Resources from Waste Peer Reviews

Peer Reviews and Responses

Prepared for:

BC Ministry of Community Services

29 February, 2008

Mr. Dale Wall
Deputy Minister
Ministry of Community Services
PO Box 9490 Stn Prov Govt
Victoria BC V8W 9N7

February 29, 2008

RESOURCES FROM WASTE PEER REVIEWS

Dear Mr. Wall,

We refer to the final report of the IRM Study Team of this date, in which reference was made to reviews by selected independent experts. This document combines the peer reviews in their unedited formats with the Study Team's comments where appropriate.

As you are aware, the peer reviews were submitted to the Steering Committee and the comments made available to the IRM Study Team. The reviews included some excellent observations and the Study Team elected to add some comments within the report to better explain and clarify the report. In other instances, comments made by the peer reviewers merit clarification but in the Study Team's opinion do not require amendment of the report itself.

The Study Team appreciated that all four reviewers concluded that IRM was conceptually sound and would make a meaningful contribution to the Province’s climate action plan and green city agendas.

We concluded that while there were a number of important technical comments presented by the reviewers, it was not appropriate to make substantive amendments to the modeling or business case as many of the peer review comments can be addressed in further assessment stages, or in implementing IRM, as recommended by the Study Team and indeed, is unanimously recommended by the peer reviewers.

The Study Team felt it would be helpful to provide responses to the reviews submitted by Dr. Dawson and Mr. Nilsen, in an effort to clarify their comments and in case the contexts were misinterpreted by lay readers. The Study Team comments are included in this document and have been restricted to more significant points of clarification. No comments were deemed desirable for the peer reviews provided by Lewis & Zimmerman or Dr. Charles McNeill as their nature is more at an executive level.

We again state the Study Team's opinion that the very professional contributions of the peer reviewers are greatly appreciated and are accepted with thanks.

Yours truly,

The IRM Study Team

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Dr. Charles McNeill

United Nations Development Programme

To: Deborah Rasnick
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11 February 2008

From: Charles Ian McNeill, Ph.D.
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Subj: Comments on 'Resources from Waste': Integrated Resource Management Phase I Study Report

I have reviewed all the materials provided to me associated with the "Integrated Resource Management Study Report" which was prepared for the BC Ministry of Community Services with the purpose to determine whether there is a business case for a more sustainable and integrated approach to wastewater management and resource recovery for communities in British Columbia. I have the following observations:

First, I am encouraged to learn that the BC Province is considering such an integrated resource management approach to its municipalities that could consider issues of solid waste, waste water, drinking water, energy, transportation needs and greenhouse gas (GHG) emissions from the perspective of optimizing the value of recovered resources. However, I am not surprised that this kind of important and innovative exercise would be undertaken in BC in view of the Province's growing reputation worldwide and its local track record of leadership in sustainability issues.

In fact, there is a rapidly growing body of evidence from countries throughout the world that the kind of integrated approaches to urban resource management that is illustrated in BC's IRM study may in fact be the way of the future. But getting the details right is all important, as the authors' of this study acknowledge.

I write this today just hours after being with the UN Secretary General and with New York City Mayor Michael Bloomberg here at the UN's Special General Assembly Debate on Climate Change where both leaders expressed how urgent it is for cities, municipalities and communities to take immediate action to address the climate change risk and the range of other serious environmental challenges confronting humankind. Mayor Bloomberg, in particular, spoke to innovative initiatives like this IRM study and referred to his own experience with New York City and with 40 other cities through the C40 Climate Leadership program, by emphasizing that 'reducing the carbon footprint of a city or municipality increases the social and economic wellbeing of its people" and that "serious carbon emission reduction targets will not hamper economic growth – quite the contrary.

I realize that this is rightfully an initial feasibility study but to summarize my view, after reviewing numerous studies of similar approaches from many different countries, I conclude that this IRM plan is conceptually sound and on the right track, and if implemented it would likely provide a model of great value to countless municipalities throughout the world.

An impressive effort has been made here to assess the business case for IRM, but as the authors' state clearly, more details related to specific pilot sites need to be gathered to fully understand the financial implications of various approaches and to be able to select the optimal ones to ensure successful pilots.

As other reviewers will surely have commented already, the presence of an 'enabling' or a 'disabling' governmental policy and regulatory environment will have a critical bearing on the success or failure of a cutting-edge initiative like this. A review of various BC government decisions taken over recent years, especially with regard to climate change, suggests to me that BC may in fact have the kind of 'enabling' policy environment to support innovative work such as IRM. Fortunately, there is a solid basis of regulatory and policy decisions taken in BC on climate change, energy, water management, waste management, biodiversity, etc. to provide support to an IRM approach.

In my own work with the United Nations and with the Global Environment Facility (GEF) in developing countries across Africa, Asia and Latin America, I am aware that examples of the various types of technologies proposed in this study (i.e. those related to energy and water conservation; biogas; cogeneration; reclamation of treated water for beneficial uses; recovery of heat energy via heat pumps for district heating and cooling; recovery of methane from wet organic waste for use in buses and cars; and recovery of biogas from organic waste for production of electricity and heat, etc.) are all successfully under implementation in various parts of the developing world.

I am of course also aware that European nations, especially the Nordics (Denmark, Finland, Norway, Sweden) and Germany, Netherlands, Spain, UK are leading the way in integrated approaches to these technologies and approaches and therefore they offer a richness of examples and models that can inform British Columbia's municipalities as well.

With this experience in mind, I can say that the technologies, models and costing methodologies are well-known and properly used by the authors' of this study. Of course, as the authors' emphasize, the precise calculations of the various income and costing sources will depend on which specific circumstances are selected for further study and implementation.

And although there are many benefits to an integrated approach (related to the sound management of water, land, energy, biodiversity, chemicals, etc.), and in fact, the actual viability of the approach is a function of the sum total of these various lines of benefits and values, it is worth focusing on one area of significant likely benefits from this approach: greenhouse gas reductions.

Having recently returned from the United Nations Framework Convention on Climate Change (UNFCCC) 13th Conference of the Parties meeting in Bali in December 2007, it is clear to me that the entire global community will be moving strongly to very significantly reduce GHG emissions in the next few years, to ensure a global reduction of at least 50% emissions from 1990 levels by 2050, and to ensure a peaking of emissions no later than 2020.

It is also clear that every investment in infrastructure that does not maximize GHG reductions will create a problem for decades to come. This is widely appreciated at the global level where, to take extreme examples, China's and the U.S.'s numerous new coal-fired plants that are being brought on line now, will challenge these countries' ability to reduce GHG emissions for literally generations. Given Canada's commitments under the Kyoto Protocol, it needs to take a different approach and to actively replace more highly GHG emitting development options with low-GHG emitting options through the use of approaches like IRM.

Therefore, the value of investing in IRM for the GHG reduction benefits should not be underestimated. And although it is true that the price of carbon in voluntary markets can range from a few dollars per tonne to $30 or more (called Voluntary Emission Reductions – VERs – not Certified Emission Reductions – CERs, as one reviewer suggested – which refer to compliance markets like the Clean Development Mechanism - CDM) the value of carbon in compliance markets, like the CDM or the European Trading Scheme (ETS) is currently above $30 per tonne, and likely to increase significantly as the risks of climate change become even more severe in coming years.

The potential for IRM to help local governments to meet commitments of the BC Climate Action Charter by itself provides a compelling rationale for further exploration of the IRM approach. In fact, several of the Province's climate change commitments could be advanced by IRM, especially the intention to reduce GHGs by 33% by 2020, with interim targets for 2012 and 201; the regulation of landfills for methane use; the new requirement that 50% of new energy should be obtained from energy conservation, etc.

That said, I think it would be worthwhile for the next phase of the study to focus in on the carbon calculations of the project since as the authors' note, methodologies and technologies are now widely available to fairly accurately assess the climate-related benefits of the IRM proposal.

Of course, climate change is likely to make the current prevailing water shortages that afflict over 2 billion people in the world far more severe and therefore the benefits of IRM in reducing water requirements and replenishing the water table and aquatic ecosystems will become increasingly valuable.

As I have seen firsthand in southern California's Orange County, including the Irvine Ranch area, the realization that not all uses require drinking water quality has led to highly economically viable programs that use partially treated waste water for watering parks, gardens and roadways. Re-use of water will reduce pressure from the potable water supply and increase water to lakes, rivers and other natural waterways to support aquatic ecosystems. This is important for many reasons, but one of them is that these aquatic ecosystems are the most highly threatened ecosystems in the world.

So in terms of the almost inevitable increasing severity of climate change impacts, worsening water quality and quantities, biodiversity threats, and energy shortages, the value of the IRM approach will surely increase sharply in the coming years. That is why it is so important to carry out further analysis now and to get pilots started as soon as possible. This is also why I would consider some of the assumptions of the IRM model to be conservative: since the value of the ecological benefits of the model may be undervalued at present because water, carbon and other ecosystem services are clearly not yet fully reflected in market prices – but they will be increasingly reflected in the near future.

Suggestions:

I would offer the following suggestions on how to advance the work of the IRM study further:

Contact Konrad Otto-Zimmerman, Secretary General of the International Council on Local Environmental Initiatives (ICLEI)'s Climate Program and inquire how IRM approaches are being implemented among the 700 or so local municipalities from throughout the world, as well as among the C40 large cities that are part of the C40 Climate Change program.

Contact Janet Ranganathan, World Resources Institute (WRI) for access to advanced and innovative European examples of integrated ecosystem management schemes like IRM.

Explore the range of European models on IRM-like approaches more fully to assist with the actual detailed assessment of the business case.

On Table 1, page 4, the 'Climate Change' row: the text in the 'Traditional Waste Management' and "IRM' boxes needs to be fleshed out further since the text there is not sufficiently clear or compelling.

A Few Final Recommendations:

I strongly believe that there is a need to more fully evaluate the IRM approach and distributed waste treatment plants through pilot projects.

IRM does appear to have the potential to be implemented in the Capital Regional District and should go forward for more detailed and precise planning and assessment for the implementation of pilots. Obviously, further work is needed since although each individual technology is well established and under implementation in countless locations around the world, fewer models exist where the full range of technologies work together synergistically.

I would expect no less from the Province of British Columbia than to go forward with this exciting and high potential endeavor. The world is counting on BC's continued leadership in this area. Thank you for the opportunity to participate in this important exercise.

Lewis & Zimmerman

RESOURCES FROM WASTE
Integrated Resource Management
Capital Regional District
Victoria, British Columbia

Peer Review Comments
Phase I Study Report Submittal

February 2008

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February 1, 2008

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re: Peer Review of the Integrated Resource Management (IRM) Study Report

Dear Ms. Rasnic:

Lewis & Zimmerman Associates, Inc. is pleased to present two copies of the peer review comment report on the referenced project. The key issues noted in the report deal with the durability, construction and O&M costs of the below grade wastewater treatment plants. A number of issues appear outstanding and clarification could greatly improve the economics of the IRM concept. Placing the treatment plants underground, while convenient in existing right of way locations, greatly degrades the process equipment, shortens the life of the process basins, and creates a confined space environment that may be detrimental to maintenance staff. Further conceptual design may solve many of these issues.

We appreciate your assistance in the conduct of this study, and hope that these recommendations will provide a variety of improvements that will enhance the true value and viability of the IRM concept. Please feel free to contact David Hamilton at 253/925-8741 if you have any questions as you review this report. On behalf of Lewis & Zimmerman Associates Inc., we hope our services have been informative and useful to the goal of optimization of the IRM concept.

Sincerely,

LEWIS & ZIMMERMAN ASSOCIATES, INC.

David A. Hamilton, P.E., CVS, CCE, LEED™ AP
Vice President
Certified Value Specialist No. 910506 - Life

Enclosures

PEER REVIEW COMMENTS

INTRODUCTION

This letter report contains comments on the Integrated Resource Management Plan (IRM) under study by the British Columbia Ministry of Community Services. Lewis & Zimmerman Associates, Inc. (LZA) conducted this review under contract to the Ministry and presents the following discussion to assist the Ministry in their optimization and clarification of the IRM concept. The goal of this review was to review the presented data, offer suggestions for optimization and clarification, and assist the Ministry in moving the process forward.

The IRM program as presented is a true paradigm shift in handling wastewater and offers numerous interesting concepts to capture energy, generate needed revenue, and reduce the carbon footprint in the Victoria, B.C. area. The concepts are absolutely intriguing and suitable for further study by the Ministry.

The following documents were reviewed under this task:

Resources from Waste – Integrated Resource Management Phase I Study Report, prepared by Integrated Resource Management Study Team, dated 30 November 2007.

The Core Area Wastewater Management Program, The Path Forward, Approved by the Capital Regional District on June 13, 2007.

IRM Study – Ancillary Data, prepared by Asset Strategies, dated 18 December 2007.

PEER REVIEW COMMENTS

1. Reasonableness of engineering principles and proposed infrastructure models, and whether they are sound;

- **Integrated Resource Management Plan –** The IRM concept offers a generational improvement in our current wastewater collection and treatment paradigm used in North America and the current figures reveal an average ROI in the range of 7 years. This most interesting and revolutionary concept should be investigated further. Capture of heat energy with heat pumps located near the source of the waste stream offers clear revenue opportunities while reducing greenhouse gas emissions. Proceed with the next phase to examine this model.

- **Other Concepts, Private-Public-Partnership** – Different forms of infrastructure ownership should be investigated besides government owned and operated. A number of municipalities in North America have gone the path of private ownership and maintenance for water and sewer system treatment, distribution/collection. If finding the least cost to provide these services, the free market economy has proven to be a winner. Since their business models are more streamlined than municipal organizations and employee costs are generally lower, savings has been noted when bid against governmental operations.

- **Page 24 – Return on Investment and Setting Priorities for Investment –** To aid in the analysis of the program, the overall return on investment (ROI) should be calculated for each module in the concept. For example, all cost (capital + O&M) and revenues for the Heat Pump concept should be compared in a table showing the ROI to give the reader a sense of the profitability of this portion of IRM model. Individual investments could then be analyzed based upon their overall profitability. Some portions of the plan may be of little value on a ROI basis, while others should be vigorously advanced. Items such as Greenhouse Gas Reductions and CO_2 credits are not driven by ROI, but are societal goals and should be evaluated as part of the triple bottom line decision-making process. Setting priorities allows for specific portions of the IRM program to be targeted for pilot studies and can aid the government in the funding process.

- **Page 25 – Similar Treatment Plants -** The IRM model would use 32 localized treatment plants designed using "off the shelf" components. If the same supplier were used for all 32 plants, repair of components would be greatly streamlined. However, if these units are purchased at different times under competitive bidding arrangements, a number of suppliers may be used over the course of several years. This leaves the maintenance superintendent with 32 treatment plants, many of which have different manufactures for pumps, blowers, starters, instrumentation, and screens. Spare part management could be a monumental task and require a large inventory.

- **Page 26 – Recharge to Groundwater –** Footnote 13 suggests that disinfection of the effluent will bring the quality closer to drinking water standards. In a gross concept, this may be true, but we are still talking about wastewater with CBOD's in the range of 10mg/l and some remaining coli form counts. Some bacteria may present depending upon the chlorine residual. The comparison to drinking water should not be made. Investigation should be done to verify the applicability for recharge of this effluent quality to groundwater aquifers and how this may affect surrounding potable water wells.

- **Page 26 – Groundwater Recharge** - Groundwater recharge with effluent treated to 10m/l CBOD would be problematic in many States. Treatment to either 5mg/l or 3m/l CBOD would be required. Specific permitting guidance is needed.

- **Page 28 – Landfills -** Elimination of all biosolids to landfills appears questionable; even composting facilities have a byproduct. Vernon, BC for example recycles nearly 100% of its treated liquid waste stream, but landfills all of its biosolids. Where do the solids go?

- **Page 28 – Digestion -** Digesters by their nature are somewhat sensitive to temperature and VOC levels in the influent stream. Does anyone have experience mixing sludge with other materials such as kitchen or yard waste, and has it affected the operation of the digesters?

- **Page 35 – Failure Modes** – As the number of pieces of equipment increases, the complexity of the system and instrumentation controls increase geometrically by introducing hundreds of possible failure points in a system that currently may have several dozen. The implication of environmental risk associated with failed pumps, spills, etc. should be investigated along with the need for emergency generators, bypass overflows, and alarm systems. It should be recognized that the decentralized treatment concept greatly increases the number of possible failure points and requires additional staff to maintain this equipment. Travel time to a failure point should also be included in the analysis.

- **Page 59 – Competition Among Technologies** – Depending upon the bidding environment, specifications, and installation schedule, multiple treatment technologies could exist in the 32 decentralized plants. This complicates the staff training process as well as the spare parts issues noted. It may be best to standardize on one process, and bid all 32 plants at the same time. This will ensure similar pumps, equipment, and instrumentation in all locations. Delivery of the plants could be phases as needed.

- **Single Vendor to Supply Plants and Maintenance** - A single vendor should be identified and a maintenance contract executed to supply key parts. It is common for agencies to require the vendor to warehouse spare parts in a local facility and be available to support the City with technical representatives as needed. Another option would be to purchase all 32 plants but require the vendor to perform all maintenance for a specific period, say 10 or 15 years. This ensures quality materials and reliable operating characteristics.

- **Underground Construction** - Building wastewater treatment facilities below grade has been done previously in congested urban areas, but a capital cost premium should be added as well as increased O&M cost for reduced life of equipment and steel basins, increased odor control, and potentially hazardous underground environment for staff. In the U.S., hazardous underground entry for plant maintenance staff is covered by OSHA and is taken as a very serious activity requiring management approval, coordination, and strict backup support.

- **Capital Cost Data -** The capital cost data used for analysis purposes appears to be based on small treatment plants within BC. I would assume that these are built at-grade and the numbers may lack appropriate capital funds for the underground construction planned for the IRM concept. Cost or contingencies should be added for retaining vaults, ventilation, odor control, moisture protection from groundwater, buoyancy, and explosion proof equipment.

- **Page 96 – Package Plants -** Package wastewater treatment plants are commonly used in commercial applications where re-capitalization for replacement units (year 20, etc.) is palatable. However, in municipal settings, refunding for total replacement of units may be difficult. Further, package units are generally viewed by many in the industry to be "temporary" fixes until more permanent facilities can be built. Complicating the O&M aspect of the plant is the nature of underground operation of rotating equipment, controls, and power distribution panels in highly humid areas. It would be reasonable to assume an expected life of the plant to be in a range not to exceed 20 years. Other specific equipment such as controls and electrical equipment may have shorter lives. Therefore, recapitalization of the total plant should be budgeted at year 20.

- **Page 98 – Effluent Quality** - Figure 16 - Discharging effluent with 10mg/l CBOD, 10mg/l TSS, and 5mg/l TN into small streams with low flows may not be allowable considering the affect of DO sag and overall nutrient loading on the receiving waters depending upon local permit review. In the U.S., effluent qualities in the range of 5/5/3 are typical used for these situations. There is a capital cost risk for catchment areas in upstream locations where environment impacts upon fisheries may exist. A permitting risk may apply here.

- **Page 101 – UV Disinfection -** Use of UV disinfection has many advantages over either gas or liquid chlorine, but has a similarly higher capital and O&M cost. In addition, UV does have some limitations on higher levels of Total Suspended Solids (TSS). Some permitting agencies such as the State of California – Title 22 Regulations require a chlorine residual prior to distribution. If the B.C. requirement is similar to the Title 22 requirements, chlorine could be added downstream of the UV system, or a total liquid chlorine system installed to perform all disinfection. This would probably be the least cost of a chlorine residual is required.

- **Page 102 –Treatment Level -** The level of treatment mentioned in the analysis appears to vary from secondary to tertiary in the report and should be carefully defined to insure that capital costs are truly comparable to other BC plants and that discharge options be evaluated to ensure environmental compliance in small streams lacking year round flows. Many wastewater reuse systems in the U.S. require "advanced tertiary" treatment, which is even more stringent.

- **Page 107 – Treatment Levels -** Recycled water requires various levels of treatment for the final use intended and can range from spray irrigation of land with non-public access to residential home distribution for irrigation or gray-water functions. The capital cost of treatment can vary widely depending upon the final usage and may increase the budget numbers stated and processes proposed. For example, in the State of California, residential distribution of recycled water requires full tertiary treatment including chlorine disinfection and required residual. Further, turbidity levels must meet a 2 NTU daily average with BOD's at or near non-detection. Treatment to this level may significantly increase the capital costs noted in the financial analysis. Further investigation is needed to verify final treatment levels required in Victoria.

- **Page 145 – Table 14 WERC Cost Analysis** – I am not convinced that the 20% credit for Process Simplicity and Shared Operations is valid. Having dozens of plants all over town will require a small fleet of roving maintenance people monitoring the plants by radios or laptops, gathering samples, repairing equipment, removing screenings from the underground plants, adjusting the process, and checking chemical storage levels. Some of this can be done through telemetry, but results in a mass of instrumentation I/O points throughout the City. A new central monitoring facility would be required to receive these signals and act as the backbone of the system. For example, the existing Macaulay Point and Clover Point treatment plants may each have five to six blowers for process aeration. Under the distributed program, the 32 small plants may have three blowers each. That is a total of 96 blowers to maintain, monitor, inspect, and repair on a daily basis. The labor requirements for this could be astounding. Somewhere in the system a blower will probably be failing. Agreeably, the smaller units are easier to replace, but each unit still needs attention, periodic testing, vibration analysis, and general preventative maintenance.

- **Capital Cost Validity** – As a general comment, the capital cost could be as much as 50% low if these "package plants" are placed underground and some type of concrete enclosure is needed for earth support and street level access. Lacking further breakdown in the current capital cost estimates, I would assume that these plants would require excavations in the range of 15 – 20ft deep, making groundwater and earth support large cost components. If the plants are placed on existing right of way, they may adjacent to existing buildings, requiring underpinning during the installation process. These costs can grow rapidly. Comparing this type of installation in a more urban setting to that of grade mounted treatment plant in an open field clearly underestimates the effort required. Clarification is needed.

- **Asset Strategies Memo – Page 14 & 15 – Capital and O&M Cost –** The capital cost estimating Method 2 uses curves from the Canadian Council of Ministers of the Environment, which, I'm assuming may reflect the cost for treatment facilities above ground with steel or concrete tanks. This should be explored and a factor added for totally underground installations. Similarly, the O&M costs may be from small plants constructed of concrete. In addition, the 20% credit for Process and Simplicity and Shared Operation may be overstated. The IRM plants will provide tertiary treatment, well beyond the average provided in most locations in B.C. For early planning purposes, I would recommend eliminating this credit for the sake of financial conservatism.

- **Asset Strategies Memo – Page 23 – Pumping Efficiency** – Pumping efficiencies will increase since we will be pumping treated in lieu of raw sewage, but I would suggest using a pumping efficiency improvement from 45% to 75%, rather than 25% to 75%. This will slightly reduce the calculated net energy saved. Even grind pumps have efficiencies in the range of 50%.

2. Environmental (including climate-related) benefits and challenges;

- **Page 99 – Screenings -** Removal of screenings from the headworks of the WERC's is an odorous operation at best and could be highly objectionable to residents in these urban neighborhood settings. This undoubtedly will surface as a community concern during public meetings. Lifting the screenings and dumping them into a trash bin is one of the most odorous locations on a treatment plant and would need to be enclosed to mitigate the impacts on the local residents.

Challanges

- **Page 49 – Public Education -** Reusing reclaimed water for residential uses including irrigation should be quite tolerable to the public, but education will be needed before introducing this water into the inside of a building for cooling, flushing of toilets, and general washing. LEED strongly endorses this practice and will need to be encouraged through a well-directed public program.

3. Energy benefits and challenges;

- Benefits – There appears to be immediate benefits to capturing the residual heat from the wastewater and selling it to adjacent property owners. The value of the heat of course will be dependant upon the temperature at the customer's delivery point. Water at 90-degrees C has a higher value to the customer than water at 60-degrees C. Some clarification is need here so that the capital cost of the heat pump system can be ascertained.

4. Validity of the high-level business case modeling (financial, risk, other) and assumptions; identify its winning points and challenges. Particular interest is whether the assumptions around realizable revenues are sound, and credibility of overall risk analysis;

Winning Points:

- The financial plan appears to be well documented, but the capital and O&M costs should be verified further. This could be done through a pilot test phase where a typical treatment plant design is developed to the point that gross dimensions can be verified and process tank volumes confirmed. Confirmation of the digester gas production cost will be more difficult.

Challenges:

- **Sampling and Lab Testing -** The decentralized plants will require a considerable amount of time to gather samples, perform testing, record the results, etc. to insure permit compliance. The number of lab technicians to conduct these tests will be increase geometrically from current staffing.

    - **Page 98 – Confined Space Plant Operation -** Building "preferably subsurface construction" for the WERC will add a considerable amount of cost compared to the data shown for other above ground plants in B.C. The plants are described as two or three levels below grade. Below ground facilities may require uplift protection, concrete retaining structures, and bring with it major impacts of operating a plant in a confined space. Confined space operation may require explosion proof equipment, generate excessive amount of moisture around what appears to be steel tanks, and the labor impact of requiring two operations people to accomplish all below ground tasks. Some agencies also require staff to have two-way radios, and have backup ambulance service available and notified of their activities. The underground concept may be highly susceptible to both capital cost and O&M increases and should be studied further prior to confirming this model. The key cost drivers here are groundwater, lateral earth pressures, and confined space operation. The confined space issue places a significant risk on the concept and must be addressed.

- **Staffing Plan -** Capital cost and O&M costs should be studied further by preparing a management plan with staffing requirements, procurement process, permitting, and typical operational mode for the system. An estimate of maintenance staff per individual plant or multiple plants per staff member is needed to accurately estimate the O&M cost. Staff will also need added vehicles to travel from one plant to another.

- **Page 151 – Financial Model – Discount and Inflation Rates** – Table 16 shows a "Chosen Value" for the real discount rate of 8.0% and General Inflation rate of 1.9%. Since future rates are always quite variable, a sensitivity analysis should be conducted on both of these factors. In general, the lower the discount rate, the more emphasis is placed on future O&M costs. In the U.S., the Federal Office of Management and Budget policy for 2008 is to use a "net" discount rate of 3.1% and zero rate for inflation. This is the "constant dollar" method and has been used for more than 20 years in the States on capital construction projects. Variable inflation rates can be included for energy costs, but typically operation and maintenance expenditures are calculated at current dollars without inflation, and then discounted in one calculation. It should be emphasized that a net discount rate of 3.1% places more emphasis on future O&M costs which many prefer since funding for these activities is often quite limited. Decisions then lean towards more durable materials which may actually add capital cost. Based on the rational in the IRM report though, current method of analysis actually results in more emphasis being placed on capital cost than future O&M costs. Some may say this "cheapens" the facilities. This may be subtle point, but attention should be paid to expected cash flow in future years. The 8.1% discount factor with 1.9% inflation results in a smaller O&M cost component than the 3.1% net discount rate with zero inflation. Additional calculations are needed, but the sensitivity of the discount rate cannot be minimized.

- **Page 151 – Annual Construction Inflation Rate –** Table 16 presents a "Chosen Value" for the Annual Construction Inflation Rate of 10%, with a minimum range of minus 10%, and a maximum value of 15%. Agreeably, the past 2 to 3 years have seen inflation rates on construction projects in the 10 – 12% range, but this appears to be modulating and rates closer to 5% may be on the horizon. I would suggest an inflation number in the range of 6 to 7% instead of 10%. As noted above, the "constant dollar" method of present worth analysis should be investigated and included when the sensitivity analysis is performed.

- **Page 151 – General Construction Contingency** – Early conceptual estimates typically are prepared using a contingency rate of 25% rather than the 15% due to the large number of uncertainties. A business model such as this often carries contingencies of in the range of 30%. The net affect will be an increase in the capital construction cost for the IRM, but should be analyzed on sensitivity basis.

- **Page 157 – Monte Carlo Simulations -** As noted in previous comments, the model should be taken to the next level of analysis using Monte Carlo simulations for capital cost, O&M, and revenue. Ranges for each key cost parameter should be established by a panel of experts with experience in finance, environmental permitting, and engineering, construction, operations, and revenue generation. Costs or revenues with highly sensitive drivers should be analyzed and mitigations brainstormed to improve the viability of the program. The revenue stream is especially sensitive and requires Monte Carlo simulations to insure adequate cash flow for the program.

5. If not covered in above risk discussion, or elsewhere;

- **Political interest/benefits and challenges**
  - The cost sharing aspect of this program will become challenging and may require inter-agency transfers to pay for energy. One agency may prosper from this program while the others expenses actual increase.

- **Social interest/benefits and challenges**
  - Local neighborhoods will need to recognize the need to take ownership for their waste and help in locating these plants in agreeable spaces.

- **Technological benefits and challenges**
  - The concept of multiple decentralized plants is manageable from a technology perspective since appropriate applications of instrumentation including CCTV's make long distance monitoring feasible.

- **Environmental benefits and challenges**
  - The benefit of local distributed wastewater discharges is clearly noted in the reports to enhance groundwater and stream recharge. However, the impact of these discharges must be balanced against the simplicity of ocean outfalls.

- **Potential for resource recovery and associated revenues**
  - A clear benefit for the IRM concept is the resource recovery and carbon footprint possibilities. This is a huge advantage over current concepts.

6. Institutional synergies and barriers, for example:

- **Environmental benefits and challenges –**
  - Benefits are numerous for the IRM program, but the economic analysis must be furthered and expanded to ensure decisions are based on accurate analysis, which is sensitive to the ranges of all key variables.

- **Regulatory** – Modifications to the Municipal Sewage Regulations and BC Building Code may be necessary to clarify the level of wastewater treatment required and possible uses including spray irrigation, groundwater recharge, and residential use. Specific treatment levels for CBOD, TSS, and chlorination residuals need to be developed similar to those in the State of California – Title 22 Regulations.

- **Municipal structure –** Roadblocks will have to be addressed to modify current codes, attitudes, and gain neighborhood ownership of these treatment facilities. This may require generational changes in permitting agencies.

7. Other relevant points;

8. Based upon your experience and report review, overall opinion of whether the IRM approach appears valid and worth pursuing further, and whether the report and its analysis are sufficiently credible to support the approach.

- This is an extremely interesting concept. Proceed with further investigation.

- **Pilot Test -** The IRM concept is extremely interesting and offers many initiatives, which reduce carbon emissions; however, a pilot test should be conduced in two catchment basins to test the political, environmental, and economic viability of this concept. This should be a full-scale pilot test using equipment from the two most favorable manufacturers. The competitive environment will allow analysis of the two fully functioning treatment plants including heat exchangers, heat distribution system to local consumers, and waste discharge to local receiving waters. The pilot test will establish capital costs to install the equipment as well as provide extremely useful information regarding the following:

  - Screenings removal
  - Odor control required
  - Treatment efficiency and ability to consistently meet permit
  - Impact upon upstream receiving waters
  - Electrical energy required to run the plant
  - Ability of the equipment to handle peak hydraulic loads
  - Grab sample and testing procedures
  - Staffing requirements
  - Instrumentation functions back to main plants
  - Reliability and durability of equipment
  - Ability to generate revenue
  - Neighborhood feedback
  - Verification of economic model
  - Identify most favorable treatment plant manufacturer

- **Funding for Pilot Tests** - Funding requirements for the pilot test would be modest in comparison to the full-scale investment but would allow a logical phased approach with the goal to initiate the IRM concept. Applications for capture of and sale of the digester gas could also be investigated on a pilot scale.

- **Master Plans for Macaulay Point and Clover Point Treatment Plant –** As a comparison to the IRM concept, master plans should be prepared for both of the existing treatment plants in Victoria to identify their built-out capacities within existing or easily acquired real estate. It is reasonable to assume that both of the plants would be upgraded to full secondary treatment capability with disinfection. The analysis should be flexible enough to include a third treatment plant into the catchment area if needed and economically justified. Cost estimates for capital and O&M should be developed and compared to the IRM program. If possible, many of the positive attributes of the IRM concept, especially the heat pumps, should be incorporated into the plant improvements to improve their triple bottom line score. This investigation should be conduced with the same rigor and detail as the IRM process so that both options can be effectively evaluated for capital cost, O&M requirements, and possible revenue streams. Since larger plants are typically constructed of very durable materials, such as concrete, with replacement in the range of 50 years, appropriate benefits should be recognized when comparing this solution to the IRM concept with steel package plants having replacements in the range of 20 – 25 years. The present worth analysis should be conducted over a 50-year period and appropriate replacements of the package plants made at year 20 or 25.

- **Cost Models –** The following page is a Cost Histogram of capital cost for the IRM program. These models should also be prepared for O&M cost and the revenue stream also. They have proven to be an exceptionally useful tool in identifying key cost parameters, setting priorities, and eliminating low worth elements.

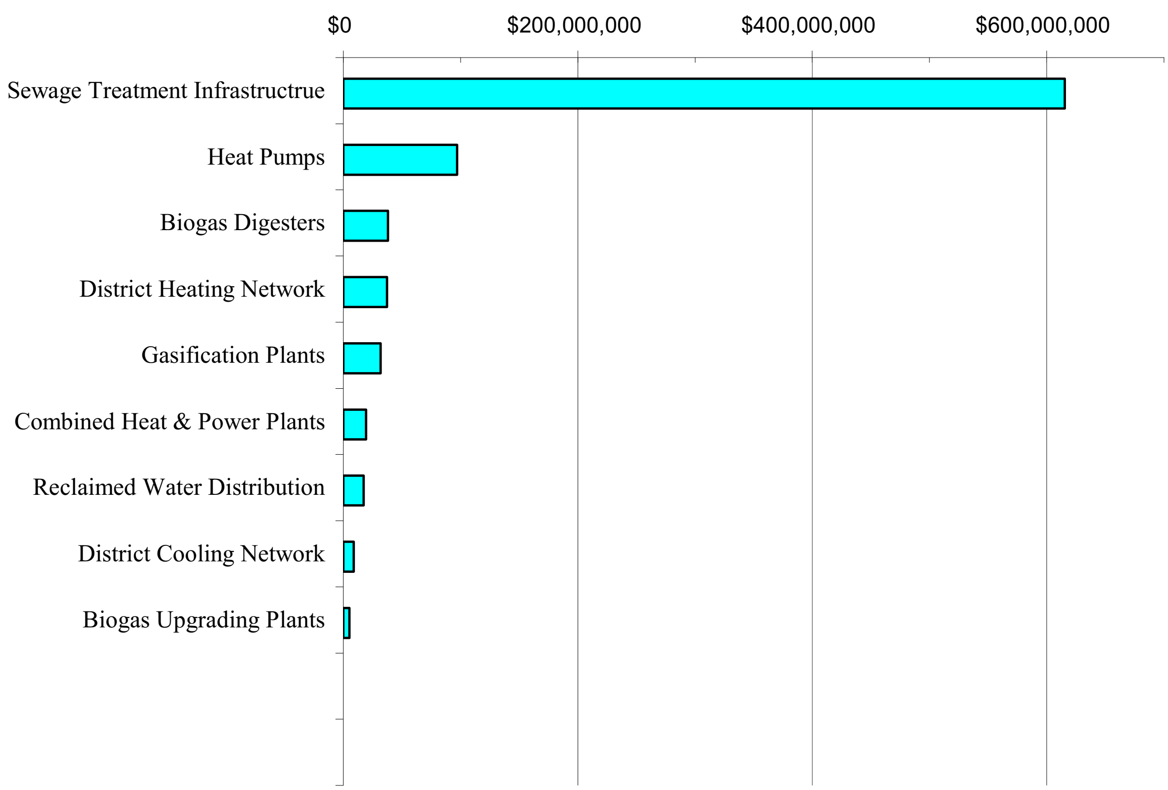
In summary, the IRM concept offers great advantages over the current paradigm of centralized wastewater treatment, but needs to be evaluated competitively against the centralized treatment concept, and a privately owned and operated system. All three of these need further evaluation so that an equitable analysis can be made.

It is hoped that these comments further and clarify the IRM concept and have improved the value of the report for the Capital Regional District.

COST HISTOGRAM

PROJECT: **INTEGRATED RESOURCE MANAGEMENT (IRM)**
Capital Regional District, BC

CAPITAL COST ANALYSIS	COST	PERCENT	CUM. PERCENT
Sewage Treatment Infrastructrue	615,359,250	70.70%	
Heat Pumps	96,944,669	11.14%	11.14%
Biogas Digesters	38,145,871	4.38%	4.38%
District Heating Network	37,261,668	4.28%	8.66%
Gasification Plants	31,772,448	3.65%	12.31%
Combined Heat & Power Plants	19,402,520	2.23%	14.54%
Reclaimed Water Distribution	17,432,359	2.00%	
District Cooling Network	8,901,398	1.02%	
Biogas Upgrading Plants	5,140,027	0.59%	0.59%
Subtotal	***870,360,210***	100.00%	
TOTAL CONSTRUCTION, INFLATED W/CONTINGENCY	**$ 870,360,210**	Comp Markup:	



Mr. Carl Nilsen

REVIEW OF INTEGRATED RESOURCE MANAGEMENT PHASE 1 STUDY DATED 30 NOVEMBER 2007

Prepared For:

MINISTRY OF COMMUNITY SERVICES

Review Report Prepared by:

ALTUS GROUP LIMITED

Effective Date: February 2008

February 8, 2008 Ref: 707580

Ms. Deborah Resnick
IRM Study Project Director
Local Government Dept.
Ministry of Community Services
4th Floor, 800 Johnson Street
Victoria, BC

Dear Ms. Resnick:

Re: Integrated Resource Management Phase 1 Study Review Report

As requested by you, I have reviewed a report entitled "Resources From Waste – Phase 1 Study Report" dated November 30th, 2007 (the "Report") for the purpose of providing you with comments regarding the methodology and conclusions of certain aspects of the Report. As you know, my professional training and expertise is in the field of real estate valuation and appraisal and I have therefore confined my comments to those parts of the Report which deal with valuation and cash flow or economic analysis. While the subject matter of the Report is not real estate, the valuation techniques proposed in the Report adopt methods similar to those used in real estate investment analysis and I have therefore made my comments on the basis of my experience in that area. Consequently, it has not been my intention to confirm or refute the findings of the Report; my goal has been to comment on the valuation methods used in a general sense and identify issues which may need further clarification.

This review has been undertaken in the context of the Canadian Uniform Standards of Professional Appraisal Practice for review reports. These are the standards with which, as a member of the Appraisal Institute of Canada, I am required to comply. For the purpose of this review, I have regarded the Report, due to its form and content, as a consulting report. This review is therefore in a number of different sections, the headings of which should be self-explanatory.

Purpose and Intended Use

The purpose of this review has been to undertake an analysis of the Report in order to assist the Ministry of Community Services in evaluating its contents. It is intended that the review be used solely for this purpose and, if required, for assisting in a more detailed analysis of the proposed resource management system.

Scope of Review

The scope of this review has focused on the following reports provided to me:

- "Resources from Waste *Integrated Resource Management Phase 1Study Report"* prepared for the BC Ministry of Community Services and dated November 30th, 2007. The Report (provided to me as a "Confidential Draft") was prepared by the "Integrated Resource Management Study Team." The authors and their qualifications are identified on page 1 and in Appendix B of the Report.
- A report prepared by Asset Strategics and Farallon Consultants dated December 18th, 2007 under the signatures of Chris Corps, BSc MRICS and Stephen Salter, P.Eng., two of the four authors of the Report. The purpose of this report entitled "IRM Study – Ancillary Data" was to provide "comments ancillary to the main report, which should assist the reviewers ... in understanding the model."

I was also provided with the following report which I have referred to in order to provide further context for this review.

- "The Core Wastewater Management Program" Supporting Report prepared for the Capital Regional District by Associated Engineering (BC) Ltd. This report was prepared as part of the programme development and facility planning process relating to a wastewater management strategy for the region. It was approved by the CRD on June 13th, 2007.

I have also reviewed a number of publications referred to in the Report, including:

- Capital Asset Management Framework – Guidelines May 2002
  Province of British Columbia
- Vancouver Valuation Accord – March 2007
- International Valuation Standards – Eighth Edition, 2007
- Material available on the internet relating to "Comprehensive Project Appraisal"

Report Background

In this section, my understanding of the contents of the Report is summarized. Comments on specific elements of this summary have been included at the end of this section, referenced to the text as appropriate.

On page 16 of the Report, the Purpose and Scope of the study is defined as being "to determine whether there is a business case for a more sustainable and integrated approach to wastewater management and resource recovery for communities in British Columbia." The Report undertakes this analysis in both a general sense, primarily by describing what Integrated Resource Management (IRM) is, and in a more specific way by developing a case study using the Capital Regional District as a model. The figures derived from the economic and valuation analysis – the business case - therefore relate to that case study. The Report is careful to state in a number of places that the analysis has limitations. On page 17, for example, the following qualification is noted:

> The IRM study will require a more detailed assessment of treatment cost and revenue resource recovery opportunities (Phase 2) than can be provided in this initial Phase 1 analysis. It is thus important to understand that this current study has limitations and falls short of the detailed analysis needed for full analysis and application of an IRM approach.

As described in the Report, IRM is a process which looks at alternative methods of waste management, including the management of wastewater, in order to identify ways in which the disposal, processing and potential reuse ("resource recovery") of waste can result in the highest net returns. The Report therefore comprises two principal components. One is a technical analysis of possible methods of developing an IRM system. The other component is the financial analysis which looks firstly at the costs of developing and maintaining the infrastructure proposed in the technical analysis, and secondly at the potential revenues (in either actual or proxy form) that may be anticipated from the different elements of resource recovery identified. Part of the development of the financial model involves technical analysis of potential supply of and demand for energy resources generated by IRM. As the Report states on page 3, the aim of this analysis is to determine "the net highest and best use and value." In undertaking the analysis, the Report analyses not only revenues to a "single entity" as would be the case using common valuation and Accounting principles, but also considers broader value parameters such as social and environmental benefits. The Report describes this approach as being "consistent with the valuation principles that underlie the Vancouver Valuation Accord." (1)

The Valuation Methodology is discussed in Appendix G of the Report. Traditional valuation methods, which typically rely on a discounted cash flow approach (DCF) in establishing a market value do not, the Report argues, adequately address broader potential project impacts, particularly those related to public benefit or minimization of negative effects affecting the community at large. The Report suggests the need to "consider carefully, what business methods need to be used to evaluate wastewater management and any potential move towards IRM." *(Page 128)*. With this in mind, the Report concludes that the requisite guidelines for such evaluation are contained in the Province of BC's "Capital Asset Management Framework" (CAMF) and a UK document entitled "Comprehensive Project Appraisal" (CPA) (2). (*Page 131)*. International Valuation Standards (IVS) are also cited as having the "flexibility in principle to adapt to assessing IRM." *(Page 129)* (3) The Report suggests that by using the CPA approach it has followed "international valuation standards and practices and (sic) are consistent with provincial standards. (*Page 142)*(4)

What these guidelines are and how they would be used in this specific case is not discussed in any detail in the Report. What is discussed, however, are traditional approaches to the value - comparison, investment, development and cost. The preferred approach suggested by the Report is the "development method" which considers project costs and the revenues derived from the implementation of IRM. The Report also discusses the effect of discounting cash flows on present values and questions the use of DCF analysis as a "single tool for assessing a project" *(page 134)*. As a result, the Report favours the use of several indicators.

The Report emphasises the importance of the concept of Highest and Best Use in the analysis of value. The concept is well known in the valuation of real estate and, as pointed out in the Report, typically requires a detailed consideration of the costs and revenues associated with alternative projects. The Report is careful to point out, however, that the complexity of such an exercise in this instance has precluded a detailed review (5).

As a final point, it is noted that the Report makes reference to the fact that the CRD study was expected to analyze revenues from resource recovery, but has not yet done so (*Page 3).* This is contrasted with the IRM approach, which "uses revenues as the driver." (6)

Comments:

1. Rather than establishing a defined set of "valuation principles," The Vancouver Valuation Accord (VVA) is statement of intent which sets out to address the interrelationship of sustainability and valuation through a review process. VVA envisages this process taking place over the three years following the 2007 conference at which the accord was signed, with a full report on progress targeted for GLOBE 2010 in Vancouver. The principles of valuation which underlie the VVA are therefore general in nature and subject to further development.

2. It would be helpful to have included a more detailed discussion of the challenges associated with evaluating projects which are subject to non-traditional valuation criteria such as social and environmental benefits. More importantly, perhaps, it would have been useful to know how the CAMF and CPA papers suggest solutions. In the final analysis, the Report creates a financial model with monetary values attached to each element of value. This does produce a number (or series of numbers) but it is not clear whether the CPA methodology was actually used to derive them or, if they were, how this was done.

3. IVS do not currently address the specific circumstances of the valuation parameters suggested in the Report for IRM. They do, however, set out a standard for valuations on "Bases other than market value." This standard (Standard 2) requires the Valuer to, among other things, "define the basis or bases of value used and state the purpose and intended use of the valuation, the effective date of the valuation and the date of the report." The definition of "Basis of Value" is: "a statement of the fundamental measurement principles of a valuation on a specified date."

   The Report does set out the measurement principles; the sources of potential revenue are identified and the costs associated with development of the facilities that generate those revenues are quantified. The more difficult question to answer is whether the Report has estimated values in accordance with other standards set out in IVS or whether it intended to do so in its entirety. Because the financial exercise is so different from the conventional valuation processes to which IVS are applicable, it is not clear to me how the Report can be said to have fully followed international valuation standards.

4. Although CPA is cited as being the approach followed, it is not clear whether this is intended to mean that it is followed in principle (such as by recognizing a broader spectrum of potential values other than economic) or in form. As this is a relatively new concept, it would be of great benefit to have included a more detailed description of the approach and how the specific measurement of different aspects of value can be quantified.

5. There is no doubt that evaluation of alternative potential uses involving IRM will be complex, but an assessment of the variables within each alternative will be required before an appropriate conclusion of highest and best use can be reached. Factors such as the timing of costs and revenues as well as risks applicable to alternatives will need to be addressed.

6. A benefit of any model will be that the results can be compared with alternatives other than IRM on a consistent basis. In the absence of a similar model relating to those alternatives, it is difficult to conclude which is the most beneficial.

Financial Analysis - Methodology

The process for undertaking the financial analysis is summarized on page 137 of the Report. In essence, this involved:

- Identifying potential IRM options
- Analysis of costs and revenues associated with different options and conducting preliminary financial modeling to identify potential highest and best use options
- Confirmation of preliminary financials through research on costs and revenues.
- Creation of financial model for identified options.

Again, the Report emphasizes the limitations of the analysis:

> "While there have been considerable complexities faced in this initial analysis, we expect that efficiency in using IRM will improve as knowledge increases. However, the complexity and need for an integrated team to optimise the design cannot be overstated. The current study is necessarily limited by available time and budget and is intended as a preliminary assessment of IRM's potential and application in British Columbia. The evaluation is in consequence somewhat restricted and limited, but does provide an understanding of IRM's potential." *(Page 137).* (1)

Under the heading *"Observations on Methodology (Page 143),* the Report also notes the following:

- No detailed cash flow was undertaken due to time limitations. Discounting formulae as created or embedded in Excel were used
- Averaging methods were used for life cycle cash flow calculations
- More work is required to refine timing assumptions relating to implementation and revenues.
- The financial simplifications are considered to "average themselves out." The "high profitability of IRM" provides an adequate margin for this averaging. (2)

Comments:

1. It is clear from this and other similar statements throughout the Report that there are a number of basic assumptions on which the financial analysis relies. Because these assumptions are spread throughout the Report, it would have been helpful if these could have been summarized and included in a separate section prior to the financial analysis rather than included as part of the text.

2. The ability of a reader to evaluate the merits of a cash flow analysis is dependent to a significant degree on the details of the assumptions regarding all of the inputs in the cash flow. For a proper review, it would also be necessary to review the calculations within the model itself. Although the Report does refer to the extensive nature of the model *(Page 143)*, the Report contains insufficient information on which to base a meaningful comment about the overall methodology and conclusion. Where details are provided by the Report with respect to certain items (such as revenues), I have commented on these in the following section.

Financial Analysis - Results

The conclusions of the financial analysis are summarized on pages 7 and 50 of the Report. These result from the development of a hypothetical model using IRM in the Capital Region, based on the methodology described above. The summary is reproduced below:

	Chosen Values	Optimistic Values	Pessimistic Values
Annual Revenues	**$114,000,000**	**$436,000,000**	**$60,000,000**
Annual Costs	**$(53,000,000)**	**$(50,000,000)**	**$(54,000,000)**
Net Revenues	**$ 61,000,000**	**$386,000,000**	**$ 5,000,000**
Projection to end (Yr)	**2065**	**2065**	**2065**
Total NPV, IRM, Stabilized	**$505,000,000**	**$6,334,000,000**	**$(244,000,000)**
Total Value (Cost), stabilized, undiscounted	**$3,053,000,000**	**$18,514,000,000**	**$45,000,000**
Capital Cost (Current Dollars)	**$(671,000,000)**	**$(600,000,000)**	**$(748,000,000)**
Capital Cost (Inflated)	**$(870,000,000)**	**$(594,000,000)**	**$(976,000,000)**
Reduction in GHG emissions below 1990 in CRD (tonnes/yr)	**378,000**	**404,400**	**367,500**
Reduction in GHG emissions below 1990 in CRD (%)	**23%**	**25%**	**23%**
Electricity Energy Saved and Produced (GWh/year))	**116**	**129**	**124**
Electricity Saved and Produced ($)	**$6,000,000**	**$12,000,000**	**$6,000,000**
Fossil Fuel Displaced - Vehicle fuel (litres/ year)	**28,405,000**	**30,590,000**	**26,220,000**

On the basis of the numbers shown above, the Report concludes: "It appears that IRM will lead to positive net revenues in most scenarios." *(Page 146).*

As described in the methodology section of the Report, the approach taken to the valuation follows what, in real estate valuations, would be called a "development method." This approach requires consideration of revenues, costs and timing of the resulting cash flows in order to generate a Net Present Value. A well-known feature of the development method is that the conclusions are very sensitive to relatively small changes in the key components. Nevertheless, despite the potential for significant variations in results, it is a method widely used and relied on by the real estate industry, usually to estimate residual land value or to determine financial feasibility. The exercise undertaken in the Report more closely resembles a business valuation model in which a series of revenues from four sources are identified. Specialized knowledge of the business associated with each of these sources would therefore be required.

After reviewing the figures set out above and the explanation for them in both the Report (including the Ancillary Data provided in the letter from Asset Strategics dated December 18th, 2007), my comments are as follows:

Comments

1. Sensitivity

As noted above, the results of the development method are subject to a high degree of sensitivity to variations in inputs. This sensitivity is exacerbated the more preliminary or uncertain are the nature of the project, the revenues that might be generated and the costs associated with its implementation. In recognition of this, the Report continually stresses the preliminary nature of the analysis, the fact that the results are an "order of magnitude" (*Page 50)* and the need for further analysis to "confirm the projections are achievable" *(Page 153).* The Report does provide some guidance regarding sensitivity resulting from a 10% variation in the amounts of individual components *(Table 15, Page 149)* and does provide three scenarios as shown above; without having details of the model, however, it is difficult to comment on the overall results. Given the preliminary nature of the analysis, it appears the Report is properly urging the reader to be cautious about the results presented.

2. Revenues

Revenues in the model are derived from four primary sources and are quantified as follows:

Biofuels		
▪ Tipping Fees	$10,352,918	
▪ Methane Fuel	$26,558,570	
▪ Electricity Cogeneration	$ 6,895,249	
▪ Heat Cogeneration	$ 5,870,592	
		$ 49,677,329
Heat Energy recovered via Heat Pumps		
▪ Space heating/hot water	$26,870,100	
▪ Replacement of Electricity	$ 4,538,945	
		$ 31,408,935
Reclaimed Water		$ 1,776,637
Greenhouse Gas Reductions		$ 11,340,361
Total (2007$)		$ 94,203,272
Growth Adjusted		$114,123,975

(Source: Ancillary Data letter, pages 3-6)

As noted previously, projections of revenues generated from the sale of energy would need to be based on expertise in that industry. Because of my own lack of expertise in this area, I can therefore make general observations only. These are as follows:

a) Revenues for a number of inputs (tipping fees, methane for fuel in cars and buses, delivered price of natural gas etc.) appear to be based on the prices paid by consumers. These prices can also include taxes and will reflect the cost to the retailer of management, distribution, rent, marketing etc. Such costs are not specifically identified in the model (although a 15% discount is applied) and it is therefore not clear whether they have been reflected and, if they have not, why that is the case.

b) As the Report notes " Markets for each revenue stream have to be secured and the values confirmed" *(Page 54).* Although the Report does indicate that allowances were made for the "appreciable time" required to secure revenues from these markets and cites examples of how this was done in a general way, there does appear to be a significant element of cost risk associated with the timing and extent of the markets identified. Whether this has been fully reflected in the model is unclear, although the Report does recognize that "further work on these items will be necessary if the model is to be implemented optimally." (*Page 54)*

c) Methane fuel for vehicles is a particularly significant component of the projected revenue, accounting for over 25% of the total. The cost necessary for the distribution and marketing to work is referred to in the Report (*Page 39)* but the extent to which this has been taken into account in the model needs to be clarified. Similarly, it will need to be ascertained whether the price discount referred to on page 39 will be sufficient to generate the projected demand.

d) The specifications for determining the value of heat and electricity are set out in the Ancillary Data Letter at page 5. The reasonableness of these assumptions (which could have a material effect on the result) will need to be verified. It is also noted that there is a discrepancy in the table referring to the Value of Reclaimed Water on page 5 of the Letter. The revenue appears to be based on a volume of 16,784 m^3 per day, rather than per year as shown.

e) One of the principal challenges in building the financial model is determining the method by which ecological aspects can be evaluated. The Report is quite frank on this point, describing them as having been assessed "in a crude way." Clearly, and as suggested on page 167 of the Report, "more work is required to understand broader ecological and Greenhouse Gas metrics."

3. Costs

The Report and Ancillary Data Letter set out data relating to costs in much greater detail than that for revenues. The Letter also notes that "Estimates of capital, operating and maintenance costs were prepared by a professional engineer with extensive experience in distributed wastewater treatment facility design…" *(Letter, Page 6).* Again, reviewing these in detail is not within my area of expertise and I am therefore unable to provide other than more general comments, largely associated with the way they are applied in the financial model. With that in mind, my comments are as follows:

a) The cost estimates detailed in the Letter are stated to include "…capital, operating and maintenance costs for resource recovery equipment in the IRM model…" *(Letter, Page 6).* In most cases, operating and maintenance (O & M) costs are based on a percentage of capital costs. However, the Letter does not state what specific items are intended to be included in the allowance. On the basis of the material set out in the Report or Letter, it is therefore not possible to know whether this would adequately cover all the O&M costs associated with the various operations (tipping, sale of methane, etc.), not simply the equipment.

b) Details of the components of the cost estimates are not provided in the Letter. It will therefore be necessary to verify what items are included in the cost estimates and whether there are other elements of cost that need to be considered (such as design fees).

c) The capital costs set out in the Letter can be reconciled with the total costs under the "Chosen Value" column in the value table included above. However, the total of the O&M costs shown on page 8 of the Letter ($28,168,360) is very different from the figure of $53,000,000 found in the value table. While it is recognized that the figure of $28,168,360 is not inflated (unlike the cost figure) I have not been able to find an explanation in the Report for the difference between these figures.

d) The Report and Letter note that land costs are not included in the model on the assumption that treatment facilities will "…occupy existing lift station facilities and rights of way…" *(Letter, Page 17).* Whether this is a reasonable assumption will therefore need to be determined by considering the land use requirements in more detail. Following such an analysis, the cost of the land components can then be ascertained.

4. Timing of Cash Flows

a) Because the Report does not provide details of how the discounting process is undertaken, it is not possible to comment on the method used to determine the Net Present Value (NPV). It can be said, however, that in a cash flow analysis the timing of revenues and costs is critical to the result. In particular, the relationship of the timing of costs and revenues is of great importance. For example, if a financial model includes capital expenditure that occurs some time before projected revenues are realized, the NPV will be much different from that resulting from a model in which expense and revenues occur at the same time. Details of how these timing issues have been dealt with in the financial model will therefore need to be clarified.

b) The Report presents the conclusions of the financial model in two ways: as an NPV and as an absolute, undiscounted, total. The rationale for the latter is described at the bottom of page 55 in the Report where it is noted that, because of discounting, "… traditional financial methods 'devalue' our future and, if left unchecked, can lead to short-term bias." While the comparison of discounted and undiscounted figures does indeed illustrate the effect of discounting, whether this creates a "short-term bias" is a more of a philosophical issue than financial. Resolution is therefore required of an appropriate parameter for addressing this issue. For example, it could be considered appropriate to place a higher economic value on some future benefits (for social or ecological reasons) than might otherwise be the case.

5. Discount Rates and Discounting

a) On page 55, the Report notes that "Discount rates are usually one of the most sensitive aspects of a financial analysis." The Report does not, however, discuss the choice of the "real discount rate" of 8% *(Page 151)* or the criteria on which it was based. Such a discussion would be normal practice – not to say a requirement – under most valuation standards. This would require consideration not only of the current level of interest rates, but also the risks associated with the projected cash flows in the context of the business model being evaluated.

b) As noted above, the model relies on revenues generated from a number of alternative energy sources. Such revenues have potential to be more variable than other forms of economic revenue (such as real estate). Whether this potential variability has been reflected in the choice of discount rate is not stated in the Report.

Conclusions

The Report makes a strong case for further consideration of IRM, but is quite open about the limitations of the analysis, including the financial model. Although comprehensive and broad in its scope, it is clear that further work is required to refine the model in both a technical and an operational sense as well as to establish a sound business and financial model.

The basis of the financial model, which is to consider economic, social and environmental costs and benefits (Triple Bottom Line), is one in which I do not have personal experience, but does appear to be a useful and recognized tool for decision making and project evaluation. The success of such an evaluation process will, however, require a rigorous set of guidelines to be established. As I have noted, while the Report does make reference to a number of guidelines (such as Comprehensive Project Appraisal) it is not clear what the details of these are and, as a consequence, it is unclear from the Report how they should be applied in the circumstances of this case. It is also not clear whether the Report has actually followed them. In particular, it is the parameters for evaluating the social and environmental elements that need greater definition.

My comments regarding some of the key inputs into the financial model have been intended to identify areas for which more knowledge is needed before a conclusion as to the validity of the model's results can be reached. I would nevertheless conclude that the Report does provide a good basis for further study. The extent to which the benefits of IRM exceed those of a more conventional system will therefore be more capable of evaluation after such an analysis has been undertaken.

Yours truly,

ALTUS GROUP LIMITED

M.C. Nilsen
B.Sc., FRICS, AACI, P.App., RI

CERTIFICATION

Date: February 11, 2008

Re: Review of Report entitled
"**Resources From Waste – Phase 1 Study Report**"

I certify to the best of my knowledge and belief that:

- the facts and data reported in the review process are true and correct.
- the analyses, opinions, and conclusions in this review report are limited only by the assumptions and limiting conditions stated in this review report, and are my personal, unbiased professional analyses, opinions, and conclusions.
- I have no present or prospective interest in the subject matter that is the subject of this review report, and I have no personal interest with respect to the parties involved.
- I have no bias with respect to the subject matter that is the subject of this review report or to the parties involved with this assignment.
- my engagement in this assignment was not contingent upon developing or reporting predetermined results.
- my compensation is not contingent on any action or event resulting from the analyses, opinions, or conclusions in, or the use of, this review report.
- my analyses, opinions, and conclusions were developed and this review report was prepared in conformity with the Canadian Uniform Standards.
- I have the knowledge and experience to complete the assignment competently with respect to those elements of the Report identified in the review.
- no one provided professional assistance to the person signing this review report.
- as at the date of this review the undersigned has fulfilled the requirements of The Appraisal Institute of Canada Continuing Professional Development Program for designated members.

M.C. Nilsen
B.Sc., FRICS, AACI, P.App., RI

Response to Mr. Nilsen's Review

Instead of focusing on individual items in the review by Mr. Nilsen, we focus on the key issues in the reviewer's response.

First, the comments made are generally accepted. We appreciate the considerable thought given by the reviewer and professional tone of the response. We are very grateful to Mr Nilsen for his constructive and commendable input.

On page 1 of the review, Mr Nilsen states that he has applied the context of the Uniform Standards of Professional Appraisal Practice as the principles that he is required to use by the Appraisal Institute of Canada. This is further reflected in later references to International Valuation Standards and other items. Since these are appraisal standards and the report is not an appraisal (and does not purport to be one), the basic framework for the reviewer's comments are those of a market value basis for analysis, since these are the foundation for appraisal standards. Consequently, appraisal standards while useful are not necessarily best suited for this analysis without adaptation. As a result, the framework used by Mr. Nilsen for his review is somewhat at variance with the methodology used in the IRM report to undertake a sustainable analysis of waste recovery.

On page 4 of Mr. Nilsen's review, he states "*Rather than establishing a defined set of 'valuation principles', The Vancouver Valuation Accord (VVA) is statement of intent*." In fact the Accord did indeed establish principles. These principles acknowledge that appraisal standards may be at variance with sustainability, i.e. they may be insufficient, or conceivably even at odds with sustainability.

The Vancouver Valuation Accord included a declaration developed jointly by the Appraisal Institute of Canada, the Royal Institution of Chartered Surveyors and the US Appraisal Institute. The Accord included a definition of sustainability (accepting the Brundtland Commission definition); secondly a definition of value as set out by the International Valuation Standards, and pivotally, the statement that "*Currently the valuer's primary responsibility in accordance with IVS and other recognised standards, is to reflect market sentiment, in which value and sustainability may be at variance*." Thus, the Accord did include principles and moreover, the professions formally recognized the possibility of variance between sustainability and market value.

The Premier of British Columbia and authorised senior representatives of the professions signed the Accord, which contained a footnote referring to these as "*the Accord's principles*." Thus, the standards framework used in Mr Nilsen's review might not be sufficient to properly address the principles used in developing the business case for IRM.

On page 8, the reviewer states that "*… the development method are (*sic*) subject to a high degree of sensitivity…*" Mr. Nilsen also states on page 8 and again on page 10 that he lacks experience in the subject area. Unfortunately the detailed IRM analysis was not available to Mr. Nilsen to help address these concerns and augment his knowledge.

The model is in fact not very sensitive due to the multiple variants, costs and revenue flows involved. Further, the model was only *based* on the development residual approach, i.e. it went beyond a traditional method. This is in part because a traditional residual approach would have been insufficient to properly assess IRM, i.e. a basic residual would conceivably have been at variance the sustainable aspects of the project (exactly as recognised by the Accord). The concerns over sensitivity are thus less of an issue than have been raised by the reviewer.

Mr Nilsen nevertheless makes some good suggestions for further detailed analysis and clarification. These are valuable points that need to be considered by government in the context of the next level of analysis leading to implementation, as recommended by the Study Team.

We appreciate Mr Nilsen's statement, that "*I would nevertheless conclude that the Report does provide a good basis for further study*" (see page 12 of the review). Since this was the original brief for the study, we conclude that Mr Nilsen is in agreement that further study is desirable, as recommended by the Study Team, and therefore, that the IRM study has met its original objective.

Dr. Bob Dawson

R.N. Dawson
Peer Review of
Resources from Waste
Integrated Resource Management Phase 1 Study Report

January 22, 2008

Stantec

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R N Dawson
Peer Review of
Resources from Waste
Integrated Resource Management Phase I Study Report

1.0 Introduction

This brief report summarizes Dr R.N. Dawson's peer review of the report entitled "Resources from Waste - Integrated Resource Management (IRM)".

IRM is a process used for planning and implementing liquid (sewage and stormwater) and solid waste management in a manner which minimizes environmental impact and optimizes the extraction of energy and materials from these sources. As well, another objective is to augment water resources through wastewater reuse for water supply, and supplementing ground and surface water.

The IRM system uses a spreadsheet model to evaluate the economic benefits of integrating solid and liquid waste management. In the report, the model was applied to the Capital Regional District (CRD) waste management situation to demonstrate the economic benefits of integrated waste management.

2.0 Overview Comment on the IRM Process

The basic concept in IRM of integrated planning and implementation of wastewater and solid waste management, and water supply is definitely the direction and ultimate goal that the Province and the CRD should be striving to accomplish. This coordinated approach is consistent with the direction being taken in the wastewater industry and the authors have provided several examples where IRM principles have/are being applied. The authors have quite rightly pointed out that this approach is common in Europe but not well established in North America. The degree to which the approach can be utilized in BC and specific communities such as the CRD will be governed by the capital and operating costs of the facilities, potential revenues and value generated by resources relative to market prices.

The IRM report is quite impressive at first glance but does not provide enough site specific detail to support the conclusions. In fact, the report lacks the market assessment required to confirm the conclusions drawn about the number of dispersed plants and potential revenue.

There definitely are benefits of integrating wastewater management to solid wastes but the linkage requires an expenditure of significantly more capital than would be required to provide an environmentally acceptable system for wastewater management alone. The additional capital required could make the financing of a particular project over a short period unattractive to the public and government.

The proponents of IRM have assumed that wastewater treatment must be planned and implemented using a large number of neighbourhood treatment plants (dispersed wastewater treatment providing tertiary treatment). Dispersed treatment ensures that the facilities are close to markets for their products (useable heat, highly treated effluent, electrical energy, synthetic fuel, nutrients and extracted materials). The IRM thesis is that this proximity optimizes the revenues from such products and reduces the costs. **Actually,** the multiple plants significantly increase both the operating and capital cost of waste treatment and biosolids resource recovery, mainly because of the higher degree of treatment and loss of economy of scale in providing the necessary facilities. There are also serious public acceptance, environmental and regulatory issues that are also problematic for dispersed waste treatment, particularly in an established area such as the CRD.

Most of the revenue identified in the IRM process is derived from biosolids, and dry and wet organic solid wastes which are separated from the general solid waste stream. There is no reason that the wastewater problem (if it is the most urgent situation to be cleaned up for environmental reasons) could not proceed first and be designed to include as much energy recovery (cogeneration of electricity), heat recovery from the effluent and wastewater processes, resource extraction and water reuse as economically feasible. The technology for generating these portions of the revenue stream is well established

As funds become available, the energy and resource recovery facilities required to handle the appropriate solid waste streams could be integrated into the wastewater biosolids system. The technologies for producing biofuels from gasification of solid wastes and residual wastewater biosolids are more common in Europe and could be considered emerging technologies. The markets for the biofuel products are not well established and could be very risky because of quality control and reliability of supply. Although the benefits of reducing greenhouse gases are very significant, it is probably prudent to delay the implementation of biofuel components of solid waste integration until the technology and markets are firmed up.

In many cases throughout BC optimum resource recovery could be achieved with a single plant or in the case of larger urban municipalities such as the CRD, two to five plants for wastewater treatment with a single facility for biosolids management.

The application of a spreadsheet economic model to evaluate IRM is a good one. The model estimates the revenue from a full range of opportunities including the financial impacts of reduction of greenhouse gases and the sale of electrical energy, biofuels, heat extraction for buildings, extracted products, e.g. metals and phosphates, and either sale or credits for water reuse for irrigation and industrial processes. However, the economic analysis should be based upon:

- Site specific capital costs for all facilities
- Realistic operating costs for all facilities
- Provision of a full range of ancillary facilities such as outfalls for residual effluents, recharge facilities, effluent transmission facilities, wet and dry solid waste collection and preprocessing facilities, residual solids disposal facilities, odour and emission control facilities, district heating facilities and pipelines
- Accurate assessments of energy requirements to dewater and pre-process sludges and dry solid wastes
- Accurate assessments of yields of energy, heat, fuels, recovered materials
- Realistic markets and unit prices for resources as well as energy and heat recovery
- Technologies that are proven reliable

- Reasonable assessments of risk of market availability and unit revenues
- Assessment of public acceptance of components, sites, products
- Potential for regulatory approval
- Evaluation and mitigation of public health concerns

As discussed below, many of these items are inadequately confirmed by IRM for the model application to the CRD project.

The IRM proposal report strives to justify the requirement for many (32 in the case of the CRD) small treatment plants implemented as a requirement or as the only way to optimize the resource utilization and environmental benefits. The IRM process requires this to ensure that the facilities are close to markets. In fact, for a particular location and the CRD in particular, it would be more appropriate to have fewer facilities at strategic locations in the first few phases; Macaulay, Westshore, Westshore satellite, Clover, University satellite, for instance.

Perhaps an additional smaller tertiary plant(s), (similar to the proposed University facility) might make sense in the eastern trunk area tributary to Clover Point for this first phase. The added plant would eliminate the need and costs of transmission sewers from the Clover to Macaulay collection systems. This additional plant could be located close to where existing outfalls are located and where there is potential for seasonal irrigation.

In the Westshore area, new residential areas might be serviced by dispersed plants if this can be achieved in an environmentally acceptable and cost effective manner.

A start could be made in the CRD project with some components of resource recovery such as cogeneration and augmentation of methane production with wet organic solid wastes at Hartland, perhaps heat recovery and seasonal effluent reuse at the University, and some seasonal irrigation at the University and on golf courses adjacent to Westshore facilities. This would achieve an affordable wastewater management system for the whole of the CRD Victoria sewer system close to or less than the current engineering study estimates.

As markets and technologies become better defined and public acceptance occurs, district heating could be implemented, e.g. in the Victoria downtown core, additional seasonal effluent irrigation could be implemented in conjunction with development of additional smaller tertiary plants. The development of biofuel generation facilities and associated heat recovery could be developed as additional capital becomes available and the business case is fully confirmed for the technology and available markets.

2.1 REASONABLENESS OF ENGINEERING PRINCIPLES

The concept of dispersed wastewater treatment looks good in theory but is very impractical because of the high capital and operating costs, environmental impact, public health and public acceptance issues. The IRM has assumed that there is a real market or need for the dispersed plants but the market and the need have not been confirmed nor quantified. The IRM has also attempted to do this for the CRD by identifying the heat extraction potential locations and some of the water reuse potentials such as the University or golf courses. However, the potential for the customers to participate has not been firmed up. In Arizona and the Okanagan, where I have been involved in many water reuse projects and where we have used effluent heat and cooling extraction, we usually precede the plans and designs by intensive studies of the market.

The multi-plant (a network of small neighbourhood plants) approach, as proposed by the IRM, does not consider the extra infrastructure required for effluent disposal during wet and winter weather conditions. Much of BC, particularly the Coast and the CRD (Victoria) experiences wet weather, which will make ground water infiltration impractical. Groundwater aquifers with adequate capacity in BC, particularly in an urban setting, also make this impractical. For Victoria in particular, much of the land is rocky with very few aquifers suitable for infiltration of wastewater. As well, the CRD area receiving streams are sensitive fishery habitat or tributary to near-shore sensitive coastal waters. Groundwater infiltration can not be recommended until a comprehensive groundwater model has been run to confirm its feasibility. The impact of even tertiary effluent on ground and surface water streams in an urban area also adds to the impracticality of the dispersed treatment scenario.

The multi-plant scheme, as proposed by the IRM, depends upon interconnection of small plants to achieve redundancy in the event of major plant failure and this means that each individual plant would have to have extra unit process capacity. The infrastructure to achieve interconnection would be significant and much more costly than building a smaller percentage of redundancy into larger plants. The practice of inserting plant interconnections as a conduit within an existing sewer is very impractical.

The multi-plant scheme requires the treatment of wastewater to tertiary effluent quality levels, which means that nitrification and denitrification, and phosphorus removal as well as high quality solids removal (effluent filtration or equivalent) and very efficient effluent disinfection would all have to be added to allow effluent reuse stream augmentation or groundwater recharge. These features add significantly to plant size and cost.

Multi small plants located in residential neighbourhoods will require covering or burial perhaps on several levels, requiring significant extra excavation and more rigorous structural components. The HVAC and odour control systems would also be more sophisticated. These additional requirements would add significantly to the capital cost (say 20 to 25%) and to the operating costs as discussed below. One recent cost estimating study for relocating the GVRD Lions Gate plant showed that subsurface plants added about 50 to 75% to capital costs in comparison to above ground plants.

In our opinion, the plant footprint for the dispersed plants suggested by IRM team is too low. For example; the IRM 2ML/day plant claimed to occupy 300m^2 would, in reality, have to be built on a 900m^2 footprint to adequately accommodate the unit processes identified by IRM.

For the wastewater treatment portion of the facilities utilizing methane gas generated from anaerobic digestion of biosolids in a cogeneration facility, utilizing the waste heat from the processes and extracting heat from the effluent stream are well established technologies utilized elsewhere in BC, and are planned as part of the CRD study report proposed scheme. Cogeneration facilities should provide around 40 to 50% of the power required for waste treatment and will result in significant greenhouse gas savings and operating cost savings.

Adding additional wet organic solid waste diverted from the landfill, and food waste and grease collected in the community to the WWTP digesters is also a good way to increase gas and energy production by about 20 to 30%. The extra digester and cogeneration capacity could cost effectively be built into any project and the CRD scheme in particular. I agree that this is a way to achieve significant GHG and cost savings and revenue generation for a reasonable capital cost expenditure using standard technology. The IRM has suggested that the highest revenue and best value for using the methane from anaerobic digestion for BC communities and the CRD in particular, would be to clean up the methane and convert it into biofuel, which could be used for fueling automobiles. This technology of converting the anaerobic digester gas (methane/carbon dioxide mixture) to synfuel is problematic, it requires sulphur scrubbing facilities and bottling facilities. As well, blending with natural gas or using for vehicle fueling is currently not common in North America and would require acceptance by potential markets. Development and operation of a pilot project to confirm design criteria and costs would definitely be required prior to application for a major area such as the CRD.

The idea of directing the residual anaerobically digested sludge, together with dry solid wastes diverted from the landfill, to a waste to energy facility (incineration, cogeneration and heat recovery) is certainly a good option for many communities in BC. For the CRD in particular, the 100,000 tonnes per year could be diverted to generate significant power and revenue. CRD solid waste personnel are leaning towards a separate collection system for wood waste and dry organics directed to such a waste-to-energy facility.

The IRM has suggested that the highest value technology (greatest revenue) for the waste-to-energy facility and for the combination of dry solid wastes and anaerobically digested sludge would be gasification to synfuel and then use of the gas in a cogeneration facility. However, the technology of gasifying anaerobically digested sludge and dry organic municipal waste mixture is not well defined technology complex (pyrolysis?). There are few successful installations in North America. Some industrial installations in the Kamloops area are using waste wood, which is a much more consistent feedstock than mixtures of anaerobically digested sludge and dry organic waste. Prior to its application in the CRD or BC in general, it would be prudent to carry out pilot tests.

Perhaps a more generally applied waste-to-energy technology could be applied as a first stage for a number of years such as incineration of the dry combustible solid wastes and the anaerobically digested sludge/wet organic solid wastes. Steam generated from such a facility could be used to generate electricity and waste heat used for heating the anaerobic digesters and sold to adjacent customers. This is a similar facility to the waste-to-energy plant in Burnaby operated by GVRD. The higher biofuels generation could come along later, after the pilot plant and the markets are firmed up.

2.2 REASONABLENESS OF PROPOSED INFRASTRUCTURE MODEL

The spreadsheet model covers most of the revenue streams, as well as the main components of the integrated liquid and solid waste management systems proposed by IRM. However, some components have not been included and have not been accurately costed as indicated below:

- Capital costs of dispersed treatment are much too low. Unit capital costs used in the IRM model were $2,357/m^3/day of capacity, based on an average plant size of about 6,000m^3/day. For a similar sized tertiary plant in Tucson Arizona, we have recently estimated unit capital costs of $3,872/m^3/day. Recent capital costs for Whistler, which is a 14,000 m^3/day tertiary plant (and which we have adjusted for addition of filtration and headworks and primary clarifiers), indicate that the unit cost for this size plant should be $3,313/m^3/day capacity. In our opinion, the capital costs used in the model are approximately 60% lower than they should be for distributed treatment. This means that to provide 211,000 m^3/day of capacity for the CRD, the capital cost of treatment works would be about $820 million not the $495 million predicted by IRM model.

- It is our experience that tertiary wastewater treatment facilities should cost about 25% more in capital than secondary treatment works and therefore, a reasonable unit cost for the small plants might be $2,900/m^3/day. It is interesting to note that the Sooke 5,000m^3/day secondary plant unit costs quoted by the IRM are $3,163/m^3/day. Economies of scale are also significant such that the unit cost of secondary treatment for a plant of a capacity of 200 ML/day would be about $2,300/m^3. Considering the combination of economies of scale and tertiary versus secondary treatment for distributed treatment versus more centralized treatment, the premium in terms of capital cost of treatment plants alone would be around 50 to 60%.

- Capital, and operating and maintenance costs of seasonal or year round effluent disposal infrastructure have not been included or underestimated, e.g. for groundwater recharge facilities, effluent lines to a suitable area for connection to an outfall. Recently Stantec estimated the costs for wetlands and ground water infiltration in Arizona for the effluent from a 10,000 m^3/day facility at about $2 million. Considering the conditions in the CRD area, similar facilities for 32 plants could add $50 to $100 million to the projects capital costs.

- Capital costs of cogeneration facilities have been estimated by IRM as approximately $1.0 million per MW of capacity. Examination of recent costs of cogeneration facilities in King County in Washington State suggests the capital costs are more likely in the order of $4.0 million per MW. The costs of the cogeneration facilities for 9.9 MW would therefore be about $40.0 million rather than the estimated $13 million suggested by IRM for 13.3 MW.

- Capital costs of biosolids gasification were difficult to check because of the lack of experience in North America without spending significant time. Based on the underestimation by the IRM proponents for waste treatment and cogeneration, I suspect that the gasification and biogas upgrading facilities might have been significantly underestimated as well.

- Operating costs are too low. Operating costs of small wastewater treatment plants are significantly underestimated by IRM; small plant operating costs would be 30 to 70% higher in operating costs than larger plants (not 20% less as suggested by in IRM report). The main reason for these extra costs is that all plants require labour for daily operation, preventative maintenance and housekeeping. Multiple plants actually require more labour because of travel time, set up and clean up time for maintenance on more individual pieces of mechanical equipment. The model operating costs for wastewater treatment are therefore significantly underestimated.

- Operating costs for tertiary treatment plants are typically about 50 to 100% greater than for secondary plants. For example, the 100ML/day Winnipeg SEWPCC currently has a unit operating cost for secondary treatment of about $0.10/$m^3$ and these costs have been calculated to escalate to about $0.17/$m^3$ when upgraded treatment is installed. It is interesting to note that the operating costs derived from the literature graphs referenced in the IRM modeling study report show an operating cost of $0.21/$m^3$ which is in the same ballpark as Winnipeg's predicted unit operating costs. The unit costs shown in the cost curves also escalate with decreasing plant capacity and this is our experience as well. The operating costs for the Saanich Peninsula plant operating at about 9.3 ML/day and currently producing a nitrified effluent (not exactly tertiary treatment but close) are $0.41/m^3 therefore, a reasonable operating cost, which should be used for distributed treatment should be around $0.41/m^3. The IRM modelers used $0.33/m^3 which is too low. The CRD operating costs should be increased to about $15.3 million ($0.3/m^3) for the ADWF of 105,000 m^3/day in comparison to the $12.7 million per annum calculated by IRM.

- Note that the recent CRD study used a tertiary treatment plant operating cost of $0.50/m^3 for a 7.1ML/day MBR pant for the Westshore.
- Note the economy of scale of operating cost for secondary treatment is evident from the following reported annual unit treatment costs: Annacis Island 453 ML/day @ $0.09/m^3; Lulu Island 76.5 ML/day @ $0.16/m^3; Langley 9.2 ML/day @ $0.28/m^3.
- The technology described by IRM for the treatment systems will provide satisfactory tertiary treatment and is based on the use of small footprint technology e.g. very fine screens for preliminary treatment, dissolved air flotation for primary settling, moving bed bioreactor technology, UV disinfection and an undisclosed solids separation system integral to the bioreactor as well as fabric tertiary filters. **However**, the claims that the technology will provide reduced capital costs because of off-the-shelf availability, less requirement for capacity redundancy than centralized plants and a cookie cutter approach to plant implementation are not true. The approach is not a good strategy for cost effective plant supply and efficient operation. Certainly the argument that such plants allow more capability for changing the technology as new more cost effective developments occur does not make sense.
- Generation rates of gas from anaerobically digested sludge and from dry solid wastes reported by IRM are questionable; they appear to be too high based upon experience with WWTP facilities.

3.0 Environmental Benefits and Challenges

There are many environmental benefits from integrating liquid and solid waste management planning and implementation. The IRM report explains the advantages very well but does not point out the disadvantages and challenges. Definitely there would be significant greenhouse gas reductions.

- One of the benefits multi-plants treating to a high level and maximizing reuse certainly provides is reduction of pollutant loads on receiving waters and spreading out of the load over a larger area. The reduced and smoothed load comes with increased risk of system breakdown, with resultant serious environmental damage on more sensitive ecosystems in an urban environment compared to marine discharge for the CRD or to a larger surface water with more assimilation capacity as practiced and well regulated throughout BC.

- Increased probability of upsets at dispersed plants operating in an urban environment would result in increased public health and nuisance risk in comparison to the probability of operational upsets from larger plants discharging to an environment with more assimilative capacity.

- Statistically the larger number of facilities for the dispersed plant situation will result in a higher probability of non compliance with environmental regulations.

- Reuse of the plant effluent for groundwater recharge is a challenge - problematic for many urban areas because of subsurface geology considerations (need to avoid groundwater mounding and resurfacing downslope, and groundwater quality considerations as well as avoid nitrate build up. There is perhaps a need enhanced nitrogen removal technology, say total nitrogen <3 mg/l; <2.2 FC/100Ml; <0.05mg/l Total P).

- A significant portion of the environmental benefits are dependant upon the projected production quantities of electrical energy, bi-fuel production, heat energy extraction from the wastewater effluent and elimination of methane escape to the environment resulting from diversion of organics from landfill, all of which result in significant greenhouse gas emission quantities. As discussed below, the magnitude of all of these products or GHG reductions most likely have been overestimated.

- The potential for these environmental benefits also depends upon the market acceptance of the products such as biofuels, the public and industry acceptance of discharge of tertiary effluent to sustain low flow in streams, or the acceptance of renovated water for golf course irrigation. It will be a challenge to develop these markets.

- There are some impacts from the gasification and biofuel production processes which are not fully described and explained such as residual solids and air emissions from these industrial type processes. What is the magnitude of these, do they have characteristics of special wastes and how are they to be handled?

4.0 Energy Benefits and Challenges

- Energy recovery from sewage sludge solids is over estimated. Note that the energy generation capability at Annacis Island is 4.2 MW for a secondary capacity of

580ML/day. Currently the plant uses about 134,184 kw hrs of power per day, 43% of which is generated by cogeneration. For the CRD in 2065 at an ADWF of 167 ML/day, the generating capacity from methane produced in anaerobic digesters would probably be about 1.2 MW and the power requirements of treatment would be in the range of 2.7 MW.

- Energy derived from the gasification of approximately 100,000 tonnes per year (273 tonnes per day) day of dry solid wastes has been estimated by the IRM team for the CRD as 13.4 MW. This is generated by gasification of the solids, gas clean up and subsequent use of the gas for electrical energy generation. This seems to be a high amount of power when compared to electrical energy generation in William's Lake using steam turbines by burning 1810 tonnes per day of wood waste, which produces 65 MW of electricity. By proportioning back to the solid wastes at the CRD, a generation capacity of about 9.9 MW might be possible. However, the consistency and moisture content of wood waste is probably more uniform than solid wastes which also contain anaerobically digested sludge. The electrical energy production capability is probably at least 35% overestimated.

- From the process flow diagrams in the report, it would seem that the biofuel generation stream is derived from producing methane gas from the anaerobic digestion of wastewater biosolids and organic food wastes, and other wet organic solids diverted from the landfill (approximately 80000 tons per year). The quantity of biofuel generated (as reported by IRM, is equivalent to 28 million litres per year of biofuel) from such quantities does not seem to be possible when one considers the usual methane generation rates from such organics and the water content of these solids. A more reasonable estimate for biofuels production would be the equivalent of 4.9 million litres/year, worth approximately $4.6 million.

- There are significant energy requirements for the methane production partially because of the water content of the biosolids and solid wastes, which may not have been adequately accounted for in the IRM team estimates.

- To eliminate the difficulty that readers may have in arriving at the energy generation and heat generation recovery from the effluents, it would be useful to provide an overall process flow for the IRM model for the CRD in particular, as well as a solids and potential energy heat balance. These balances should be for the optimistic, pessimistic and chosen conditions so that the concern over possible double accounting goes away. For example, it appears as though the same stream of solids (the maximum tonnage) was used to calculate both electrical energy and biofuels.

5.0 Business Case - Financial validity

The business case is based on the assumption that the market is there for energy, heat, water, extracted materials and greenhouse gas credits. If dispersed facilities are constructed then the prospective clients will take advantage of the products and the revenues will flow and these will far exceed the estimated costs. There are several factors which make the business case risky and make the financial validity questionable:

- The market assessment, particularly for heat extraction, sale of biofuels and water reuse, is weak. There is a high probability that the predicted customer base and the high volume of sales will never materialize.
- The capital and operating costs of dispersed tertiary treatment, energy cogeneration and biofuels have been significantly underestimated.
- The quantity of the prospective products has been overestimated and combined with the questionable market, it follows that the revenues have been significantly overestimated.

The overall impact of these factors is significant. For the CRD, as an example, dispersed treatment facilities would be built at significantly more cost than currently estimated. Because of technology problems, predicted product levels and GHG reductions would be significantly less. The level of customer participation would be significantly lower than predicted and hence, the revenues will only be a small fraction of the modeled values.

6.0 Business Case - Risk Analysis Credibility

- Overestimation of the market for heat extraction from wastewater processes and effluent. The potential customers would have to be sold on the rapid payback of capital outlay to convert to heat recovery. There is a high risk that the predicted participation level of potential clients will not be achieved.
- The risk of not finding multiple WW treatment plant sites acceptable to the public is high and the model underestimates the difficulty and costs, particularly for the CRD where 32 sites are proposed by IRM – currently there is concern over several (all) of the 5 sites proposed by the engineering consultant.

- The risk of overestimation of the energy recovery as electrical energy from dry solid wastes is high due to variability of moisture content/characteristics of the feedstock.
- The risk of overestimation of the reliability of the technology and its efficiency and cost effectiveness for gasification of dry solid wastes, production of synfuels which may result in the future abandonment of the facilities.
- Because of the high capital costs of dispersed treatment combined with the uncertainty and potentially high capital costs of the solid waste to energy components there is a risk that a particular project will be underfinanced or delayed.
- Risk of a low level of public acceptance for multiple plants (located in residential areas), reuse of effluent for golf coarse irrigation, residential irrigation, and organic solid gasification facilities.
- There is a significant risk of achieving approval of the dispersed waste treatment systems because of environmental regulations and concerns for groundwater problems and surface stream impacts.
- These above risks create a very real risk of significant delay of the project.

7.0 Business Case - Assumptions on Realizable Revenue

In general, the realizable revenue has been overestimated for tipping fees, revenues from fueling cars and buses, and revenue from cogeneration of electricity. Most of the revenue estimated by IRM is derived from the biosolids revenue and 70% of that is generated from the solid wastes stream.

Tipping fee revenue resulting from diversion of 100,00 tonnes per year of wet and dry solids from the landfill is a reasonable concept but the overall annual revenue should be reduced by about 30 % to 40% to account for the (i) mass of residual solids (20 to 30 tonnes per year) that have to be returned after use of the solids for biogas generation or cogeneration (ii) handling and transportation costs back to a suitable disposal site (iii) increase in tipping fee for residual solids above the $84/tonne because of chemical content of this residue. The net revenue maybe $7.2million rather than the IRM estimate of $10.4 million per annum.

The biofuels are generated from the conversion of methane produced in the thermophilic anaerobic digestion of sewage sludge, grease and restaurant wastes. If this is the source then the 83,000 tonnes per year would generate an estimated 5,000,000 litres per year, not the 28.4

million litres per year predicted by IRM. It appears that there may be some double accounting of biofuel generation from both wet and dry solids conversion to biofuel **(the dry diverted solids and residual anaerobically digested solids are specified for gasification to produce synfuel and subsequent use of the synfuel for generation of electrical power).** As well the methane requirements for heating the digesting solids and to overcome heat losses through the digester walls seems to have been ignored. The revised revenue might be $4.6 million rather than $26 million per year.

- The revenue from cogeneration is derived by gasifying about 98,000 tonnes per year of dry solids diverted from construction waste disposal, backyard wastes from the landfill and residual anaerobically digested sludge. The synfuel is then cleaned up and burned to generate electricity. The potential for electrical energy is estimated by IRM for this technology at 117 million kwh/year, equivalent to the output from a 13.4 MW generation plant. It is interesting to note that the Williams Lake Cogeneration facility operated by EPCOR burns approximately 1450 dry tonnes/day of sawdust and generates 569 million kwh/yr using more conventional technology (equivalent to the output from a 65 MW generating station). Therefore, it would seem that the power output from CRD dry solid wastes should be around 9.9 MW. The revised revenue might be around $5.3 million per year rather than $6.9 million.

- The revenue from extracting heat from the wastewater treatment plant effluent and high temperature side streams could be as high as estimated by IRM if dispersed treatment were cost effective. Previously we have demonstrated that the costs of dispersed treatment will be too high. Therefore, the practicality of reaching all the markets identified in a cost effective manner is extremely low so that a more realistic value of this revenue stream might be about $2.0 million.

- The greenhouse gas credit value of $30/tonne of CO2 used by IRM is high. We contacted an industry expert who indicated that a value of $15 to $20/tonne is the going rate in Canada. As well, the amount of biofuel production, electrical power generation, and the heating and cooling generated by a practical wastewater treatment scheme is uncertain and, in my opinion, could be highly overestimated by the methods prescribed by IRM. A significant reduction in the GHG's will definitely occur if all of the techniques prescribed by IRM are undertaken but the magnitude of reductions is uncertain. The overall impact of the above is that the CRD estimated annual GHG credits are overestimated by >100%.

8.0 Public/Market Acceptance

Public, government or industry acceptance of the various components is uncertain for the following items, which significantly affect the technical and financial success of the process.

- Location of dispersed treatment plants will experience an extremely high NIMBY reaction - more logarithmic in nature rather than linear relationship to the number of plants because of perceived impacts on property values, potential for odours, increased traffic, public health impacts of aerosols, public safety (chemicals high temperature), and ecological damage from residual effluent disposal.
- The potential clients for marketing heat extracted from the plant effluents may not be enthusiastic to pay their portion for the infrastructure to change from their current heating and cooling systems because of residential or government budget restrictions. I have been involved in projects where heat extraction from effluent is occurring, e.g. Okanagan College in Kelowna and Olympic residences in Whistler. In those cases, the large plant is located adjacent to the client and the effluent is returned to the plant, which has a well controlled effluent disposal system.
- Potential clients for accepting biofuels to blend with their current products may not be as enthusiastic as reported to purchase or utilize this fuel due to quality control or reliability of supply issues (**need a market survey).**
- The market for water reuse for irrigation purposes will be slow to develop because of reluctance to use an inferior product and one which has a real or perceived public health risk. I have experienced this in the Okanagan and internationally where golf courses need water for irrigation but are not keen on using renovated water. Usually in Canada where we have persuaded use, e.g. Penticton, Kamloops and Vernon, the clients accept the treated effluent as long as there is no charge. Most likely they will not be willing to pay for the renovated water in the near future.
- The local government agencies responsible for operation would more than likely resist the idea of multiple plants because of the increased staff levels and operational/maintenance time and costs. As well, they would be reluctant to take on the extra potential environmental and public health risk resulting from more potential for upsets and non compliance.

- Public acceptance of high technology processes for syngas production and gasification will be difficult for facilities perceived to be industrial in nature with emission and odour generation potential and public safety issues of flammable and gaseous product production.

9.0 Regulatory Considerations

The regulatory agencies would certainly be in favour of combining solid and liquid waste management wherever environmental benefits can be proven. However, there are several serious regulatory concerns for the details of the IRM concept:

- Regulatory agencies will no doubt have difficulty with approving multi small plant ground water discharge of effluent or discharge to small volume urban streams, particularly those tributary to Saanich Inlet.
- Residual effluent quality, particularly for nutrients, will be an issue and it is more than likely that total nitrogen levels of < 3 mg/l and total P of < 0.05 mg/l may be required, which would require provision of plants operating at the limits of technology, which would require significantly higher cost and skill level.
- Operational reliability and monitoring to ensure compliance of multiple discharges will be issues.
- Similarly, the discharge of residual effluents to groundwater will require significant study to determine if there is sufficient permeability and hydraulic capacity in the aquifers such that downstream surfacing does not occur.
- Considerable public health regulatory issues are highly probable for either urban surface water or groundwater discharge.
- There will be air emissions and residual solid waste management issues which have not been adequately addressed for the waste-to-energy and biofuels components and which will be of concern to regulatory authorities.

Regulatory issues would require significant study and time to resolve for the dispersed treatment facilities, which would significantly delay the potential projects and result in higher operating and capital costs – in particular, for dispersed facilities in the CRD region.

10.0 Overall Comments on IRM Methodology

- The IRM concept of integrating solid and liquid waste management planning and development of infrastructure is a very good process and components of it should be implemented over an adequate time schedule. There are significant energy recoveries; heat and electricity, and greenhouse gas reductions achievable, particularly on the solid waste and biosolids side.

- The Waste Management Planning processes currently used in the province provide an excellent process for integration of waste management. The Ministry of Environment could mandate that these planning exercises be integrated and that goals of optimizing greenhouse gas reduction, water reuse, heat and energy extraction be included in the development of the facilities. Investigation of the opportunities for providing satellite plants (dispersed facilities could be a part of this process). A spreadsheet financial model similar to that proposed by IRM could also be employed in the waste management planning exercises to compare the financial viability of competing schemes.

- Cost effective integration of facilities for wastewater treatment with solid waste management facilities does not depend upon the use of multiple small capacity neighbourhood plants to achieve most of the IRM goals for energy and product recovery. It is important to realize that most communities have secondary or higher waste water treatment in the province of BC. Victoria is unique in the province in only providing preliminary treatment (screening).

- Dispersed treatment is more applicable to new “Green Community” residential developments where the treatment facilities and dual reticulation facilities could be installed to increase effluent reuse for irrigation of residential lots or reuse for toilet flushing.

- In the CRD area, the rapid development of Westshore provides opportunities close to golf courses for seasonal water reuse and areas where residual effluent disposal could occur from satellite plants. The high capital costs can be recovered in the sale price for the residential units. Similarly, in the University of Victoria and East Coast Trunk areas, distributed waste treatment plants could be employed cost effectively with outfall of residual effluent to the sea.

- Dispersed facilities could also be applied to rapidly growing communities where densification is requiring additional treatment capacity and this could be done by satellite plants if there are suitable conditions for residual effluent discharge to the groundwater or surface water close to the new plants.

- Most of the revenue and GHG, and energy credits etc. are generated from the organic solids stream with a high percentage derived from other than sewage treatment sources. These biosolids and other solids processing facilities can economically be one plant for each community.

Implementation of the sewage treatment and management does not have to be implemented at the same time as the solid waste stream. The capital and operating costs for the biosolids and energy, and biofuels production are significant and most likely more than reported by IRM in the CRD example. The technology is not as proven and the operating costs are fuzzy at this time for the biofuels and gasification portion. The wastewater biosolids management, in the short term, for any municipality and the CRD in particular, could be developed using more proven technology to generate energy from wastes and reduce green house gases.

Integration of the general solid wastes could be included when additional funds are available.

<u>Note that the capital costs of solid waste processing, as identified in the IRM model using highest revenue generating technology, represent an increase in the cost of providing wastewater treatment for the CRD of >25%. Although the revenues are significant, such added costs may create project financing difficulties. It would be prudent that, before the more emerging technologies are employed, the necessary market surveys and pilot programs be completed to prove out the magnitude of the benefits. Biofuel generation from the solids streams could be implemented at later phases of any project.</u>

Response to Dr. Dawson's Review

Dr. Bob Dawson, PEng of Stantec was asked by the Ministry of Community Services to act as a peer reviewer of the IRM Report, and his comments are provided in *Peer Review of Resources from Waste Integrated Resource Management Phase 1 Study Report*, dated January 22, 2008.

The IRM Study Team welcomes the comments from Bob Dawson PEng in support of the IRM approach, including *"The IRM concept of integrating solid and liquid waste management planning and development of infrastructure is a very good process and components of it should be implemented over an adequate time schedule. There are significant energy recoveries; heat and electricity, and greenhouse gas reductions achievable, particularly on the solid waste and biosolids side."*

The IRM Study Team also recognizes a number of concerns raised by Bob Dawson PEng. For the sake of time, the IRM Study Team members have limited their responses to a few critical areas. The following pages comprise a detailed comment by the IRM Study Team.

Peer Reviewer: Bob Dawson PEng, Stantec

Bob Dawson PEng Comments	IRM Study Team Response
Page 2. "There definitely are benefits of integrating wastewater management to solid wastes but the linkage requires an expenditure of significantly more capital than would be required to provide an environmentally acceptable system for wastewater management alone. The additional capital required could make the financing of a particular project over a short period unattractive to the public and government." and Page 18. "Note that the capital costs of solid waste processing, as identified in the IRM model using highest revenue generating technology, represent an increase in the cost of providing wastewater treatment for the CRD of >25%."	The IRM Study Team acknowledges that additional capital expenditures for resource recovery will be required, and these are included in the IRM model. Since the additional capital required (e.g. for cogeneration equipment) results in revenue streams (e.g. sales of energy) and in reduced costs of operating other infrastructure (e.g. landfills), the financial results for the public and government will be positive. This is the premise and promise of the IRM approach. The IRM Study aims to show that this investment brings returns which exceed the costs of infrastructure for both resource recovery and wastewater treatment. The IRM approach actually decreases the overall cost to taxpayers of managing municipal resources. The IRM Study Team notes that the total estimated capital cost of wastewater treatment and resource recovery infrastructure in the IRM model is actually lower than the estimated $1.2 billion cost of traditional treatment forecast for the Capital Region. This $1.2 billion cost estimate is for plants having capacity for a population which is 86% higher than today's population. In addition, CRD budget information shows that roughly 2/3 of the estimated $1.2 billion is for wastewater treatment facilities, with most of the balance allocated to infrastructure (e.g. piping) to deliver wastewater to the plants. The IRM Study Team believes it could be wiser to invest in infrastructure which will result in revenues rather than invest in excess capacity which will not be needed until the year 2065, if at all. CRD Water Department data shows that water conservation programs have resulted in a decrease in per capita consumption, meaning that water consumption levels have remained constant over the last decade even as the regional population increased. Concerning waste-to-energy infrastructure costs, we have relied on information provided by operators of existing waste-to-energy plants, as well as cost estimate information provided by Blair McCarry PEng of Stantec.

Peer Reviewer: Bob Dawson PEng, Stantec

Bob Dawson PEng Comments	**IRM Study Team Response**
Page 2. "There is no reason that the wastewater problem (if it is the most urgent situation to be cleaned up for environmental reasons) could not proceed first and be designed to include as much energy recovery (cogeneration of electricity), heat recovery from the effluent and wastewater processes, resource extraction and water reuse as economically feasible. The technology for generating these portions of the revenue stream is well established."	If "form follows function", the outcome of a design optimized for waste disposal will be very different from the outcome of a design optimized for resource recovery. Taken in isolation from a consideration of revenues from markets for recovered resources, the former would likely result in larger, more centralized plants. The Integrated Resource Management approach on the other hand first looks for clients for energy and reclaimed water; this results in treatment plants being located closer to clients for energy and renovated water. We believe that a truly Integrated Resource Management approach cannot be layered onto traditional infrastructure after the fact, because such layering results in sub-optimized resource recovery, reduced environmental benefits, increased costs, and therefore lower value.

Peer Reviewer: Bob Dawson PEng, Stantec

Bob Dawson PEng Comments	**IRM Study Team Response**
Page 3. "The technologies for producing biofuels from gasification of solid wastes and residual wastewater biosolids are more common in Europe and could be considered emerging technologies."	It is interesting that the Capital Regional District commissioned a report titled *Energy Recovery from Solid Waste, a Feasibility Report Prepared for the Capital Regional District* from B.H. Levelton & Associates Ltd.. The report discusses the economics of energy recovery options such as gasification (invented in 1699), and identifies potential clients for energy recovered from waste, including BC Hydro, the University of Victoria, the Royal Jubilee Hospital, the Department of National Defence, and the Parliament Buildings. The report's summary states: *"The Authors suggest that CRD must first reaffirm its commitment to energy recovery as the prime disposal system and then proceed to implement the principle."* The report was delivered on June 1, 1976 when heating oil cost $0.09 per litre ($0.32 per litre in current dollars). Gasification, anaerobic digestion, cogeneration, and heat pumps are established technologies, extensively used in Europe, Japan, and North American industry. The fact that these technologies have not been widely applied to Canadian municipal infrastructure may reflect our mind-set with respect to disposal rather than our technological capability. One of the points we hope to make through the IRM Study is that continuing to do what Canadian cities have always done will not bring British Columbia closer to meeting its sustainability and greenhouse gas reduction objectives.

Peer Reviewer: Bob Dawson PEng, Stantec

Bob Dawson PEng Comments	**IRM Study Team Response**
Page 3. "The markets for the biofuel products are not well established and could be very risky because of quality control and reliability of supply."	The IRM model includes the infrastructure required to upgrade biogas to natural gas quality. Since vehicles in Canadian cities are already burning compressed (fossil) natural gas and since vehicle conversion to CNG is a well-established technology, we feel the risks is of adopting natural gas from biological sources for use in vehicles is no greater in Canada than it is in Europe, where this practice is common. The IRM Study Team also notes the recent commitment made by B.C. Transit to increase the use of biofuels in its fleet. During the time required for vehicle fleets to be adapted to biofuels, surplus biogas could be burned for cogeneration, or even sold to natural gas utilities for distribution.

Peer Reviewer: Bob Dawson PEng, Stantec

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<tr><th>Bob Dawson PEng Comments</th><th>IRM Study Team Response</th></tr>
<tr><td>Page 5. "The IRM has assumed that there is a real market or need for the dispersed plants but the market and the need have not been confirmed nor quantified. The IRM has also attempted to do this for the CRD by identifying the heat extraction potential locations and some of the water reuse potentials such as the University or golf courses. However, the potential for the customers to participate has not been firmed up."

and

Page 12: "The market assessment, particularly for heat extraction, sale of biofuels and water reuse, is weak. There is a high probability that the predicted customer base and the high volume of sales will never materialize."

and

Page 14. "The revenue from extracting heat from the wastewater treatment plant effluent and high temperature side streams could be as high as estimated by IRM if dispersed treatment were cost effective. Previously we have demonstrated that the costs of dispersed treatment will be too high. Therefore, the practicality of reaching all the markets identified in a cost effective manner is extremely low so that a more realistic value of this revenue stream might be about $2.0 million."</td><td>The scope of the IRM Study did not include confirming individual clients for district heating, reclaimed water, green electricity, or biofuels. Rather, the study aimed to illustrate that magnitude of the opportunity which integrated resource recovery presents. The IRM Study outlines a design approach rather than an engineered solution.

Fortunately, Canadian leadership in the area of greenhouse gas-neutral energy is rapidly emerging, in step with the Canadian motivation to curb greenhouse gas emissions. In specific, support for recovering energy from waste streams (e.g. district heating and district cooling via heat pumps, and biofuel production from sludge and solid organic waste) in the Capital Region has been clearly expressed to IRM Study Team members:

a) At the national level by the Department of National Defence; the Ministry of Transport, Infrastructure and Communities; and the Ministry of Natural Resources.
b) At the provincial level by the Premier of BC; the Climate Action Secretariat; the Ministry of Environment; Accommodation and Real Estate Services (Ministry of Labour and Citizens' Services); the Ministry of Community Services; and the Ministry of Energy, Mines and Petroleum Resources.
c) At the local level by the City of Esquimalt; the City of View Royal; the City of Colwood; the Vancouver Island Health Authority (Saanich Peninsula Hospital, Victoria General, Royal Jubilee Hospital); Royal Roads University; Camosun College; the University of Victoria; and the Fairmont Empress.

It is encouraging that most of the entities listed above operate buildings which consume natural gas for space heating and domestic hot water, and have specifically expressed interest in adapting their buildings to accept heat energy recovered from treated wastewater through heat pumps.

Further, the IRM model does not include other revenues which could be realized from the sale of inorganic nutrients. Edmonton's Gold Bar treatment plant for example recovers about 500 kg/day of "Crystal Green" through the Ostara process, currently being piloted for 20% of their total flows (see Wastewater reactor turns sewage into money, Edmonton Journal, December 4, 2007).</td></tr>
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Peer Reviewer: Bob Dawson PEng, Stantec

Bob Dawson PEng Comments	IRM Study Team Response
Page 6. "This technology of converting the anaerobic digester gas (methane/carbon dioxide mixture) to synfuel is problematic, it requires sulphur scrubbing facilities and bottling facilities."	The IRM Study Team believes the comment refers to biogas from anaerobic digestion rather than to syngas (synthesis gas) from gasification. Study Team members have observed biogas upgrading equipment manufactured by Malmberg (www.malmberg.se) in operation in Sweden. Upgrading equipment based on pressure swing adsorption and biofilters is commonly available in North America. Over three thousand biogas plants operate in Europe, where the processes for production, upgrading (scrubbing) of biogas to methane, and distribution are routine.
Page 6. "Adding additional wet organic solid waste diverted from the landfill, and food waste and grease collected in the community to the WWTP digesters is also a good way to increase gas and energy production by about 20 to 30%."	In the IRM model, biosolids from the existing Central Saanich Wastewater Treatment Plant and biosolids which are predicted to come from the future Core Area treatment plants account for only 16% of the total organic solid waste stream. Further, the energy content of biosolids is low compared with other organic waste components, especially oil and grease. Taking these two factors into account, the IRM model shows that energy available from the total supply is 500% larger than the energy which would be provided by digesting biosolids alone.

Peer Reviewer: Bob Dawson PEng, Stantec

Bob Dawson PEng Comments	IRM Study Team Response
Page 8. "Capital costs of cogeneration facilities have been estimated by IRM as approximately $1.0 million per MW of capacity. Examination of recent costs of cogeneration facilities in King County in Washington State suggests the capital costs are more likely in the order of $4.0 million per MW."	The cost estimate for cogeneration facilities applies to GE Jenbacher reciprocating engines (recommended by Blair McCarry PEng of Stantec in *Resources from Waste Report-Phase One*, prepared by on September 14, 2007), generators, and controls. Cost estimates for the gasification equipment to produce the fuel for this equipment are accounted for separately. The source for the capital cost estimate for cogeneration equipment is BC Hydro: *Distributed Generation: Reciprocating Engines, Microturbines, Fuel Cells, Stirling Engines, and Photovoltaics* which includes estimates ranging from $0.4 to $1.0 million per MW. The cogeneration facilities in Washington State's King County include fuel cells. Capital costs for fuel cell cogeneration equipment is significantly higher: BC Hydro estimates this at $4.0 million per MW. The figure of $1.0 million per MW chosen by the IRM Study Team is actually $1.4 million per MW after it inflation and construction contingencies are applied.

Peer Reviewer: Bob Dawson PEng, Stantec

Bob Dawson PEng Comments	**IRM Study Team Response**
Page 9. "The approach is not a good strategy for cost effective plant supply and efficient operation. Certainly the argument that such plants allow more capability for changing the technology as new more cost effective developments occur does not make sense."	Apart from energy recovery infrastructure, the IRM Study compares two approaches for wastewater treatment plant development design, bearing in mind that the BC Ministry of Community Services asked the IRM Study Team to use the Capital Region as a case study. The Capital Region has developed cost estimates based on building a small number of larger plants having a capacity for a population 86% greater than today's levels. In the IRM option, a larger number of smaller plants would be sited to optimize the return of water and energy to their communities, and capacity would match today's demands. Building plants with excess capacity will cement in place today's technology, while just-in-time expansion of capacity will allow communities to benefit from newer technologies. Each new treatment facility can use the latest technology, and as individual plants are replaced over time, they can be upgraded with current technology. We believe this adaptability offers taxpayers significant value. In the end, additional capacity may not be required; CRD Water Department data shows that water conservation programs have resulted in a decrease in per capita consumption, meaning that water consumption levels have remained constant over the last decade even as the regional population increased. Finally, a just-in-time approach allows the cost of any expanded capacity to be borne by new developments. Treatment plant infrastructure cost estimates were provided by David Jackson PEng of WorleyParsons Komex. We believe that a final determination of capital and operating costs will need to be determined for each application and location.

Peer Reviewer: Bob Dawson PEng, Stantec

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Page 9. "Generation rates of gas from anaerobically digested sludge and from dry solid wastes reported by IRM are questionable; they appear to be too high based upon experience with WWTP facilities."
and
Page 10: "Energy recovery from sewage sludge solids is over estimated. Note that the energy generation capability at Annacis Island is 4.2 MW for a secondary capacity of 580ML/day. Currently the plant uses about 134,184 kw hrs of power per day, 43% of which is generated by cogeneration. For the CRD in 2065 at an ADWF of 167 ML/day, the generating capacity from methane produced in anaerobic digesters would probably be about 1.2 MW and the power requirements of treatment would be in the range of 2.7 MW."
and
Page 11. "The quantity of biofuel generated (as reported by IRM, is equivalent to 28 million litres per year of biofuel) from such quantities does not seem to be possible when one considers the usual methane generation rates from such organics and the water content of these solids."
and
Page 11: "There are significant energy requirements for the methane production partially because of the water content of the biosolids and solid wastes, which may not have been adequately accounted for in the IRM team estimates."
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Yields of biogas from digestion of biosolids at existing wastewater treatment plants are not directly comparable with yields of biogas in the IRM model, for the following reasons.
a) Existing wastewater treatment plants use mesophilic digesters, while the IRM model is based on thermophilic digesters. Thermophilic digestion is known to result in higher biogas yields and lower retention times than the more traditional mesophilic digesters.
b) Canadian wastewater treatment plants digest only biosolids, while the IRM calculations are not limited to production of biogas from sludge, but include all sources of wet organic solid waste in the Capital Region. Biosolids account for only 16% of the total flow of wet organic waste in the IRM model.
c) Infrastructure costs in the IRM model include Microsludge equipment to precondition biosolids as a means of increasing biogas yields. (Metro Vancouver will be upgrading its biogas production by means of Microsludge technology, with a goal of making the LuLu Island WWTP energy self-sufficient.)
The IRM model estimates yields from wet organic solid waste by taking into account the following factors for each type of feedstock (e.g. sludge, kitchen waste, oil and grease, and so on):
a) the moisture content of each feedstock
b) % volatile solids of each feedstock
c) % volatile solids reduction during digestion
In addition, the following factors were used to calculate the overall yield of methane from raw biogas:
a) methane content of raw biogas
b) methane yield during raw biogas conversion and upgrading
Reliable industrial sources have been used for these five factors.
Finally, in order to account for the effect of population growth in the Capital Region over the life of the model (to 2065), a growth factor of 0.7% per annum taken to the mid-point of the project was applied to the revenues.
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Peer Reviewer: Bob Dawson PEng, Stantec

Bob Dawson PEng Comments	**IRM Study Team Response**
Page 10. "A significant portion of the environmental benefits are dependant upon the projected production quantities of electrical energy, bi-fuel production, heat energy extraction from the wastewater effluent and elimination of methane escape to the environment resulting from diversion of organics from landfill, all of which result in significant greenhouse gas emission quantities. As discussed below, the magnitude of all of these products or GHG reductions most likely have been overestimated."	The IRM Study Team is unclear concerning the factual basis for concern that estimates of greenhouse gas reductions have been overestimated. Details concerning the greenhouse gas estimates have been included in the *Explanation of the Greenhouse Gas Estimates* section of the *IRM Study Ancillary Data document*, provided to the Ministry of Community Services on December 18, 2007. The greenhouse gas estimates in the IRM model are based on methodologies provided by Environment Canada, the Intergovernmental Panel on Climate Change, and the National Council for Air and Stream Improvement. Emission factors for the analysis are taken from the *IPCC National Greenhouse Gas Inventories Programme*.
Page 11. "The electrical energy production capability is probably at least 35% overestimated." and Page 14. "Therefore, it would seem that the power output from CRD dry solid wastes should be around 9.9 MW. The revised revenue might be around $5.3 million per year rather than $6.9 million."	A comparison between the predicted energy yield from gasification in the IRM model, and the yield from the Williams Lake generation plant is unlikely to be exact. The feedstock for gasification in the IRM model includes plastics (limited to those which can be safely gasified); the inclusion of plastics was recommended by an IRM Technical Advisory Committee member, Dr. Bruce Jank PEng. Plastics have a significantly higher calorific value than wood waste alone. Conversion efficiencies for the GE Jenbacher reciprocating engines are based on recommendations by Blair McCarry PEng of Stantec in *Resources from Waste Report-Phase One*, prepared by on September 14, 2007.

Peer Reviewer: Bob Dawson PEng, Stantec

Bob Dawson PEng Comments	IRM Study Team Response
Page 11: "For example, it appears as though the same stream of solids (the maximum tonnage) was used to calculate both electrical energy and biofuels." and Page 14: "It appears that there may be some double accounting of biofuel generation from both wet and dry solids conversion to biofuel (the dry diverted solids and residual anaerobically digested solids are specified for gasification to produce synfuel and subsequent use of the synfuel for generation of electrical power).	Double accounting of dry and wet organic waste streams has been carefully avoided in the IRM model, which includes two separate solid waste streams: a) Approximately 81,000 tonnes/year of wet organic solid waste (e.g. kitchen waste from homes and restaurants, oil and grease, and biosolids from the wastewater treatment plants) for thermophilic anaerobic digestion to produce biogas (CH_4, CO_2), which is then upgraded to natural gas quality methane for use as vehicle fuel. b) Approximately 98,000 tonnes/year of dry organic solid waste (e.g. paper and paper board, wood waste and demolition waste, yard and garden waste, plastics which can be safely gasified, and dewatered residues from the anaerobic digesters) for gasification to synthesis gas (CO, CO_2, H_2, CH_4) for cogeneration of electricity and heat. Dewatered residuals from thermophilic anaerobic digestion (4,000 dry tonnes per year) were included in the feedstock for gasification, and a low energy value of 2 GJ/dry tonne (versus 14 GJ/dry tonne of wood waste) was assigned to this source because of the high proportion of inorganic material in digester residues.
Page 12. "The risk of not finding multiple WW treatment plant sites acceptable to the public is high and the model underestimates the difficulty and costs, particularly for the CRD where 32 sites are proposed by IRM – currently there is concern over several (all) of the 5 sites proposed by the engineering consultant."	The IRM Study Team hopes that in this day of greater understanding of climate change, response by the public to a small, local, self-contained facility designed to recover resources and reduce greenhouse gas emissions will be significantly different from historical reactions to large wastewater treatment plants. Two polls in the Capital Region show a very high level of support for treatment and resource recovery, even before the public has been made fully aware of how a Water and Energy Recovery Cell (WERC) could work. Public support for Victoria's Dockside Green development (which incorporates its own treatment/water reclamation plant and gasifier), and indeed the rapid rate at which the Dockside units were sold, suggests that our hopes may not be unjustified.

Peer Reviewer: Bob Dawson PEng, Stantec

Bob Dawson PEng Comments	IRM Study Team Response
Page 14. "As well, the amount of biofuel production, electrical power generation, and the heating and cooling generated by a practical wastewater treatment scheme is uncertain and, in my opinion, could be highly overestimated by the methods prescribed by IRM."	The IRM Study Team has based the estimates of resource recovery on credible sources, including heat pump COP and cogeneration plant efficiencies taken from *Resources from Waste Report-Phase One*, prepared by Blair McCarry PEng of Stantec on September 14, 2007. The IRM Study Team recognizes that estimates of yields of energy, water and other resources will be refined as individual communities move ahead with their implementations.
Page 15. "The potential clients for marketing heat extracted from the plant effluents may not be enthusiastic to pay their portion for the infrastructure to change from their current heating and cooling systems because of residential or government budget restrictions."	The capital cost of heat pumps, controls, insulated district heating pipes, and treated effluent distribution pipes have been accounted for in the IRM model, as though these costs were borne by an energy utility. A client for district heating would only cover the cost of installing a heat exchanger in their buildings. In Revelstoke, BC the Revelstoke Community Energy Corporation charges clients for district heating at a rate with is 5% below the cost of the fossil fuel alternative it replaced. Clients signed onto the community energy project because twenty-year contracts guarantee energy clients that this rate will only increase at the rate of general inflation, and because the Revelstoke Community Energy Corporation paid for the relatively minor cost of installation of heat exchangers in client buildings.[1] The IRM Study Team notes that the IRM model assumes district heating would need to be sold at a discount of 15% below the cost of the fossil fuel alternative. Changing this discount to 5% adds $4.6 million or 7.6% to net revenues in the IRM Model.

[1] Per David Johnson, President, Revelstoke Community Energy Corporation, as presented to the Community Energy Association in Vancouver, BC on February 28, 2007.

The IRM Study Team has briefly analyzed the impacts on the IRM model of three new items of information: the BC Carbon Tax, BC Hydro's March, 2008 energy call for electricity from biomass, and the community energy discount rate used by the Revelstoke Community Energy Corporation. The impacts of these changes on the IRM model are summarized as follows:

	Carbon tax	**Electricity**	**District energy discount**	**Total**
Nature of the Change	Carbon tax of $1.74/GJ of natural gas, and $0.0724/litre of gasoline per the 2008 BC Budget.	Selling price of electricity from biomass increased from $0.077 to $0.10 per kWh to match BC Hydro's March, 2008 energy call.	Discount for the value of district energy reduced from 15% to 5%, based on actual contract rates for the Revelstoke Community Energy Corporation, per David Johnson, President.	
Additional Annual Revenues	$7,868,987	$2,495,155	$4,666,372	$15,030,514
% Change in Annual Revenues	6.9%	2.2%	4.1%	13.2%
% Change in Net Annual Revenues	12.9%	4.1%	7.6%	24.6%