## Capital Regional District
## Core Area Wastewater Management Program

## Integrated Resource Management Strategy

# Discussion Paper – Biosolids Management/Organic Residuals Energy and Resource Recovery
## 031-DP-3

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# 1 Objective

The objectives of this Discussion Paper are three-fold. First, the paper provides a topic area overview of technology and applications in the context of organic residuals energy and resource management. From this overview, discussion is provided on energy and re-use potential of organics generated within the CRD. The information developed was used to identify potential biosolids management / organic residuals energy and resource recovery strategies subsequently presented in the paper.

The second Discussion Paper objective is to document the refined long-list of alternatives and component options that were presented and discussed at a July 3, 2008 workshop on biosolids management / organic residuals energy and resource recovery, which includes examination of wastewater – solid waste integration opportunities. The workshop provided a facilitated forum to engage CRD staff and the consultant team in dialogue on a specific set of topics. The primary goal of the workshop was to develop consensus on a short-list of alternatives.

The third Discussion Paper objective is to identify the developed short-list of alternatives that will be subjected to further analysis. This subsequent analysis will generate information that the CRD can use in its further development and decision-making for the Core Area Wastewater Management Program.

# 2 Topic Area Overview

## 2.1 Energy Recovery and Re-use Technology

Wastewater treatment facilities create primary and secondary sludges. These sludges contain organics and, as such, contain potential energy that can be extracted, at least to some degree, through a variety of processes. These processes include anaerobic digestion for the creation of biogas, composting, and thermal destruction of various kinds. Source-separated organics, such as those from a kitchen and restaurant waste solid waste diversion program, can also be treated in the same manner as wastewater sludges to create energy and/or a soil amendment. These processes can occur separately for both the wastewater sludges and the source-separated organics or they can be done together, i.e. wastewater treatment sludges and source-separated organics, commingled and treated together, depending on the situation.

### Anaerobic Digestion and Biogas Use

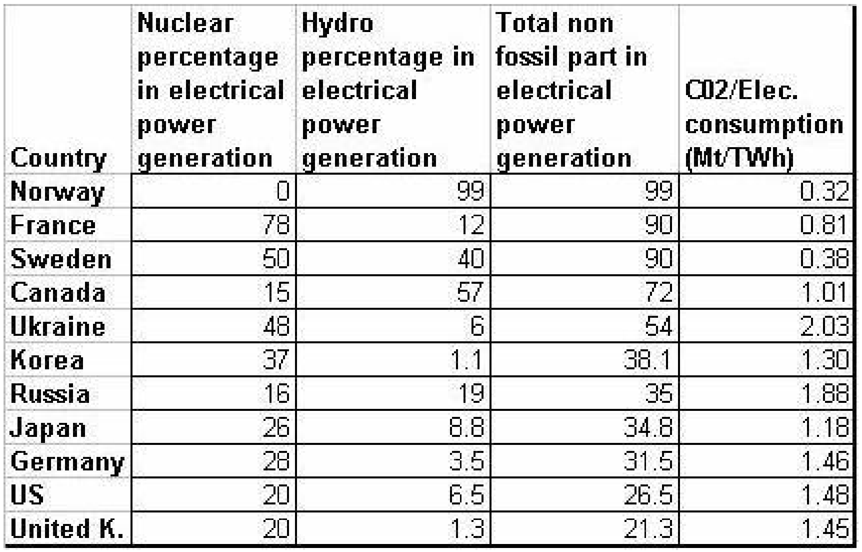
Anaerobic digestion is a three-stage bacterial process that takes place in a liquid slurry, in a closed vessel, in the absence of oxygen at temperatures of either 37°C or 55°C. The stages are hydrolysis, acidogenesis and methanogenesis. Hydrolysis involves the breaking down of lipids, polysaccharides, proteins and nucleic acids to simpler compounds such as fatty acids, monosaccharides, amino acids, purines and simple aromatic compounds. Acidogenesis involves the conversion of the hydrolysis products to even simpler fatty acids and amines. Methanogensis is the conversion of the acidogenesis products to methane and carbon dioxide. As such, the final digester gas is typically in the range of 60% to 65% methane and 35% to 40% carbon dioxide with various amounts of hydrogen sulphide, siloxane (a silica-based compound), ammonia and other gases. Anaerobic digestion results in a stabilized organic residue. If the digestion was at 55°C for long enough, the pathogen content of the biosolids will be greatly reduced. After some treatment, the biogas can be used in a number of ways, including cogeneration (cogen) to create heat and electricity and/or use as a fuel for vehicles.

Treatment of biogas depends on the final use of the biogas. After treatment to remove $H_2S$ and moisture, biogas has, in the past, been commonly used to heat the treatment plant, including the digesters, with excess gas flared (burned). It subsequently became more common to add cogen engines, i.e. spark-ignition reciprocating piston engines driving electric generators, and use the treated biogas ($H_2S$, moisture and siloxane removal) to fuel the engines. Siloxane, which is based on the silica used in personal care products such as make-up and deodorants, became a problem in the early to mid-1990’s and now has to be removed via chilling and/or activated carbon to prevent problems with equipment used in cogen.

Cogen has more recently expanded beyond piston-engines to include other devices such as microturbines driving generators and fuel cells that convert the methane to hydrogen and then the hydrogen to electricity. In all cases, heat is a by-product that is extracted to help heat the treatment facility, including the digesters. As such, cogen systems typically convert approximately 30% to 40% of the energy in the biogas to electricity and about 40% to 50% to heat. In doing so, the use of biogas in cogen engines helps to decrease the dependency of the treatment facility on outside energy sources, including fossil fuels like natural gas that might otherwise have been used to heat the facility. In fact, the heat developed by the cogen system can be both a blessing and a burden: in the colder months, it is likely that most of the heat can be used to heat the plant and the digesters whereas in the summer there would be an excess amount of heat. Fortunately, this does provide the possibility of using the excess heat to at least partially dry dewatered biosolids in the summer months, making the biosolids more useable in a municipal solid waste (MSW) waste-to-energy (WTE) facility or cement kiln.

Whether the digester biogas is used for cogen or for other purposes, such as vehicle fuel (after further treatment) depends, in part, on the green house gas ($CO_2e$) burden in the local electricity supply system. For example, as shown in the table below, in Norway, which produces almost all of their power from hydroelectricity, has a very low $CO_2e$ burden per kWh. Sweden, where most of their electricity comes from either hydro power or nuclear power plants, has an electricity GHG burden that is also very low. Canada comes fourth behind Sweden, but with a significantly higher overall $CO_2e$ burden. British Columbia, because of its high percentage of hydropower, would likely fall somewhere in the range of between Norway and Sweden. Alberta would be closer to the US and the UK because of their higher use of coal-fired power plants for electricity generation.

### Example Green House Gas Burden for Electricity Generation for Various Countries



| Country | Nuclear percentage in electrical power generation | Hydro percentage in electrical power generation | Total non fossil part in electrical power generation | C02/Elec. consumption (Mt/TWh) |
|---|---|---|---|---|
| Norway | 0 | 99 | 99 | 0.32 |
| France | 78 | 12 | 90 | 0.81 |
| Sweden | 50 | 40 | 90 | 0.38 |
| Canada | 15 | 57 | 72 | 1.01 |
| Ukraine | 48 | 6 | 54 | 2.03 |
| Korea | 37 | 1.1 | 38.1 | 1.30 |
| Russia | 16 | 19 | 35 | 1.88 |
| Japan | 26 | 8.8 | 34.8 | 1.18 |
| Germany | 28 | 3.5 | 31.5 | 1.46 |
| US | 20 | 6.5 | 26.5 | 1.48 |
| United K. | 20 | 1.3 | 21.3 | 1.45 |

In a separate BC Hydro study, British Columbia's GHG intensity was predicted to be 33 t $CO_2e$ / GWh in 2005 and increasing to 72 in 2010, as indicated in the BC Hydro Greenhouse Gas Report, March 2005. The 33 value compares quite closely with the 37 value reported in Sahely et al (2006). From Sahely et al (2006), 91% of the power in BC comes from hydro generation. The big jump that BC Hydro predicts from 2005 to 2010 is likely due to the predicted import of external power from fossil sources. In comparison, Sahely et al (2006) estimates Alberta's intensity to be 757 t $CO_2e$ / GWh, with 82% of the power coming from coal. For context, Sahely et al (2006) reports Ontario at 128 t $CO_2e$ /GWh, where about 56% of their power is nuclear.

The point of this discussion is when the electricity already has a fairly low $CO_2$ burden, like in BC, it may not make as much sense to use the digester biogas in a cogen system than it might make in an area with a higher $CO_2e$ burden, like Alberta. Where the $CO_2e$ burden in electricity is low, from a GHG viewpoint, it might make more sense to use the biogas to make biomethane (at least 97% methane) by removing $CO_2$, as well as $H_2S$, moisture and siloxane and then use the biomethane as a vehicle fuel, displacing fossil fuels such as diesel with a renewable fuel source. Based on the

CRD's recent fact-finding trip to Sweden, the use of biomethane from anaerobic digesters to fuel buses is becoming more common and is already well utilized in larger Swedish cities like Goteborg and Stockholm and smaller cities like Västerås. There is also an overall program in Europe called BiogasMax that has a goal of replacing 25% to 35% of vehicle fossil fuels biomethane derived from digester biogas. As such the biogas can come from either anaerobic wastewater sludge digestion or anaerobic source-separated organics digestion, or a combination of these two options.

Residuals from anaerobic digestion have, in the past, been used as a soil amendment, based on the organic content of the biosolids. Depending on the pathogenic bacteria concentrations, this land application is either restricted (Class B) or unrestricted (Class A).

In considering anaerobic digestion it is important to think about the issue of practical scale. Historically, the decision to implement anaerobic solids digestion at wastewater treatment facilities, with some form of energy recovery, was made on a relatively simple economic basis. The costs were such that only larger treatment facilities had the economy-of-scale necessary to justify the investment of anaerobic digestion and energy recovery.

There are several examples of mid-sized treatment facilities that use anaerobic digestion and some form of energy recovery in western Canada. These facilities represent the current low-end in terms of size: the City of Red Deer (32 ML/d), the City of Lethbridge (49 ML/d), the Regional District of Nanaimo, BC, Greater Nanaimo Pollution Control Centre (GNPCC) (~ 30 ML/d) and the City of Chilliwack, BC (~ 18 ML/d). All of these facilities recover energy from mesophilically (~ 38°C) produced digester gas by using some of it to fuel boilers. The heat generated is used to heat the sludges undergoing anaerobic digestion, in addition to providing heat for treatment facility buildings.

Lethbridge has relatively recently taken the next step in energy recovery from digester gas. The City installed cogen engines that can be fueled by digester gas, which allows on-site generation of electrical power for use at the treatment facility. Similarly, the Regional District of Nanaimo is currently embarking on a project to implement cogen at the GNPCC, which will allow it to use all produced digester gas. Energy remains relatively inexpensive in Canada and the current economies of cogen at this scale are such that, at least for the case of the GNPCC, it would not pay for itself unless some of the capital cost was off-set by senior government funding.

However, there are new drivers evolving that may enhance the feasibility of anaerobic digestion and energy recovery at smaller facilities. The first is that additional energy can be made available if external sources of carbon (e.g. solid waste organics) are co-digested with wastewater sludges. Another key driver influencing the feasibility of solids digestion and energy recovery are greenhouse gas (GHG) emissions and carbon footprint.

### Composting

Composting is an aerobic process by which dewatered raw sludge or digested biosolids and/or source-separated solid waste organics are mixed with a woody amendment, such a wood chips, and then aerated for a period up to 21 days, achieving temperatures in the 55°C to 65°C range.

This primary composting phase is followed by a lower temperature, actively aerobic, curing phase and then by a longer term (several weeks) less aerobic final curing phase. After screening out the wood chips that have not been broken down, the resulting compost is very much like a natural organic-rich top soil both in sight and odour. Providing the temperatures were held high enough for long enough, e.g. three days at 55°C or higher, the resulting product will also have a very low pathogen content, in addition to being well stabilized to prevent vector (fly) attraction.

Composting of raw wastewater sludges is practiced successfully in the Comox Valley Regional District and in the Vernon area for the City of Kelowna and City of Vernon biological nutrient removal mixed raw primary and secondary sludges. Comox Valley markets their product for landscaping and gardening use as “Skyrocket”. Kelowna markets their product for similar markets as Ogogrow™. In both cases, the demand is generally greater than the supply. This does not mean there is a profit, just that some costs are off-set by revenues and that they have no problems in disposing of their final product. The compost products are typically used in landscaping applications rather than on food or forest crops. The CRD initiated a pilot program in July 2008 to market and make available, to the public via pick-up at the Hartland Landfill, lime-stabilized Saanich Peninsula WWTF biosolids, known as “PenGrow”.

It should be noted that source-separated organics can be composted in a similar manner. However, because of odour issues, source-separated organics are best composted in enclosed systems, e.g. “envessel” systems or “Dutch Tunnel”-type systems. The City of Hamilton, Ontario operates a source-separated “Green Cart” system for composting kitchen wastes and a restricted variety of other house hold organics (nothing plastic or hazardous and no large woody debris or grass clippings (separate yard waste composting program)). The composting process is a “Dutch tunnel” type aerated static pile with excess foul air treated in a biofilter. There are also similar but smaller scale source-separated organics composting systems in the Lower Mainland and on Vancouver Island. The CRD currently has a regional bylaw in place that requires in-vessel food waste composting at a regional facility – currently the CRD is using a private facility located in the Cobble Hill area.

## 2.2 Energy Recovery Application

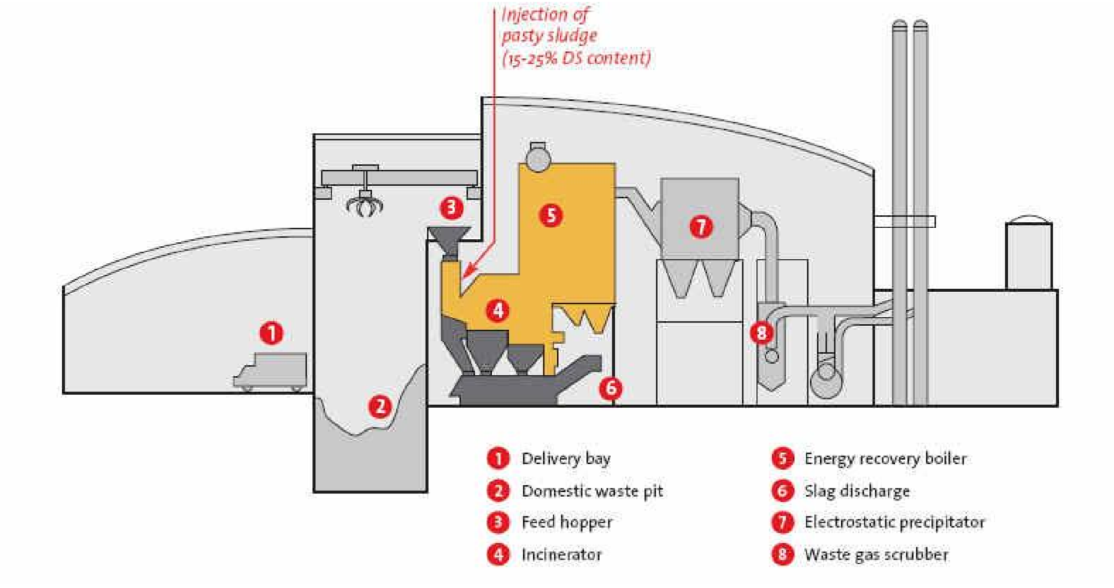
Thermal destruction, used in the context of energy recovery, can take various forms including:

- Mixing with MSW in a mass burn WTE boiler system that creates heat and electricity.
- Combustion in a fluidized bed combustion (FBC) reactor with the hot gases used to create electrical energy.
- Gasification/plasma destruction and gasification.
- Drying and combustion in a cement kiln as a coal substitute.

### Co-combustion in an MSW WTE Facility

Mass burn of dewatered biosolids could occur in a MSW WTE facility that uses mass burn boilers, similar to those in Metro Vancouver’s MSW WTE facility in Burnaby and the two facilities in Sweden that were visited by CRD and consultant team staff in April 2008. The wastes burned in these boilers heat water in tubes in the boiler walls and the resulting steam is used to drive steam turbine-generators to create electricity. The flue gases from the boilers are wet and dry scrubbed and filtered to remove noxious gases and particulates. Bottom ash is used as an aggregate substitute. Fly ash from the electrostatic precipitators and bag filters is fixed with cement powder and landfilled. Excess heat and/or steam can be sold off site to other users, e.g. paperboard manufacturing (in the Burnaby example), greenhouses or district heating systems (if they exist).

**Schematic of a Typical MSW WTE Facility**



Such facilities typically have restrictions on the amount of dewatered biosolids that can be mixed in with the MSW without causing operational problems. For a typical 28% dry solids dewatered biosolids product, the theoretical upper limit for the percent biosolids in the overall biosolids-MSW mix is in the order of 20%. However, MSW WTE facility operators would prefer to keep the percentage down to below 10%. In either case, this greatly affects to the ability of MSW WTE facilities to accommodate dewatered biosolids. In the example of Metro Vancouver, once the Iona Island and Lions Gate wastewater treatment plants have been upgraded to secondary treatment, there isn’t enough MSW to support a 20% or even a 10% biosolids to overall loading ratio based on 28% dry solids at the beginning point.

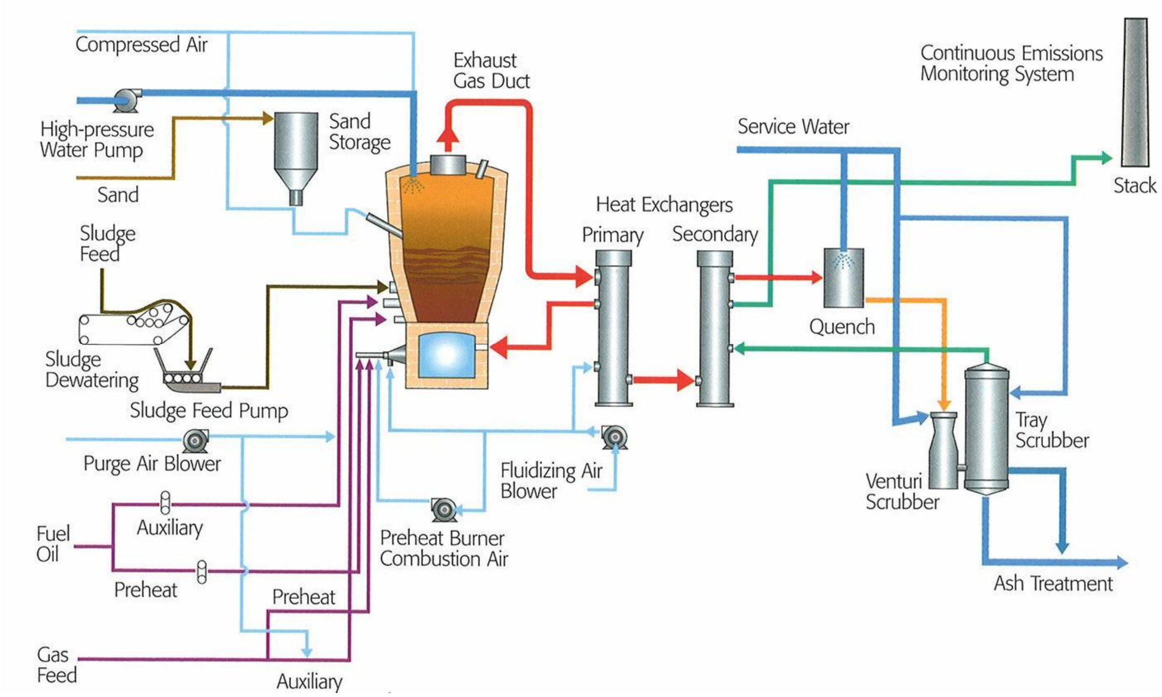
Improving the capacity of an MSW WTE facility to accept biosolids for beneficial destruction can be accomplished but only if the biosolids are dried to some degree beforehand. This drying could be accomplished through mechanical drying with external energy input or through biological drying, i.e. composting with chipped wood waste.

### Fluidized Bed Combustion

FBC involves injecting the dewatered biosolids into a bed of extremely hot sand that is heated by an external fuel source, e.g. natural gas, and kept in air suspension ("fluidized") by a powerful fan system. The organics in the biosolids are combusted, raising the temperature of the flue gases leaving the top of the FBC unit. Some of these hot flue gases are recycled to pre-heat and dry the biosolids as they enter the FBC.

The remaining hot flue gases are used to create steam to drive steam turbine-generators to create electricity. The flue gases are then wet and dry scrubbed and filtered to remove noxious gases and particulates. Fly ash from the electrostatic precipitators and bag filters is fixed with cement powder and landfilled. There is no bottom ash (it becomes part of the fluidized bed inert material). There is no excess heat and/or steam since the heat is used to pre-heat and dry the biosolids, and thereby, decrease the need for on-going external fuel use.

**Schematic of a FBC System**



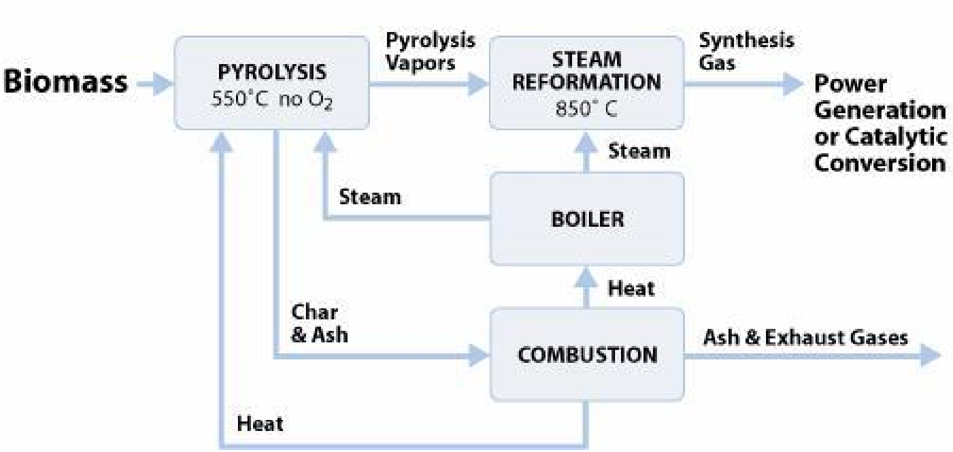
### Gasification/Plasma

Both gasification and plasma systems would require that the dewatered biosolids and/or digested source-separated organics are pre-dried to something in the 90% range. Under conditions of high heat and pressure and with minimal oxygen, the organics in the biosolids are converted to gaseous components that are then combined to form synthetic gas that effectively is a natural gas substitute.

The resulting syngas can used to fuel systems that generate electricity and heat. In some cases, it is cleaned to the point that it can be used as a substitute for natural gas.

Gasification and plasma are the newer thermal destruction options and are still, to some degree, under development relative to the well proven mass burn and FBC systems. There are some residuals that need to be managed, e.g. char from the bottom of the gasification/plasma vessels and some exhaust gas particulates and water scrubbing materials.

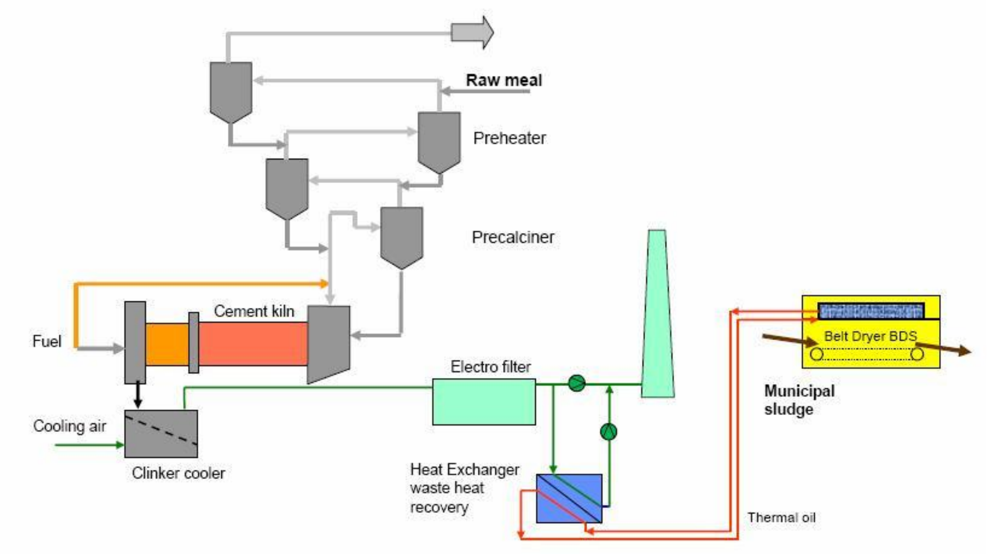
**Schematic of One Gasification Process Used to Create "Syngas"**



### Cement Kiln

The kilns at cement manufacturing facilities are users of massive quantities of fossil fuels, e.g. natural gas and/or fuel oil to convert the raw limestone to Portland cement powder. As a result, they are major sources of green house gases such as carbon dioxide. As it happens, dried digested biosolids have approximately 18,000 kJ/kg energy potential when compared to some softer coals at about 26,000 kJ/kg. Dried undigested biosolids have a calorific value of approximately 22,000 kJ/kg, even closer to that of coal. Since biosolids are a renewable energy resource and burning biosolids does not add new $CO_2$e to the atmosphere (because the carbon in the biosolids originally came from the atmosphere), substituting dried biosolids for coal in a cement kiln has positive green house gas credits. Metro Vancouver is considering this option as one means of beneficially using the biosolids from their five wastewater treatment plants.

### Schematic of a Cement Manufacturing Process Using Waste Heat to Dry Biosolids That are Subsequently Used as a Coal Substitute in the Cement Kiln



### Capacity of Thermal Destruction Units

Similar to anaerobic digestion systems, it is worthwhile to consider the size/capacity of thermal destruction units since they do not come in an infinite size range. There are certain components that do not scale down very well and, as a result, there are some practical size limitations. For FBCs reactors, units smaller than about 20 to 25 dry tonnes (dt) per day are typically either unavailable or are uneconomical, i.e. some of the components are oversized, even at their minimum size. That said, there are a number of smaller FBC units in the 16 dt/d range installed in the US.

In contrast, coming from the other end of the scale with solid fuel biomass boilers, there is less size restrictions at the low end. Solid fuel biomass boilers are available in very small sizes but not very large sizes. This makes having heat production from dewatered and dried biosolids at a smaller distributed treatment facility potentially possible.

Drying would be required for both the cement kiln option for a larger treatment plant or a solid fuel boiler for a smaller treatment plant. As with the FBCs, some of the drier systems do not scale down well, while others are more flexible. For very small plants, like a distributed treatment facility, it would be possible to have a vacuum-low pressure steam recessed-plate dewatering and drying system of the correct scale. Such equipment is not yet big enough for a more central larger treatment plants. Such plants could use stacked-tray (small foot print) type indirect driers with some minimum size issues or hollow-auger type indirect driers with little or no minimum size restrictions at that scale.

## 2.3 Re-Use Application

Biosolids residuals from anaerobic digestion of wastewater treatment sludges and/or residuals from the anaerobic digestion of source-separated organics can be used in a variety of land application situations, depending on the quality of the material and the acceptability of its use, either technically or politically.

### Residuals Landfill Land Application

Digested biosolids and/or source-separated organics can be either buried in the landfill or applied to the landfill as part of a final vegetative cover system. If the biosolids were simply buried in the landfill, they would continue to decompose over time. Since this decomposition would be without oxygen, i.e. anaerobic conditions, some additional biogas (about 60 to 65% methane) would be created, in addition to the biogas that will be generated from the solid waste organics also buried in the landfill. Such decomposition of already mostly stabilized biosolids will be relatively slow. Landfill biogas collection systems can be used to capture and beneficially use the biogas.

If used as part of the landfill vegetative cover system, the digested biosolids would provide both nutrients and tilth to the vegetative cover soil. The biosolids would also provide a “seed” of bacteria that convert methane to carbon dioxide and water and, in doing so, would help to mitigate green house gas effects from fugitive biogas emissions.

### Residuals Land Application within Urban and Adjacent Areas

Under the current BC Environment’s Organic Matter Recycling Regulation (OMRR), biosolids can be land applied as long as they meet OMRR Class B or Class A requirements. Both classes have restrictions on the concentrations of certain metals and pathogens. Class B has some restrictions on the location and timing of the land application. Class A biosolids have far fewer restrictions with regard to where and when they can be applied.

Based on the above, Class A biosolids can technically be applied to agricultural land up to the limits of the soils to accept nutrients and metals. Class B biosolids can also be applied to agricultural lands, albeit with more restrictions than Class A. Class B biosolids are perhaps best applied to non-agricultural lands including forestry lands and mine reclamation sites.

### Residuals Land Application Outside Urban Areas

The quality requirements for land application of biosolids outside of the CRD are currently the same as inside the CRD boundaries, i.e. OMRR Class A or Class B. The only major difference is the land base potentially available for the land application is larger, both in agricultural and, more importantly, forestry, areas. While the CRD does not have jurisdiction over land application outside its boundaries, other municipalities and Regional Districts likely have the potential to accept or reject potential land application proposals, either through existing or future bylaws.

One possible use of biosolids land application that might be acceptable to all involved is application to willow coppice. Coppice is when trees or shrubs are grown like a crop in that they are allowed to grow up from their root stock for a period of time, e.g. three years, and then they are cut back and harvested, to just above the roots. The wood is used in a variety of ways, including as a renewable energy source for a biomass-fired boiler system or as a supplement to an MSW WTE facility. Willow is a common coppice crop because it is relatively fast growing. On the recent fact-finding trip to Sweden, members of the CRD team saw fields of willow coppice on their travels to Västerås. It turns out Örebro and Västerås are the two largest Swedish cities supplying sludge to willow coppice plantations. Most new plantings incorporate a specific contract for sludge application. During 2002 about 50% of the harvested plantations were fertilized by sludge (nearly 1,000 hectares). The resulting willow coppice is used as one of the fuel sources for a combined heat and power plants that create electricity for the local power grid and heat for the local district heating system.

**Harvesting Short-Rotation Willow Coppice During Winter Using a Specially Designed Machine**

# 3 Energy and Re-use Potential

## 3.1 Energy Unit Basis

Based on data from a large BC secondary wastewater treatment facility, the calorific value in the raw, undigested, mixed primary and secondary sludges ranges from approximately 21,000 kJ/Kg (dry solids basis (dsb)) to just under 23,000 kJ/kg (dsb), for an average of about 22,000 kJ/kg (dsb). Digestion converts some of the potential energy to biogas and, as a result, the calorific value of digested biosolids is lower than the raw, undigested sludges. In the same example, the range for the energy in the digested biosolids was from about 17,000 kJ/kg (dsb) to just over 19,000 kJ/kg (dsb) for an average of around 18,000 kJ/kg (dsb). For context, soft coals have calorific values in the order of 26,000 kJ/kg (dsb). This points out that biosolids from wastewater treatment plants have some potential for creating “green” energy, based on the renewable, biogenic nature of biosolids (or sludges).

Biogas production is typically in the range of 0.75 to 1.12 $m^3$/kg of volatile (organic) soils converted, with 1.0 $m^3$/kg VS destroyed being a reasonable rule of thumb. Volatile solids destruction rates vary from location to location but are typically in the 60% range, depending on the original make up of the organics. Biogas is typically 60% to 65% methane. Methane has a pure energy content of about 36,000 kJ/$m^3$. As a result, biogas, at about 65% methane has a calorific value of about 22,400 kJ/$m^3$. Natural gas (a mixture of methane, propane and butane) has a caloric value of about 37,300 kJ/$m^3$. As a result, removal of $CO_2$ from biogas and bringing the methane content up to at least 97% methane produces a “biomethane” gas that has a calorific value of about 35,000 kJ/$m^3$, which is reasonably close to that of natural gas. As a result, with proper treatment to remove contaminants such as $H_2S$ and siloxane, biomethane can be used in applications where natural gas is used, i.e. pipeline quality gas and/or vehicle fuels.

Conversion of dewatered biosolids to energy is not necessarily efficient overall. For example, the energy content input of dewatered digested sludges placed into a fluidized bed combustion system produced a gross output of about 12.7% energy output as electricity and no useable heat (the produced heat is used to internally dry the wet dewatered biosolids entering the FBC unit(s)). Of this 12.7%, about 40% (5% of the input energy in the biosolids) is consumed by the FBC combustion system, leaving the remaining 60% of the energy (about 7.6% of the input energy in the biosolids) for consumption within the treatment plant. The following example considers the implications of this situation. For an assumed system with a capital cost of $90 million and annual operating costs of about $3 million, with a 6%, 25 year amortization period on the capital cost, the real cost of the kWh exported from the FBC for treatment plant use would be about $0.84/kWh. This cost is far in excess of what power could be purchased off the grid at between $0.05 and $0.07/kWh. As purely a disposal method, this particular FBC option example worked out to be in the order of $475/dry tonne (about $133/wet tonne), which is not exorbitant compared to some other alternatives.

### 3.2 Re-Use Unit Basis

Re-use of digested biosolids and/or digested source-separated solid waste organics in land application would be possible if they met the requirements of the OMRR for pathogens, metals and nutrients. If the materials met OMRR Class A requirements, technically they can be applied to farmland as well as forest lands without restrictions. If they only met Class B requirements, then there would be some restrictions, typically related to a time period between application and human and/or animal contact. The same would be true if the wastewater sludges or biosolids or source-separated organics were composted. OMRR would still govern the land application opportunities for the Class A or Class B compost product. Land application of biosolids or compost will be based on either metals loadings or nutrient loadings, e.g. kg/hectare.

A biosolids or compost Land Application Plan may be required. For example, a Land Application Plan is required in the following situations: Class A biosolids over 5 $m^3$ in volume, Class B biosolids, and Class B compost. Alternately, a land application plan is NOT required for these applications: Class A biosolids under 5 $m^3$ in volume, biosolids growing media (i.e. a biosolids or compost-based manufactured soil), and Class A compost.

Typical Class A biosolids land application rates, for the Victoria area, would be in the order of 27 dry tonne/ha-yr, based on nitrogen loading.

## 3.3 Regional Potential

The following discussion considers the regional potential of organics produced within the CRD in consideration of the energy and re-use unit potential discussed in Section 3.2.

**Biogas**

The total amount of biogas that would be generated within the CRD, from the Core Area Wastewater Management Program, would be approximately 10,700 $m^3$/day (240 GJ/day) in Year 2015. Based on data from Westport-Cummins, the local BC company that makes engines for compressed natural gas buses, each bus would consume approximately 40,500 kg per year of purified biogas (i.e. biogas with $CO_2$, $H_2S$, siloxane and moisture removed). As a result, in 2015 there could be enough biogas to power up to 65 properly-equipped compressed natural gas-engined transit buses. If the same buses were running on diesel, they would each consume approximately 56,000 litres of diesel fuel (at 80,000 km/yr per bus and 0.7L/km fuel consumption). This is the equivalent of about $5.4 million/yr of avoided fuel costs.

Cogen, i.e. the generation of heat and electricity by burning biogas in a reciprocating piston engine driving a generator, is the other potential use of the biogas. On this basis and using conversion factors of 30% of the biogas energy goes to electricity and 40% goes to heat, in 2015, the approximately 10,700 $m^3$ biogas could be used to generate approximately $439,000 per year of electricity (at $0.06/kWh). If heat was included (at about 40% of the energy in the biogas) at the same equivalent to electricity (as an example), the heat would have a value of about $585,000 per year for an overall total of about $1,024,000 per year total revenue.

While the cogen revenue might seem to be attractive, the equivalent revenue from biomethane developed from the biogas and used in the estimated 65 buses would be equivalent of about $5.4 million of avoided fuel costs. This tends to confirm what was seen in Sweden, i.e. the use of biogas to fuel buses has a much higher value that using the biogas in a cogen system. While the above analysis does not include the cost of the cogen system or the cost of the system to clean, compress and store the biomethane for use in buses, with a difference of over $13 million in favour of the bus fuel option, it would be unlikely that cogen would be the economic winner. When the relatively clean nature of BC electricity, from a GHG viewpoint, is considered, fueling buses with biomethane is an obvious winner because of the biogenic nature of the $CO_2e$ that would be produced, as compared to the non-biogenic fossil fuel nature of the diesel fuel-based $CO_2e$ that it would prevent.

On the basis of the above analysis, there would seem to be justification for digestion of raw sludges. To further develop this justification, the option of taking dewatered and dried raw undigested sludges to a cement kiln needs to be considered. In Year 2015, for example, there would be approximately 27 dry tonnes of mixed raw primary and secondary sludge produced within the CRD from the Core Area Wastewater Management Program. At a calorific value of about 22,000 kJ/kg, this would be the equivalent to about 22.7 tonnes of coal (at 26,000 kJ/kg of coal). At $150/tonne of coal, this would be about $3,400 per day or about $1,243,200 per year of potential gross revenue from the sale of dried undigested biosolids. In contrast, in Year 2015, there would be about 16 dry tonnes of digested sludge produced within the CRD that would be the equivalent of about 11.1 tonnes of coal or about $610,300 gross revenue per year (i.e. $150/tonne), for a difference between undigested and digested dried "fuel" equivalent of about $632,900. This additional potential benefit of non-digestion is less than the potential revenue from cogen at about

$1,024,000 and is significantly less than the potential revenue from using the biogas as a vehicle fuel. While this example highlights relative differences in revenue potential, capital and operating/maintenance costs would have to be brought into the framework to complete the analysis and provide a more accurate picture of absolute revenue potential.

**Biosolids**
The total amount of biosolids that would be generated within the CRD, from the Core Area Wastewater Management Program, would be approximately 16 dry tones per day in Year 2015. Based on a 27 dry tonne/ha-yr land application rate for Class A biosolids, a sustainable land application program would initially need approximately 220 ha for a 7 to 10 year application period.

# 4 Component Options and Long-List of Thematic Alternatives

## 4.1 Overview

A May 12, 2008 workshop was held with CRD and consultant team staff to discuss an initial long-list of alternatives for biosolids management/organic residuals energy and resource recovery. This workshop refined the long-list and further defined the alternatives.

To this end, Table 4-1 presents what are called Component Option descriptions. These options address three specific questions that are somewhat independent of the overall alternatives (i.e. strategies). The component options were screened on their own, with the findings considered in assembling the overall Thematic Alternatives. Table 4-2 presents the long-list of the Thematic Alternatives.

Sections 4.2 and 4.3 provide written descriptions of the Component Options and Thematic Alternatives, respectively.

## **Table 4-1.** Component Option Descriptions

| Component Option | Question Addressed | Thermal Destruction | Material End Use | Energy End Use |
|---|---|---|---|---|
| Material End Use Options | End use of biosolids? | | | |
| | | | a. biosolids landfill land application - Hartland | |
| | | | b. biosolids land application within CRD | |
| | | | c. biosolids land application outside CRD | |
| Thermal Destruction Options | Thermal destruction technology used? | | | |
| | | a. mass burn | | |
| | | b. FBC | | |
| | | c. gas/plasma | | |
| | | d. cement kiln | | |
| Energy End Use Options | Energy end use? | | | |
| | | | | a. pipeline natural gas/vehicle fuel |
| | | | | b. co-generation (heat and electricity) |

**Table 4-2.** Long-List of Thematic Alternatives

| Thematic Alternative | Stabilization | Thermal Destruction | Material End Use | Energy End Use |
|---|---|---|---|---|
| 1. Traditional | | | | |
| SW organics | compost - Hartland Area | n/a | SW organics land application - distributed within CRD | n/a |
| WW sludges | digest - Macaulay Area | n/a | biosolids landfill land application - Hartland Landfill | co-generation (heat and electricity) |
| 2. Maximum Integration and Maximum Energy Recovery | | | | |
| SW organics | co-digest - Hartlanrd Area | co-mass burn with MSW, FBC for remainder - Hartland Area | ash reuse | pipeline natural gas/vehicle fuel |
| WW sludges | co-digest - Hartland Area | co-mass burn with MSW, FBC for remainder - Hartland Area | ash reuse | pipeline natural gas/vehicle fuel; electricity |
| 3. Separate Digestion and Maximum Energy Recovery | | | | |
| SW organics | digest - Hartland Area | same as Alt 2 | same as Alt 2 | same as Alt 2 |
| WW sludges | digest - Macaulay Area | same as Alt 2 | same as Alt 2 | same as Alt 2 |
| 4. Separate Digestion and Balanced Energy Recovery / Benefical Reuse | | | | |
| SW organics | digest - Hartland Area | n/a | same as Alt 1 | same as Alt 2 |
| WW sludges | digest - Macaulay Area | same as Alt 2 | same as Alt 2 | same as Alt 2 |
| 5. No Digestion, No Integration | | | | |
| SW organics | compost - Hartland Area | n/a | same as Alt 1 | n/a |
| WW sludges | n/a | FBC - Macaulay Area | ash reuse | electricity |

🟥 selected from component options

## 4.2 Component Option Descriptions

The component options considered included Material End Use, Thermal Destruction, and Energy End Use.

**Material End Use Options**
Three potential options were developed for material (i.e. biosolids) end use (Table 4-1):

- (a) Biosolids landfill land application. This option would utilize biosolids at the Hartland landfill either as part of a vegetative cover system or simply buried within the landfill.
- (b) Biosolids land application within CRD. In this option biosolids would be made available to the public and CRD for land application within the CRD proper.
- (c) Biosolids land application outside CRD. This Option (c) is similar to Option (b), except that the biosolids would be applied to lands outside the CRD.

**Thermal Destruction Options**
Four potential options were developed for thermal destruction (Table 4-1):

- (a) Mass burn. This option envisions feeding solid waste organics and wastewater sludges into a mass burn system that is also receiving municipal solid waste.
- (b) Fluidized bed combustion. This option assumes a FBC system to thermally destroy only wastewater sludges.
- (c) Plasma/gasification. This option involves feeding solid waste organics and wastewater sludges into a plasma/gasification system that is also receiving municipal solid waste.
- (d) Cement kiln. This option assumes the transport of undigested but dried wastewater sludges to a cement kiln located in the Lower Mainland. The sludges represent a low-grade coal substitute as a fuel for the kiln.

**Energy End Use Options**
Two potential options were developed for energy end use (Table 4-1), which in this context means possible end uses of biogas produced in anaerobic digesters:

- (a) Pipeline natural gas / vehicle fuel. This option would involve the upgrading of digester biogas to biomethane, through contaminant and carbon dioxide removal, to produce a pipeline-grade natural gas equivalent for off-site export. The biomethane would also be suitable as a vehicle fuel.

- (b) Cogen (heat and electricity). In this option digester biogas would be used to fuel cogen engines to produce heat and electricity for on-site use at the wastewater treatment facility.

## 4.3 Thematic Alternative Descriptions

As shown in Table 4-2, the five developed thematic alternatives include:

- Maximum Beneficial Reuse
- Maximum Integration and Maximum Energy Recovery
- Separate Digestion and Maximum Energy Recovery
- Separate Digestion and Balanced Energy Recovery/Beneficial Reuse
- No Digestion and Balanced Energy Recovery/Beneficial Reuse

The implicit assumption in all described thematic alternatives is that wastewater sludges generated at all wastewater treatment facilities would be processed at a single location. Given the potential size of a larger distributed treatment facility in the West Shore or other area, it is possible that these facilities could process their own sludges along with some locally generated solid waste organics. This processing could include anaerobic digestion and cogen or possibly drying undewatered sludges and feeding them to a solid fuel biomass boiler system for heat production and sludge volume reduction.

However, it is important to note that the assumption described does not have a direct impact on the alternatives considered in this paper and the information required in this context. Therefore, further consideration of solids processing at distributed wastewater treatment facilities will be assessed in the separate distributed wastewater management strategy activity.

### Alternative 1 – Maximum Beneficial Reuse

For this alternative, the source-separated solid waste organics would be composted in the area of the Hartland landfill. The wastewater residuals would be digested at a Macaulay area wastewater treatment facility. There would be no thermal destruction and the residuals from the source-separated organics composting process would be distributed for land application within the CRD up to the limits of demand and then outside the CRD for the remainder. For the purposes of this alternative, it is assumed that the digested biosolids would be sent to the Hartland landfill for a combination of landfilling and incorporation into the final vegetative landfill cover. The biogas from the biosolids digestion at the Macaulay area treatment facility would be used to fuel a cogen system to produce heat and electrical power for on-site use.

### Alternative 2 – Maximum Integration and Maximum Energy Recovery

In this alternative, the wastewater treatment residuals would be co-digested with the source-separated organics in a digestion system located in the Hartland landfill area. The resulting biosolids from this co-digestion would not be land applied but would be thermally destroyed with MSW at a MSW WTE facility located in the Hartland area, up to the 10% to 15% limits that MSW WTE operators would impose. For the purposes of presentation and analysis, it was assumed that remainder of residuals would be directed to a FBC system. It is important to note that the CRD does not need to make a decision at this time regarding thermal destruction technologies: it is the overall strategy within an alternative that is the current focus. The MSW WTE facility would produce some electricity and heat for sale; the FBC would produce some electricity for sale. The ash from these two processes would be beneficially reused for its nutrient value. The gas from the co-digestion system would be cleaned to pipeline quality in one facility and used as vehicle fuel for the revenue and GHG credits.

**Alternative 3 – Separate Digestion and Maximum Energy Recovery**
This alternative is very similar to Alternative 2 except that the digestion of the source-separated organics and the wastewater sludges would be kept separate. The source-separated organics would be digested at a Hartland landfill area digestion facility. The wastewater residuals would be digested at the Macaulay area treatment plant. The resulting dewatered digested wastewater biosolids would be destroyed in an assumed FBC at the Macaulay area treatment plant and the ash used for land application. The dewatered residuals from the source-separated organics digestion system would be reused in land application the same as alternative No. 1, i.e. within the CRD up to the limits of available use, and then outside the CRD for the remainder. As in Alternative 2, the biogases from the two digestion systems would be cleaned to pipeline quality and then used for vehicle fuel. The difference would be there would two gas cleaning systems, one at the Macaulay area treatment plant and one at the Hartland area digestion facility.

**Alternative 4 – Separate Digestion and Balanced Energy Recovery / Beneficial Reuse**
This alternative is similar to Alternative 3 except after the source separated organics are digested, they are not thermally destroyed for energy recovery but, instead, land applied for beneficial reuse.

**Alternative 5 – No Digestion and Balanced Energy Recovery / Beneficial Reuse**
In this alternative, the source-separated organics would be composted at Hartland, as in Alternative 1, with the resulting product used in the CRD area up to the limits of available use, and then outside the CRD for the remainder. For the purposes of this alternative, it is assumed that the undigested raw biosolids would be dewatered and then thermally oxidized in a FBC at the Macaulay area wastewater treatment plant with the ash going to beneficial land application use. Some electricity would be produced but the excess above the needs of the FBC system would be used by the treatment plant.

# 5 Decision-making Elements

## 5.1 Overview

As per Discussion Paper 031-DP-1, the two evaluation elements of the sustainability assessment framework include the multi-objective alternative analysis (MOAA) and the risk identification and analysis (RIA). These elements were discussed and refined at the May 12, 2008 workshop. In addition, the workshop was used to develop relative importance weights for the objectives hierarchies used in the MOAA. The following sub-sections summarize the decision-making elements.

## 5.2 Objectives Hierarchies

Table 5-1 contains the objectives hierarchy for the long-list of Thematic Alternatives.

Table 5-2 contains the objectives hierarchy developed for the Component Options analysis that considered the Thermal Destruction Options. This hierarchy contains the same objectives that were used in the hierarchy for the long-list of Thematic Alternatives (Table 5-1).

## 5.3 Performance Measures and Scales

Table 5-1 also contains the updated performance measures and scales that accompany the objectives hierarchy for the long-list of Thematic Alternatives. The performance scales were modified to account for the objectives changes described in Section 5.2. Other minor changes were made to the wording used in some of the performance scales.

Table 5-2 contains the performance measures and scales used in the Thermal Destruction Options analysis. These measures and scales were modified to suit this particular analysis.

## 5.4 Weights

CRD staff workshop participants, facilitated by consultant team staff, developed the relative importance weights for the various objectives contained in the hierarchies, which are shown in Table 5-3.

Objectives 2, 3, and 4 have multiple sub-objectives. CRD staff first developed relative weightings for the sub-objectives within these main objectives. This task was achieved by first recording individual staff weightings, which was followed by a facilitated group discussion to arrive at a consensus on the final values.

Once completed, CRD staff then assigned relative weightings to the five main objectives. A similar process as described above was used by the group to arrive at the final values.

The weights shown in Table 5-2 reflect the final values for the various sub-objectives and objectives. Note that for Objectives 2, 3 and 4, the sub-objective values shown in the table represent the mathematically scaled values due to the weight given to the entire objective category.

## 5.5 Risk Identification and Analysis Approach

The May 12 workshop discussion confirmed the risk identification and analysis approach, and did not identify the need for any changes from the general material proposed in Discussion Paper 031-DP-1. Figure 5-1 shows the risk assessment matrix, with Table 5-4 describing the risk impacts.

**Figure 5-1.** Risk Assessment Matrix

| **Likelihood** | **Impact** | | | | |
|---|---|---|---|---|---|
| | Insignificant | Minor | Moderate | Major | Extreme |
| Almost Certain | **M** | **M** | **H** | **C** | **C** |
| Likely | **M** | **M** | **H** | **C** | **C** |
| Possible | **L** | **M** | **M** | **H** | **H** |
| Unlikely | **L** | **L** | **M** | **H** | **H** |
| Rare | **L** | **L** | **M** | **M** | **M** |

| | |
|---|---|
| **L** | low risk |
| **M** | medium risk |
| **H** | high risk |
| **C** | critical risk |

**Table 5-1.** Objectives Hierarchy, Performance Meaures and Scales for Long-List of Thematic Alternatives

**Decision Context: Screen a Long List of Wastewater/Solid Waste Integration Opportunities Resulting in a Short List of Alternatives for Further Evaluation.**

| Objectives Hierarchy | | Performance Scales for Thematic Alternatives | | |
|---|---|---|---|---|
| | | 5 | 3 | 1 |
| **1. Minimize Long-term Life Cycle Cost (after accounting for revenues)** | | <$6 per hh per month increase | $6-12 per hh per month increase | > $12 per hh per month increase |
| **2. Minimize Environmental Impacts** | | | | |
| | CO2eq and other emissions (PM10, NOx) from vehicles | More than a 5% reduction in vehicle travel distance | Similar vehicle travel distance as today | More than a 5% increase in vehicle travel distance |
| | CO2eq generated from energy, process, or end use | Minimize carbon footprint: e.g., co-digest to recover energy with beneficial use, and thermal treatment of all SW and WW residuals | | Poor management of carbon: Maximum use of landfill for SW and WW residual |
| | Localized odours from LW/SW infrastructure | No noticeable odours likely | Odour potential with sensitive receptors at more than one site | Odour potential with sensitive receptors at five or more sites |
| | Chemical demand | One dewatering step for WW sludges and no organics digestion | | Two dewatering steps for WW sludges and organics digestion |
| **3. Minimize Socioeconomic Impacts** | | | | |
| | Community disruption | WW solids or SW organics being trucked only to and from existing locations | | End use products hauled to new reuse locations |
| | Potential siting concerns such as cultural and terrestial resource protection (historic, cultural, archaeologically signifcant resources, endangered species, etc). | Extremely unlikely that cultural and/or terrestrial resources will be affected | Cultural and/or terrestrial resources may be affected, but effects can likely be mitigated | Unmitigatable cultural and/or terrestrial resource effects likely |
| | Economic development opportunities | WTE brings the potential for industial development and beneficial use of steam and electricity | | No WTE |
| **4. Maintain Flexibility** | | | | |
| | Consistent with implementation schedules for both wastewater and solid waste programs | No foreseeable impact on implementation schedule of either program | Potential delay of up to two years in implementing one program | Highly likely result in 2 or more year delay in implementation of one program |
| | Maintains the abiltity to adapt to beneficial future technologies and opportunities | Provision of drying at CRD facility | | Thermal destruction at CRD facility limits future options |
| | Ability to respond to future regulatory change | No land application of biosolids and no WTE (emission requirements) | | Land application of biosolids and WTE |
| **5. Ease and Safety of Operations and Maintenance** | | No WTE or WW/SW digestors | | WTE and WW/SW digestors (pressure, steam) |

**Others Considered but Not Included**

Maximize resource recovery, biogas recovery or minimize energy - should be captured in CO2eq measurement
Technological flexibility is relevant for wastewater treatment but less so for biosolids and organics. Also, see risks.
Economic development not likely to help us distinguish between alternatives
Waste diversion - all alternatives assumed to divert similar quantities of organics from landfill
Public process / education - won't distinguish between alternatives
Politically implementable - a means to an end

**Table 5-2.** Objectives Hierarchy, Performance Meaures and Scales for Thermal Destruction Component Options

**Decision Context: Screen a Long List of Thermal Destruction Component Options Resulting in a Short List of Alternatives for Further Evaluation.**

| **Objectives Hierarchy** | **Performance Scales for Component Options** | | |
|---|---|---|---|
| | **5** | **3** | **1** |
| **1. Minimize Long-term Life Cycle Cost (after accounting for revenues)** | <$6 per hh per month increase | $6-12 per hh per month increase | > $12 per hh per month increase |
| **2. Minimize Environmental Impacts** | | | |
| CO2eq and other emissions (PM10, NOx) from vehicles | All barge tranport | No barge, some trucking | All truck transport |
| CO2eq generated from energy, process, or end use | Benefit to CRD | | Benefit to non-CRD operator |
| Localized odours from LW/SW infrastructure | No noticeable odours likely | Odour potential with sensitive receptors at one site | Odour potential with sensitive receptors at more than one site |
| Chemical demand | One dewatering step | | Two dewatering steps |
| **3. Minimize Socioeconomic Impacts** | | | |
| Community disruption | < 1 truck per day and no shore-line activity | | > 5 trucks per day and shore-line activity |
| Potential siting concerns such as cultural and terrestial resource protection (historic, cultural, archaeologically signifcant resources, endangered species, etc). | Extremely unlikely that cultural and/or terrestrial resources will be affected | Cultural and/or terrestrial resources may be affected, but effects can likely be mitigated | Unmitigatable cultural and/or terrestrial resource effects likely |
| Economic development opportunities | WTE brings the potential for industial development | | No exportable power or heat |
| **4. Maintain Flexibility** | | | |
| Consistent with implementation schedule for wastewater program | No foreseeable impact on implementation schedule | Potential delay of up to two years in implementing program | Highly likely result in 2 or more year delay in implementation of program |
| Maintains the abiltity to adapt to beneficial future technologies and opportunities | Provision of drying at CRD facility | | Thermal destruction at CRD facility limits future options |
| Ability to respond to future regulatory change | No land application of biosolids and no WTE (emission requirements) | | Land application of biosolids and WTE |
| **5. Ease and Safety of Operations and Maintenance** | No WTE or combustion | | WTE (pressure, steam) or combustion |

**Others Considered but Not Included**

Maximize resource recovery, biogas recovery or minimize energy - should be captured in CO2 measurement
Technological flexibility is relevant for wastewater treatment but less so for biosolids and organics. Also, see risks.
Economic development not likely to help us distinguish between alternatives
Waste diversion - all alternatives assumed to divert similar quantities of organics from landfill
Public process / education - won't distinguish between alternatives
Politically implementable - a means to an end

**Table 5-3.** Objectives Hierarchy Weights

| Objectives Hierarchy | | Relative Importance Weight | % of Total |
|---|---|---|---|
| **1. Minimize Long-term Life Cycle Cost (after accounting for revenues)** | | 100.0 | 26.3 |
| **2. Minimize Environmental Impacts** | | | |
| | 2a. CO2eq and other emissions (PM10, NOx) from vehicles | 31.3 | 8.2 |
| | 2b. CO2eq generated from energy, process, or end use | 31.3 | 8.2 |
| | 2c. Localized odours from LW/SW infrastructure | 31.3 | 8.2 |
| | 2d. Chemical demand | 6.3 | 1.6 |
| **3. Minimize Socioeconomic Impacts** | | | |
| | 3a. Community disruption | 36.8 | 9.7 |
| | 3b. Cultural and terrestrial resource protection (historic, cultural, archaeologically signifcant resources including endangered species) | 22.1 | 5.8 |
| | 3c. Economic development opportunities | 11.1 | 2.9 |
| **4. Maintain Flexibility** | | | |
| | 4a. Consistent with implementation schedules for both wastewater and solid waste programs | 15.0 | 3.9 |
| | 4b. Maintains the abiltity to adapt to beneficial future technologies and opportunities | 15.0 | 3.9 |
| | 4c. Ability to respond to future regulatory change | 30.0 | 7.9 |
| **5. Ease and Safety of Operations and Maintenance** | | 50.0 | 13.2 |

## **Table 5-4.** Risk Impacts

### ***Public Acceptability Risk Impacts***

Any new wastewater or solid waste project is likely to result in opposition. The risk of adverse public perception, including political risks, is evaluated in the context of whether an activity is likely to run counter to public expectations. If the opposition is strong enough, experience has shown that the project might fail to be implemented as planned.

| Rating | Impacts / consequence |
|---|---|
| Insignificant | • Project enjoys broad support with no organized opposition.<br>• No news coverage<br>• Media call but no follow up story |
| Minor | • Pockets of isolated opposition to the project.<br>• Negative letter(s) to the editor |
| Moderate | • Substantial proportions of the public are against the project.<br>• Public opinion survey results in a below average / unsatisfactory rating<br>• A negative news story |
| Major | • Public opinion negative. Project would fail in a public vote. Intervention from city political leadership; city legislation<br>• Negative news stories<br>• 25,000 phone calls in one day (not necessarily complaints) |
| Extreme | • Public opinion strongly aligned against project. Project would soundly fail in a public vote.<br>• Daily local negative news stories<br>• Negative national news coverage<br>• Vote of no confidence by elected representatives |

### ***Technologic and Financial Risk Impacts***

The risk exists that a new process or technology will not work as planned, thus resulting in unbudgeted costs and political embarrassment to correct the deficiencies. Such unanticipated changes in costs have the potential to trigger unplanned rates increases or decreases.

| Rating | Impacts / consequence |
|---|---|
| Insignificant | • Does not require budget revisions<br>• No rate or financial performance impacts<br>• Some staff time to correct errors |
| Minor | • Small but noticeable impact on short-term financial performance<br>• Small (1-2% or less) impact on short-term rate, with no noticeable impact on medium to long term rate path(s) |
| Moderate | • Short-term rate impact 2% - 4% rate increase<br>• Noticeable rate impact (1%/year) on medium- and long-term rate path |
| Major | • Short-term rate impacts 4% - 6% rate increase<br>• Noticeable rate impact (>1%/year) on medium- and long-term rate path<br>• Rating agencies make note of errors in ratings reports, and/or warns the CRD of downgrade potential |
| Extreme | • Short-term rate impact > 6% or more rate increase<br>• Rate impact >2%/year on medium and long-term rate path |

## ***Climate Change Risk Impacts***

The risk exists that climate change will result in unanticipated sea level rise and/or a substantial increase in the volatility of weather patterns and extreme events. Such changes have the potential to require costly retrofits to parts of the wastewater or solid waste system.

| Rating | Impacts / consequence |
|---|---|
| Insignificant | • Does not require budget revisions<br>• No rate or financial performance impacts<br>• Some staff time to correct errors |
| Minor | • Small but noticeable impact on short-term financial performance<br>• Small (1-2% or less) impact on short-term rate, with no noticeable impact on medium to long term rate path(s) |
| Moderate | • Short-term rate impact 2% - 4% rate increase<br>• Noticeable rate impact (1%/year) on medium- and long-term rate path |
| Major | • Short-term rate impacts 4% - 6% rate increase<br>• Noticeable rate impact (>1%/year) on medium- and long-term rate path |
| Extreme | • Short-term rate impact > 6% or more rate increase<br>• Rate impact >2%/year on medium and long-term rate path<br>• Rating downgrade for CRD debt |

# 6 Short-List of Thematic Alternatives

Following the May 12 workshop, the component options and long-list of thematic alternatives were subjected to an initial high-level screening analysis, using the elements described in Section 5, by the consultant team. This information was presented and discussed at the July 3, 2008 workshop. These initial results provided some insights and suggested that Alternatives 1 and 5, which were generally simpler and less capital intensive, had some advantages over Alternatives 2, 3 and 4. However, at a screening level, the complexities of the alternatives precluded eliminating any particular alternative on the sole basis of this level of numerical analysis.

However, the workshop discussion did result in a refinement of some of the alternatives and the elimination of one alternative:

- Long-term biosolids landfill land application at the Hartland Landfill, which was part of Alternative 1, was noted to be inconsistent with CRD policy and the need to preserve landfill capacity. To this end, the use of a market survey was discussed as a means to evaluate the potential opportunities for biosolids land application and other uses outside the CRD area. CRD staff directed that a high-level market survey on biosolids reuse opportunities outside of the CRD be initiated to generate information for the alternative analysis. This survey was completed in August 2008.

- Alternative 3 was concluded to be a less practical long-term alternative since efforts to stabilize SW organics via separate digestion, with energy recovery, should be used to produce a product suitable for reuse (i.e. land application, as in Alternative 4) rather than a feed for a thermal destruction / energy recovery system. Therefore, Alternative 3 was removed from further consideration as a short-list alternative.

- It was recognized that Alternative 4 could include some co-digestion of SW organics, generated locally, with WW sludges. Accepting SW organics that require minimal processing (e.g. fats/oils/grease) could reduce costs associated with pre-processing. Therefore, Alternative 4 will include this element in the further evaluation

- Alternative 5 included thermal destruction of WW sludges at a CRD facility. The other possibility, which was considered as a component option, involved off-site cement kilns. Both options will be considered in the further evaluation.

Table 6-1 presents the short-list of alternatives with the various refinements discussed above.

**Table 6-1.** Short-List of Thematic Alternatives

| Thematic Alternative | Stabilization | Thermal Destruction | Material End Use | Energy End Use |
|---|---|---|---|---|
| 1. Maximum Beneficial Reuse | | | | |
| SW organics | compost - Hartland Area | n/a | SW organics land application - distributed within CRD | n/a |
| WW sludges | digest - Macaulay Area | n/a | biosolids land application outside CRD | co-generation (heat and electricity) |
| 2. Maximum Integration and Maximum Energy Recovery | | | | |
| SW organics | co-digest - Hartland Area | co-mass burn with MSW, FBC for remainder - Hartland Area | ash reuse | pipeline natural gas/vehicle fuel |
| WW sludges | co-digest - Hartland Area | co-mass burn with MSW, FBC for remainder - Hartland Area | ash reuse | pipeline natural gas/vehicle fuel; electricity |
| 4. Separate Digestion and Balanced Energy Recovery / Benefical Reuse | | | | |
| SW organics | digest - Hartland Area | n/a | same as Alt 1 | same as Alt 2 |
| WW sludges[1] | digest - Macaulay Area | same as Alt 2 | same as Alt 2 | same as Alt 2 |
| 5. No Digestion and Balanced Energy Recovery / Beneficial Reuse | | | | |
| SW organics | compost - Hartland Area | n/a | same as Alt 1 | n/a |
| WW sludges[2] | n/a | FBC - Macaulay Area or cement kiln | ash reuse | electricity |

Notes:
1. Includes potential for co-digestion of locally generated SW organics.
2. Both options will be evaluated to generate information.

# 7 Next Steps

The consultant team will conduct a more detailed analysis of the short-list alternatives that will consider new information developed by the biosolids reuse market survey. The analysis findings will be documented in a subsequent Discussion Paper and the information used to further develop the Distributed Wastewater Management Strategy.