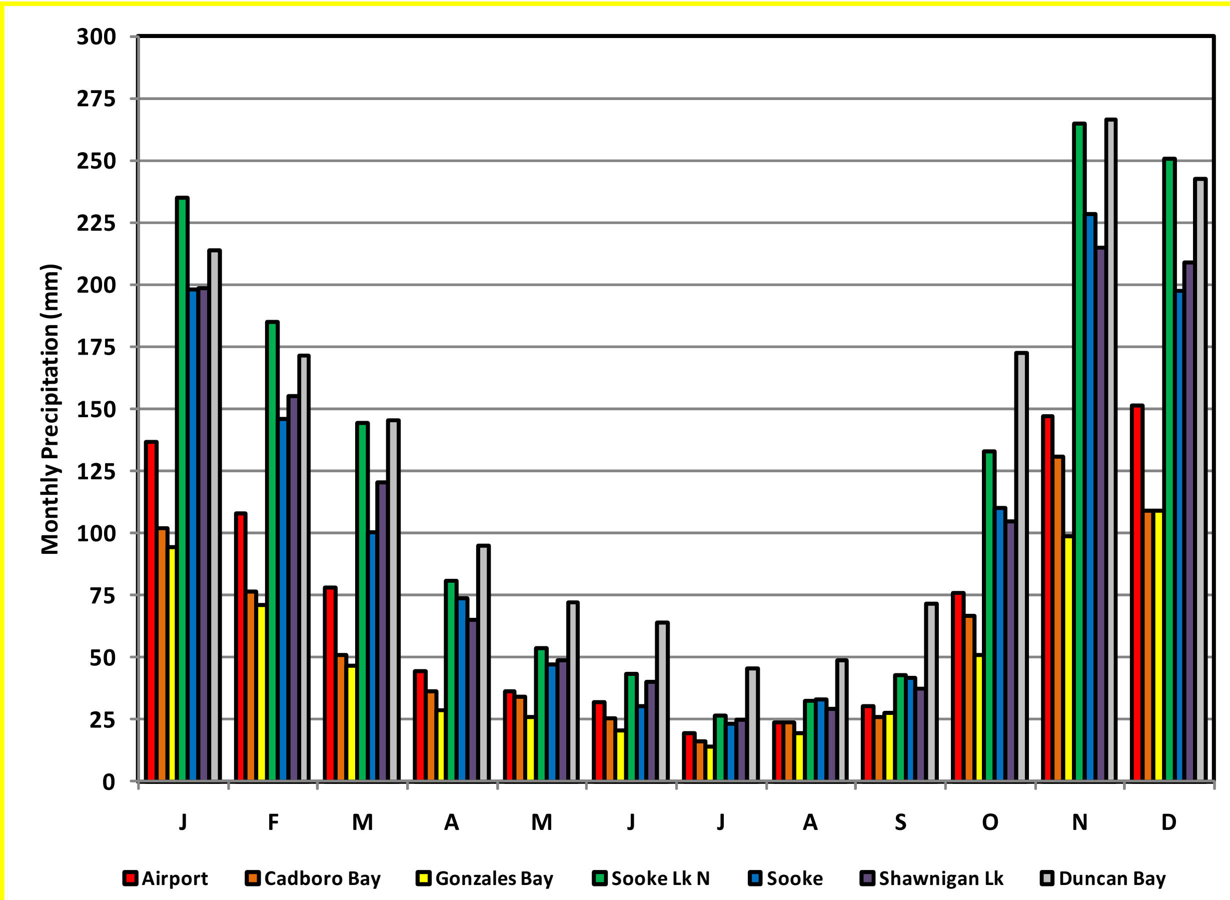
land for application of biosolids, particularly during the wettest period from October to March.

5. The PRT recommends a risk analysis of the cement kiln fuel supplement option be conducted in regard to worker and public health. The drying, pelletizing, storing, transporting, preparing and feeding raw wastewater sludges as a fuel supplement must be done with great care to the design, equipment selection and operation to ensure that pathogenic organisms are not released to the environment and pose a risk to worker and public health and safety. This issue is not only one of public perception, but also pertains to the integrity of the design, construction, and on-going operation and maintenance of all components in the project.

**Table 5-4 Annual Precipitation Data for Selected Weather Stations in CRD and Nearby Areas** (Source: 1971-2000 Canadian Climate Normals from Environment Canada Website at http://www.climate.weatheroffice.ec.gc.ca/Welcome_e.html )

| | | Straight Line Distance from Legislature Buildings (km) | | |
|---|---|---|---|---|
| Victoria Int'l A | 48° 39.000' N<br>123° 25.800' W | 26 km N | 19.2 | 883.3 |
| Victoria Phyllis Street (Cadboro Bay) | 48° 27.600' N<br>123° 16.200' W | 8.3 km NE | 7.6 | 698.6 |
| Victoria Gonzales Heights (Bay) | 48° 24.600' N<br>123° 19.800' W | 3 km E | 69.5 | 607.6 |
| Sooke Lake North | 48° 34.800' N<br>123° 38.400' W | 27.5 km NW | 231.0 | 1492.4 |
| Victoria Marine (near Sooke) | 48° 22.200' N<br>123° 45.000' W | 26 km W | 31.7 | 1235.7 |
| Shawnigan Lake | 48° 39.000' N<br>123° 37.800' W | 32.5 km NW | 138.0 | 1247.6 |
| Duncan Bay | 50° 4.200'N<br>125° 16.800 W | 50 km NW | 11.0 | 1609.3 |

**Figure 5-2 Monthly Precipitation Data for Selected Weather Stations in Core Area and Nearby Areas** (Source: 1971-2000 Canadian Climate Normals from Environment Canada Website at http://www.climate.weatheroffice.ec.gc.ca/Welcome_e.html )




## CAPITAL COSTS

The consultants have estimated the capital and operation and maintenance (O&M) costs of the three system configurations summarized earlier in this section. The total capital costs to serve the wastewater needs of the CRD through the year 2065 are estimated by the consultants as:

- Option 1 $1,103,000,000
- Option 2 $1,543,000,000
- Option 3 $1,852,000,000

The elements that comprise the total cost of these options are summarized in Table 5-5.

**Table 5-5 Elements of Consultants' Estimates of Capital Costs, Options 1-3**

| | | | |
|---|---|---|---|
| Treatment, Liquid | $726,000,000 | $1,136,000,000 | $1,378,000,000 |
| Treatment, Solids | $139,000,000 | $120,000,000 | $156,000,000 |
| Plant Related Conveyance | $39,000,000 | $34,000,000 | $33,000,000 |
| Wet Weather Treatment Stream | Included in Liquid Costs | $24,000,000 | $24,000,000 |
| Outfalls | $50,000,000 | $54,000,000 | $107,000,000 |
| Heat Recovery System/ Piping | $8,000,000 | $8,000,000 | $10,000,000 |
| Land Purchase | $20,000,000 | $27,000,000 | $35,000,000 |
| Wastewater Conveyance | $68,000,000 | $87,000,000 | $54,000,000 |
| Hartland Biosolids Drying | $53,000,000 | $53,000,000 | $53,000,000 |
| Total | $1,103,000,000 | $1,543,000,000 | $1,852,000,000 |

The major difference in the cost of the options is related to the differing cost of liquid and solids treatment. Hence, the PRT focused its review of costs on treatment costs.

The PRT agrees that the capital costs related to treatment will increase as the number of treatment facilities increases from the three secondary treatment plants included in Option 1 to a greater number of smaller plants included in Options 2 and 3. This increase is an expected result because the economy of scale affects the cost of wastewater treatment. For example, the cost of one 100,000 cu m/day wastewater treatment plant will be significantly less than the total cost of ten 10,000 cu m/day wastewater treatment plants.

It was beyond the scope and budget of the PRT to develop an independent estimate of the costs of the various facilities in the three system options. However, the PRT compared the estimated cost of the treatment facilities with the cost of several other recent wastewater treatment plants as a rough check of the reasonableness of the consultants' cost estimates. Many factors affect the comparison of costs of similar facilities in different locations. Such factors include the bidding climate at the time the project is bid, the project delivery method (design-bid-build, design-build, design-build-operate, design-build-operate-finance, etc.), foundation conditions, site constraints, nature of support facilities included within the plant (laboratories, maintenance buildings, operations buildings, visitor centres, etc.), architectural treatment, conservatism of design, redundancy of process and equipment, degree of automation, availability of construction materials and equipment, construction labour availability, availability of access to the site, type and extent of sludge processing, accuracy of adjusting costs at the time the project bid to account for the effects of inflation to current levels and amount of odour control. Thus, such comparisons provide only a general perspective on the reasonableness of the cost estimates. Because, as noted previously, the consultants used an MBR process as their representative treatment process for comparison of system options, the PRT reviewed the cost of other MBR projects. The PRT found cost information for 11 MBR facilities with plant capacities in a range similar to those in the three System Options. These are summarized in Table 5-6.

**Table 5-6 Capital Cost of MBR Treatment Facilities**

| Location of Facility | Secondary Treatment Capacity Cubic metres/day | Unit Cost $CA/cubic metre/day of Secondary Capacity |
|---|---|---|
| Healdsburg, CA | 5,299 | $8,590 |
| Henderson, NV | 30,280 | $8,111 |
| Bonita Springs, FL | 12,491 | $7,904 |
| King County, WA | 117,714 | $7,498 |
| Picnic Point, WA | 15,519 | $7,352 |
| Loudon County, VA | 41,635 | $7,240 |
| Santa Paula, CA | 12,869 | $6,626 |
| Spokane, WA | 30,280 | $6,082 |
| Clovis, CA | 11,355 | $5,062 |
| North Las Vegas, NV | 94,625 | $4,245 |
| Winlock, WA | 3,785 | $3,630 |

The cost for these MBR facilities varies from $3,630 to $8,590 per cubic metre per day of secondary treatment capacity. Of the 18 facilities estimated by the consultants, 16 fall within a range of $3,130-$8,571 per cubic metre of secondary treatment capacity per day. One falls below this range (the Juan de Fuca plant in Option 2 that is a large liquid treatment only facility) and one falls above this range (Macaulay/McLoughlin in Option 3 which includes sludge processing for six other plants). The treatment plant cost estimates developed by the consultants generally falls within the range of costs experienced at other MBR treatment facilities and can be used for purposes of comparing system options,

The CRD and the public should be aware that the consultants' estimate of cost will be refined and will change during pre-design and design. These changes may result in either an increase or decrease in the estimated cost. Cost will remain an estimate until the actual bids are received. Estimates made during a preliminary planning phase such as at this stage of this project are generally considered to have an accuracy range of –15% to +30%.

## OPERATION AND MAINTENANCE (O&M) COSTS

The PRT understands that the consultants' estimates of O&M costs were developed by CH2M HILL OMI, a company that provides contract O&M services to a large number of public water and wastewater agencies. Because the consultants' estimates of O&M costs constitute only 15-30% of the net present worth of each treatment facility, minor changes to the consultants' estimates of O&M costs are not likely to have a major effect on the relative net present worth of the system options.

The PRT reviewed the resulting staffing levels. The consultants have shown the estimated number of staff for the liquid stream portion of each treatment plant in each option. They also separately estimate the total labour costs for the solids processing O&M including the West Shore plant, the McLoughlin plant, Hartland drying facility and the willow coppice program. The total labor equates to 43.5 staff. The overall staffing is similar to the staffing levels at highly automated contractor-operated wastewater treatment facilities where much of the maintenance work is performed by outside contractors rather than plant staff. It appears that the 1% of capital cost allowance for maintenance discussed below would provide funds for contract maintenance work. The estimated labour portion of the O&M costs are representative of an approach based on contract operation.

The consultants made some assumptions to simplify the comparison of the system options:

- Allowance of annual maintenance cost of 1% of capital cost
- Lump sum allowance for administration of $100,000 per year per plant

The 1% allowance for maintenance costs was compared to the maintenance-related cost in a recent (2008) bid for contract operation of a greenfield 30,280 cubic metre per day MBR plant in Spokane, Washington. The annual cost for preventive maintenance, corrective maintenance and repair and replacement was equivalent to 0.7% of the capital cost of the project, only slightly less than the 1% assumed by the consultants.

Application of the same administrative cost of $100,000 per year regardless of the size of the treatment facility results in higher unit O&M costs for the smaller treatment facilities. However, the $100,000 allowance for administration is only 3.6% of the present worth cost of the smallest facility, is 1-2% for most of the facilities and does not have a significant effect on the relative present worth costs of Options 1, 2 and 3.

The consultants approach to estimating O&M costs and related unit costs for the various components of O&M cost were uniformly applied to the three system options and is a reasonable approach for comparing the cost of system options.

Another O&M consideration is that O&M complexity and number of potential failure points increases as the number of treatment plants and the number of pieces of equipment in the system increases. This complexity is a consideration when comparing the three secondary plants in Option 1 to five secondary plants in Option 2 and to 10 secondary plants in Option 3.

## REVENUES

In preparing their analysis of the alternatives, the consultants have also considered the potential revenues that might accrue from the sale of heat and reclaimed water. The PRT suggests caution should be exercised in viewing such revenues. Each of these commodities is considered separately below.

### Heat

In preparing their analysis for heat recovery from wastewater, the consultants have made the following assumptions and conclusions:

- Available heat will be sold to a private third party utility who would act as the retailer to the public
- The assumed maximum unit selling price of heat of $14.00/GJ, 87% of the current energy market price
- CRD will transport effluent to the third party utility's heat recovery facility
- An assumed value for the selling price of heat was made for each wastewater treatment facility
- The amount of saleable heat was based on a market evaluation for each wastewater treatment facility service area
- Saleable heat is the lesser of either supplied or demanded heat for each service area for each year through 2065
- The total CRD cost to recover heat is estimated at between $0.10/GJ and $0.20/GJ for Options 2 and 3 and more than $0.65/GJ for Option 1

The PRT believes that the projected revenues for the sale of heat are optimistic with respect to: (1) process efficiency of existing commercially available heat pumps (2) the willingness of purchasers to provide the necessary infrastructure to utilize the heat effectively (3) the price they are willing to pay for heat given infrastructure costs for making use of that heat compared with that for alternative energy sources, and (4) for the need to provide a standby source of heat to account for anticipated service interruptions, which are unavoidable.

In an evaluation reported in Technical Memo 5, Page 5, contained in Discussion Paper - *Identification and Evaluation of Resource Recovery Opportunities*, 036-DP-1, dated December 2, 2008, the weighted winter time Coefficient of

Performance (COP) for Victoria for use of air was indicated to be 2.87 while that of wastewater to be 4.01. If the cost for a GJ of electrical energy in Victoria is $18 ($0.075/kwh), then using wastewater, 4.01 GJ of energy could be obtained with an input of $18 worth of electric power, or $4.49 per GJ of heat energy obtained from the wastewater and supplied to a building. Using air, such cost would be $6.27 per GJ. Thus, a GJ of supplied heat to a building would be $1.78 less when using wastewater compared with using air. However, air would be available at the building, while wastewater would need to be transported to the site for use. The cost for transport to the building would reduce the advantage. Certainly, if free and available at a building, use of wastewater heat would be an attractive option for a building owner, but if the cost of delivery of the wastewater to a building were equal to or greater than $1.78 per GJ of wastewater heat, then wastewater as a heat source would not be attractive. The consultants have estimated that wastewater heat would have a resource value at the building on the order of $14/GJ. Such projections for the value of this resource in Victoria are unrealistic. Further, potential purchasers who are willing to commit to the purchase of wastewater heat have yet to be identified.

**Reclaimed Water**

In preparing their analysis for reclaimed water, the consultants have made the following assumptions and conclusions:

- Reclaimed water will be sold for large-scale, non-residential irrigation and for toilet flushing
- Unit selling price for reclaimed water is 80% of the price of potable water

The PRT similarly believes that the assumed value for the sale of reclaimed water is optimistic with respect to: (1) the purchase of reclaimed water that is only needed seasonally and would require storage to utilize effectively; (2) the willingness of purchasers to provide the necessary infrastructure to utilize the reclaimed water, especially through property they may not own; and (3) the price they are willing to pay for reclaimed water given that a separate distribution system and storage facilities to utilize the reclaimed water effectively would be needed. Additionally, membrane filtered and disinfected water has rather limited value compared with potable water, lower than 80%, as it cannot be used in a potable water supply system. The major use for reclaimed water would be for irrigation. Potential purchasers who are currently willing to commit to the purchase of reclaimed water at 80% of the cost of potable water have not yet been identified, A clear example of the low value of such reclaimed water is given in South San Francisco Bay, where membrane and disinfected equivalent wastewater from several million people is currently being discharged to the ocean because of lack of buyers for it, even though water supply there is extremely short, potable water costs are several times higher than in Victoria, prime agriculture land is close at hand, and the potential for year around use is high. This treated wastewater is essentially free for the taking at the fence of the treatment facility. It is the infrastructure cost for transport to agricultural lands that is the primary barrier to greater use. Some is accepted very locally for use for landscape irrigation and golf course watering. From this and other examples, the PRT believes that it will take significant discounts from conventional sources to generate interest.

As a final note, in spite of the example in South San Francisco Bay, wastewater reclamation is highly practiced in California because of the great shortage of water there. Water shortages could materialize in the CRD in the future through possible climate change impacts and large population increase. However, sale of reclaimed wastewater should not be considered a net revenue generating activity, rather it is an activity that becomes justified when because of limited availability the price rises significantly, justifying additional treatment costs, or if it is a free commodity that is simply available for those who have a use for it.

### Finding on Revenue

In Options 2 and 3 the wastewater treatment and resource recovery facilities are distributed over a larger portion of the service area to provide greater revenues from resource recovery. The consultants' evaluation of the costs and revenues of Options 2 and 3 compared to the cost of Option 1 is summarized in Table 5-7. As discussed previously, the PRT believes that the consultants' estimates of revenues are optimistic. Even using the consultants' optimistic estimates of revenues, it can be seen from Table 5-7 that the added revenue and GHG credits gained in Options 2 and 3 are far less than the added cost. In Option 2, added costs with an NPV of $363.2 million would be expended to gain $62.9 million NPV in revenues relative to Option 1. In Option 3, added costs with an NPV of $491.7 million would be expended to gain $101.3 million NPV in revenues relative to Option 1. The incremental cost of using the more distributed wastewater treatment systems in Options 2 and 3 is 5 to 6 times greater than the incremental revenue generated when compared to Option 1.

**Table 5-7. Consultants' Estimates of Costs and Revenues for the Three System Options** (Costs in millions of dollars)

| | | | Increase in NPV of GHG Credits Plus Revenues vs. Option 1 | |
|---|---|---|---|---|
| Option 1 | 63.0 | 1,174.5 | - | - |
| Option 2 | 125.9 | 1,537.7 | +62.9 | +363.2 |
| Option 3 | 164.3 | 1,666.2 | +101.3 | +491.7 |

NPV = Net Present Value
GHG=Greenhouse Gas
Source: Discussion Paper 036-DP-02, March 9, 2009, Figure 4-6.

The environmental costs in terms of energy usage and greenhouse gas production as well as the economic costs for recovering heat and reusing wastewater in Victoria far exceed the current value and environmental benefit of these resources, and this is likely to be the case well into the future. There is a high cost to use multiple treatment systems in anticipation of revenue generation from the sale of heat and water resources. As shown above, the cost to recover these resources far exceeds their economic value.

In addition to the projections of revenue from resource recovery being optimistic, there is no assurance that revenues from resource recovery will materialize. Potential revenues will not become assured revenues until signed contracts with purchasers are in hand. On the other hand, costs for wastewater conveyance and treatment will assuredly be incurred. Therefore, the PRT strongly recommends that the cost of the proposed wastewater alternatives be compared only on the basis of wastewater conveyance and treatment costs without the inclusion of potential revenues from resource recovery. The potential for resource recovery could be included as a factor in the scoring of social benefits in the Triple Bottom Line analysis.

## FLEXIBILITY

There are many future unknowns that make it difficult to prepare a design that will be optimal for economically meeting today's needs, future regulatory requirements and resource recovery potentials for the CRD wastewater handling and disposal facilities. For this reason, facilities that meet today's needs and opportunities, using currently available technology, should be designed with maximum flexibility for meeting changes that will inevitably occur in the future. Such changes include regulatory requirements, population growth and distribution, development of new treatment and control technology, resource availability and costs, markets for wastewater-related resources and climate change impacts.

### Utilization of Resources

New development offers the best opportunity for capturing the energy, water, and nutrient resources contained in wastewater. Constructing heat and reclaimed water distribution systems in new developments is much less costly than constructing and retrofitting them in densely developed urban areas. New developments can be planned from the outset with due consideration to all aspects of resource recovery.

The three system configurations under consideration by the CRD are compatible with potential construction in new developments of satellite treatment facilities to capture the resource potential of wastewaters. Connection of such satellite facilities to central facilities found in each of the three system options that can better handle waste biosolids and provide redundancy in case of satellite overload, failure, or shutdown time for maintenance is highly desirable.

There is currently rapid development of new technology for treatment and control of wastewater. Flexibility to permit economical adaptation of such newer technologies as they develop in the future is needed when selecting treatment plant sites and in the design of current treatment facilities.

### Future Changes

Major changes likely to occur in the future that will affect the need for greater resource recovery from wastewater relate to the interacting effects of energy cost, water shortage, and climate change. Growing concern with climate change is increasing the pressure to reduce dependence on inexpensive fossil fuels. As a result energy costs are likely to see sizeable increases, thus increasing the emphasis on use of heat and the production of biofuels from wastewater. Climate change is shifting water availability away from western areas of the continent to greater rainfall in the eastern portion. Thus, while rainfall and current water supplies may be sufficient to meet current water needs in the CRD, the future here is far from certain. Climate change aspects were discussed previously in Section 4 of this report.

### Selecting a Flexible Configuration

Based on the above discussion, clearly a number of future unknowns including future regulations (see Chapter 3) among others need to be considered when designing the overall facilities for wastewater handing and treatment within the CRD. Selecting a system configuration that meets today's needs economically, while providing maximum flexibility to allow addition of newer facilities to meet possible changes in regulatory requirements and permit greater resource recovery as the need arises is important.

## STAGING OF CONSTRUCTION

### Proposed Staging

The planned staging of facilities, as described in Discussion Paper 036-DP-2 (March 2, 2009), was based on three stages of construction: Initial stage completed by 2017, Stage Two (completed by year 2030) and Stage Three (completed by year 2045) with the ultimate facilities designed for the year 2065. The costs related to the staging for each option as presented by the consulting team are summarized in Table 5-8. In Option 1, the $64 million in Stage Two costs include approximately $10.3, $47.3 and $6.4 millions for expansions at the Saanich East, South Colwood, and Macaulay/McLoughlin facilities respectively. The specific components in the Stage Two expansion at each site are not identified in the documentation.

**Table 5-8 Staging of Construction Costs Proposed by the CRD's Consultants**

| | Total Construction Cost, $ | Stage Two (2030) Cost, $ | Stage Three (2045) Cost, $ | Staging cost as % of total cost |
|---|---|---|---|---|
| Option 1 | 1,103,000,000 | 64,000,000 | 0 | 5.8% |
| Option 2 | 1,543,000,000 | 84,000,000 | 16,000,000 | 6.5% |
| Option 3 | 1,852,000,000 | 66,000,000 | 15,000,000 | 4.4% |

### Time Between Stages

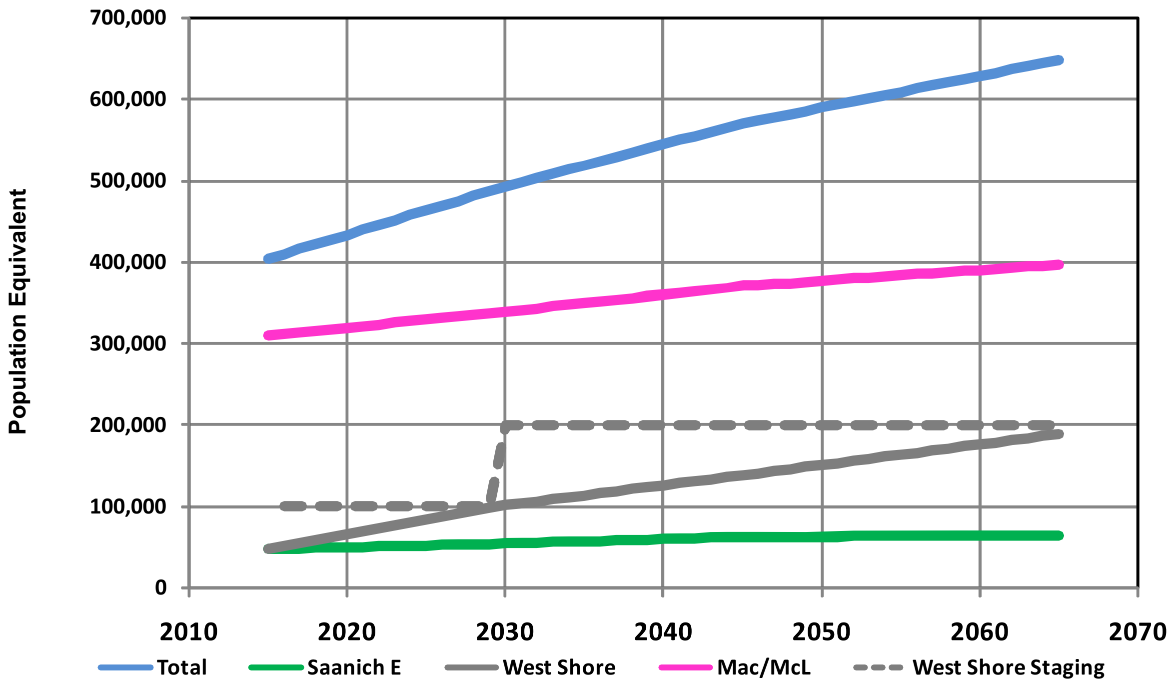
Typical staging practice for major wastewater treatment plants is to provide capacity for 10 to 15 years between plant expansions. The first stage of the CRD facilities must be in operation by the end of 2016. Thus, the capacity needs of 2030 would typically be the basis for the first stage of construction with Stage Two being completed by about 2030. Although 43% of the ultimate demand will not develop until after 2030, none of the construction cost in Option 1 has been deferred to Stage Three. Very little is deferred to Stage Three in the other options (1% for Option 2 and 0.8% for Option 3). Similarly, the amount deferred to Stage Two is disproportionately low when compared to the growth in equivalent population to be served from 2030 to 2045.

Projected population equivalents to be served by the various facilities are plotted as solid lines in Figure 5-3. This information was taken from the February 2009 Draft Version 1.0 "Wastewater Management Options 1, 2 and 3 Detailed Cost Summary" that was given to the PRT during the March 11-13, 2009 series of meetings.

The staging for Option 1A includes a significant staging of plant construction only at the West Shore facility. Included on Figure 5-3 is a dashed line showing the consultants' proposed staging of the West Shore plant. The plant would initially be designed with a capacity to serve a population of about 100,000 (year 2030 projected population served). It would be expanded in 2030 to provide a capacity to serve a design population of about 190,000 to accommodate anticipated growth to 2065. At 2065, another increase in the capacity of the West Shore plant would be required if growth continues.

The consultants' estimates of costs for staging (8% of plant cost occur in Stage Two) at Saanich East are very low because the contributing population to the Saanich East plant increases only modestly throughout the planning period which reduces the potential benefit of staging of construction.

**Figure 5-3 Plot of Consultant's Option 1 Project Staging (projected population data for the solids lines are taken from the February 2009 Draft Version 1.0 "Wastewater Management Options 1, 2 and 3 Detailed Cost Summary")**




The costs for staging at McLoughlin (2% of plant cost occur in Stage Two, 0% in Stage Three) are very low even though the population served by this plant is projected to increase from about 300,000 to 400,000 during the planning period. It appears that there is no significant staging at the McLoughlin plant because space and access at the McLoughlin site is so limited that the plant must be built out to the fence line during the initial construction. This results in an acceleration of cash flow for construction and costs of maintaining facilities for several years before they are needed.

There was no staging allowance made for the $53.2 million in capital costs associated with the Hartland biosolids drying facility that is common to all System Options summarized in Table 5-5 by the CRD's consultants. Presumably then, the initial capacity of the Hartland biosolids drying facility would be constructed to suffice until the end of the planning period in 2065.

The PRT recommends that the subsequent predesign effort develop a staging approach that better matches the growth in population served. Discussion of specific staging opportunities is found in Section 6 of this report.

# 6
# PEER REVIEW SUGGESTED ALTERNATIVES

When the Peer Review Team (PRT) first became involved in the CRD project in February 2009, it was evident that a considerable amount of work had been completed over the preceding two years to examine alternative strategies to implement a wastewater treatment system for the member municipalities of the CRD and to develop a decision process for the Core Area Liquid Waste Management Committee (CALWMC). In addition, several technical discussion papers had been prepared on a broad variety of relevant topics ranging from population projections, to wastewater flows, to wastewater treatment and biosolids processing technologies, to facility siting options, to resource recovery opportunities, among other topics. Based on a review of materials provided by the CRD, the PRT has developed two suggested alternative versions of Option 1, the system configuration determined by the consultants to have the lowest cost, for consideration by the consultants and the CALWMC. In this section, the alternative versions of Option 1 suggested by the PRT for further evaluation are presented and contrasted to Option 1 as presented by the consultants.

## WASTEWATER SYSTEM OPTIONS

Some of the material presented to the PRT by the consultants during the PRT meetings on February 12 and 13, 2009 and subsequently documented in a Discussion Paper – Development of Distributed Wastewater Management Strategies (No. 036-DP-2 dated March 9, 2009) presents conceptual developments for three options for the development of distributed wastewater treatment facilities for the Core Area and to develop a decision process for the Core Area Liquid Waste Management Committee (CALWMC). Further, each option provides considerable opportunities for resource recovery – on a regional basis for Option 1, on both a regional and a local basis for Option 2, and on a more local basis for Option 3. Each option has the potential to satisfy the treated effluent quality limits mandated by the BC Municipal Sewage Regulation and also provide varying degrees of resource recovery opportunities. The PRT is supportive of resource recovery and the panel members have each been involved in wastewater treatment projects with resource recovery components.

### Decision Making Building Blocks

The PRT believes that the decision making task of the CALWMC would be made easier if the information in Discussion Paper No. 036-DP-2 were supplemented with comparable information on a wastewater treatment system capable of meeting the essential requirements of the BC Municipal Sewage Regulation irrespective of providing opportunities for resource recovery. With such information in hand, the options for providing wastewater treatment to the Core Area can be presented to the CALWMC in a hypothetical “building block” fashion starting with the cost and approach for the basic wastewater treatment needs and then adding different resource recovery options with associated extra plant capital costs, revenue, resource recovery implementation capital costs and additional operating costs to facilitate comparisons and enable value judgments based on costs, revenues and non-economic benefits. For example drawing on material already developed by the CRD’s engineering consultants, information on capital and operating and maintenance costs, potential revenues, and corresponding social and environmental benefits could be assembled by the CRD’s engineering team into hypothetical “building blocks” for consideration, debate and decision making by the CALWMC. These hypothetical building blocks could include:

1. Basic treatment facilities to meet the BC Municipal Sewage Regulation for discharge to an open marine environment with no provision for extensive resource recovery other than what is commonly applied at municipal wastewater treatment plants using current state of the art treatment technologies.
2. Reclamation and sale of municipal treated effluent for various reuse applications, many of which are described in the BC Code of Practice for the Use of Reclaimed Water, a companion document to the BC Municipal Sewage Regulation.
3. Recovery and sale of thermal energy from the municipal wastewater treated effluent.
4. Generation and sale of biomethane gas with and without the inclusion of the available municipal solid waste organic fraction.
5. Recovery and sale of magnesium ammonium phosphate fertilizer from processing anaerobic digester centrate at the sludge processing facilities. This step also suggests that an anaerobic contact zone in the treatment process would be worthwhile to enhance phosphorus removal in the wastewater treatment system (and hence subsequent phosphorus recovery).
6. Land application of biosolids on a controlled willow coppice plantation with subsequent harvesting and sale of woodchips as a biofuel.
7. Biosolids drying and transport to cement kilns in the Lower Mainland to use as a fuel supplement.

Building blocks for other resource recovery opportunities can be conceived and developed as appropriate and added to the above list. It is essential that the original design concept for the basic building block make adequate allowances in the wastewater treatment facility site layouts and hydraulic grade lines to incorporate future resource recovery components.

### Decision Making

Presentation of the potential system components in "building block" format could assist the CRD and the CALWMC members in their deliberations and decision making on these very complex issues. Information assembled in building block format will help the CALWMC members to compare costs, revenues, other benefits, and value for money spent to implement varying levels of resource recovery from wastewater. As senior governments are likely to provide financial support only for those components of the treatment system necessary to meet essential treated effluent quality requirements, the committee members will be in a position to decide on which components are desirable to include in the initial construction work and which components can be implemented in later stages as required.

## DESCRIPTION OF OPTION 1

As discussed in the preceding section of this report, the PRT agrees that of the three options evaluated by the consultants, Option 1 provides the most economical approach for meeting regulatory requirements today while providing flexibility to take advantage of future changes in technology as well as future challenges and opportunities for greater resource recovery as they present themselves.

### Principal Components

Option 1 – Resource Recovery on a Regional Basis as described in the March 9, 2009 Discussion Paper No. 036-DP-002 includes the four principal components as follows:

- **Saanich East Plant:** A liquids stream only wastewater treatment plant located in Saanich East with a new outfall into Haro Strait. The plant would include preliminary treatment, chemically-enhanced primary treatment, and membrane bioreactor secondary treatment. Byproduct sludges generated at this facility would be transported by sewer for processing at the Macaulay/McLoughlin treatment plant. Treated effluent from the Saanich East plant would be of a quality suitable for water reuse. In addition, thermal energy would be recovered from the wastewater.

- **McLoughlin Point (or Macaulay Point) Plant:** A liquids and solids processing treatment plant located at McLoughlin Point or Macaulay Point including preliminary treatment, chemically-enhanced lamella primary treatment, membrane bioreactor secondary treatment (reusable quality effluent), biomethane production, fertilizer recovery, facilities to pump effluent to a district energy system in Victoria for heat recovery, and production of sludge cake for haulage to off-site disposal. Much of the treatment plant would be buried to allow use of the surface area. At this time, focus of the engineering development work is on the McLoughlin Point site rather than the Macaulay Point site because the resolution of land acquisition issues is thought to be easier for the former.

- **South Colwood Plant:** A liquids and solids processing treatment plant with similar technologies as at the Macaulay Point/McLoughlin Point plant but with no need to bury the processing units.

- **Clover Point Plant:** A pumping station to direct wastewater flows up to 2.0 times dry weather flow to the Macaulay Point/McLoughlin Point plant and a wet weather treatment facility incorporating preliminary treatment plus high-rate chemically-enhanced primary treatment for flows in excess of 2.0 times dry weather flow for discharge through the outfall to the Strait of Juan de Fuca. Solids removed from the treated wet weather stream would be passed on to the Macaulay Point/McLoughlin Point plant for processing.

**Operational Considerations**

At the Saanich East, Macaulay Point/McLoughlin Point, and South Colwood plants, the membrane bioreactors are designed to accommodate 1.5 x dry weather flow. As treated effluent from such a facility would not be in compliance with the BC Municipal Sewage Regulation which requires the secondary treatment capacity to treat 2.0 x dry weather flow, the concept design employs a blending scheme whereby during wet weather periods, a fraction of the effluent from the chemically-enhanced primary treatment system would be blended with the much higher quality membrane bioreactor effluent to meet the BC Municipal Sewage Regulation “not to be exceeded” secondary treatment requirement of 45/45 mg/L $BOD_5$/TSS.

In the documentation presented to the PRT, it appears that the treatment plants would require operation in bypass blending mode less than 5% of the time. Presumably the purpose of the blending scheme is to accommodate the limited space particularly at the McLoughlin Point site, and to reduce the size (and hence capital and O&M cost) of the relatively expensive membrane bioreactor technology.

## PRT CONCERNS ABOUT CURRENT VERSION OF OPTION 1

Option 1 is designed both to meet the BC Municipal Sewage Regulation and to provide opportunities for a significant degree of resource recovery. Concerns about the use of MBR technology and site constraints are reviewed in the following discussion.

## Use of MBR Technology

To meet the BC Municipal Sewage Regulation and to provide high quality reclaimed water together will require a more complex (and correspondingly costly) MBR treatment system than required to satisfy the requirements of the BC Municipal Sewage Regulation alone. As noted in the PRT's March 16, 2009 Interim Report, the use of MBR technology increases the cost of treatment for several reasons:

- The membranes are expensive to install and are likely to require replacement at substantial cost every 7 to 10 years
- The MBR process requires the use of long sludge ages in the bioreactor to avoid premature fouling of the membranes
- This long sludge age results in nitrification. The alkalinity in the wastewater is low. As discussed in Appendix E, nitrification will likely require the addition of chemicals to maintain an adequate alkalinity and adequate pH in the bioreactor. The PRT recommends that chemical storage and feed for alkalinity adjustment be provided.
- Nitrification requires more oxygen for the nitrification reaction. Nitrification is not required to meet the regulatory standards for discharge nor is it required for water reuse.
- The high mixed liquor solids in the bioreactor required for the long sludge age reduces the oxygen transfer efficiency of the aeration equipment in the bioreactor which in turn increases energy consumption.
- The combination of added oxygen requirements for nitrification, poorer oxygen transfer, air required for membrane scouring and head loss through the membranes increases overall energy requirements of the treatment process substantially when compared to conventional non-nitrifying activated sludge processes.

The membrane treatment process will produce an effluent total suspended solids and biochemical oxygen demand of less than 2 mg/L. This high level of treatment goes well beyond the regulatory requirement of 45 mg/L. Although the resulting effluent quality of 2 mg/L is excellent for the portion of the flow reclaimed for reuse, there is no need to treat the bulk of flow to this level because it will almost assuredly be discharged to saltwater until water reuse projects are developed. Filtration of the portion of the effluent intended for reuse can be provided in the future as needed in a CAS plant by adding conventional tertiary granular media filters, cloth media disk filters or dedicated membrane filters at lower cost and less energy consumption than by using membrane treatment of the entire dry weather flow. Hence, if a site of adequate size for a conventional activated sludge plant can be found, the initial capital and operating costs for treatment can be reduced significantly.

## McLoughlin Site Constraints

The McLoughlin Point site has some significant constraints, including:

- The site is extremely small for the size of plant under consideration. It will require the use of compact (and typically more expensive to construct and operate) technologies and reclaiming of seabed to expand the available area of the site. Essentially, there will be no buffer space or screening between the process tankage and the property line of the site.
- The site will require full buildout to the fenceline at the outset thereby limiting future options for the installation of additional or alternate technologies in future as may be required.
- Negotiations must be undertaken with Imperial Oil to acquire the south part of the site, and with Transport Canada to reclaim the foreshore area on the east by placing fill for structures in Victoria Harbour. Additional area beyond these sties will be required.
- If it proves impossible to gain approval from Transport Canada for placing treatment structures on fill in Victoria Harbour, it would be necessary to split the plant between two sites, possibly pumping sludge to sludge handling and digestion facilities located at a different site. This would increase both capital and operating costs.
- The process tankage slated for the northern portion of the site must be excavated into rock and subsequently covered to permit access to the surface following completion of construction.
- The PRT understands that access to the north part of the site will be required once the construction of the treatment plant is completed. This raises at least two additional issues:
  - How will such access be controlled? The covers on the treatment tankage will have a finite load bearing capacity. It is essential that the weight of whatever equipment is allowed on the covers does not exceed this load limit at any time.
  - Will the CRD have immediate access to the tankage for routine and emergency maintenance? The proposed process tankage will incorporate such things as aeration systems, membranes, submerged mixers, pumping equipment, flow meters, as well as instrumentation for monitoring and controlling the process. Such equipment requires periodic servicing as well as repair and/or replacement from time to time possibly on very short notice.
- The southern portion of the site has been used as a bulk oil terminal for several decades. Given experiences at other bulk oil terminal sites that have been in operation for many years, there likely will be issues relating to hydrocarbon and perhaps other contamination of the soils and in the rock fissures on this part of the site, and it is very possible that these concerns

extend into the near shore sediments. Although the cost of the site cleanup is the responsibility of the previous owner, the length of time to complete the cleanup is an unknown at this time and could potentially create a delay in implementing this project.

- The site is prominently visible from the water as well as from the cruise ship wharves and heliport terminal on Ogden Point across the harbour entrance to the east.
- To accommodate a treatment plant of the required capacity on this site the consultants have determined that effluent from a MBR process sized for 1.5 times ADWF will be blended with chemically-enhanced primary treatment effluent during periods of wet weather flow. This adds complexity to both the design and operation of the plant. The system will require close monitoring and attention by the plant operating staff particularly during the wet weather season. As the blending feature will be idle most of the time, it will require periodic exercising to ensure that it will be operational on short notice.

In view of the concerns and constraints expressed above, the PRT has serious reservations about the McLoughlin site. Resolving these issues will entail a major and possibly prolonged effort. Before proceeding too far down the path of trying to resolve these issues, it would be prudent to ensure that the facilities currently proposed for the McLoughlin site as part of Options 1 and 2 can indeed be accommodated by the site in a reasonable and satisfactory manner. To this end, the PRT recommends that further development of the conceptual engineering work presented in Discussion Paper No. 034-DP-3 Facilities Siting Alternatives (October 7, 2008) and Discussion Paper No. 036-DP-2 Development of Distributed Wastewater Management Strategies (March 9, 2009) be done to confirm the feasibility of developing the McLoughlin site for the intended purpose. A preliminary list of items to be incorporated into the site layout and hydraulic grade line are discussed below. This list is not intended to be complete; rather it represents the PRT's initial thoughts on some immediately apparent items for consideration. Doubtless the CRD and its consultants will add more items to this list as they deem appropriate.

1. The administration and operations and maintenance buildings should be large enough to provide:
    - Needed personnel facilities
    - Maintenance shops, including areas for mechanical, electrical, instrumentation and controls, paint shop, stores, shipping and receiving, etc.
    - Offices, meeting rooms, reception area, operator training area, etc.
    - Laboratory
2. Parking space for employees, visitors and CRD plant vehicles.
3. Electrical substation plus two independent power supplies to the site via separate access.

4. Standby power generation for continued operation of essential equipment during power failures.
5. Semi-trailer access for bulk and tote chemical deliveries of chemically enhanced primary treatment chemicals, chemicals for alkalinity and pH control, dewatering polymers, odour control reagents, fuel for standby power generator, reagents for membrane cleaning, etc.
6. Dual access into the processing areas of the plant. There are options for entering and leaving the plant site from Esquimalt Road to the north. However each option involves access over DND land. It will be essential to have security pre-clearance for the O&M and administrative staff to gain 24/7 access to the wastewater treatment plant site during times of national crisis and/or mobilization.
7. Access to use the area over the bioreactor tankage poses unique difficulties. As noted previously, the loading limits on the covers over the bioreactor tankage must be respected at all times. Presumably all piping and equipment for the wastewater treatment plant will be housed in tunnels below grade so as not to obstruct use of the surface. Nevertheless, the CRD's operating and maintenance staff will require access to the process tankage for routine process monitoring, equipment maintenance and/or replacement. If this cannot be accommodated to permit access hatches or the removal of portions of the covers on a routine daily basis for some activities, or on very short notice for others, then such access for the CRD's O&M staff must be provided entirely below grade. This will require significant deepening of the excavation into bedrock and lowering of the process tankage by as much as 6 metres or more to provide headspace sufficient for removal and reinstallation of membrane cassettes, removal and replacement of broken aeration piping, pumps, mixers, and other process equipment as necessary.

In addition to the above concerns about the McLoughlin site, the wet weather treatment facilities proposed at Clover Point would be expensive because of land and environmental constraints, even though it would be operated only infrequently. Because of these concerns, the PRT examined other possible locations for a major centralized treatment facility under Option 1 that would provide a site large enough to eliminate the need to rely on MBR and be flexible enough to provide wet weather treatment facilities.

Should it become available, the Macaulay site should be evaluated as an option to the McLoughlin site. However, the Macaulay site may have access issues similar to those described above for the McLoughlin site. The PRT understands the focus has been on the McLoughlin site because it is believed that the Macaulay site cannot assuredly be available in time to meet the regulatory deadlines for this project.

Another possible site for the centralized treatment plant in Option 1 is located at the gravel pit area in the western portion of the CRD. Adequate land is available at this site for other more economical treatment options and to provide flexibility for resource recovery options. The PRT thus suggests two additional variations of Option 1 that are called Options 1B and 1C, while the original is now termed as Option 1A.

### Evaluation of Alternative Options

During the Path Forward study, an option (West Shore Regional WWTP) that may appear similar to Options 1B and 1C as proposed herein by the PRT was evaluated. However, there is a critical difference between that earlier analysis and the one suggested here. In the earlier evaluation, the relative economics of the option of providing secondary treatment at McLoughlin Point / Macaulay Point and the option of providing that treatment in the western area were analyzed using the same secondary treatment process in both locations. In the analysis suggested by the PRT, the options would be compared using the membrane bioreactor process at the McLoughlin site and a conventional, high rate non-nitrifying activated sludge process in the western area. Options 1B and 1C are described and discussed below. The evaluation in the Path Forward document also did not include the benefits of a Saanich East plant when the West Shore Regional WWTP option was evaluated.

The PRT strongly recommends that the consulting team conduct a detailed analysis to assess Options 1B and 1C including:

- Determine the effect on overall system capital and operating and maintenance costs.
- Assess the relative environmental and social impacts/benefits.
- Assess costs with and without including facilities for heat recovery, effluent reuse, and other resource recovery opportunities.
- Determine the net present value as done previously for Option 1A.
- Consider implementation issues.

## DESCRIPTION OF OPTION 1B

The components of Option 1B that differ and are common with Option 1A are presented and defined, along with the opportunities and potential advantages in the following discussion.

### Component Differences and Similarities Between Options 1B and 1A

The components of Option 1B that differ from Option 1A are:

- The major secondary treatment plant for the first stage of the project is located at the gravel pit site on the western shore rather than at McLoughlin Point. The West Shore plant would be a conventional, high rate non-nitrifying activated sludge plant rather than a membrane bioreactor plant. It would also incorporate conventional primary clarification rather than chemically-enhanced primary clarification.

- An underwater pipeline is used to convey two times average dry weather flow to the gravel pit site.
- A wet weather treatment plant is located at the existing Macaulay site (no plant is located at the McLoughlin site) for wet weather flows of two to four times average dry weather flow.

The components of Option 1B that are common to Option 1A are:

- The Saanich East Treatment Plant.
- Conveyance of dry flows up to two times average dry weather flow from Clover Point to McLoughlin.
- A wet weather treatment plant at Clover Point for treatment of flows from two to four times average dry weather flow.
- Screening and discharge of wet weather flows in excess of four times average dry weather flow at Clover Point and Macaulay.

**Opportunities and Potential Advantages for Option 1B**

The PRT has identified the following opportunities and potential advantages for Option 1B:

1. Opportunities for Integrated Resource Recovery

   Because the plant would be located near a largely undeveloped area, the installation of resource recovery systems such as heat distribution systems and dual water distribution systems to serve future development will be greatly eased as compared to installing such systems in the densely developed areas near McLoughlin Point, either in Esquimalt or in the City of Victoria. The lower cost of these distribution systems increases the probability that the wastewater-related resources will actually be used.

2. Sustainable Community Development

   Residential development is planned for the gravel pit area. The location of the plant in this area offers the potential for a large Dockside Green-type sustainable community, replacing what is currently a scar on the earth. The plant would occupy a very small part of the developable site and could readily be screened from view.

3. Reduced Energy Consumption

   As discussed earlier, the larger West Shore site allows the use of a wastewater treatment process that uses substantially less electrical energy than the MBR process used at the McLoughlin site. These savings will be offset somewhat by the added energy required to pump the wastewater to the

West Shore site. However, the consultants' initial analysis of Option 1B shows a 12% net savings in electrical energy consumed compared to Option 1A.

4. Elimination of the Need to Deal with McLoughlin Site Issues

   Construction of a wastewater treatment plant to serve the majority of the Core Area on the West Shore site eliminates the need to deal with the numerous issues associated with the McLoughlin site that have been discussed earlier in this section. Some of these issues may turn out to be irresolvable within the time frame available for implementation of this project or simply irresolvable.

5. Reduced Operating Costs

   Treatment plant operating costs will be reduced because a basic secondary plant can be constructed that meets the requirements of the Provincial and Federal treatment requirements. The use of a basic plant avoids being forced by the site constraints at McLoughlin to use a more costly and complex membrane treatment with primary/secondary effluent blending system. Water reclamation facilities can be added as the demand for reclaimed water matures, providing an opportunity for phasing of treatment costs not offered by the McLoughlin site.

6. Reduced Treatment Plant Construction Costs

   Treatment plant construction costs will be reduced because a basic secondary plant can be constructed that meets the requirements of the Provincial and Federal treatment requirements. Treatment plant construction costs will be further reduced because construction in the gravel soils will be less costly than in the rock found at McLoughlin Point. The costs associated with burying portions of the plant at the McLoughlin Point site are avoided. The costs of filling a portion of the bay at McLoughlin Point are avoided. The greater potential for staging of treatment plant construction described below offers the potential to reduce initial capital costs.

7. Greater Flexibility for Treatment Plant Staging and for Future Options

   In Option 1A, only 1.6% of the treatment plant cost is deferred to the second stage. The readily accessible, larger gravel pit site will allow staging of a conventional activated sludge plant to match growth in population. With 42% of the projected population growth occurring after 2030, there is the potential to reduce initial treatment plant costs by 30-35%. The larger site also provides much greater flexibility for future resource recovery facilities such as a biodiesel fuel production plant, an option that may be incompatible with the restricted space at McLoughlin Point.

8. Preserves Potential for Distributed System

   This option preserves the ability to construct other plants distributed in various parts of the service area because it is merely a relocation of the first stage of secondary treatment. Because 35-45% of the treatment capacity could be deferred to later stages, the option would remain to centrally locate this capacity or provide it in distributed facilities.

9. Synergy with Upstream Water Reuse

   If upstream, smaller satellite water reclamation facilities are constructed in the future, biosolids from these plants could be transmitted through the collection system to the West Shore plant. Unused reclaimed water could be conveyed to the plant as well providing a backup method of effluent handling.

10. Sludge Management Opportunities

    The limitations on sludge management options inherent in the constrained site at McLoughlin Point are removed.

11. Training and Education Opportunities

    The plant site is close to Royal Roads University. The University has expressed interest in the potential for using a treatment facility for training courses and for other research projects.

12. Difficult Permitting Avoided

    The uncertain length of time associated with gaining approvals for filling part of the harbour at McLoughlin Point is eliminated. The uncertainty associated with how long it will take to deal with the contamination related to past use of the McLoughlin Point site as an oil storage site is eliminated. Access to the West Shore site is better than that to the McLoughlin Point site. There would be minimal disruption to neighbourhoods.

## DESCRIPTION OF OPTION 1C

The components of Option 1C that differ and are common with Option 1A are presented and defined, along with the opportunities and potential advantages in the following discussion.

### Component Differences and Similarities Between Options 1C and 1A

The components of Option 1C that differ from Option 1A are:

- The major secondary treatment plant for the first stage of the project is located at the West Shore gravel pit site rather than at McLoughlin Point. As for Option 1B, the West Shore plant would be a conventional, high rate non-nitrifying activated sludge plant rather than a membrane bioreactor plant. It would also incorporate conventional primary clarification rather than chemically-enhanced primary clarification.
- All treatment facilities for wet weather flows of two to four times dry weather flow are located at the West Shore gravel pit site and treatment facilities for these wet weather flows at Macaulay and Clover Point are eliminated.

- Conveyance for four times dry weather flow is provided from Clover Point to Macaulay Point.
- An underwater pipeline system is used to convey up to four times average dry weather flow to the West Shore gravel pit site from Macaulay Point.

The components of Option 1C that are common to Option 1A are:

- The Saanich East Treatment Plant.
- Screening and discharge of wet weather flows in excess of four times average dry weather flow at Clover Point and Macaulay.

**Opportunities and Potential Advantages for Option 1C**

The PRT has identified the following potential advantages for Option 1C in addition to those identified and described for Option 1B:

1. Eliminates Intermittently Operated Wet Weather Plants

   Option 1A and Option 1B include wet weather treatment facilities for flows of 2 to 4 times dry weather flow that operate only a few days per year. Often times, immediately placing such facilities into service when a storm occurs is problematic. In Option 1C, primary clarifier capacity would be provided for these flows at the West Shore gravel pit site. This primary treatment capacity could also be used during dry weather so that the problems with bringing seldom-used processes into operation when a storm event occurs are avoided.

2. Reduces Treatment Costs

   The capital cost for incrementally increasing primary clarifier capacity at the gravel pit site will be less than construction of the same wet weather capacity in two separate wet weather plants located at Clover Point and Macaulay Point. The cost of the Clover Point wet weather treatment facility has been estimated as $141 million by the consulting team. Operating costs would also be reduced because the added labour required for remote wet weather treatment facilities would be eliminated as staff at the secondary plant would provide the needed operation and maintenance. The operating and maintenance staff thus would better be able to focus attention on servicing the two main treatment plants at Saanich East and the West Shore.

3. Reduced Energy Consumption

   The consultants' initial analysis of Option 1C shows a 16% net savings in electrical energy consumed compared to Option 1A.

4. Avoids Major Disruption of Clover Point Park

   The construction of wet weather treatment facilities at Clover Point will involve two to three years of disruption of the Park. There would be considerably less disruption of the Park for construction involved in the installation of a new pumping station this option.

A potential disadvantage of a West Shore site is the need to purchase the site from the existing private owner. However, negotiating the acquisition and access to either the McLoughlin Point site or the Macaulay Point site will also be a time consuming process. Another consideration is the cost to transport flow from the east service area to the West Shore.

## COMPARATIVE ECONOMIC ASSESSMENT OF OPTIONS 1A, 1B, AND 1C

The PRT recommended in an interim report dated March 16, 2009 that the consultants conduct a detailed analysis of the economic and non-economic tradeoffs between Options 1A, 1B and 1C. The consultants provided the results of their preliminary economic assessment to the PRT and these results are summarized in Tables 6-1 and 6-2.

**Table 6-1 Consultants Preliminary Estimates of Capital Cost of Option 1 Alternatives (Costs in millions of dollars)**

| | | | |
|---|---|---|---|
| Treatment plants | | | |
| S. Colwood + McLoughlin | 593 | | |
| S. Colwood | | 598 | 674 |
| Saanich East | 128 | 128 | 128 |
| Clover Point wet weather | 141 | 141 | |
| Clover Pt Pump Station | | | 44 |
| Macaulay wet weather treatment or pump station | | 94 | 45 |
| Hartland Biosolids Drying | 53 | 56 | 56 |
| Plant related conveyance | 39 | 57 | 109 |
| Wastewater conveyance | 71 | 71 | 71 |
| Outfalls | 50 | 44 | 40 |
| Heat Recovery System/piping | 8 | 3 | 3 |
| Land purchase | 20 | 19 | 14 |
| **TOTAL** | **1,103** | **1,211** | **1,184** |

**Table 6-2 Consultants Preliminary Estimates of Net Present Value of Option 1 Alternatives (Costs in millions of dollars)**

| | | | |
|---|---|---|---|
| Item | 1A | 1B | 1C |
| **REVENUES** | | | |
| GHG | 1.9 | 2 | 2 |
| Heat | 13.2 | 13.2 | 13.2 |
| Reclaimed water – irrigation | 2.5 | 0.7 | 0.7 |
| Reclaimed water – toilet flushing | 30.1 | 30.1 | 30.1 |
| Dried sludges | 1.3 | 1.4 | 1.4 |
| Biomethane | 8 | 8.4 | 8.4 |
| Woodchips | 6 | 6.3 | 6.3 |
| **TOTAL REVENUES** | **63** | **62.1** | **62.1** |
| **COSTS** | | | |
| O&M | 395.1 | 408.4 | 393.3 |
| Capital | 842.3 | 921.8 | 896.3 |
| **TOTAL COSTS** | **1,237.4** | **1,330.2** | **1,289.6** |
| **NET PRESENT VALUE** | **1,174.4** | **1,268.1** | **1,227.5** |

The insignificant differences in revenues shown in Table 6-2 indicate that the consultants have identified little difference in the resource recovery potential of these three versions of Option 1.

## RECOMMENDATION BASED ON ECONOMIC EVALUATION

Based on the consultants' cost estimates, the capital costs of 1B and 1C are 6% to 9% more than 1A and the present worth costs are 5% to 8.5% more than 1A. At this preliminary planning phase of the project, cost differences of less than 10% are not significant and options 1A, 1B and 1C should be considered equivalent in cost. The PRT recommends strongly that the analysis of the economic, social and environmental aspects of Options 1A, 1B and 1C be continued through the Triple Bottom Line Analysis.

## BIOSOLIDS MANAGEMENT

In Section 5, the PRT noted concerns and unresolved issues pertaining to the consultants' proposed biosolids processing and resource recovery strategy. The strategy relies on two markets for the ultimate disposition of the anaerobically digested sewage solids:

- Drying of the biosolids and transportation to a cement kiln located on the Lower Mainland for use as a fuel supplement; and,
- Land application on a dedicated willow coppice located within trucking distance of the CRD Core Area with subsequent periodic harvesting of willow

bushes for conversion to wood chips and sale as a biofuel or for use as a compost bulking agent.

The biosolids would be split on an approximate 50:50 basis between the two markets. The consultants' proposed biosolids processing and resource recovery strategy is illustrated in Figure 5-1 in Section 5 of this report.

**Backup Strategy**

The PRT is concerned that there is no back-up strategy if and when either or both of the markets becomes unavailable due to reasons beyond the control of the CRD. Such conditions could include labour strife, cement product quality concerns due to perceived effects of the dried biosolids as a fuel supplement, closure of one or both of the cement manufacturers, prolonged periods of inclement weather denying access for land application of biosolids and/or willow bush harvesting, and so on.

When the first wastewater facilities commence operation, the biosolids reuse methods must be immediately available, otherwise a large covered and controlled area will be required to stockpile the products. Stockpiling would entail double-handling of the material and associated costs, plus the risks involved in long term storage such as product quality deterioration and odour generation.

**Recommended Biosolids Actions**

As noted in Section 5, the PRT recommends the willow coppice program be implemented in a carefully planned step-by-step fashion that would include the following components as a minimum:

- **Field studies of suitable areas** within reasonable trucking distance from the Core Area focusing on topography, soil conditions, hydrogeology, local climate, and related matters.
- **A pilot program** operating on at least two candidate sites to verify feasibility of the concept and to establish region-specific design and operating criteria. The pilot program must also focus on the monitoring and control of potentially contaminated runoff and groundwater from the willow coppice area. The pilot program should begin as soon as possible using biosolids generated by the CRD's wastewater treatment facility located in North Saanich near Victoria International Airport. Results from the pilot program should be made public as part of a marketing effort to win support for the willow coppice program.
- As the new Core Area wastewater treatment facilities become operational, a **staged implementation program** gauged to build on initial success and expanding forward from there is suggested for the willow coppice biofuel program.

In addition to the preceding recommendations for the proposed willow coppice program, the PRT strongly recommends that the CRD also develop a Third

Biosolids Option designed to process 100% of the biosolids produced in the Core Area as backup for ultimate disposition of the biosolids. This backup method would not rely wholly on external markets. Candidate processing technologies for consideration for the Third Biosolids Option could include but not be limited to:

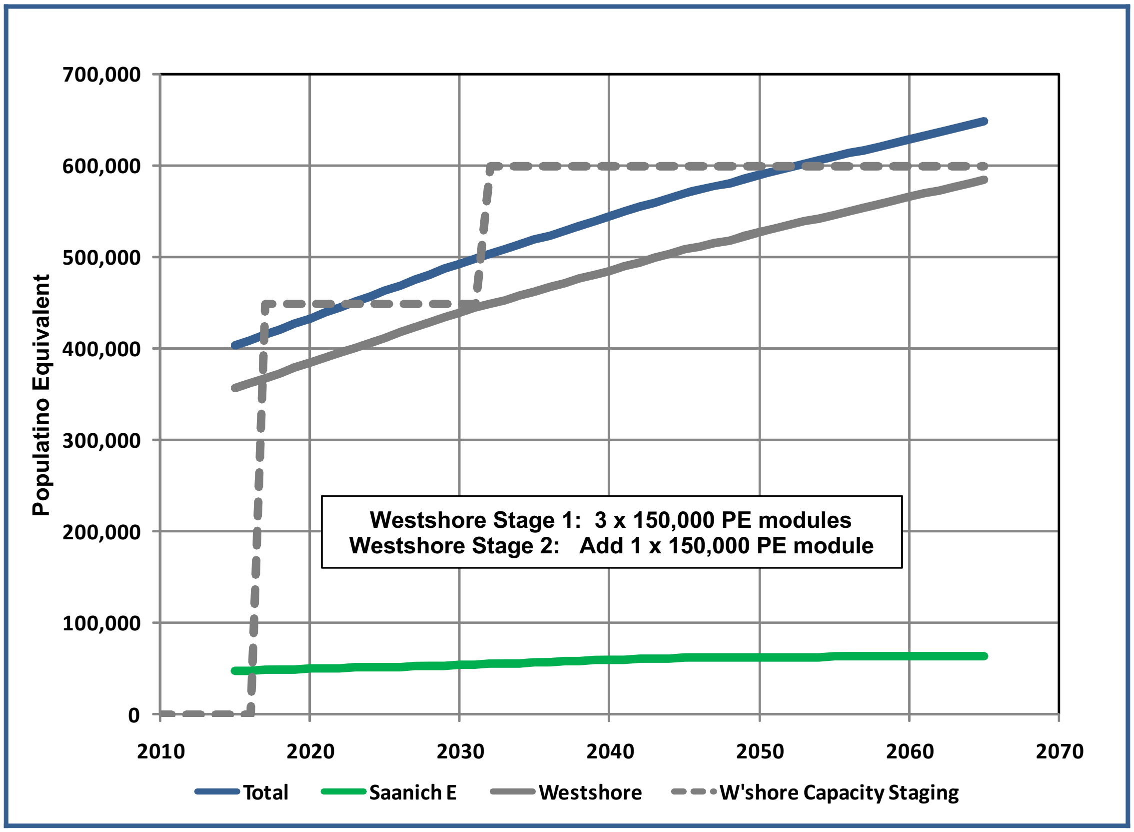
- Anaerobically digested sludge dewatering and ultimate disposal in dedicated monofill cells at Hartland, possibly blended with dried sludge to meet solids monofill solids content operating specifications as necessary. Although landfill disposal of biosolids is not considered a suitable long-term solution, it or some other means of storage must nevertheless be considered as a backup option.
- Anaerobically digested sludge dewatering and fluidized bed incineration of the sludge cake with electricity generation. Landfilling of the incinerator ash residue.
- A waste-to energy plant using dewatered sludge and solid waste as fuel.

## STAGING

### Liquid Stream Treatment Train

As discussed in Section 5, the opportunities for staging Option 1A were limited essentially to about 17,000 $m^3/d$ ADWF plant expansion by 2030 at the West Shore facility. Options 1B and 1C provide more opportunity for staging the construction and associated costs over the planning period. Population equivalents (PE) served by the wastewater system increases from about 400,000 in 2015 to about 650,000 by 2065 (Figure 6-1). In Options 1B and 1C, the initial construction of the West Shore plant could consist of three parallel liquid stream treatment modules each with a nominal design capacity of 150,000 PE. At about 2032, a fourth module would be required, thereby providing treatment capacity until about 2065, at which point another expansion would be necessary if growth continues. The 150,000 PE expansion module to come on line at about 2032 would be approximately equivalent to an ADWF capacity of 30,000 $m^3/d$ which represents a postponement of the construction of about an additional 13,000 $m^3/d$ of treatment plant capacity from Stage 1 to Stage 2 compared to the staging proposed for Option 1A.

**Figure 6-1 PRT's Suggested Staging for Option 1B or 1C**




## Solids Processing Train

As noted in Section 5, there is no staging of the solids processing train in any of the system options evaluated by the consultants. The capital cost of the solids processing train in Option 1A is $138.6 million.

The PRT has made an estimate of the amount of by-product solids that would be produced by the West Shore wastewater treatment facility under Option 1B or 1C. The estimate is based on the following assumptions:

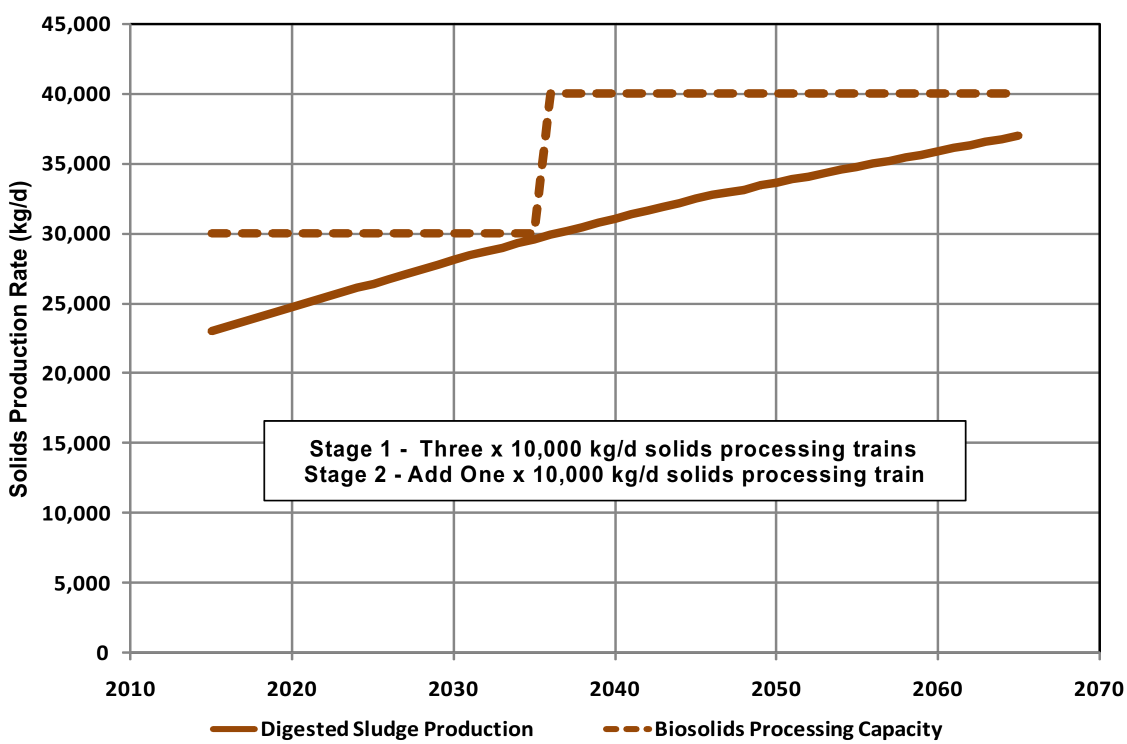
- Primary sludge production of 0.054 kg/cap/d with a volatile content of 70%.
- Secondary waste activated sludge production of 0.035 kg/cap/d with a volatile content of 75%.
- 72% volatile solids content in undigested blended sludges.
- 50% volatile solids reduction across the anaerobic digestion system.

The projected total digested sludge biosolids production for the West Shore wastewater treatment facility including the solids transferred from the Saanich East plant is illustrated in Figure 6-2. In preparing this figure, it was assumed that the total contributing population equivalent follows the blue curve plotted in Figure 6-1. In Figure 6-2, all of the biosolids production facilities are assumed to be located at the West Shore plant including:

- The primary sludge and waste activated sludge thickening steps.
- The sludge blend tank.
- The anaerobic sludge digesters.
- The digester gas upgrading plant and transhipment terminal for production of pipeline quality biogas.
- The digested sludge dewatering equipment that produces the biosolids sludge cake.
- The dewatered biosolids loadout facility to ship biosolids to a staging area at the Hartland landfill for subsequent application to the willow coppice lands and drying for trans-shipment to cement kilns located in the Lower Mainland for use as a fuel supplement.

For the Stage 1 construction, it is envisioned that three 10,000 kg/d solids processing trains would be constructed. This would provide capacity until approximately 2036 when an additional 10,000 kg/d solids processing train would be added in parallel which would be sufficient to provide solids processing capacity beyond the Year 2065 as indicated in Figure 6-2.

**Figure 6-2 Projected Biosolids Production over the Planning Period**



In the PRT's System Options 1B and 1C, all of the biosolids would be generated and treated at the West Shore site. This provides an opportunity to ship dried biosolids via barge to the cement kilns in the lower mainland rather than hauling the biosolids to Hartland for drying and trans-shipment to the Lower Mainland by truck. The only dewatered biosolids hauled by truck would be those to be applied to the willow coppice lands. These biosolids could be hauled directly from the plant site to the point of application, weather and field conditions permitting. Alternately they could be hauled to the Hartland landfill site for interim storage during times of inclement weather or if field conditions are temporarily not suitable for land application. The barging and direct hauling to land application may provide opportunities for reduced operating costs.

# 7
# METHODS FOR PROJECT ALTERNATIVE ANALYSIS

Over the years a number of different approaches have been used to assess the technical, social, environmental, and cost aspects of project alternatives. One method that has received considerable attention in recent years is the Triple Bottom Line (TBL) analysis, in which environmental and social benefits are balanced against project cost. The TBL approach is described in this chapter along with the methodology used in its application. An example of the application of this method is presented, and other methods of analysis are described briefly. To the degree possible, it is often preferable to frame the criteria for environmental and social/community issues in a fashion that elicits a quantitative response when applying the criteria to assess alternative options. This usually enables rapid comparison of the alternatives. Two examples are described below.

## DESCRIPTION OF TRIPLE BOTTOM LINE ANALYSIS

The TBL analysis is an accepted approach for assessing the relative merits of several competing development paths for a project and many jurisdictions have adopted it for broad use. The three principal elements of a TBL analysis are: (1) environmental, (2) social/community, and (3) economic issues, which by their very nature are not truly comparable. Environmental and social/community concerns usually involve subjective judgments and thus are often difficult to quantify in absolute terms. The economic aspects of a project can usually be quantified by a dollar figure, which may have an uncertainty band associated with it, depending on the level of the cost estimate.

## TRIPLE BOTTOM LINE ANALYSIS METHODOLOGY

The methodology for a TBL analysis involves (1) development of a scoring spreadsheet for the individual evaluation criteria that will be applied, (2) the development of a base case as a frame of reference, and (3) comparison of alternatives based on different criteria weighting, and (4) informed discussion based on the results of the TBL analysis. Each of these steps is described below.

## The Scoring Spreadsheet

A spreadsheet can be developed to assist in ranking the various project options. A simple example to use by way of introduction to the methods of applying criteria to rank various alternatives is illustrated in Table 7-1. The scores in this table are assigned a range of values from 1 (least preferred) to 3 (most preferred) for various criteria grouped into Economic, Environmental and Social/Community categories to rank three hypothetical Project Options A, B and C. In this simple example, the scores for each criteria group are averaged for each Project Option and the averages are summed at the bottom of the table. In this example for which only a few basic criteria are used, it is seen that Project Option C is preferred over Project Options A and B because it has the highest average bottom line score.

**Table 7-1 Simple Hypothetical Scoring Example for a TBL Analysis**

| | | | | |
|---|---|---|---|---|
| | Lowest capital cost | 1 | 2 | 3 |
| | Lowest operating & maintenance cost | 2 | 1 | 3 |
| | Lowest net present value | 1 | 2 | 3 |
| | Averages for Economic Criteria Group | 1.33 | 1.67 | 3.00 |
| | Least impact on fisheries habitat | 2 | 1 | 3 |
| | Fewest watercourses crossed | 2 | 1 | 3 |
| | Averages for Environmental Criteria Group | 2.00 | 1.00 | 3.00 |
| | Least community disruption during construction | 3 | 1 | 2 |
| | Least proximity to residential areas | 1 | 3 | 2 |
| | Averages for Social & Community Criteria Group | | | |
| **Sum of Triple Bottom Line Criteria Group Averages** | | **5.33** | **4.67** | **8.00** |

The scoring spreadsheet sheet for applying the criteria can be set up such that individual criteria can be weighted as desired, or criteria grouped and weighted according to project goals and guiding principles. The scores for the various groups can be normalized in the spreadsheet, if desired, to account for the possibility that some groups may contain more criteria than others. Wherever possible for social and environmental issues, it is preferable to establish criteria that are as quantifiable as possible with a hard number.

## Development of the Base Case

The first base case is with the weights for all criteria being equal. In any group of people, there will be a variety of opinions about the relative weight that should be assigned to economic versus social versus environmental criteria. To test the effect on the outcome of the TBL analysis of these differences of opinion, various weightings can be used in a sensitivity analysis as discussed below.

## Assessing Impact of Different Criteria Weighting

In general, based on numerous TBL analyses, a 20% change in weighting is not likely to make much difference in the outcome. For example, if it is known that environmental issues are likely to trump social issues for a specific project, then the spreadsheet could be redone using double, triple or even quintuple the weighting on environmental criteria to see the outcome. Alternately, if it is known that a certain issue(s) is (are) particularly sensitive for the community (say for example minimizing disruption during construction, or possibly achieving a high degree of resource recovery), then the weighting for these criteria can be increased by a factor of 2 or 3 or more.

## Informed Discussion Based on Results of TBL Analysis

Evaluation of the environmental and social/community issues often involve subjective considerations. On the other hand, economic issues are usually defined quantitatively by a dollar figure. Strictly speaking, the two are not directly comparable, much like apples and oranges. When doing a TBL analysis, it is sometimes helpful to separate the environmental and social/community issues from the economic issues in some fashion.

For municipal infrastructure projects which usually do not have a net payback, it is possible to separate the economic aspects from the non-economic issues and arrive at a quotient that is a measure of the “value” of an alternative development path by dividing scores for the non-economic criteria by the cost for a given development path. The value quotient is computed using the following expression:

$$\text{Value} = \frac{\text{Environmental Issues Score + Social \& Community Issues Score}}{\text{Cost}}$$

The cost can be expressed as net present value (NPV), capital cost, operating and maintenance (O&M) cost, or as a particular component of each. Thus, when comparing alternative development paths that have similar costs, the one with the highest score for the non-economic criteria has more “value” than the others. Conversely when comparing alternative development paths that have similar non-economic scores, the one with the lowest cost has more “value” than the others. It is also interesting to note that a project with higher cost can be selected, based on "value," if the environmental and social/community scores are significantly higher than those for the other alternatives.

If significant capital grants will be available for the project under consideration, then it may be desirable to place more weight on a lowest O&M cost criterion than on either lowest capital or lowest net present value estimates when doing the analysis. On the other hand if capital costs are a major consideration due, for example, to a borrowing cap on money to finance construction costs, then it may be desirable to place more weight on a lowest capital cost criterion.

Even though the TBL analysis performed as described above results in a relative quantitative scoring of alternatives, a major value of the process is the discussion of the evaluation of each alternative against the scoring criteria. Once the scoring is complete, this preceding discussion then can form the basis for reflection upon the results to decide upon the preferred option.

### Application of TBL Method of Analysis

A more complex example of a TBL spreadsheet taken from a recent project for which one of the PRT members was responsible is illustrated in Table 7-2. This example includes the three triple bottom line criteria groups plus a fourth group containing “Other Project-Specific Criteria” that do not necessarily relate to either economic, environmental or social/community issues. Although Table 7-2 was designed to allow variable weighting of individual criteria as well as the various criteria groups, in the example shown a uniform weighting was applied. The fourth, fifth and sixth last rows illustrate various ways to average the sums of the criteria groups. Two different value quotient calculations are presented in the last two rows.

## OTHER METHODS OF ANALYSIS

Although the TBL analysis is a widely accepted approach, some agencies have used other methods. In one approach, the criteria and system alternatives are shown in a matrix with the criteria listed vertically in the left hand column of the matrix and the alternatives listed across the top of the matrix with a column dedicated to each alternative. A discussion is held about the merits of each alternative relative to a given criterion. If the alternative rates favourably against that criterion, a “+” is entered. If the option is considered neutral against that criterion, a “0” is entered. If the alternative is rated negatively against that criterion, a “-“ is entered. The process is repeated for each criterion for all of the alternatives. Once the matrix is completed, a facilitated discussion is held to reach agreement upon the preferred alternative considering the relative positives, neutrals and negatives of each alternative. During this discussion, individuals may express opinions about the relative weights of the criteria but no quantitative differences are assigned.

## Table 7-2 Example for Application of Triple Bottom Line + Other Project-Specific Criteria to Optional Development Pathways

**Note 1:** You must assign scores in the range of 1 (not preferred) to 3 (preferred) in the cells under each pathway. You may adjust an individual criterion and criteria group weights as desired. Averages for criteria groups are normalized to 3.00.

**Note 2:** Unweighted averages for each Criteria Group will have a maximum value of 3.00 regardless of the weighting placed on any individual criterion in that group.

**Note 3:** Weighted averages for each Criteria Group will have a maximum value fo 3.00 multiplied by the respective Weighting Factor for that group.

| Criteria Group | Description of each Criterion | Criterion Weight | Pathway ID and Description | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1A'<br>FC U/G ('16)<br>PC-2A ('16)<br>BB-D ('25) | 1C'<br>FC U/G ('16)<br>BB-D ('16)<br>PC-2A ('19) | 1B'<br>FC U/G ('16)<br>PC-2A ('16)<br>PC-2B ('25) | 3A<br>FC Decom ('16)<br>PC-2A&B ('16)<br>BB-D ('27) | 3B<br>FC Decom ('16)<br>PC-2A&B ('16)<br>PC-3A ('27) | 5C<br>FC Decom ('16)<br>NC-1 ('16)<br>PC-2A ('17)<br>PC-2B ('23) | 5D<br>FC Decom ('16)<br>PC-2A ('16)<br>NC-1 ('18)<br>PC-2B ('23) | 5B'<br>FC U/G ('16)<br>PC-2A ('16)<br>NC-1 ('24) | 1C"<br>FC U/G ('16)<br>BB-D ('16)<br>FC Exp ('19) | 1B"<br>FC U/G ('16)<br>FC Exp ('16)<br>PC-2A ('22) | 1A"<br>FC U/G ('16)<br>FC Exp ('16)<br>BB-D ('22) |
| Economic (to 2033) | Capital cost (WWTP's + pumping & transmission) | 1.0 | 3 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 3 | 2 | 3 |
| | Net Present Value | 1.0 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 |
| | Value-1 = ∑CAPi / NPVi | 1.0 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 3 | 3 |
| | Value-2 = ΔCAPi / NPVi | 1.0 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 2 | 1 | 1 | 1 |
| | Other? | | | | | | | | | | | | |
| | Average for Economic Criteria Group | | 2.75 | 2.75 | 2.50 | 2.50 | 2.00 | 2.00 | 2.00 | 1.75 | 2.50 | 2.25 | 2.50 |
| | Weighting factor for Economic Criteria Group | 1.0 | | | | | | | | | | | |
| | Weighted average for Economic Criteria Group | | 2.75 | 2.75 | 2.50 | 2.50 | 2.00 | 2.00 | 2.00 | 1.75 | 2.50 | 2.25 | 2.50 |
| Environmental (to 2075) | Project footprint | 1.0 | 2 | 2 | 2 | 3 | 3 | 2 | 2 | 1 | 2 | 2 | 2 |
| | Length of trunk mains | 1.0 | 2 | 2 | 2 | 1 | 2 | 3 | 3 | 3 | 2 | 2 | 2 |
| | Number of new river crossings | 1.0 | 1 | 1 | 1 | 2 | 1 | 3 | 3 | 2 | 1 | 1 | 1 |
| | Ease of regulatory approval | 1.0 | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 1 | 3 | 3 | 3 |
| | Average for Environmental Criteria Group | | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.25 | 2.25 | 1.75 | 2.00 | 2.00 | 2.00 |
| | Weighting factor for Environmental Criteria Group | 1.0 | | | | | | | | | | | |
| | Weighted average for Environmental Criteria Group | | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.25 | 2.25 | 1.75 | 2.00 | 2.00 | 2.00 |
| Social (to 2075) | Proximity of WWTP plant to residents | 1.0 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 2 | 1 | 1 | 1 |
| | Traffic thru/near sensitive areas | 1.0 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 2 | 1 | 1 | 1 |
| | Noise near sensitive areas | 1.0 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 2 | 1 | 1 | 1 |
| | Aesthetics / Visual | 1.0 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 2 | 1 | 1 | 1 |
| | Trunk Main Length in built-up/sensitive areas | 1.0 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 1 | 1 | 1 |
| | Disruption during construction (plants & transmission) | 1.0 | 1 | 1 | 1 | 2 | 2 | 3 | 3 | 1 | 1 | 1 | 1 |
| | Public & Stakeholder Acceptability | 1.0 | 2 | 2 | 2 | 3 | 3 | 1 | 1 | 1 | 2 | 1 | 1 |
| | Average for Social Criteria Group | | 1.71 | 1.71 | 1.71 | 2.57 | 2.57 | 2.71 | 2.71 | 1.86 | 1.14 | 1.00 | 1.00 |
| | Weighting factor for Social Criteria Group | 1.0 | | | | | | | | | | | |
| | Weighted average for Social Criteria Group | | 1.71 | 1.71 | 1.71 | 2.57 | 2.57 | 2.71 | 2.71 | 1.86 | 1.14 | 1.00 | 1.00 |
| Other Project-Specific Criteria | Ease of O & M re- no. of Pumping Stn's & Pumps | 1.0 | 2 | 2 | 2 | 1 | 2 | 3 | 3 | 3 | 2 | 2 | 2 |
| | Ease of O & M re- no. of WWTP's and different processes | 1.0 | 1 | 1 | 1 | 3 | 3 | 2 | 2 | 1 | 1 | 1 | 1 |
| | Expandability for population increases (flexibility) | 1.0 | 1 | 1 | 1 | 2 | 2 | 3 | 3 | 3 | 1 | 1 | 1 |
| | Upgradability for more stringent permit limits | 1.0 | 1 | 1 | 1 | 2 | 2 | 3 | 3 | 3 | 1 | 1 | 1 |
| | Treatment Process Complexity | 1.0 | 1 | 1 | 1 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 |
| | Opportunities for Water Reuse | 1.0 | 2 | 2 | 2 | 1 | 1 | 3 | 3 | 3 | 2 | 2 | 2 |
| | Average for Other Project-Specific Criteria Group | | 1.33 | 1.33 | 1.33 | 2.00 | 2.17 | 2.83 | 2.83 | 2.33 | 1.33 | 1.33 | 1.33 |
| | Weighting factor for Other Project-Specific Criteria Group | 1.0 | | | | | | | | | | | |
| | Weighted average for Other Project-Specific Criteria Group | | 1.33 | 1.33 | 1.33 | 2.00 | 2.17 | 2.83 | 2.83 | 2.33 | 1.33 | 1.33 | 1.33 |
| **Sum of City's Triple Bottom Line weighted averages** | | | 6.46 | 6.46 | 6.21 | 7.07 | 6.57 | 6.96 | 6.96 | 5.36 | 5.64 | 5.25 | 5.50 |
| **Sum of City's TBL Plus Other Project-Specific weighted averages** | | | 7.80 | 7.80 | 7.55 | 9.07 | 8.74 | 9.80 | 9.80 | 7.69 | 6.98 | 6.58 | 6.83 |
| **Sum of only Non-Economic Criteria weighted averages** | | | 5.05 | 5.05 | 5.05 | 6.57 | 6.74 | 7.80 | 7.80 | 5.94 | 4.48 | 4.33 | 4.33 |
| **Net Present Value ($E+06)** | | | $1,166 | $1,193 | $1,205 | $1,241 | $1,314 | $1,339 | $1,340 | $1,318 | $1,172 | $1,203 | $1,206 |
| **Value Quotient #1 = [Sum of City's TBL Wgt'd Avg's] / [NPV] (x 1000)** | | | 5.54 | 5.42 | 5.16 | 5.70 | 5.00 | 5.20 | 5.20 | 4.06 | 4.82 | 4.36 | 4.56 |
| **Value Quotient #2 = [Sum of only Non-Econ. Criteria Wgt'd Avg's] / [NPV] (x 1000)** | | | 4.33 | 4.23 | 4.19 | 5.29 | 5.13 | 5.82 | 5.82 | 4.51 | 3.82 | 3.60 | 3.59 |

## CRD TRIPLE BOTTOM LINE ANALYSIS

At the time of this report, the CALWMC had not yet selected between Options 1, 2, and 3. The CRD consultants conducted a TBL workshop in late March 2009. Another TBL workshop is scheduled for late April or early May. The results of that workshop will be used to select between Options 1, 2, and 3. If Option 1 is selected, the PRT recommends that another TBL analysis be conducted for Options 1A, 1B and 1C. The PRT also recommends that separate TBL analyses be conducted for the wastewater and biosolids management programs. The basis for this recommendation is that typically the distribution of capital and operating and maintenance costs between wastewater treatment and biosolids management will be approximately the same. In some recent designs, the cost for biosolids management has been greater than 50% of the total. Further, to ensure objectivity, the PRT recommends that an independent neutral facilitator be retained to conduct the TBL workshops. Some of the criteria (factors) that should be considered in the TBL analyses are discussed below.

### Wastewater Treatment

The consultants to the CRD have developed a TBL analysis based on the goals of the wastewater management program. While the PRT believes that this approach is suitable for the selection between Options 1, 2, and 3, if Option 1 is selected then, as noted above, separate TBL analyses should be conducted for both wastewater treatment Options 1A, 1B and 1C and biosolids management. As an aid to the CALWMC, the PRT has developed a series of criteria that should be included in a TBL assessment for wastewater treatment Options 1A, 1B and 1C. The criteria are presented in the form of a spreadsheet in Table 7-3. The criteria presented in Table 7-3 are not meant to be exhaustive, but are offered as a starting point for the CALWMC deliberations. It is anticipated that additional criteria will be added to reflect the concerns of the several constituencies.

### Biosolids Management

The criteria for the TBL for biosolids management will be similar to those given in Table 7-3, but must include criteria related to resource recovery and a long-term sustainable strategy. The currently proposed biosolids management program involves the use of dried biosolids as fuel for cement kiln operation and the use of a dedicated willow coppice. As noted previously, the PRT is concerned that no backup strategy has been proposed in case either of these options should be unavailable. Although landfill disposal of biosolids is not considered a suitable long-term solution, it or some other means of storage must nevertheless be considered as the ultimate contingency option. Thus, in developing criteria for the TBL assessment of biosolids, it will be important to consider the fact that landfilling or some other form of storage must be a part of any sustainable strategy. Another factor that must be considered in the development of criteria for the TBL assessment of biosolids management is the potential to develop a solid waste combustion facility in which the biosolids could be co-combusted.

**Table 7-3 Suggested Triple Bottom Line and Other Project Specific Criteria for the Evaluation of Options 1A, 1B, and 1C**

| | | | Option | | |
|---|---|---|---|---|---|
| | | | **1A** | **1B** | **1C** |
| Economic | Capital Costs | | | | |
| | Capital Costs Eligible for Grants | | | | |
| | O and M Costs | | | | |
| | Present Worth of Costs | | | | |
| Environmental | Conveyance System Impacts | | | | |
| | Visual Impacts | | | | |
| | Carbon Footprint | | | | |
| | Heat Recovery Potential | | | | |
| | Water Reuse Potential | | | | |
| | Biomethane Production | | | | |
| | Power (energy) Usage | | | | |
| Social | Proximity of WWTPs to Residents | | | | |
| | Operations Traffic in Sensitive Areas | | | | |
| | Operations Noise in Sensitive Areas | | | | |
| | Odour Potential | | | | |
| | Visual Aesthetics | | | | |
| | Construction Disruption | | | | |
| | Public and Stakeholder Acceptability | | | | |
| | Impacts on Future Development | | | | |
| | Loss of Beneficial Site Uses | | | | |
| | Compatibility with Designated Land Use | | | | |
| | Cultural Resource Impacts | | | | |
| Other Project Specific Criteria | Ease of O and M for Treatment Plants | | | | |
| | Flexibility for Future Treatment Process Opportunities | | | | |
| | Flexibility for Future Resource Recovery | | | | |
| | Expandability for Population Increases | | | | |
| | Treatment Process Complexity | | | | |
| | Ease of Biosolids Management | | | | |
| | Flexibility to Accommodate Future Regulations | | | | |

## PRT RECOMMENDATION

Based upon consideration of the relative costs, system operability, system reliability, probable resource recovery and the preliminary TBL analysis conducted by the consultants and the CRD, the PRT recommends that Option 1 be carried forward for further development and more detailed evaluation including consideration of the alternative configurations of Option 1A, 1B and 1C. Other variations of Option 1 may arise during this subsequent evaluation.

# *APPENDIX A*
# *PEER REVIEW TEAM BIOGRAPHIES*

**GORDON CULP**, **P.E. (Chair)**
Independent Consultant
Las Vegas, Nevada

Gordon Culp is an independent consulting engineer specializing in the wastewater treatment and water reclamation fields. Has been involved in water reuse projects throughout his 46-year career including groundbreaking projects at Lake Tahoe (recreational reuse), Orange County, California (recharge of potable groundwater aquifer), Muskegon, Michigan (agricultural reuse) and Upper Occoquan, Virginia (reclaimed water discharge to drinking water reservoir). Has chaired or served on review panels for numerous projects throughout the United States including those serving New York City and Boston. Has authored or co-authored ten books and over 70 published papers.

**PERRY MCCARTY, Sc.D., NAE**
*Professor Emeritus*
*Stanford University*

Dr. Perry McCarty is a professor emeritus and independent consultant. Recipient of the Stockholm Water Prize in 2007 and numerous other honours. Has conducted research on aerobic and anaerobic processes for biofuel production. Has served on review panels for water reuse projects, been a member of the State of California Innovative and Alternative Technology Committee and the National Academy of Engineering Committee for Strengthening Science-Based Decision Making. Author or co-author of over 350 publications. Dr. McCarty is a member of the US National Academy of Engineers.

**WILLIAM OLDHAM, Ph.D., P.Eng.**
*Professor Emeritus*
University of British Columbia

Dr. William Oldham is currently an independent consultant. Prior to his academic positions he worked as a consulting engineer. He has expertise in biological wastewater treatment, biological removal of nitrogen and phosphorus, biosolids digestion and use of reclaimed effluent for irrigation using resource management techniques. He has extensive international experience and has been involved in wastewater projects in several continents. He has authored or co-authored more than 50 published papers including several on anaerobic digestion of biosolids. He is a registered professional engineer.

**DAVID STENSEL, Ph.D., P.E.**
*Professor*
*University of Washington*

Dr. David Stensel is a professor and independent consultant. Two-time recipient of the Water Environment Federation's Harrison Prescott Eddy Research Medal as well as numerous other honours. He has specialized expertise in onsite and decentralized wastewater treatment, sustainable environmental engineering technology, biological wastewater treatment processes, wastewater reuse and co-digestion of solid waste and wastewater biosolids to enhance methane production. He has authored or coauthored over 120 technical publications and textbooks. Prior to his academic positions, he spent 10 years in consulting practice applying wastewater treatment processes. He is a registered professional engineer.

**NORBERT SCHMIDTKE, Ph.D., P.Eng.**
Independent consultant
*Ontario, Canada*

Dr. Norbert Schmidtke has extensive international experience having completed assignments in 32 countries on 5 continents. Honoured by the Canadian Society for Civil Engineering with Canada's most prestigious environmental engineering award, the Albert E. Berry Medal. Among the many training courses he has conducted is "New Developments, Directions and Challenges in Wastewater Technology" including decentralized treatment, water reclamation, energy conservation, waste heat recovery, greenhouse gas emissions and carbon footprint. He has authored or co-authored over 300 technical papers, reports and books. He is a registered professional engineer.

**GEORGE TCHOBANOGLOUS, Ph.D., P.E., NAE**
*Professor Emeritus*
*University of California, Davis*

Dr. George Tchobanoglous is a professor emeritus and independent consultant. Recipient of the Waste-To-Energy Research and Technology Council Distinguished Service Award for Research and Education in Integrated Waste Management and numerous other honours, consultant to San Francisco on the co-digestion of solid waste and wastewater biosolids, has experience in small and decentralized wastewater management systems and solid waste management, author or co-author of over 375 articles, books and reports including the Metcalf and Eddy Wastewater Engineering book. He is a registered professional engineer. Dr. Tchobanoglous is a member of the US National Academy of Engineers.

**WARREN WILSON, Ph.D., P.Eng.**
*Independent* Consultant
*Calgary, Alberta, Canada*

Dr. Warren Wilson is an independent consulting engineer with international experience gained from his involvement in numerous wastewater projects in North America, Europe, Australia and the Far East. He has recently been involved in the master plan for Calgary's wastewater treatment system including analysis of multiple treatment plants, review of new technologies, water reuse and the application of Triple Bottom Line criteria. He has participated in peer reviews for communities as diverse as New York City and Brisbane, Australia. He has experience with recovery of magnesium ammonium phosphate from wastewater as a slow release fertilizer. He is a registered professional engineer.

# APPENDIX B
# AGENDA AND NOTES, FIRST PEER REVIEW TEAM MEETING

**PEER REVIEW TEAM**
**MEETING NOTES**
**February 12-13, 2009**

**AGENDA**
**PEER REVIEW TEAM MEETING**
February 12-13, 2009
Room 107
CRD Building

## THURSDAY, FEBRUARY 12

| | | |
|---|---|---|
| 8:00-9:00 | PRT role, scope, planning | CRD and Panel |
| 9:00-10:00 | Project background and overview of issues | CRD/CH2M/AE |
| 10:00-Noon | Integrated Resource Management Report | IRM Authors |
| Noon-12:45 | Lunch | |
| 12:45-3:30 | Tour of service area | Bus tour |
| 3:30-5:00 | Status of and summary of current work | CRD/CH2M/AE |

## FRIDAY, FEBRUARY 13

| | | |
|---|---|---|
| 7:30-9:30 | Status of and summary of current work, planned approach for remaining work | CRD/CH2M/AE |
| 9:30-10:00 | Final list of CRD questions addressed to panel | CRD |
| 10:00-2:00 | Discussion of issues, approach, schedule (includes catered lunch) | Panel |

## THURSDAY, FEBRUARY 12

### PANEL ROLE, SCOPE, PLANNING

Using a map of the service area, CRD reviewed the existing CRD system and the challenges faced in moving forward with the wastewater treatment program. The primary expectations of CRD for the panel are that the panel will address the amended January 7 list of questions (the questions are discussed further later in these notes and are found in Attachment 7), that the panel will provide their frank opinions and that these opinions will assist CRD in making decisions.

CRD confirmed the mid-March and mid-April panel meetings. In addition, CRD requested that as many as possible of the peer panel attend the March 11 CALMC meeting. The peer panel will also meet as planned on March 12 and 13 adjourning at noon on March 13.

## PROJECT BACKGROUND AND OVERVIEW OF ISSUES

The consulting team made a presentation on the project background and issues. The purpose of the current phase of work is not to select treatment technology but rather to decide on how to maximize resource recovery, how many treatment/resource recovery plants, the locations of the plants and develop credible cost estimates. The overall system architecture is an issue, not just selecting a treatment approach. The three goals to be met are protect public health and the environment, manage wastewater in a sustainable manner and have cost-effective solutions.

## INTEGRATED RESOURCE MANAGEMENT (IRM) REPORT

The team that authored the IRM report made a presentation. Goals include reducing greenhouse gas (GHG) emissions, water consumption, reduction in solid waste going to landfill, maximizing resource recovery from solids and liquid wastes and achieving carbon neutrality. The authors noted that their energy recovery projections were based on one part biosolids and six parts solid waste and that inclusion of solid waste was an essential part of their model. The panel questioned the wastewater treatment plant cost estimates in the IRM report. The report authors stated that they believe their cost estimates are reasonable. The report authors stated that the 32 plants shown in their report was conceptual and that 10 to 15 plants may be appropriate. They said they had recently done a study for Colwood that identified five plants but that only one was viable. They believe they have underestimated the potential value of recovered heat and that the future value of water and GHG is very difficult to estimate.

## TOUR OF SERVICE AREA

The panel and some of the CRD and consulting team staff toured the eastern portion of the service area including the Saanich East area, Currie Pump Station, Clover Point, Macaulay Point, McLoughlin Point and the Dockside Green project.

## STATUS AND SUMMARY OF CURRENT WORK

The consulting team made a presentation on the conceptual planning and current work. The peer panel noted that there were limited data on wastewater characteristics and that the data were not adequate to select treatment technology. The consulting team noted that only representative treatment approaches are being used in this phase of work to test various system strategies and that final treatment technology selection will occur in the next phase of work. CRD noted that they have begun an intensive raw wastewater sampling effort and will provide past data and details of the current characterization study to the panel. There is extensive flow monitoring information. Fifty flow monitoring stations were installed in 1989. There are 35 permanent flow-monitoring stations with data recorders. There has been a trend for I/I flows to increase as the collection system ages. The sewers with high I/I are those in the member municipalities, not those in the regional CRD system. I/I programs may only maintain current flows rather than reducing them. The municipalities have started more aggressive I/I programs. Secondary treatment is defined as maximum day values of 45 mg/L for BOD and 45 mg/L for Total Suspended Solids. The plan is to provide secondary treatment for 4 times average dry weather flow and to reduce SSOs to less than one per five years to non-sensitive waters. The wastewater treatment technology selected as representative for purposes of this phase of work is enhanced primary treatment with membrane bioreactors (MBR) treating a portion of the flow. The primary and MBR effluents will be blended to produce secondary effluent quality for up to two times the average dry weather flow. The goal of 200 fecal coliform per 100 ml at the edge of the dilution zone throughout the entire water column in non-shellfish areas can be met without disinfection according to the modeling work done.

The long term goals used to define system strategies are to recover the heat in the wastewater, use energy found in waste solids and to reuse the treated wastewater to the maximum extent practical. Based on preliminary estimates, the revenue from sale of heat may approximate 10% of the total O&M costs for the wastewater system and the value of the methane in excess of that needed for digester heating may be about 1% of the total O&M costs for the wastewater system. The revenue from reclaimed water could exceed these. Estimates of system costs are not yet complete but preliminary results are that the system costs will increase as the number of plants increase.

The water supply for the service area is surface water. CRD owns the watershed and no public access is allowed. CRD recently purchased more watershed. CRD recently raised the level of the dam at the Sooke Reservoir. The treatment provided is ultraviolet disinfection with chloramination to maintain a residual in the distribution system. The water supply is anticipated to be adequate for future demands.

The three system options described in the slides in Attachment 6 were discussed. The consulting team will present these three system options to CALWMC on February 25. Capital cost estimates are expected to be complete next week with life cycle costs and system option descriptions available in mid-March. The panel suggested some improvements for the graphics being used to represent the system options. Further discussion of the system options will be found on the February 13 notes below.

## Friday, February 13, 2009

### BIOSOLIDS/SOLID WASTES

Biosolids and solid waste management was discussed. The analysis by the consulting team concluded that the best resource recovery will be achieved by separate processing of the solid waste organics. The option selected as the representative biosolids strategy involves thermophilic digestion of biosolids.

About half of the digested biosolids would be dried using natural gas and the dried material would be used as a coal substitute for cement kilns in Vancouver. There are two cement producers in Vancouver. There is enough kiln capacity for Vancouver and Victoria biosolids for use as kiln fuel. The offset of coal use in the cement kilns reduces the carbon footprint. Options that offset electricity use do not have much of an impact on carbon footprint because hydropower commonly used in the area has a low footprint. The other half of the digested biosolids would be used in a willow coppice program that would produce wood chips for use in composting operations. Future production of biofuel is an option. There will initially be surplus biosolids digester capacity that could be used for kitchen waste and/or grease. The economic evaluation considered carbon values ranging from $15/ton to $160/ton of carbon. Variations over this range did not make a significant difference in the relative costs of solids processing options. The panel suggested some improvements for the graphics being used to represent the biosolid/solid waste options.

The discussion returned to the overall system options. Rather that considering them as three separate system options, the peer panel suggested that it would be more appropriate to consider project phases with the first phase focusing on the elements common to the three system options discussed on the preceding day. The peer panel suggested that such a phasing approach would allow flexibility to adapt the system to best manage resource recovery by meeting future demands for energy, heat and reclaimed water when and where they occur. The Saanich East plant would provide a good opportunity to test and demonstrate heat recovery and water reuse as part of the first phase. Information from this demonstration would be useful in planning and implementing heat recovery and reuse projects in future phases. Treatment and resource recovery elements from the system options developed by the consulting team would be selected as appropriate for future phases. The consulting team responded that they were required to develop the three system options to address CALWMC questions on the relative benefits and costs of varying degrees of distributing plants in the service area but agreed that phasing was an appropriate approach to program implementation.

The peer panel suggested consideration of a plant serving the combined sewer area in Oak Bay. The cost to separate the sewers in the Oak Bay area is estimated at $15 to $17 million. Also, if capacity at Macaulay/McLoughlin is limited by site constraints, a dry weather plant near Windsor Park would provide an option to a site near James Bay and downtown. With a Saanich East plant and a plant near Windsor Park, it would be possible to reduce capacity at a wet weather plant at Clover Point. The Oak Bay area has a hospital that offers potential for heat recovery and a golf course that offers water reuse potential.

A collaborative planning effort with West Shore communities about system options for that area would be preferable. CRD said that a meeting with the West Shore communities is being scheduled.

## PANEL APPROACH AND SCHEDULE

CRD requested that the panel present any initial findings to CALWMC at the March 11 CALWMC meeting at 10:30 AM. The panel believes it can offer comments for the March 11 meeting on some aspects of the IRM approach, system phasing and responses to some of the items on the CRD list of questions. Assignments were agreed upon with materials to be provided to Gordon for compilation no later than February 23. The compiled material will be distributed to the panel for comment. A summary will be provided to CRD by February 27 to allow time for inclusion in the CALWMC meeting information package:

- Perry – Discussion of combined versus separate processing of solid wastes and biosolids
- George – Discussion providing perspective on GHG and energy consumption involved in wastewater treatment versus other activities (response to CRD question 4e and 4f)
- George – Comments on risk and long term viability of applying biosolids to the land and monitoring effects (response to CRD question 1e)
- George Discussion of any missed opportunities for integrated resource management including organics (response to CRD question 4c)
- Dave – Discussion of things to consider in heat recovery and the components of cost in heat recovery
- Warren – Discussion of the triple bottom line approach and other analytical approaches that could be considered (Response to CRD question 2c)
- Gordon – Discussion of typical capital costs for wastewater treatment plants and comparison to costs used in IRM report

## CRD LIST OF QUESTIONS

The list of questions was discussed briefly. Further work is required to completely address the questions.

# *APPENDIX C*
# *AGENDA AND NOTES SECOND PEER REVIEW TEAM MEETING*

**PEER REVIEW TEAM**

**MEETING NOTES**
**March 11-13, 2009**

**AGENDA**
**PEER REVIEW TEAM MEETING**
March 11-13, 2009
Room 107
CRD Building

**WEDNESDAY, MARCH 11**

| | |
|---|---|
| 8:30-10:00 | Discuss work status, prepare for CALWMC meeting |
| 10:00-11:30 | Participate in CALWMC meeting |
| 11:30 | Lunch |
| 12:00-2:00 | Discuss work status and work plan |
| 2:00-5:00 | Tour western portion of service area |

**THURSDAY, MARCH 12**

| | |
|---|---|
| 8:30-12:00 | Meet with consulting team, discuss their analysis of options |
| Noon | Lunch |
| 12:30-5:00 | PRT discussion and analysis of consulting team report |

**FRIDAY, MARCH 13**

| | |
|---|---|
| 8:30-11:00 | PRT continues discussion, prepares final report outline, agree on assignments, begins preparation of findings |

## Wednesday, March 11

There was general discussion of project related issues. CRD has done a pilot study of separate food waste collection. Each community does its own solid waste collection. A ban on organics in the landfill goes into effect in 2012 – unclear if this will apply to biosolids. Paper is banned already.

Must meet secondary treatment requirement by December 2016 - Provincial deadline. Federal deadline is 2020.

If a jurisdiction withdraws from regional system, it has to pay extra costs experienced by other jurisdictions.

Three-phase public involvement program starting. Newspaper insert going out soon. Third phase in June will deal with specific site mitigation.

Ernst and Young will do business case analysis and could recast cost in a building block approach at that time.

Estimated costs of $500 per year per household for wastewater program based on local share costs of one third of total costs. Provincial and Federal dollars will be for basic treatment, not IRM add-ons.

PRT expressed its concern that planning work is proceeding without adequate waste characterization data, especially soluble BOD data to judge the viability of the effluent blending approach. PRT requested that it receive such data from the ongoing wastewater characterization study as soon as possible.

The PRT participated in the CALWMC meeting and addressed questions asked by the committee members.

The PRT toured the western service area. After the tour, the PRT brainstormed ideas for system configurations. Based on the tour of the western service, the PRT felt that an option using the gravel pit site as the location of the major secondary treatment plant should be evaluated. Several potential advantages were identified. The comments of the PRT in this regard were compiled and the draft of an interim report prepared. That report should be referred to for details of the PRT discussion on this topic (report subsequently issued on March 16). The report recommends that the consulting team evaluate two variations of system Option 1 in which the major secondary treatment plant be relocated from the McLoughlin site to the gravel pit site.

## Thursday, March 12

Some further discussion of the PRT system western shore gravel pit plant option occurred. CRD advised PRT that the Path Forward included an evaluation of a western shore plant. PRT pointed out that the previous analysis was based on the same secondary process used at both McLoughlin and the West Shore. The PRT is suggesting that the analysis continue to be based on MBR technology at McLoughlin where site constraints force the use of MBR, but that a conventional, high rate non-nitrifying activated sludge be considered on the West Shore. CRD pointed out that acquisition of the gravel pit may be difficult and that the owner of the site was asking $200 million. Only a small portion of the site would be needed for the plant.

The consulting team made a presentation that reviewed their recently released Discussion Paper 036-DP-2 on system options and costs.

The Oak Bay combined sewers will be separated. The estimated cost is $8 million.

The current regulations define secondary treatment as a not-to-exceed value of 45 mg/L for both BOD and TSS. The regulations do not specifically call for biological treatment, hence the proposed approach for blending primary effluent and MBR effluent. Primary treatment would be operated with chemical addition during wet weather. Secondary treatment must be provided for up to two times average dry weather flow.  It is estimated that blending will occur only 5% of the time. Modeling indicates that effluent disinfection will not be required to meet receiving water standards.

Membrane replacement costs have not been included as a separate O&M costs. A total O&M allowance of 1% of capital cost is intended to include membrane replacement costs.

Although the MBR system will nitrify, no allowance has been made for adding alkalinity. The PRT pointed out that the ammonia and alkalinity data made available to the PRT indicates alkalinity addition will probably be needed.

PRT raised a concern that the McLoughlin treatment plant costs in Option 1 appear low compared to the Seattle Brightwater plant and other plant costs. PRT suggested that the consulting team check their estimates for this plant. PRT subsequently provided details to the consulting team on the basis for their concern.

The McLoughlin site is very confined. The south part can be purchased from the oil company. Use of the site will require fill into the harbour. The Macaulay site would require at least five years to obtain and may not be obtainable. The PRT asked if ultrasonification of sludge to reduce digester size and increase methane production had been considered. It has not been considered at this stage of the study. Current digester sizing provides a conservatively large footprint.

CRD has recently obtained more watershed and is confident that the water supply is adequate for the next 50 years. About 2.5% of water is currently used for irrigation. Cost for water is currently $0.90 per cubic metre. Current wastewater flow is estimated to be 225 liters/capita/day to sewer.

The cost of heat recovery exceeds the value of recovered energy. To break even, the cost of energy would have to go up 9% per year for 50 years vs. 3% per year general inflation. The cost of energy is now estimated at $16 per GJ delivered to the customer's door. A cost of electricity of $0.07 per kwh has been used in the analysis. The PRT suggested that error bars needed to be added to the charts describing revenue from heat sources. The PRT also suggested that revenue projections should not affect the decision on how to treat wastewater because there is a great uncertainty about what revenues will be actually realized. Current projections are based on the amount of energy available at the treatment plant fence line without a firm customer for that energy.

The low GHG emissions from hydropower account for the better than carbon neutral footprints of the system options. GHG emissions from the nitrous oxide associated with nitrification, methane from the collection system and methane from septic tanks has not been considered in the GHG evaluation.

Land costs have been included in the cost evaluation. Land costs are generally not grant eligible.

There has been resistance by some communities to any land application of biosolids. For example, a proposed two-week test of application to a daffodil farm was rejected by neighbours.

It has been assumed that the haul distance for silviculture is 90 km. Push back led to the concept of the willow coppice program. There is a perception that the willow coppice program would be more controlled. Would need 600 HA (1,500 acres) for willow coppice program for 21 years of operation. Harvested material would be used for compost or sent to a gasification plant for energy generation. This could be used as fuel for cement kilns as well. The backup to the willow coppice/cement kiln options for biosolids disposal is fluidized bed incineration. The option of no anaerobic digestion has been considered but the conclusion was that digestion is needed for flexibility.

Ninety percent solids will be needed for the biosolids used as fuel in the cement kilns. The combination centrifuge-dryer equipment used in Europe has not yet been evaluated.

The balance of Thursday was spent preparing the PRT interim report and drafting an outline and assignments for the PRT final report.

## Friday, March 13

Discussion of the implications of use of MBR dictated by the constrained site at McLoughlin was held. MBR increases the cost of treatment for several reasons:

- The membranes are expensive to install and are likely to require replacement at substantial cost every 7 to 10 years.
- The MBR process requires the use of long sludge ages in the bioreactor to avoid premature fouling of the membranes.
- This long sludge age results in nitrification. Because the alkalinity in the wastewater is low, nitrification is likely to require the addition of chemicals to maintain an adequate alkalinity and adequate pH in the bioreactor.
- Nitrification requires more oxygen for the nitrification reaction. Nitrification is not required to meet the regulatory standards for discharge nor is it required for water reuse.
- The high mixed liquor solids in the bioreactor required for the long sludge age reduces the aeration equipment oxygen transfer efficiency to the bioreactor which also increases energy consumption.
- The combination of added oxygen requirements for nitrification, poorer oxygen transfer, air required for membrane scouring and head loss through the membranes increases overall energy requirements of the treatment process by at least 50% to 70% when compared to conventional non-nitrifying activated sludge processes.

The membrane treatment process will produce an effluent total suspended solids and biochemical oxygen demand of less than 2 mg/L. This level of treatment goes well beyond the regulatory requirement of 45 mg/L. Although the resulting effluent quality of 2 mg/L is excellent for the portion of the flow reclaimed for reuse, there is no need to treat the bulk of flow to this level because it will almost assuredly be discharged to saltwater until water reuse projects are developed. Filtration for reuse can be provided as needed by adding conventional tertiary granular media filters at lower cost and less energy consumption than by using membrane treatment of the entire dry weather flow. Hence, if an adequate site with respect to size can be used, the capital and operating costs for treatment can be reduced significantly.

Further discussion of biosolids issues was held. There are 35 to 40 years useful life remaining for the landfill. Landfill is not lined. The landfill is covered with a clay layer. Portions of landfill gas collected and used to generate electricity. No evidence of contaminate plume leaving the landfill site. Sludge goes into clay-lined trenches at landfill

About 90% of Saanich raw biosolids (25% solids content) goes to landfill, use heat treatment plus lime for whatever portion they can market, have had odor problems with the resulting product.

Estimate $52/year/household for separate solid waste collection

Campbell River, 30,000 population, grows poplars with extended aeration sludge, lime stabilized. Have been doing for five years, anticipate heavy metal accumulation will limit useful life of site to two more years

Maybe start with a small demonstration of willow coppice program – maybe with 5% of biosolids and monitor closely.

Food wastes have not been included in calculations of methane generation.

# *APPENDIX D*
# *ANSWERS TO SPECIFIC CRD QUESTIONS*

## 1. Population, Capacity Projections and system Configuration

*(a) Is the method used for calculating the population projections reasonable?*

Accepted and common practice in planning of regional systems is to rely on the population projections of individual municipal planning divisions. This approach was used and is reasonable.

*(b) Is the Stage 1 design horizon adequate?*

Stage one design horizon of the year 2030 is reasonable. Based on this period of time, the useful life of the first stage of construction is 13 to 14 years assuming the mandated deadline of the end of 2016 for completion of the first stage is met. The system options developed by the consultants provide facilities with useful lives beyond 2030. The PRT believes, as discussed in Section 6 of this report, that there is an opportunity for improved staging of construction to better match the Stage 1 facilities with the population to be served from 2016 to 2030.

*(c) Are the strategies sufficiently flexible and adaptable given the possibilities for future population growth, future changes in carbon credits, government carbon and pollution polices, available technologies etc. given the design life of the project?*

As noted in the PRT report (see Section 6), the PRT believes that there is an opportunity for improved staging of construction to reduce initial cash flow and reduce long-term maintenance costs. Such action could also increase flexibility to incorporate new technologies for wastewater treatment and resource recovery, adapt to population growth and to comply with changing regulations and policies.

*(d) Are the assumptions and strategies optimal for the management of wet weather flow? Are there other strategies that should be considered?*

Short of obtaining a change in regulatory requirements for management and treatment of wet weather flow, the strategies for treating wet weather flows of 2 to 4 times dry weather flow are reasonable. The PRT recommended that a plant serving the Oak Bay area be considered as an element of the wet weather management strategy. The PRT has recommended that a variation of System Option 1 (System Option 1C as described in Section 6 of this PRT report) be evaluated which would eliminate the intermittently operated wet weather treatment facility at Clover Point and provide wet weather treatment of these flows at a central plant located at the West Shore gravel pit site. This is consistent with the strategy of treating wet weather flows of 2 to 4 times dry weather flow and is merely a change in location of providing that treatment. The PRT also understands that CRD has encouraged member municipalities to spend 1% per year on maintenance of their collection systems as part of an infiltration/inflow control program. Infiltration/Inflow control and separation of combined sewer areas should be a part of the wet weather flow management strategy.

*(e) Are the assumptions and strategies optimal for management of biosolids? Are there other strategies that should be considered? Please comment on the risks of long term viability of applying biosolids to the land and any anticipated difficulties in monitoring the effect of this on multiple properties.*

The consultants have recommended a biosolids plan including thermophilic anaerobic digestion, biomethane production and sale to Terasen Gas, digested biosolids going to both willow coppice production and drying for use as a green fuel in the cement industry in Vancouver, use of local separated organic waste for additional feed to the biosolids anaerobic digesters and use of the chipped willow product in a solid waste composting operation. The PRT is concerned that there is no readily available Plan B if one or more of the interlinked, multiple components of the recommended plan fail or are unavailable. The PRT recommends that the CRD develop backup strategies that will provide 100% redundancy to the recommended plan. Backup strategies that could be considered include landfilling, application to natural forest land as done by Seattle, incineration and an energy-generating plant that would use biosolids and solid wastes as fuel.

*(f) Which strategy minimizes operating costs?*

The PRT agrees with the consultants' findings that operating costs will increase as the number of plants increases beyond the three plants shown in Option 1. In a variation of Option 1, Options 1B and 1C suggested by the PRT (see Section 6 of this PRT report) involve two plants, the Saanich East plant and a plant on the West Shore at the gravel pit site. The gravel pit site is large enough to allow the use of conventional activated sludge treatment. Because Options 1B and 1C avoid the use of the energy-intensive MBR treatment technology, they will provide lower treatment O&M costs. However, the O&M costs associated with transporting flow from the east service area to the West Shore must also be considered. The consultants' initial estimate is that Options 1B and 1C will provide an overall energy savings of 13-16% including consideration of the energy to pump flow to the West Shore. The consultants' estimates of O&M costs for Options 1A, 1B and 1C show no significant difference with the Net Present Value of O&M costs over a fifty-year period all falling with a 3% range. Options 1A, 1B and 1C are the strategies that minimize operating costs.

*(g) Are the strategies for dealing with endocrine disrupting chemicals (a) in keeping with industry standards in Canada or (b) in keeping with the best standards in use in North America or (c) in keeping with reasonable projections for likely requirements for treatment within the design life of the project? If not (c) then is there an available strategy that would meet this level or at least make it easier to meet in the future?*

Reduction of endocrine disrupters has been found to improve with increasing sludge age in biological systems. The sludge age in the proposed MBR systems is longer than in low SRT conventional activated sludge systems. Conventional activated sludge systems remove 80% or more of many endocrine disruptors. Advanced oxidation and urine separation are options for further reductions in future phases. Reverse osmosis is the most effective method of reducing endocrine disrupters but costs are very high. Current state of knowledge is inadequate to provide a definitive answer.

*(h) Are the strategies for dealing with heavy metals (a) in keeping with industry standards in Canada or (b) in keeping with the best standards in use in North America or (c) in keeping with reasonable projections for likely requirements for treatment within the design life of the project? If not (c) then is there an available strategy that would meet this level or at least make it easier to meet in the future?*

Source control is key to dealing with heavy metals. The current CRD control program needs to be reviewed to insure that, where needed, effective pretreatment is planned and enforced.

**2. Economic and Financial Analysis**

*(a) Are the approach and assumptions for I&I reduction reasonable? Are there other approaches to consider?*

Infiltration and inflow occurs in the sewer systems owned and operated by the member municipalities. Reduction is an issue for the member municipalities, not the CRD. The CRD has adopted a policy recommending that municipalities budget 1% of their sewer system costs to I/I reduction. Separation of combined sewer areas should also be an integral part of the plan to reduce wet weather flows.

*(b) Are the assumptions for the program and costs reasonable for the following:*

- *linear infrastructure?*
- *liquid treatment?*
- *biosolids?*
- *resource recovery (e.g. water reuse, biogas and future heat recovery)*

As noted in this PRT report, cost estimates at this stage of planning are subject to change as detailed pre-design and design work proceeds. The assumptions and cost estimates developed to date can be used for comparing system configuration strategies. A discussion of the consultants' proposed alternatives, their costs and potential revenues from resource recovery is presented in Section 5 of this report. Also, please see the response to 4 (b) in regard to resource recovery.

*(c) Are the methods that were used to compare costs among the strategies appropriate? Do they take appropriate account of the high impact risks of expected higher energy prices, possible water shortages as a result of climate change and the future increases in carbon credits? Are there other analytical approaches that should be considered in addition to the triple bottom line approach?*

As noted in the PRT report, cost estimates at this stage of planning are subject to change as detailed pre-design and design work proceeds. The cost estimates developed to date can be used for comparing system configuration strategies. Also, please see the response to 4 (b) in regard to resource recovery including future increases in carbon credits. Energy costs were one of the items that the PRT was concerned about when recommending that System Options 1B and 1C be evaluated. These alternatives would use significantly less energy for wastewater treatment (see Appendix G) than the membrane bioreactors in Option 1A. The energy consumed in transporting the wastewater to the plant sites in 1B and 1C must also be considered. The consultants' initial estimate is that Options 1B and 1C will provide an overall energy savings of 13-16% including consideration of the energy to pump flow to the West Shore. The PRT supports the use of anaerobic treatment for sludge treatment within a centralized system that considerably reduces external energy requirements as biofuel is produced as a product. The consultants also have given consideration to the potential for water reuse and heat recovery from wastewater. As already noted, the current value of these resources is relatively low compared with the cost of producing them, but this could change in the future. Thus staging of system implementation should be improved to better permit future application of newer and more advanced methods for greater resource recovery when appropriate. The Triple Bottom Line approach and another analytical approach that can be considered are presented in Section 7.

*(d) Which option(s) offers the best value to stage the level of treatment?*

As discussed in Section 5 of the PRT report, the currently defined system options provide very little staging of construction. The limited staging results in little opportunity to stage the level of treatment. The staging shown by the consultants is all associated with the liquid treatment portion of the treatment plants. If a simplifying assumption is made, solely for gaining a perspective relative to the deferred capacity that the deferred costs are proportional to the deferred liquid treatment capacity, then the treatment capacities out of the overall system secondary capacity of over 200,000 cu m per day deferred to Stages 2 and 3 are: Option 1 – 24,650 cu m/day, Option 2 – 36,950 cu m/day and Option 3 – 13,810 cu m/day. Although Option 2 has the largest deferred capacity, the deferred capacity is at the Juan de Fuca site. The Juan de Fuca site is in an already developed area where installation of dual water systems or heat recovery systems will be costly. The bulk of the staging (82%) in Option 1 is the liquid treatment portion of the Royal Bay treatment plant where about 35% of the liquid secondary treatment plant construction cost is deferred to Stage Two (year 2030 construction). Because the Royal Bay plant is near a relatively undeveloped area it provides a better opportunity for use of reclaimed water in a new dual water distribution system and the related staging of tertiary treatment to match the demand for reclaimed water. System Options 1A and 2 offer more options for staging that Option 3, albeit limited. As discussed in Section 6, Options 1B and 1C provide more opportunity than 1A for staging of construction of wastewater treatment over the planning period. The PRT has recommended that subsequent pre-design work after treatment sites are defined define a staging approach that matches projected population growth more closely. This would provide better opportunities for staging the level of treatment.

*(e) Have the business cases for the various strategies considered so far been properly valued and compared?*

Please refer to Section 5 of the PRT report for a discussion of the PRT comments on the consultants' evaluation and comparison of proposed alternatives. Another consultant has been retained to develop and evaluate the business case analysis. That work has not yet begun.

## 3. Technologies

*(a) Was there adequate review of established, nascent and applied technologies? Are there other technologies available or worth further investigation and would they impact the choice of sites?*

A request for expression of interest by those offering alternative technologies was made by CRD and the responses considered. The final selection of technology will occur in later phases of the project. As noted in Section 6 of the PRT report, the PRT is concerned that the constraints associated with the McLoughlin site has forced the use of MBR technology. MBR technology is costly and consumes a large amount of energy. The PRT has recommended an alternative based on a site large enough to allow use of lower cost, less energy intensive conventional, high rate non-nitrifying activated sludge treatment technology be evaluated. The PRT has suggested the West Shore gravel pit site as one option. If the Macaulay site should be available, it would offer an option that would avoid transport of east service area flows to the West Shore.

## 4. Resource Recovery

*(a) Has adequate assessment been done on energy recovery from biosolids and heat extraction?*

The PRT commends the consultants for the extensive and detailed studies they have conducted to provide information concerning the value of the energy and heat resources that might be recovered from biosolids and wastewater relative to the costs of recovering these resources. The PRT agrees with the consultants' conclusion that resource recovery may generate some revenue but far less revenue than needed for wastewater collection and treatment. Please also see 4 (b) for added comments on potential revenues.

*(b) Does each strategy optimize revenue generation from resource recovery? Which strategy or strategies maximize revenue generation from resource recovery? Are there other strategies that should be or could be pursued to increase revenue generation? Has the valuation of revenue generation (including carbon credits) adequately dealt with the likely future increases in these values over the long design life of this project?*

The differing potential for revenue generation associated with each system option including revenue sources of biomethane, dried biosolids used as fuel, woodchips from a willow coppice program, recovered phosphorus (revenue neutral), wastewater-derived heat, reclaimed water for irrigation and toilet flushing and greenhouse gas (GHG) credits are presented and discussed in the consultants' discussion paper 036-DP-2. The PRT is not aware of any other significant potential sources of revenue. Composting using biosolids has been used in other locations but the costs have typically exceeded the revenue generated from sale of the compost. The consultants have noted the considerable uncertainty in the long-term price of carbon. They used a range of values for carbon dioxide equivalents of $15 per ton in 2008 dollars to $80 per ton in 2065. Based on their analysis, potential GHG revenues are small compared to other revenues and compared to system O&M costs. The PRT believes that the consultants' estimated revenues from the sale of resources extracted from wastewater are optimistic as discussed in Section 5 of this report. In Options 2 and 3, the wastewater treatment and resource recovery facilities are distributed over a larger portion of the service area to provide greater revenues from resource recovery. The consultants' evaluation of the costs and revenues of Options 2 and 3 compared to the cost of Option 1 is summarized in Table 5-7 of the PRT report. As shown Table 5-7, even using optimistic estimates of revenues, the incremental cost of using the more distributed wastewater treatment systems in Options 2 and 3 are 5-6 times greater than the incremental revenue generated when compared to Option 1.

*(c) Are there any missed opportunities for integrated resource management including organics?*

As noted in the PRT preliminary findings, the PRT recommends that solid wastes and biosolids be processed separately. The PRT noted in its preliminary findings that the addition of grease from grease traps offers a proven method for increasing methane production from anaerobic digestion of biosolids.

*(d) Has adequate assessment been done on the availability, viability and future of markets for biosolids, reclaimed water, and heat from effluent or raw sewage?*

See response to item 4 (b).

*(e) Do the current strategies make optimum use of opportunities for water conservation and reuse and how this will reduce energy needs for sewage treatment?*

System Option 3 evaluated by the consultants includes aggressive water conservation measures that would reduce the year 2065 average dry weather flow to 122 ML/day. The consultants adjusted the unit energy requirement for wastewater treatment accordingly. The PRT believes that unless the Victoria region experiences a severe and prolonged water shortage that it is unlikely that the flow can be reduced to this level (122,000,000 L/day for 600,000 equivalent population equates to only 203 L/capita/day (54 US gallons/capita/day) including commercial, industrial, institutional and domestic consumption.

*(f) What opportunities for green house gas emission reduction are there that have not been included in current strategies and what are the potential savings from taking up those opportunities?*

The PRT preliminary findings included a discussion providing perspective on GHG and energy consumption involved in wastewater treatment versus other activities. The reduction in GHG emissions achieved by eliminating septic tanks, especially in the Western area, does not seem to have been recognized. Section 4 and Appendix H of the PRT report provide further discussion of green house gas emissions.

**5. Other**

*(a) Please review any unsolicited proposals for sewage treatment, financial support or other work received to date from third parties and comment on the advisability of further study of these proposals.*

The PRT agreed to review any unsolicited proposals, financial support or other work forwarded to the PRT by the CRD. No such items were forwarded.

*(b) Do the proposed strategies offer sufficient consideration of environmental protection in the siting, construction and operation of the various wastewater treatment plants?*

Environmental protection associated with the plant sites, construction and operation has been considered in this planning phase but the details will be developed in the pre-design and detailed design phases. As discussed in Section 6 of this report, the McLoughlin site is potentially very problematic for use as a wastewater treatment plant. The site has many technical and non-technical issues related to the proposed use. The PRT recommends that the consultants prepare a more detailed analysis for the site layouts and hydraulic grade lines for the McLoughlin site to ensure that what is proposed can be reasonably accommodated on the site. This analysis should be done before extensive effort is made to acquire and gain access to the site.

*(c) Are there other significant topics that have not been adequately addressed in the work done to date?*

As noted earlier, the PRT has suggested consideration of a plant serving the Oak Bay area to improve wet weather flow management, consideration of an improved staging plan and consideration of using less costly and less energy intensive treatment technology in System Options 1B and 1C involving a plant at the West Shore gravel pit site rather than locating the major plant in Option 1 at the McLoughlin site. If the Macaulay site becomes available (or if CRD desires to determine the potential cost and benefit of the Macaulay site), the PRT recommends that an option using the Macaulay site in a phased approach be evaluated. Such an option should include the Saanich East plant and a conventional, high rate non-nitrifying activated sludge plant at Macaulay in the first phase. By the time the interceptors conveying flow from the west to Macaulay reach capacity, another conventional, high rate non-nitrifying activated sludge plant treatment plant in South Colwood would be constructed and placed into operation. This would realize the treatment cost advantages of Options 1B and 1C by avoiding the use of MBR technology without the cost of conveying flow from the east service area to a plant on the West Shore. The effort required to make the Macaulay site available appears to be difficult and time-consuming but may very well be worth investigating in detail.

*(d) Does the peer review team agree with the number of plants recommended by the consulting team from a financial and program point of view?*

The PRT agrees with the consultants' findings that costs will increase as the number of plants increases beyond the three plants shown in Option 1. In a variation of Option 1, Options 1B and 1C involve two plants, a West Shore plant and a Saanich East plant. The consultants' estimates of costs of Options 1A, 1B and 1C are essentially equal. Options 2 and 3 are substantially more costly than any of the Option 1 alternatives. Consideration of the overall program tradeoffs between environmental and social benefits and costs of Options 1, 2 and 3 is a CRD policy matter. The Macaulay Point option described in (c) above should also be considered if use of that site is potentially feasible.

*(e) Has the consulting team considered the current available water resources and conservation programs to support population projections for the purposes of sewage treatment planning?*

CRD has stated that the available water resources are adequate for the planning period. It does not appear that the consultants have done an independent analysis of the adequacy of the water supply. As noted earlier, the consultants considered the effects of an aggressive water conservation program in their System Option 3.

# APPENDIX E
# PRT ESTIMATES OF MBR ALKALINITY REQUIREMENTS

# PRT ESTIMATES OF ALKALINITY REQUIREMENTS FOR NITRIFICATION AND DENITRIFICATION

This appendix was prepared in response to the Technical Memorandum from the consultants dated April 1, 2009, that addressed a concern by the PRT that sufficient alkalinity may not be available in Victoria wastewater to neutralize acid production through nitrification and partial denitrification that will occur in the MBR process. In their memorandum the consultants prepared a table containing raw wastewater characteristics upon which they based their analysis. This information is included in Table E1 along with average dry weather wastewater characteristics for outflow from Macaulay Point and Clover Point between August 25, 2007, and March 6, 2009.

**Table E-1 Wastewater Characteristics**

| | Consultants' Analysis | | | |
|---|---|---|---|---|
| | | Nitrification Only MR Effluent | | |
| BOD mg/L | 243 | 6.6 | 6.4 | 222 |
| TKN mg/L | 40 | 3.4 | 3.3 | 43 |
| $NH_3$-N mg/L | 26.4 | 0.14 | 0.15 | 29 |
| $NO_3$-N mg/L | 0 | 25.0 | 9.1 | 0 |
| Alkalinity mg/L as $CaCO_3$ | 300 | 120 | 175 | 159 |

The consultants indicated that based upon their model analysis, 180 mg/L of alkalinity would be required to neutralize the nitrate formed with nitrification only, but only 125 mg/l if denitrification were also included. Using the factor of 7.14 mg alkalinity per mg nitrate-nitrogen formed, their data indicate that 180/7.14 or 25 mg/L of nitrate-nitrogen is formed. The reduction of alkalinity consumed of 55 mg/l with partial denitrification that they report indicates that 55/3.57 or 15 mg/L of that nitrate-nitrogen is converted to $N_2$ during denitrification. A mass balance indicates that in order to achieve this 60% reduction of nitrate would require a minimum wastewater recirculation ratio to a bioreactor pre-anoxic zone of 1.5.

For verification, the PRT modeled an activated sludge system with nitrification and denitrification using the above Victoria dry weather flow characteristics. An SRT of 12 days was assumed along with normal biological treatment system parameters such as reported in Rittmann and McCarty (2001). In order to make a mass balance, the wastewater parameters were converted to grams/capita/day (g/cap/d) using an average flowrate as found for Victoria of 0.34 $m^3$ per capita per day. From this, changes in nitrogen forms through the treatment process were determined. The results are contained in Table E2. This analysis indicates that the estimated quantity of nitrogen nitrified to nitrate (9.3 mg) is similar to that of ammonia nitrogen in the influent (9.63 mg). The consultant's came to essentially the same result from their data and analysis.

Table E-3, based upon the PRT's analysis contains a summary of the alkalinity needed to neutralize the nitrate formed for each of the three cases of nitrification alone, nitrification with 50% denitrification, and nitrification with 60% denitrification. Here, the concentrations are given in usual units of mg/L rather than in mg/cap/d. The consultants' memorandum suggests 120 mg/L alkalinity would be required to maintain near neutral pH with 60% denitrification, but the PRT analysis based upon actual dry weather wastewater flow characteristics at Victoria suggests that a higher value of 139 mg/L would be required. The PRT's overall analysis is similar to the consultants, the major reason for the higher alkalinity requirement found by the PRT is that the actual Victoria wastewater ammonia nitrogen concentrations are higher than assumed by the consultants. Additionally, the Victoria alkalinity is quite low in the order of 160 mg/L as $CaCO_3$ rather than the 300 mg/L as $CaCO_3$ used in the consultants' BioWin modeling work

The PRT's analysis indicates that for dry weather flow and 60% denitrification, there would be only 20 mg/L excess alkalinity to maintain a near neutral pH in the biological reactors. An estimate of resulting pH can be made using carbonic acid equilibrium calculations. These require an estimation of the reactor carbon dioxide partial pressure. Assuming 5% oxygen transfer, the $CO_2$ partial pressure in the reactor off gas, which would be in equilibrium with reactor mixed liquor, would about equal the reduction in $O_2$ partial pressure through organic oxidation, which would equal 0.05(0.20) or 0.01 atm, corresponding to a solution $CO_2$ concentration based upon Henry's law of about $3.1(10^{-4})$ M. The 20 mg/L alkalinity remaining represents a concentration of $4(10^{-4})$ M. The pH can then be estimated from the following relationship:

$$pH = 6.3 + \log\frac{[HCO_3^-]}{[H_2CO_3]} = 6.3 + \log\frac{4\left(10^{-4}\right)}{3.1\left(10^{-4}\right)} = 6.4$$

Such pH is lower than usually desired for nitrification. Desired residual alkalinity concentrations are generally in the 40 to 60 mg/L, which using the above assumptions is equivalent to reactor pH values of 6.7 to 6.9, a more desirable operating range. Figure E-1 shows a plot of pH versus alkalinity.

Thus, based upon the PRT's analysis using actual Victoria dry weather flow wastewater characteristics, operation without alkalinity addition is likely to lead to low reactor pH conditions, which is likely to hamper the rate of nitrification significantly and perhaps other processes as well, such as degradation of extracellular polymers that can cause membrane clogging. Whether operation of a biofilm reactor without nitrification will be harmful to MBR operation under such conditions is not known, but might be of concern. Provision for chemical storage and feed for alkalinity adjustment would thus be prudent.

**Table E-2 Estimated nitrogen forms in wastewater, primary treatment effluent, and after aerobic biological treatment with nitrification only and with nitrification plus partial denitrification. Values are in grams nitrogen/capita/day.**

| | | Primary Effluents | | Wastewater Nitrification Only | Wastewater With Denitrification | |
|---|---|---|---|---|---|---|
| **Nitrogen Form** | **Influent** | **Wastewater** | **Sludge** | | **50%** | **60%** |
| Org-N | | | | | | |
| Dissolved | | | | | | |
| Biodegradable | 1.53 | 1.53 | 0.00 | 0.00 | 0.00 | 0.00 |
| Refractory | 0.16 | 0.16 | 0.00 | 0.16 | 0.16 | 0.16 |
| Suspended | | | | | | |
| Biodegradable | 1.80 | 0.63 | 1.17 | 0.00 | 0.00 | 0.00 |
| Refractory | 1.41 | 0.50 | 0.92 | 0.50 | 0.50 | 0.50 |
| Cells | | | | | | |
| Biodegradable | | | | 2.14 | 2.14 | 2.14 |
| Refractory | | | | 0.26 | 0.26 | 0.26 |
| $NH_3$-N | 9.63 | 9.63 | 0.00 | 0.00 | 0.00 | 0.00 |
| $NO_3$-N | | | | 9.39 | 4.70 | 3.76 |
| $N_2$-N | | | | 0.00 | 4.70 | 5.64 |
| Total - N | 14.52 | 12.44 | 2.09 | 12.44 | 12.44 | 12.44 |

**Table E-3 Alkalinity required for neutralization of the net acid formation from nitrification and denitrification. Values are in mg/L.**

| | Wastewater Nitrification Only | Wastewater With Denitrification | |
|---|---|---|---|
| | | **50%** | **60%** |
| Nitrate-N formed - mg/L | 27.8 | | |
| Alkalinity Required for neutralization – mg/L as $CaCO_3$ | | | |
| Nitrification only | 199 | 199 | 199 |
| With denitrification | 0 | -50 | -60 |
| Total: | 199 | 149 | 139 |
| Alkalinity Available: | 159 | 159 | 159 |
| Available-Required | -40 | 10 | 20 |

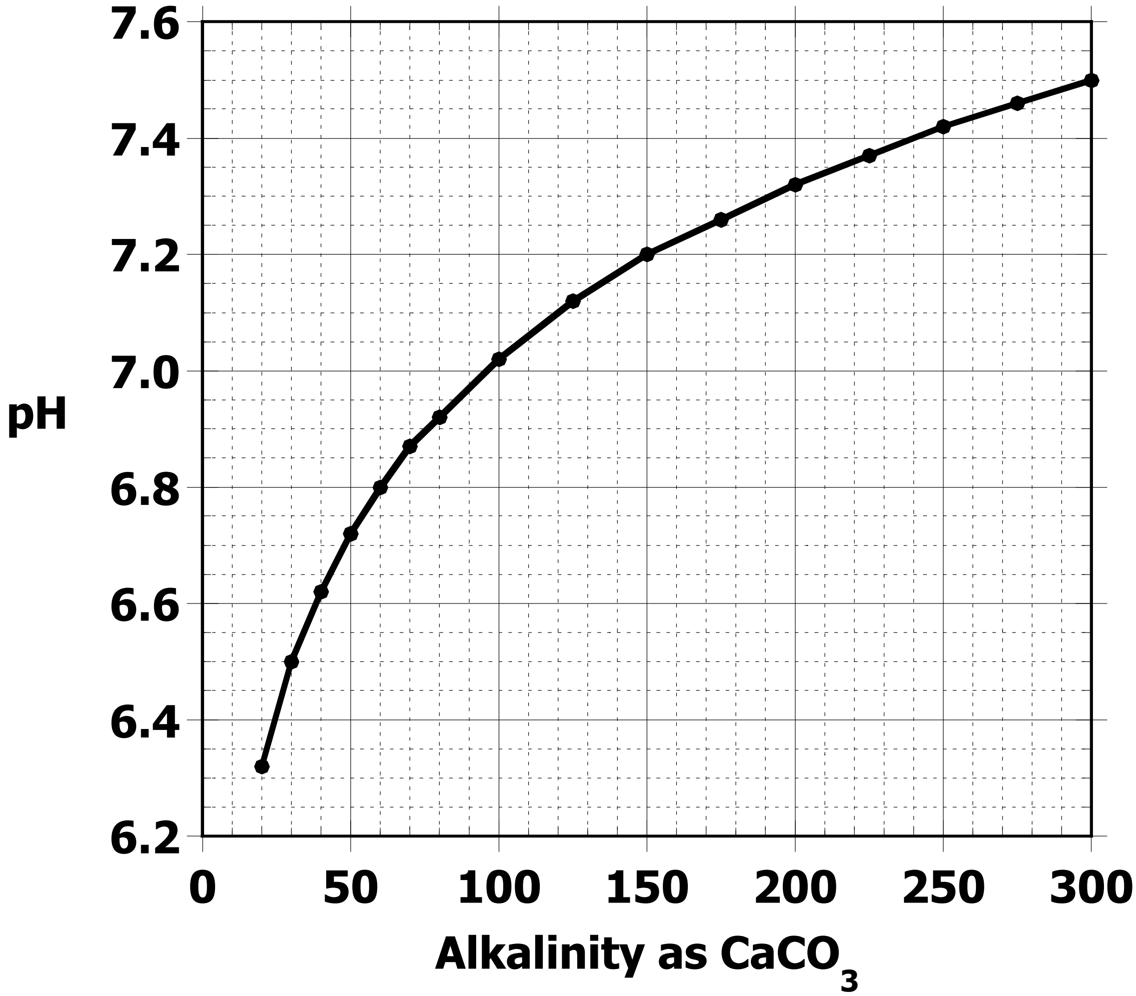



**Figure E-1 pH as a Function of Bicarbonate Alkalinity Concentration**

# *APPENDIX F*
# *SUMMARY OF BIOSOLIDS DOCUMENTS REVIEWED BY PRT*

Basic components of the biosolids management plan are 1) estimated sludge production, 2) sludge processing methods and processing locations, and 3) ultimate reuse, and/or disposal of biosolids. Information in the following discussion papers was used to evaluate the consultant team analyses and recommendations for sludge processing and biosolids reuse/disposal.

**Discussion Paper No. 7 – Biosolids Management (Mar 21, 2007)**

In Discussion Paper No. 7, a sludge production estimate for the Year 2065 was made based on a number of assumptions shown in Column 3 of Table F1 showing the daily sludge production rates. The projected sludge production for 2065 in the paper was 42.1 dry tonnes/day, which is close to the 43.5 dry tonnes/day calculated using the assumptions given. It is not clear where the value of 42.1 dry tonnes per day originates. A maximum month value would be 60.8 tonnes/day applying the report peaking factor of 1.4 to the figure of 43.5 tonnes per day. After anaerobic digestion the peak month biosolids production is estimated at 34.1 tonnes/day.

Different assumptions were used by the PRT to arrive at a sludge production estimate. These assumptions and resultant sludge production values are presented in Column 4 of Table F-1. Based on the wastewater characterization analysis, lower per capita BOD and TSS production values were used; 75 and 60 g/capita-d respectively. Typical primary clarifier BOD and TSS removal efficiencies of 35% and 65% were used, respectively instead of 20% and 50% in the Discussion Paper. In view of the relatively low fraction of soluble BOD found from the wastewater characterization analysis, the higher percent BOD removal efficiency seems appropriate. With these assumptions, the resultant daily sludge production rate is similar to the value in the discussion paper; 40.5 tonnes/day versus 42.1 tonnes/day.

The initial concept considered in Discussion Paper No. 7 to deal with the 42.1 dry tonnes per day of wastewater sludge forecast for 2065 was a central processing facility, likely located at the Hartland landfill site, to which dewatered sewage sludge from the various regional liquid stream treatment facilities would be trucked for processing. The central solids processing plant would include:

- Rewatering of the dewatered sludge cake
- Thermophilic anaerobic digestion
- Dewatering of the digested biosolids
- Cogeneration of biogas for electrical energy with thermal energy recovery
- Odour control facilities
- Land application of the digested biosolids

**Table F-1 Year 2065 Sludge Production Estimate based on Assumptions in Discussion Paper No. 7 (March 21, 2007) Compared to Corresponding Estimate by PRT using Different Assumptions**

| Parameter<br>Column 1 | Units<br>Column 2 | DP-7 Value<br>Column 3 | PRT Value<br>Column 4 |
|---|---|---|---|
| **Input Assumptions:** | | | |
| BOD | g/cap-d | 80 | 75 |
| TSS | g/cap-d | 70 | 60 |
| 2065 population | - | 600,000 | 600,000 |
| BOD | kg/d | 48,000 | 45,000 |
| TSS | kg/d | 42,000 | 36,000 |
| **Primary Treatment:** | | | |
| BOD removal | % | 20 | 35 |
| TSS removal | % | 50 | 65 |
| Primary Sludge production | kg/d | 21,000 | 23,400 |
| **Secondary Treatment:** | | | |
| Influent BOD | kg/d | 38,400 | 29,250 |
| Net solids yield | gTSS/gBOD | 0.65 | 0.65 |
| BOD removal | % | 90 | 90 |
| Secondary Sludge production | kg/d | 22,464 | 17,111 |
| **Subtotal – Primary + Secondary Sludge Production:** | | | |
| Total sludge production | tonne/day | 43.5 | 40.5 |
| Peak Month Factor | - | 1.4 | 1.4 |
| Peak Month Sludge | tonne/day | 60.8 | 56.7 |
| **Anaerobic Digestion:** | | | |
| VS reduction | % | 55 | 55 |
| VS fraction of sludge | % | 80 | 80 |
| Inert TSS, peak month | tonne/day | 12.2 | 11.3 |
| Digester VSS | tonne/day | 21.9 | 20.4 |
| **Ultimate Reuse/Disposal Peak Month:** | | | |
| Total Final sludge | tonne/day | 34.1 | 31.8 |

## The Path Forward (June 13, 2007)

The biosolids management facilities envisioned in The Path Forward document were identical to those proposed in Discussion Paper No. 7. They would be located at the Hartland site; however, it was acknowledged that they could also be located at the Macaulay site. It was assumed that the final biosolids product would be used in a beneficial manner in agricultural, land remediation and forestry applications, pending completion of a market study. The PRT's comments on this proposal would be that a close examination of the economics of dewatering+hauling+rewatering the sludges should be made *vis-à-vis* the option of stabilizing the sludges at the WWTP site(s). In addition, the daily hauling of large quantities of unstabilized wastewater sludge cake through a developed urban area must be given careful consideration. Such a practice may not be acceptable to the public.

**Discussion Paper 031-DP-3 – Biosolids Management / Organic Residuals Energy and Resource Recovery (May 8, 2008)**

This discussion paper reviewed integrated biosolids management and resource recovery practices in other jurisdictions. The paper then described a variety of resource recovery options for inclusion into a CRD solids processing system with varying degrees of integrating the processing of wastewater sludges with the processing of the source-separated solid organic fraction from municipal solids wastes. An evaluation process that began with five thematic alternative pathways eventually resulted in a short list of four alternative pathways described as follows:

- Alternative 1 – Maximum Beneficial Reuse**:**
    - Composting of organic fraction of the solid waste stream with land application of the compost product within the CRD.
    - Thermophilic anaerobic digestion of the wastewater sludges at the Macaulay site, then biosolids dewatering and land application outside the CRD.
    - Biogas from wastewater sludge digestion to be used in cogeneration with electrical and thermal energy recovery.

- Alternative 2 – Maximum Integration and Maximum Energy Recovery**:**
    - Dewatering of wastewater sludges at Macaulay and transportation to Hartland for co-digestion of the organic fraction of the solid waste stream with wastewater sludges.
    - Thermal destruction of the digested solids with municipal solid wastes in a waste-to-energy facility located at Hartland up to the 10% to 15% typically imposed for a dewatered biosolids cake.
    - The remainder of the biosolids cake would be directed to a fluidized bed incineration system.
    - The digester biogas would be processed to pipeline quality for sale or use as a dedicated transportation fleet fuel.
    - The waste-to-energy facility would produce electricity and thermal energy for sale; the fluidized bed incinerator would produce electricity for sale.

- Alternative 4 – Separate Digestion and Balanced Energy Recovery/ Beneficial Reuse
    - Anaerobic digestion of the organic fraction of the municipal solid waste stream at Hartland with land application of the biosolids product within the CRD up to the limits of demand, and then outside the CRD for the remainder.
    - Anaerobic digestion of wastewater sludges at Macaulay.
    - Dewatering and transportation of wastewater biosolids to Hartland for thermal destruction of the digested solid with municipal solid wastes in a waste-to-energy facility located at Hartland up to the 10% to 15% typically imposed for a dewatered biosolids cake.
    - The remainder of the wastewater biosolids cake would be directed to a fluidized bed incineration system.
    - The fluidized bed incinerator would produce electricity for sale.
    - Biogas from the two wastewater sludge digestion systems would be upgraded to pipeline quality for sale or use as a dedicated transportation fuel in two upgrading systems, one located at Hartland and the other located at Macaulay.

- Alternative 5 – No Digestion and Balanced Energy Recovery/Beneficial Reuse
    - Composting of organic fraction of the solid waste stream with land application of the compost product within the CRD.
    - Dewatering of the wastewater sludges at Macaulay and either,
    - Drying and transportation of dried sludge to a cement kiln in the Lower Mainland area to be used as a fuel supplement, or,
    - Dewatering and fluidized bed incineration of the wastewater sludge cake at Macaulay.
    - The fluidized bed incinerator would produce electricity for sale.

Alternative 3 pathway was dropped from consideration during the evaluations in this discussion paper.

**Discussion Paper 031-DP-9 – Biosolids/Organic Residuals Strategy Evaluation (December 9, 2008)**

This Discussion Paper presents an evaluation of the alternatives developed in Discussion Paper No. 031-DP-3. Consideration was given to life cycle analysis (including potential revenues), carbon footprint analysis and sustainability using a multi-objective alternative analysis (MOAA).

In terms of life cycle analysis, the options with the lowest net present value included:

- Alternative 1 – Maximum beneficial reuse by land application of separately-processed organic wastes (composting at Hartland) and anaerobically digested wastewater sludges (digested at Macaulay) with either:
    - Cogeneration using the digester gas, or,
    - Upgrading of digester gas to biomethane for sale.

- Alternative 5 – No digestion and balanced energy recovery by land application of composted organic wastes (composting at Hartland) and either:
    - Fluidized bed incineration of undigested wastewater sludges (at Macaulay) with electrical generation, or,
    - Dewatering and drying of raw wastewater sludges with subsequent truck transport to a Lower Mainland cement kiln for use as a fuel supplement.

The option with the lowest carbon footprint by a large margin was:

- Alternative 5 – No digestion and balanced energy recovery by land application of composted organic wastes (composting at Hartland) together with dewatering and drying of raw wastewater sludges with subsequent truck transport to a Lower Mainland cement kiln for use as a fuel supplement.

The most favoured options based on the results of the sustainability analysis were:

- Alternative 1 – Maximum beneficial reuse by land application of separately-processed organic wastes (composting at Hartland) and anaerobically digested wastewater sludges (digested at Macaulay) with one of the following:
    - Cogeneration using the digester gas, or,
    - Upgrading of digester gas to biomethane for sale.
    - Alternative 5 – No digestion and balanced energy recovery by land application of composted organic wastes (composting at Hartland) followed by dewatering and drying of raw wastewater sludges with subsequent truck transport to a Lower Mainland cement kiln for use as a fuel supplement.

The PRT was not a participant in the discussions and workshops that were a part of the evaluation processes in reported in Discussion Papers 031-DP-3 and 031-DP-9; therefore it is difficult to appreciate many of the nuances of the detailed analysis that was done to evaluate the various alternatives. As a general comment, the PRT finds the short-listed alternatives that came out of the analysis to be consistent with practices found in other jurisdictions of a similar size.

**Discussion Paper 034-DP-2 – Solids Process Alternatives Evaluation (October 7, 2008)**

This discussion paper refined the projected Year 2065 wastewater solids production estimate to 42,640 kg/d on a maximum month basis. Preliminary process tankage sizing was developed for two wastewater sludge processing alternatives to establish a footprint requirement for the Macaulay/McLoughlin site:

- Alternative 1 – Anaerobic Digestion with Biogas Production:
  - Sludge blend tanks (2 units) for combining lamella primary clarification sludge with secondary waste activated sludge from an MBR process.
  - Gravity belt thickening (3+1 units) of the blended sludges.
  - Thermophilic anaerobic digestion (2 units).
  - Dewatering feed tanks (2 units).
  - Centrifuge dewatering (1+1 units).
  - Truck or barge transportation of dewatered biosolids to off-site reuse or ultimate disposal (undefined).
- Alternative 2 – Thermal Oxidation with Energy Recovery:
  - Sludge blend tanks (2 units) for combining lamella primary clarification sludge with secondary waste activated sludge from an MBR system.
  - Gravity belt thickening (3+1 units) of the blended sludges.
  - Dewatering feed tanks (2 units).
  - Centrifuge dewatering (1+1 units).
  - Fluidized be incinerators (2 units each at 75% of 2065 forecast).
  - Waste heat boilers (2 units).

**Peer Review Team Briefing (February 12 and 13, 2009)**

A MS-PowerPoint presentation given to the PRT included eight (8) alternative strategies for the management of the organic fraction of the municipal solid waste and the wastewater sludge streams. The alternative strategies were grouped into the same four categories that follow from Discussion Paper 031-DP-3 described above. The eight alternate strategies include varying degrees of complexity and integration of wastewater sludge processing with municipal solid waste processing.

A significant addition in the PRT briefing was the inclusion of a willow coppice program in one of the eight alternative strategies. In this alternative, a portion of the anaerobically digested wastewater biosolids would be directed to a willow coppice with the remainder subjected to drying and transportation to a Vancouver cement kiln as a fuel supplement. Woodchips would be harvested from the willow coppice for use as a bulking agent to compost the organic fraction of municipal solid wastes, and also marketed as a “green” biofuel. This alternative also included upgrading of the biogas to biomethane.

### Discussion Paper 036-DP-2 – Development of Distributed Wastewater Management Strategies (dated March 9, 2009 and distributed to the PRT during the PRT’s March 11-14 Meetings in Victoria)

This discussion paper included a common management and resource recovery strategy for wastewater system Options 1, 2 and 3. The biosolids processing concept common to all three options involves drying 50% of the anaerobically digested wastewater biosolids to be used as a fuel supplement at a cement kiln in the Lower Mainland. The other 50% would be applied to a dedicated willow coppice created on an industrial land application site for the periodic harvesting of wood chips as a saleable product. This approach is shown schematically in Figure 5-1 in the body of this report.

#### Summary of Options Evaluated by Consultants

Table F-2 summarizes the sludge processing and biosolids management options evaluated by the consultants. These options were identified with the following aims:

- Maximize beneficial use (1a, 1b and 1c),
- Maximum integration and maximum energy recovery (2),
- Separate digestion balance energy recovery/beneficial reuse (4); and,
- No digestion and balanced energy recovery/beneficial reuse (5a and 5b).

**Table F-2 Sludge and Solid Waste (SW) Processing and Final Solids Reuse/Disposal Options Evaluated by Consultants**

| | | | | Final Solids Reuse or Disposal |
|---|---|---|---|---|
| 1a | 1. source separated SW<br>2. WWT sludge | 1. Compost, Hartland LF<br>2. Thermophilic Anaerobic Dig. | -<br>2.a. Heat Digester.,<br>b. Cogen electricity | 1. Residential, agricultural, urban<br>2. Forest tree farm |
| 1b | 1. source separated SW<br>2. WWT sludge | 1. Compost, Hartland LF<br>2. Thermophilic Anaerobic Dig., trucked, heat dried[1] | -<br>2.a. Heat Digester.,<br>b. Pipeline biomethane | 1. Residential, agricultural, urban<br>2. Cement Kiln |
| 1c | 1. source separated SW<br>2. WWT sludge | 1. Compost, Hartland LF<br>2. Thermophilic Anaerobic Dig. | -<br>2.a. Heat Digester.,<br>b. Pipeline biomethane | 1. Residential, agricultural, urban<br>2. Forest tree farm |
| 2 | Source separated SW plus WWT sludge | Thermophilic Anaerobic Digestion at Hartland site | Pipeline biomethane | Combusted with municipal SW in EFW facility, Ash for landfill cover |
| 4 | 1. source separated SW<br>2. WWT sludge | 1. Anaerobic Dig. Hartland LF<br>2. Thermophilic Anaerobic Dig. | 1. Pipeline biomethane<br>2.a. Heat Digester.,<br>b. Pipeline biomethane | 1. Residential, agricultural, urban<br>2. Fluidized Bed Combustion |
| 5a | 1. source separated SW<br>2. WWT sludge | 1. Compost, Hartland LF<br>2. Fluidized Bed Combustion. | -<br>- | 1. Residential, agricultural, urban<br>2. Dispose fly ash |
| 5b | 1. source separated SW<br>2. WWT sludge | 1. Compost, Hartland LF<br>2. heat dried | -<br>- | 1. Residential, agricultural, urban<br>2. Cement kiln |

LF – landfill, SW – solid waste, WWT – wastewater treatment, 1 – purchase gas for heat drying, EFW – energy from waste

# *APPENDIX G*
# *COMPARISON OF WASTEWATER TREATMENT ALTERNATIVES*

To compare the conventional activated sludge (CAS) and membrane bioreactor (MBR) treatment systems a spreadsheet process design was carried out using the Macaulay/McLoughlin Point site Option 1 design flow and the ADWF raw wastewater characteristics given in Table 3.3 of Section 3 of this report. Primary treatment BOD and TSS removal efficiencies of 35% and 65%, respectively, were assumed and the secondary treatment influent characteristics are summarized in Table G-1 below. The cold weather mixed liquor temperature was assumed at 12°C.

**Table G-1 Wastewater Characteristics for CAS and MBR Process Comparisons.**

| | | |
|---|---|---|
| Total Flow | $m^3/d$ | 87,500 |
| BOD | $g/m^3$ | 155 |
| sBOD | $g/m^3$ | 83 |
| TSS | $g/m^3$ | 68 |
| VSS | $g/m^3$ | 58 |
| TKN | $g/m^3$ | 42.4 |
| Biodegradable TKN | $g/m^3$ | 41.4 |
| Alkalinity | $g/m^3$ as $CaCO_3$ | 174 |
| Mixed liquor temperature | $^0C$ | 12 |

The operating reactor configuration and operating conditions for the CAS and MBR systems are different and affect the tank volumes needed and aeration and alkalinity requirements. The configuration used for the CAS system to provide BOD and TSS removal only is an anaerobic selector with a 45 min. contact time followed by an aeration zone sized conservatively at a 5-day solids retention time (SRT). The selector is needed to provide good settling conditions and a more stable operation. The SRT is very sufficient for BOD removal and low enough so that nitrification does not occur. The MBR system has an anoxic-aerobic tank configuration and an aerobic SRT of 10-days, which is recommended by the membrane suppliers to prevent membrane fouling by a younger, stickier biomass. At the operating temperatures full nitrification can occur at this SRT. Thus, sufficient oxygen transfer must be provided for the MBR process with nitrification or low DO concentrations will occur and cause undesirable floc characteristics for the membrane operation. Mixed liquor is recycled from the aerobic zone to the anoxic zone ahead of the aeration zone, so that about 75% of the nitrate produced can be used for BOD removal in the anoxic zone. A MLSS concentration of 10,000 mg/L was selected for the MBR system based on current membrane supplier design preference. The CAS system MLSS concentration was selected at 3,500 mg/L based on using the selector design for filamentous bacteria control. With these inputs the tank volumes, total oxygen requirements, alkalinity requirements, and sludge production were calculated in the Excel spreadsheet design at steady state conditions. The oxygen requirements were then used to approximate comparative aeration energy needs. Information from a recent Zenon bid was used to approximate the energy needed for the membrane scouring for fouling control and the energy to overcome the membrane headloss for permeate discharge.

The activated sludge total tank volume for the CAS system is about 1.6 times that for the MBR system, with resultant total hydraulic retention times (HRT) at ADWF of 4.4 and 2.8 hours, respectively, (Table G-2). In addition, the space required for the CAS is further increased for the secondary clarifiers. Based on a 1 m/hr hydraulic application rate and 5 m deep clarifiers, an additional 4.9 hours HRT are added. Thus, the MBR system requires about 30% of the area of the CAS system. Some of this is offset by the need to add fine screens (1-2 mm) and screenings washing to the MBR system.

The secondary treatment sludge production rate is higher for the CAS system due to operation at a lower SRT. For the design conditions given and assumptions on biomass yield and influent inert volatile suspended solids, the net solids yields are 0.68 and 0.59 g TSS/g BOD removed for the CAS and MBR systems, respectively. Based on 15 mg/L of effluent TSS from the CAS clarifiers (conservative for average conditions) and 0.2 mg/L of effluent TSS from the MBR system, the sludge wasting rates to the sludge processing system are 7,910 and 8,060 kg/day for the CAS and MBR systems, respectively; thus, there is little impact on sludge handling.

**Table G-2 Comparison of Required Tank Volume and HRT for the CAS and MBR Systems**

| Tank | MBR | CAS |
|---|---|---|
| Volume, $m^3$ | | |
| Anoxic | 2,020 | |
| Anaerobic | | 2,734 |
| Aeration | 8,080 | 13,177 |
| Total Volume | 10,100 | 15,911 |
| HRT, hrs | | |
| Total HRT | 2.8 | 4.4 |

Based on the discussion of alkalinity, sparge gas $CO_2$ content, and pH in Appendix E, an alkalinity of about 70 mg/L as $CaCO_3$ is needed in the process effluent to maintain an effluent pH of at least 6.9. The spreadsheet process calculations included an alkalinity balance based on alkalinity consumed for nitrification, alkalinity produced by denitrification and alkalinity in the influent and the results are shown n Table G-3. Without alkalinity addition, the final MBR alkalinity is only 17.6 mg/L as $CaCO_3$,, requiring that 4,600 kg/day of alkalinity be added for the 87.5 ML/d design flow. Alkalinity storage and feeding systems would have to be provided on the site for the MBR system.

**Table G-3 Comparison of Effluent Alkalinity from the CAS and MBR Systems Without Alkalinity Addition**

| Parameter | Units | MBR | CAS |
|---|---|---|---|
| Alkalinity for nitrification | g as $CaCO_3$/g N | 7.14 | 7.14 |
| Alkalinity from denitrification | g as $CaCO_3$/g N | 3.57 | 3.57 |
| Alkalinity used | $g/m^3$ as $CaCO_3$ | 256 | 0 |
| Alkalinity produced | $g/m^3$ as $CaCO_3$ | 99 | 0 |
| Influent alkalinity | $g/m^3$ as $CaCO_3$ | 174.0 | 174.0 |
| Final alkalinity without addition | $g/m^3$ as $CaCO_3$ | 17.6 | 174.0 |
| Effluent alkalinity goal | $g/m^3$ as $CaCO_3$ | 70.0 | 70.0 |
| Alkalinity Needed | $g/m^3$ as $CaCO_3$ | 52.4 | 0 |
| | kg/day as $CaCO_3$ | 4,587 | 0 |

The alkalinity mass balance was based on the assumption the MBR system anoxic-aerobic operation would reduce the effluent $NO_3$-N to 8.0 mg/L. Sufficient internal mixed liquor recycle to the preanoxic zone can be done to accomplish that and the anoxic volume must be large enough to remove all the $NO_3$-N in the recycle. A typical volume of 20% of the total aeration plus anoxic volume was assumed for the anoxic volume. A preliminary analysis suggested that it may have to be a little larger.

The energy requirements to provide process air for the CAS BOD removal and for the MBR BOD removal and nitrification and membrane air scour are summarized in Table G-4. The MBR system requires 2.4 times the energy needed for the CAS alternative. A large portion of this is due to the oxygen needed for nitrification. Fine bubble diffused aeration was assumed for the aeration supply except for the membrane zone. Air supplied to the membrane zone provides process as well as air scour but less efficient coarse bubble aeration is used. Based on recent Zenon bid information, only 10% of the process air was supplied in the relatively small aeration zone in this evaluation following the main aeration zone. However, the aeration transfer efficiency is one-third of that with fine bubble aeration and a higher air flowrate is needed and thus more energy. This was the only penalty applied to the membrane air scour energy requirements in this preliminary analysis.

**Table G-4 Comparison of Aeration Energy Requirement for the CAS and MBR Systems**

| Parameter | Units | MBR | CAS |
|---|---|---|---|
| Oxygen Required | kg/day | 22,674 | 14,442 |
| Aeration α | | 0.40 | 0.50 |
| Required Air Rate | scfm | 18,922 | 9,641 |
| Assumed Blower Capacity | scfm/Hp | 20 | 20 |
| Process Aeration | Hp | 950 | 480 |
| Membrane Air Scour | Hp | 160 | |
| Permeate Pumping | Hp | 60 | |
| Total Aeration | Hp | 1,170 | 480 |

Other operating cost considerations for the MBR system are the need for chemical for weekly cleaning and recovery cleaning and for eventual replacement of the membranes. Based on reported experience by Zenon, hypochlorite and citric acid may be applied to MBR membranes from one to four times per week. A recovery clean, which involves soaking the membranes in citric acid, may be done over a one-day period for membrane modules and may be needed two to three times per year. These chemical costs are small compared to the aeration energy and are not included in this CAS versus MBR comparison.

The capital costs comparison between the MBR and CAS may not be a large percent difference on the total plant cost basis. The MBR activated sludge tankage is about 60% of the CAS tankage, but the membrane cassette cost and auxiliary equipment is likely more than the CAS clarifier tankage and equipment.

The greatest difference and impact may be in the energy consumption and operating costs. The high energy demand of the membrane system and alkalinity needs run contrary to the interest in resource recovery in the wastewater treatment, which is greatly centered around capturing energy from anaerobic digestion and wastewater heat. For using MBR treatment for reclaimed water applications, the greater operating costs can be considered part of the cost of producing and using reclaimed water for irrigation and toilet flushing. In such cases this costs must be competitive with alternate water source costs. Based on this analysis the PRT recommends that the MBR technology not be applied indiscriminately in all cases for wastewater treatment. It may be better from an overall greenhouse gas effect and operating costs to use the MBR technology only where it is necessary to produce reclaimed water or where the only site available has very limited space.

Chemical enhanced primary treatment and blending can also be applied with CAS systems. In doing so, the dilution of influent soluble BOD (sBOD) by storm flows should be considered. The ADWF sBOD concentration observed in the wastewater characterization analyses (Table 3.2) for Macaulay was 82.8 mg/L. With flow at 4 times the ADWF, this could conceivably be diluted to 21 mg/L.

Assuming that the 4 times ADWF is handled by chemical treatment in the primary clarifiers with 80% TSS removal and 2 times the ADWF is directed to the CAS system with blending of 2 times the ADWF from the primary effluent and CAS effluent, the final effluent BOD concentration is near 36 mg/L, below the maximum limit of 45 mg/L. This analysis assumed a higher influent total BOD concentration (160 mg/L) than may actually occur with the stormwater dilution.

# *APPENDIX H*
# *SUPPLEMENTAL INFORMATION ON CARBON FOOTPRINTS*

The current CRD discharge of screened wastewater to the ocean would have little impact on fossil fuel carbon except for that associated with energy use for pumping. There would likely be no associated methane production with the largely aerobic ocean conditions and rapid currents. However, the ammonia represented by total Kjeldahl nitrogen (TKN) is likely to be oxidized by nitrification leading to $N_2O$ production in the ocean. How much of this is likely to escape to the atmosphere before being oxidized further in the ocean to nitrate is problematic. The Intergovernmental Panel on Climate Change (IPCC) suggests as a default value that 0.5% of the TKN be assumed to be converted to $N_2O$ through discharge into receiving water bodies (IPCC 2006). The uncertainty in such estimates is large, ranging from 0.05% to 25%! Additionally, the IPCC suggests a default value of only 3.2 g $N_2O$/cap/year for a centralized wastewater treatment plant using nitrification and denitrification, which is equivalent to only 0.001 ton equivalent $CO_2$. This value was based on studies at only one treatment plant. However, other studies of $N_2O$ formation during wastewater treatment suggest a much larger value is possible depending upon operating conditions. Factors such as low dissolved oxygen concentrations, lower pH, and higher nitrite concentrations favor $N_2O$ production, and can result in higher percentage values similar to that for discharge into receiving waters (Itokawa et al. 2001; Shiskowski and Mavinic 2006; Tallec et al. 2006). Whether future regulations on $N_2O$ production become a driver in how treatment systems are operated is currently unknown. More scientific information is obviously needed on factors affecting $N_2O$ production in the environment as well as during wastewater treatment. The potential that a portion larger than 1% of anthropogenic sources of fixed atmospheric nitrogen used for fertilizer is converted into $N_2O$ was provided in a recent analysis by the Nobel Prize winning atmospheric chemist, Paul Crutzen(2008). A worldwide mass balance between the measured rates of increase and decay of $N_2O$ in the atmosphere and fertilizer production indicated that 3% to 5% of this nitrogen is given off as $N_2O$. How generally this can be applied to TKN in treated and discharged wastewater is not known, but is an area of active research.

With treatment at larger facilities, the methane production impact from septic tanks would be nearly eliminated. The US EPA assumes as a default value that only 1% of the methane produced from controlled anaerobic digestion at larger plants is likely to escape to the atmosphere (EPA 2006). Such loss would represent an emission of only about 0.0014 metric tons $CO_2$ equivalents. The advantage for greenhouse gas emissions of centralized treatment would be offset to some degree by energy costs in transport and treatment, and by possible methane production in the sewer lines. On the positive side if anaerobic biosolids treatment were used at the treatment plant, then methane collection and use as bioenergy would help offset external energy use for treatment, possibly reducing fossil fuel usage for that purpose. Treated biosolids that result may be used as a soil amendment, which would provide some carbon sequestration and storage as well as a natural fertilizer, and so might also be considered as a greenhouse gas reduction benefit. On the other hand, incineration of biosolids without anaerobic treatment may use energy because of the high water content, would convert all organic carbon to $CO_2$ for direct discharge to the atmosphere with no sequestration benefit, and would provided no fertilizing benefit. These are all generalizations that are difficult to quantify their importance adequately as serious attention is just now being paid to obtaining a better understanding of this potential problem.

$N_2O$ production with wastewater handling and treatment might also become a problem of concern. As indicated by the range of possible $N_2O$ releases noted in Table 6-2 in the body of this report, $N_2O$ could represent as high as 0.5% of per capita $CO_2$ equivalents, which is sufficiently high to be of concern. Available information already noted indicates that under proper controlled treatment conditions, ammonia nitrogen treatment and removal can be carried out without significant $N_2O$ production. Another approach that could gain favor in the future is the capture of ammonia from wastewaters for use as fertilizer, thus offsetting the high energy and greenhouse impact of fixing atmospheric nitrogen for this purpose. This might be done through direct application of digested biosolids to agricultural land, through separate urine collection at the source, or through its incorporation along with the fertilizing element phosphorus into crystalline struvite as is currently suggested by some to offset the diminishing world supply of phosphorus.

**REFERENCES – CARBON FOOTPRINTS**

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# APPENDIX I
# AGENDA AND NOTES, THIRD PEER REVIEW TEAM MEETING

**PEER REVIEW TEAM**
**MEETING NOTES**
**April 22-24, 2009**

**AGENDA**
**PEER REVIEW TEAM MEETING**
**April 22-24, 2009**
**Room 107**
**CRD Building**

**WENDESDAY, APRIL 22**

| | |
|---|---|
| 8:30-10:30 | Discuss work status, prepare for CALWMC meeting |
| 10:30-Noon | Participate in CALWMC meeting |
| Noon-5:00 | Meet with consultants to discuss PRT questions and consultant comments on PRT draft report |

**THURSDAY, APRIL 23**

| | |
|---|---|
| 8:30-Noon | Discuss revisions of draft report |
| Noon-1:00 | Participate in Technical and Community Advisory Committee meeting |
| 1:00-5:00 | Discuss revisions of draft report |

**FRIDAY, APRIL 24**

| | |
|---|---|
| 8:30-Noon | Discuss revisions of draft report, tour industrial area |

**Wednesday, April 22**

The PRT participated in the CALWMC meeting. The PRT presented a brief summary of their draft report and addressed questions asked by the committee members.

The balance of the day was spent in discussing various aspects of the project with the CRD staff and the consultant team.

The Department of National Defence (DND) has said that the Macaulay site is off the table. The CRD has met with Transport Canada to discuss the potential fill in Victoria Harbour associated with the McLoughlin site. Transport Canada is opposed to placing structures on fill in the harbour.

Imperial Oil is the owner of the McLoughlin site. Cleanup costs will be their responsibility. Imperial Oil has removed their tanks and wants to define the site cleanup requirements before talking about sale of the site to CRD. A cleanup plan is expected by July, 2009. Use of adjacent DND property may possibly be obtained by leasing the property from DND and allowing continued DND use of space on top of covered structures for small boat storage. The only access to the McLoughlin site is through DND property.

Lehigh Cement owns the sites for options 1B and 1C. They were asking $150 million last fall.

DND is concerned about underwater pipelines or outfalls in the anchorage areas in the harbour.

A selection process for a program manager is underway. It is anticipated that the program manager will be retained by July 1, 2009.

To possibly avoid fill in the harbour if the McLoughlin site is used in Option 1A, the consultant team is considering locating anaerobic digesters in an industrial area northeast of the McLoughlin site.

The consultant team is considering a variation of Option 1 in which the West Shore plant would be delayed until 2025 and excess capacity at McLoughlin used to treat the West Shore flows until then. To further reduce the cost of the first stage, the consultants are proposing to defer the Clover Point wet weather treatment facility although this will require regulatory agency concurrence. The consultants believe that these two changes to Option 1 could potentially reduce the initial costs to $900 million.

It is anticipated that septic tanks will be connected to the sewers by 2030.

The Triple Bottom Line (TBL) analysis was discussed in a meeting on March 31. At that time, the consultants presented their TBL analysis. Results for various weighting of economic, social and environmental criteria were presented. Slides summarizing these results were provided to the PRT. These TBL results favoured Option 1. Further discussion of the TBL is planned during the next two weeks. It is anticipated that the rankings will be reviewed at the May 13 CALWMC meeting.

The PRT submitted a list of questions to the CRD and the consultant team in advance of these meetings. The responses were discussed. The questions and the consultants' written responses are attached to these meeting notes.

The possibility of accomplishing drying at the cement kiln sites was discussed. There is a great deal of waste heat available from the cement kilns. There is enough demand for fuel in the cement kilns to use all of the biosolids.

The use of Alder trees as an option to Willow trees was discussed. Alders grow well in the Vancouver Island environment.

The CRD is pursuing a zero waste goal but this does not mean that CRD will be getting out of the landfill business.

The consultants reported that the design of the secondary treatment facilities at the plant site used in Options 1B and 1C were based on activated sludge with a five-day solids retention time (SRT). The PRT voiced the opinion that a three-day SRT could have been used. This would lower the cost of 1B and 1C but the net result would likely be that 1A, 1B and 1C will still be considered equal in cost based on the preliminary estimates of cost.

In Option 1B, the consultants assumed a two-barrel polyethylene concrete=-encased pipeline to convey east service area flows across the harbour to the West Shore plant. In Option 1C, a three-barrel pipeline was used.

The consultants estimate that Option 1B will use 13% less electrical energy than Option 1A and that Option1C will use 16% less than Option 1A.

**Thursday, April 23**

The PRT participated in the Technical and Community Advisory Committee meeting. The PRT presented a brief summary of their draft report and addressed questions asked by the committee members.

The Saanich East plant was discussed. It pulls flow out of the downstream sewers which will reduce the pressure on the limited capacity of downstream sewers in wet weather. It eliminates pumping the Saanich area flows twice. The land has been purchased. The nearby University has a district heating system and may be amenable to heat recovery from the treatment plant effluent.

An engineer provided an estimate to CRD of $11,000 per lineal foot for a 10-foot diameter tunnel from McLoughlin Point to the gravel pit site. Further studies will be needed to determine if a tunnel is needed or if a seabed pipeline will suffice.

The PRT spent the balance of the day working on material for their final report.

**Friday, April 24**

The PRT worked on material for their final report. The PRT schedule for completion of the report was discussed and agreed upon. Input from individual team members will be forwarded to Gordon by April 28, a revised draft will be circulated among PRT members by May 1, comments on the revised draft to Gordon by May 4 and the final report delivered to the CRD by May 6.

The PRT toured the industrial area identified by the consultant team as a possible location for anaerobic digesters if the McLoughlin site is used in Option 1A. for the liquid portion of the wastewater treatment system.

## PRT QUESTIONS FOR CONSULTANTS, APRIL 22-24 MEETINGS

*Consultant Team Response in italics – April 21, 2009*

1. **Why do the secondary capacities being provided vary between system options?** The secondary treatment capacities described as "being provided" in 036-DP-2 are:

   a. Option 1 215 ML/day (McLoughlin 131 ML/day, South Colwood 58 ML/day and Saanich East 26 ML/day)

   b. Option 2 244 ML/day (McLoughlin 35 ML/day, South Colwood 15 ML/day, Saanich East 26 ML/day, Ogden Point 56 ML/day, Juan de Fuca 112 ML/day)

   c. Option 3 210 ML/day (McLoughlin 18 ML/day, South Colwood 12 ML/day, Saanich East 23 ML/day, Ogden Point 30 ML/day, Jan de Fuca 27 ML/day, Windsor Park 18 ML/day, Westhills 16 ML/day, Florence Lake 8 ML/day, Lang Cove 16 ML/day, Roderick 42 ML/day)

   The PRT understands that a water conservation program is included in Option 3 which would result in lower flows and need for less secondary hydraulic capacity. But why the differences in secondary capacity between Options 1 and 2?

   *The noted difference in total secondary treatment capacity between Options 1 and 2 results from differences in the ADWF multipliers assumed for the secondary treatment systems at the various WWTFs. In Option 1, all secondary facilities discharge effluent to open marine environments. As a result, the secondary treatment capacity for all facilities was set at 1.5 x ADWF. However, in Option 2, the Juan de Fuca WWTF directs effluent to a more sensitive embayed marine location. Therefore, it was assumed that all primary effluent at this facility would receive secondary treatment at all times. Both the primary and secondary treatment system capacities for the Juan de Fuca WWTF were assumed to be 2.0 x ADWF (note: surplus wet-weather flows would be conveyed to a downstream treatment facility). The large relative size of the Juan de Fuca WWTF in Option 2, and its use of the higher ADWF-based secondary treatment capacity multiplier, resulted in Option 2 having a higher total secondary treatment capacity relative to Option 1.*

2. **Should the value of effluent for heat recovery be evaluated on the basis of a comparison to the economics of heat pumps using air as the source of heat?** In Appendix A, Technical Memo 4, Figure 3, Page 4 shows the relationship between using air and using water as a source of heat for a heat pump in Victoria. The Coefficient of Performance (COP)

for a heat pump is shown there to average about 3 for air and 4 for wastewater. That means for each GJ electric energy input to a heat pump, one would get out 3 GJ if ambient air were used, but a higher 4 GJ if the wastewater were used. Thus, in Victoria, wastewater is a better source of heat energy that ambient air. Air is free, but the consultants' analysis suggests that if water is used instead, they could charge someone. It seems in an evaluation of the heat value of wastewater, the comparison should be that with a heat pump using free air. In other words, what is the maximum value in recovering 4 over 3? For say 100 GJ energy out, 25 GJ electricity would be required with water, while 33 GJ would be required with air. That 100 GJ from water would cost 8 GJ less electricity energy input, a savings at $16.10/GJ of $128.80 per 100 GJ of energy from the water. This amounts to a net benefit of $1.28/GJ of energy obtained from the water. However, the consultants report suggests that the water energy benefit is a much higher $14/GJ. It seems that apples and oranges are being compared. If air as a source of energy is free, then a buyer of energy would know this and would use air over water if the water energy costs $14/GJ.

*The life cycle analysis provided estimates of the potential revenue if wastewater-derived heat was purchased by a utility for subsequent retailing on the basis of the opportunity provided by the availability of wastewater and/or effluent. The Whistler Olympic Village and the South East False Creek development in Vancouver provide local examples where wastewater-derived heat was selected as the source for district heating systems. As a result, there is a local precedent for the feasibility of using such heat sources.*

*In the end, the decision to use any specific heat source (e.g. raw wastewater, effluent, groundwater, ocean water, air), or combination of heat sources, for use in district heating systems will ultimately be made by a third-party energy utility and in consideration of many factors.*

3. The PRT has questions about the estimated cost for the McLoughlin plant in Option 1:

    a. **Does comparison with Pine Creek costs provide a realistic check on the McLoughlin costs?** The McLoughlin site seems fraught with possibilities for unusual costs. Also, the plant includes primary capacity and digester capacity beyond that needed to match the secondary capacity. The consultants in their April 6 memo used the costs for the Pine Creek plant as a measure of reasonableness of their estimate for McLoughlin in Option 1. How representative are the costs from Pine Creek for the McLoughlin site? If Pine Creek costs $3200-$3700 per cu m/day, does that confirm that McLoughlin at $3000 is a reasonable estimate considering the differences in the plant sites and the plants? The Pine Creek site is a relatively simple and straightforward one from the perspective of constructing a WWTP. It is a relatively flat greenfield site above the river floodplain with no geotechnical, hydrogeological or seismic issues. Neither was there any contamination to do with previous activities on the site nor a need for substantial excavation into bedrock to construct the WWTP. In addition, one can reasonably expect constructability issues on the McLoughlin site when attempting to shoehorn all of the tankage into such a space-constrained site.

*We need to remember that we are working with "conceptual" level estimates and final sites / layouts have not been selected. In addition, the comparison is direct costs and the CRD estimates also include fairly conservative multipliers for various contingency factors. Basically the comparison is between an advanced WWTP constructed on a fairly ideal site with a secondary plant constructed on a site that will require a compact tankage arrangement. In terms of specific point raised, our comments are:*

*Rock Excavation: While more expensive to remove, rock provides an excellent foundation and reduces the dewatering problems. The surplus rock is required on the DND breakwater construction, that will be constructed as part of the "partnering" between the CRD and DND.*

*Site Contamination from Imperial Oil Activities: The studies by Imperial Oil are just starting. If there is contamination, this will be Imperial Oil's responsibility regardless of the ultimate use of the site.*

*Constructability Issues: While the actual construction area is confined, there is ample staging area on the DND property. In addition, the site allows both road and marine access.*

*In conclusion, while we feel the costs are in the right ball park, we would agree that they are not overly conservative. We will review the costs in the final version of the cost estimate.*

b. **Are the relative costs for McLoughlin in Option 1 and the costs for McLoughlin in Option 2 reasonable?** The cost is $410 million for 131 ML/day secondary plant capacity at McLoughlin in Option 1. The cost is $300 million for 35 ML/day secondary plant capacity at McLoughlin in Option 2. There is 370% more secondary capacity in Option 1 at McLoughlin but the cost is only 37% more. Even considering economy of scale, the relative costs seem questionable.

*While the biological secondary (MBR) capacity is considerably lower in Option 2, the primary treatment capacity is similar and the biosolids processing capacity is higher when compared to Option 1. This is why the capital costs are closer than a comparison with secondary treatment capacity would indicate.*

c. **Are the relative costs in Option 1 for the McLoughlin Point and Saanich East plants reasonable?** A capital cost of $128,000,000 for Saanich East is shown in the consultants' reports to provide secondary capacity of 26 ML/d. The Saanich East plant provides only liquid wastewater treatment with solids sent via the sewer system to McLoughlin. The proposed site is of good size and appears to have no particular site conditions that would be difficult to overcome. The proposed McLoughlin site has an estimated liquid stream capital cost of $320,000,000 to provide a secondary capacity of 131 ML/d. The site is very restricted, and has a number of conditions that will make the construction difficult and expensive. The calculated costs for the liquid stream treatment per unit of secondary capacity" is $4,923 per $m^3$/d for Saanich East ($128 million/26 ML/day) and $2,442 per $m^3$/d for McLoughlin ($320 million/131 ML/day). Given the disparity in site conditions, is a liquid treatment unit cost at Saanich East that is 200% more than the unit cost at McLoughlin reasonable?

*We significantly increased the capital cost estimate for the Saanich East WWTP in the last version of the cost estimate to allow for additional features (totally enclosed tankage, greater odour control, more extensive site and architectural development, etc.) considering that the plant was in a residential neighborhood. In retrospect, we may have been overly conservative. We will review the costs in the final version of the cost estimate.*

4. **Where are the costs for the wet weather facility at Macaulay in Option 1 shown?** In the cost report dated February, 2009, wet weather treatment stream costs are shown in Options 2 and 3 but none are shown for Option 1. The PRT understands that there is a wet weather treatment facility at Macaulay/McLoughlin in Option 1. Where are the costs for that facility included?

*The difference is that in Option 1 the surplus wet weather flow is handled through a relatively minor expansion of the primary clarifier capacity. The costs are thus in the primary clarifier estimates. In Options 2 and 3, the overall secondary capacities (primaries / MBR) are considerably lower than in Option 1. It was thus necessary to handle the wet weather flow (same magnitude as Option 1) through a separate wet weather flow process, assumed to be a high-rate process (Actiflo$^{TM}$). This is why the costs are shown separately in Options 2 and 3.*

5. **The PRT would like to see and discuss the details of the cost estimates for Options 1B and 1C including the design criteria and elements of cost for the treatment plant and the conveyance systems.**

   *We will discuss this at the meeting.*

6. **Do the consultants agree with the PRT review of the need for alkalinity addition?** Appendix E of the PRT draft report discusses the need for alkalinity addition in the MBR process. Do the consultants agree with this analysis? If not, what are the specific aspects of the PRT analysis that the consultants do not agree with?

   *We do not substantially disagree with the analysis that the PRT has conducted. But, we do disagree with the conclusion that supplemental alkalinity will be required. As we have indicated, we agree that it is prudent to include provisions for supplemental alkalinity in the design of MBR facilities. What we disagree with is a conclusion that such addition should be included in the estimated operating cost for alternatives including MBRs. Our disagreement is based on the following.*

   *First, we disagree that a pH of 6.5 to 6.9 is necessary to nitrify. There are a number of examples of facilities which nitrify at lower pH values, on the order of the 6.3 value that the PRT has calculated. It has historically been considered that lower pH values are in some fashion inhibitory to the nitrifying bacteria. More recent results suggest that this is not the case. Rather, the effect of pH on nitrifier growth for pH values less than the optimum (say 8.3) is a result of the fact that the substrate directly utilized by the ammonia oxidizing bacteria is free ammonia (NH3) and that the fraction of total ammonia present as free ammonia declines as the pH declines. This understanding helps explain why nitrification is routinely observed to occur at lower pH values than were previously thought to be necessary for nitrification to occur. In this discussion, it is important to recognize that nitrification is not required to meet a specified effluent limit. Rather, nitrification is a result of the desirable operating conditions for MBRs and, in fact, is an environmental benefit that would result with the selection of MBR treatment options.*

   *Second, as indicated in our previous response to PRT comments, low alkalinity wastewaters are widespread throughout the Pacific Northwest and substantial experience exists with their treatment. The uniform result experienced throughout the Pacific Northwest is that coupling nitrification with denitrification results in low but acceptable alkalinity and both acceptable process and effluent pH values. In fact, we find that the PRT analysis is consistent with this practical result. One might question why this result is so uniformly experienced in the Pacific Northwest. The* *reason is that alkalinity is contributed to wastewaters in direct proportion to the nitrogen added to them. Ammonia nitrogen, either added directly or through the hydrolysis of urea or organic nitrogen, adds free ammonia (NH3) which is a base. In wastewater streams, where sufficient CO2 is consistently present, this is converted into ammonium bicarbonate. Thus, it is logical that experience concerning the affects of nitrification and denitrification on net alkalinity consumption and pH values should be so consistent in similar settings. In discussing experience in the Pacific Northwest, it is important to recognize that when nitrification and denitrification was first incorporated into treatment plants in the Pacific Northwest, calculations such as those conducted by the PRT resulted in the conclusion that alkalinity addition was needed and alkalinity addition systems were installed with the full expectation that alkalinity addition would be consistently required. As noted above, experience has consistently indicated that alkalinity addition was not needed and is not routinely practiced. Thus, we can understand the PRT calculations and how they may conclude from a conservative perspective that alkalinity addition will be required. But, experience tells us these conservative considerations are not realized in practice.*

7. **Since nitrogen removal is not required or likely to be required, why include the Sharon-Anammox process in Options 2 and 3?**

   *Side-stream centrate treatment was assumed in Options 2 and 3 because in these Options the solids processing facilities are receiving significant sludge loads from other WWTFs. Without this pre-treatment, the resulting centrate stream would induce a disproportionately high nitrogen loading on the main liquid-stream system at the WWTF receiving the centrate. While it is true that nitrogen removal might not be required at the WWTFs from an effluent quality perspective, the MBRs assumed for the analysis will provide a high level of ammonia and total nitrogen removal as a result of their inherent design. Side-stream treatment of centrate using the Sharon-Anammox process will reduce the overall energy needed to oxidize the centrate nitrogen while limiting the amount of alkalinity consumed in its conversion.*

8. **Do the economics warrant the inclusion of MAP recovery at the proposed McLoughlin plant?** Phosphorus recovery as magnesium ammonium phosphate is typically economical only at treatment plants employing biological phosphorus removal technology. Is the bioreactor to be configured for a Bio-P removal process? (Neither the BC MSR nor the CCME Guidelines will require phosphorus removal in this instance.)

   *We agree that MAP recovery does make more sense when the plant is a BNR plant with anaerobic digestion. In that case, MAP recovery prevents the recycling and build up of phosphorus in the treatment plant due to centrate recycle. However, for the CRD we included MAP recovery for the* *proposed larger plants because of the Province's interest in Integrated Resource Recovery (IRR) which, by definition, would include the recovery and beneficial use of heat and nutrients even though there are no current regulations that require their removal.*

9. **Considering the nature of the plans for ultimate disposal of biosolids, why use thermophilic digestion rather than mesophilic digestion?**

   *Given the concerns that we knew had been raised about biosolids land application by some members of the various CRD committees, we felt that any land application, regardless of type or purpose, should likely be based on Class A biosolids, rather than Class B. Hence, we chose thermophilic digestion. That said, digester sizing was based on maintaining a minimum of 15 days HRT and/or no more than 3.2 kg VS/m3/day, which is somewhat longer and lower, respectively, than necessary for thermophilic digestion. Gas production was limited to typical mesophilic production rates (e.g. 1 m3 biogas/kg VS destroyed), rather than the slightly higher thermophilic gas production rate. The biogas needed to heat the digesters was based on maintaining thermophilic temps (55 deg C) year round.*

10. **What is the backup for biosolids management if either the operation of the cement kiln or willow coppice programs run into problems?**

    *The assumed back-up, for short term (maybe up to 3 months) problems was to dispose of dewatered biosolids at the Hartland Avenue landfill. For longer term issues, having Class A biosolids from the thermophilic digesters also could lead to other land application options that would not be possible with Class B biosolids.*

11. **What is the basis for the 50-50 split for willow coppice and cement kiln options. Why not a different ratio?**

    *The ratio could have been something different than 50-50. We decided to use 50-50 as the example split. Further work in the future, including detailed investigations of the lands available for willow coppice and discussions with the two cement manufacturers in the Vancouver BC area could change this ratio, either on a permanent or seasonal basis. This would impact the cost of the dryer facility. We did explore the costs of 100% to cement kiln cost in the Discussion Paper 031-DP-9 options. We did not investigate a 100% willow coppice option on the basis that it would be too risky.*

12. **What is the potential for mixing dewatered and heat dry biosolids for landfill to control moisture content?**

    *There would be some potential for such blending should the need arise. However, that would only apply for the back-up situation, not the permanent situation. We did not cover every eventuality in the analysis.*

13. **What percentage of the effluent flow from the East Saanich plant might be used in the summer months for irrigation? What is the cost of the reclaimed water transmission lines?**

    *The life cycle analysis assumes that 0.50%, or approximately 30,000 $m^3$/yr, of the annual effluent volume generated at the Saanich East WWTF would be reused for irrigation. This value was derived in consideration of current potable water use for golf course and park irrigation in the Core Area.*

    *The costs for reclaimed water transmission lines were not included in the life cycle analysis. A comprehensive economic analysis that encompasses both the CRD's water and wastewater utilities would be needed to equitably assess the cost of reclaimed water distribution infrastructure.*

14. **Is there potential to attracting industry to the option 1A site due to heat recovery benefits?**

    *We presume this is referring to the McLoughlin Point site. As the surrounding property is DND, and will remain as DND, there is no potential for attracting private sector industry. However, in confidential discussions with DND, they anticipate re-development of the surrounding area for military institutional use and are interested in both wastewater heat recovery and water reuse.*

15. **If available, the PRT would like to see and discuss the results of the Triple Bottom Line Analysis.**

    *We have presented the SAF analysis in concept to the Committee at the March 28 workshop. The first "draft" will be made public at the May 13 meeting. We will provide it to the PRT during the week of May 11.*

16. **The PRT would appreciate hearing and discussing comments from the consultants on the PRT's draft report.**

    *Our team is just going through the document and we can provide some discussion at our April 22 meeting.*