DISCUSSION PAPER

Capital Regional District
Core Area Wastewater Management Program

Greenhouse Gas Management Strategy

Discussion Paper – Methodology to Assess GHG Management Performance
032-DP-1

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1 Objective

The Capital Regional District has committed to developing the Core Area Wastewater Management Program while incorporating the principle of achieving a carbon neutral project. To this end, the overall objective of this Discussion Paper is to describe the methodology that will provide the CRD with information needed to make decisions in this context.

In meeting this overall objective, the Discussion Paper has several specific objectives. The first objective is to describe, at a high-level, the approach used to estimate greenhouse gas (GHG) emissions and how this information will be incorporated into the decision-making process of the current project. The second objective relates to setting Program GHG emission targets.

2 Approach

2.1 Overview

One of the challenges in developing a large and sophisticated infrastructure program is synthesizing complex information into a manageable and readily interpreted format. A second challenge is one of timing – oftentimes one decision will affect a subsequent decision, which could then impact the original decision. The Core Area Wastewater Management Program is not immune to these challenges; the Activities underway, including the Greenhouse Gas Management Strategy (GHGMS), were structured to address this situation.

The Program's GHG analysis is being conducted on two levels. The first level deals with specific elements or subject areas within the overall Program, where different element alternatives/ strategies/scenarios could have a significant influence on the Program's total carbon footprint. The second level focuses on the total carbon footprint of the adopted overall wastewater management strategy. A general description of these analyses is provided in Sections 2.2 and 2.3. Section 2.4 provides a general commentary on the methodologies used in the various GHG analyses.

2.2 Specific Element GHG Analyses

Work completed for the Integrated Resource Management Strategy (IRMS) revealed a number of subject areas that may have a significant relative influence on total GHG emissions or carbon footprint associated with the CRD's Program. The first area is biosolids management / organic residuals energy and resource recovery where, as presented in Discussion Paper 031-DP-4, four broad strategies were identified for analysis. There is a significant amount of potential energy contained in wastewater sludges and in organic material separated from the solid waste stream. If captured in some form, such energy could off-set the use of non-biogenic energy (e.g. natural gas, diesel fuel) and the GHG emissions associated with this energy. Alternately, some strategies require a considerable amount of material transport that, in turn, generates GHG emissions. Some strategies have the potential to sequester carbon, as well as off-set commercial fertilizer use and the GHG emissions associated with fertilizer production and transport. Other strategies include organics processing systems that themselves will be a direct, non-energy-related source of GHG emissions, particularly methane.

Clearly, this subject area has substantial complexity from a GHG perspective and notable diversity between broad strategies. To this end, specific GHG emission calculations are being conducted inside an analysis spatial boundary that considers only biosolids management / organic residuals energy and resource recovery and is constrained to operations-related emissions. The analysis includes associated GHG emissions generated through to Year 2065, which defines the temporal analysis boundary. The exclusion of construction-related emissions for this particular analysis is based on de Haas (2008), which indicated that these emissions typically account for < 5% of the total emissions associated with a wastewater treatment facility over a 15-year life-cycle. Even though this particular CRD analysis is only considering the biosolids fraction and associated infrastructure, this exclusion appears reasonable given the long time horizon of the analysis.

The biosolids management / organic residuals energy and resource recovery strategies GHG evaluation information will be presented in Discussion Paper 031-DP-10, where it will be integrated into the value model contained in the Sustainability Assessment Framework (SAF) applied specifically to this subject area (Discussion Paper 031-DP-1 provides a general overview of the SAF approach). Within this value model the broad strategies are scored relative to one another in terms of GHG emissions (e.g. total CO2e emitted over life-cycle). The SAF also considers the economic implications of GHG emissions by including a cost on emissions (e.g. \$/tonne of CO_2e) that could be incurred through future carbon taxes, cap and trade schemes or through a need to purchase offsets. Also, credits will also be applied where offsets are realized directly by the strategy. In this way, GHG emissions become part of the economic analysis.

The second subject area of specific GHG interest concerns wastewater heat recovery. Large volumes of relatively warm wastewater/effluent contain substantial heat energy that could be used to off-set non-biogenic energy (e.g. natural gas) use and their associated GHG emissions. The alignment of heat supply/demand opportunities is one of the considerations in developing a range of scenarios for the Distributed Wastewater Management Strategy, which considers the siting of distributed wastewater treatment/heat recovery facilities. Specific GHG emission calculations are being conducted within an analysis spatial boundary that considers only the distributed treatment facilities and is again constrained to operations-related emissions, extended to a temporal boundary of Year 2065. This information will be presented in an Activity 036 Discussion Paper and integrated into the value model contained in the SAF applied to this specific subject area. Again, within the SAF value model, the scenarios will be scored relative to one another in terms of GHG emissions, with carbon costs included in the economic analysis.

The IRMS identified other resource recovery opportunities (pressure energy – Discussion Paper 031-DP-5; phosphorus – Discussion Paper 31-DP-6; water – Discussion Paper 031-DP-8) that could impact the Program's carbon footprint. However, the practical extent of their recovery suggests their relative contribution to the total carbon footprint will be relatively small. More importantly, none of these specific opportunities impact key long-term Program decisions. Thus they can be evaluated in detail, from a GHG perspective, if and when they are considered for implementation.

Urine separation, also identified in the IRMS (Discussion Paper 031-DP-9), could have an important relative impact on the Program's carbon footprint if implemented. However, as presented in the Discussion Paper, this approach is a longer-term prospect that would not affect key Phase 1 (i.e. near- and medium-term) Program decisions. Thus the GHG implications of this approach can be evaluated in the future should it be considered for implementation as developing concepts and technologies allow.

2.3 Total Program GHG Analysis

The information generated from the relative GHG analyses, described above, will provide the CRD with sufficient knowledge for decision-making purposes when incorporated into the overall analysis provided by the Sustainability Assessment Framework. Ultimately, based on all available information, the CRD will select a defined wastewater management strategy and associated approaches and infrastructure elements that comprise this strategy. At this point a question can be asked – where does the Core Area Wastewater Management Program lie with respect to the principle of achieving a carbon neutral program? This question can be answered through the conduct of a carbon footprint analysis of the selected strategy.

What separates this total GHG evaluation from the earlier relative GHG analyses is the analysis spatial boundary, which is drawn more broadly to more comprehensively include GHG emissions associated with the Program. For example, GHG emissions associated with infrastructure construction are included in this analysis where practical, such as "embedded" emissions for construction materials as well as emissions due to energy expended during site activities (e.g. earthwork). Another example relates to the fate of carbon and nitrogen in effluent discharged to the environment – these elements can be transformed into powerful GHGs (e.g. nitrous oxide) in water bodies by microbial activity. The challenge in developing the spatial boundary for the absolute analysis is sensibly balancing comprehensiveness against complexity: the guiding principle is to focus on GHG emission sources that are the main potential contributors to the total carbon footprint.

As per the specific element analyses, the temporal boundary of the total program analysis will again be Year 2065. Thus the evaluation will include all GHG emissions associated with the Program infrastructure, as defined in the spatial boundary, over an approximate 50 year period. Like the specific element GHG analyses, the cost of emissions will be included in the total Program economic analysis.

2.4 Methodology Commentary

It is worthwhile to address the methodology of GHG / carbon footprint analysis as applied to wastewater management because it is a complex subject that can be easily misunderstood. There are a variety of specific contexts to consider, the first being the technical methodologies applied to the system under consideration and the individual GHG sources within a given system. The second context is broader and is related to accounting principles. A third context considers the future cost of carbon and carbon equivalents.

Technical

First consider the specific individual emission sources that may be associated with a wastewater management system. At the present time, the Intergovernmental Panel on Climate Change (IPCC) provides methodologies to estimate GHG emissions from many different types of systems (e.g. energy, industrial, agricultural, waste management, etc.), which include specific sources within these systems, in the context of national GHG inventories. The IPCC structures these methodologies into three “tiers” (IPCC 2006): **Tier 1** – a top down approach that applies an “average emission factor” to a source of interest; **Tier 2** – similar to Tier 1 but uses country-specific emission factors rather than the average values of Tier 1; and **Tier 3** – a bottom up approach that uses detailed emissions modeling and/or continuous measurement at the facility level. At the present time the IPCC wastewater system methodologies are largely constrained to Tiers 1 and 2, where emission factors are based on broad conclusions drawn from information available in the scientific literature. Researchers and wastewater industry-specific organizations are working towards methodologies that could be considered Tier 3. As an example, the US-based Water Environment Research Foundation (WERF) has such initiatives currently underway.

However, at this time, no widely-accepted, standardized guidelines yet exist to estimate emissions from wastewater infrastructure at a facility level (California Air Resources Board et al. 2008). Local governments currently use the higher tier methodologies that originate from the IPCC and have been refined by other agencies such as the United States Environmental Protection Agency (USEAP 2008) and Environment Canada (EC 2008). This same general approach has been adopted for the CRD Program at this time, where recent research findings and application case studies are being reviewed and incorporated into the methodologies where appropriate.

Accounting

Sections 2.2 and 2.3 identified a variety of specific emissions sources to be included in the GHG analysis / carbon footprint calculations. The sources can be grouped in a variety of ways based on developing GHG accounting procedures. For example, the World Resources Institute (WRI) and World Business Council for Sustainable Development (WBCSD) categorizes emissions into a series of “scopes” (WRI and WBCSD 2004): **Scope 1** – all direct GHG emissions; **Scope 2** – indirect GHG emissions associated with consumption of purchased or acquired electricity, steam, heating or cooling; and **Scope 3** – all other indirect emissions not covered in Scope 2. All of the potential emission sources discussed in the previous sections can be readily categorized into these scopes. Therefore, this WRI/WBSCD categorization system has been adopted for the CRD program to ensure consistency in definition when discussing GHG emissions.

When viewing the CRD Core Area Wastewater Management Program as a whole, in the context of the adopted strategy and the total carbon footprint of this strategy, there are resources available that the CRD can use to guide them in their accounting of this strategy. As discussed previously, of particular importance is defining the GHG assessment boundary. The WRI and WBCSD (2005) protocol for project accounting is an example of the reference documents being used in assessing the Program’s total carbon footprint.

Carbon Costs

The global carbon market today is still relatively immature and prices vary widely. For example, carbon equivalents are presently trading at approximately CDN$32 to 39 / t CO_2e on the European Climate Exchange (www.europeanclimateexchange.com). This exchange attracts the majority of carbon trading in support of the European Union Emission Trading Scheme, which allows EU member states to meet their commitments under the Kyoto Protocol. In comparison, carbon is currently trading at about CDN$3 / t CO_2e on the Chicago Climate Exchange (CCX) (www.chicagoclimatex.com). The CCX is a voluntary, legally binding trading system, which started in 2003, where its members are required to meet annual emission reduction targets. More locally, the Province’s current carbon tax on fuel prices carbon at CDN$10 / t CO_2e in 2008, increasingly linearly to CDN$30/t CO_2e in 2012 (Ministry of Small Business and Revenue 2008)

Beyond the near-term uncertainty in market carbon prices, as demonstrated above, predicting the future cost of carbon contains even greater unknowns – recent findings of IPCC Working Group III highlight the challenge. Tirpak (2008) indicated future carbon prices could vary between US$5 and 80 / t CO_2e by Year 2030 and US$15 to 155 / t CO_2e in Year 2050 in response to policies that would see a specified level of atmospheric CO_2 stabilization achieved (i.e. 550 ppm by Year 2100). The induced level of technological change is part of the variability in these prices. Lowering the CO_2e stabilization level would increase research and development efforts and investment in new technologies in the next few decades.

The analyses described in Section 2 use a Year 2065 temporal boundary and thus it is important to consider the uncertainty of carbon costs during this long horizon. In order to address this issue, a sensitivity analysis approach has been adopted for integrating carbon costs within the economic analyses. Simply stated, the analyses will be re-run several times using different carbon cost scenarios to assess the sensitivity on the overall financial analysis. Given the uncertainty in the long-term, the carbon costs will be bound within the price ranges contained in Tirpak (2008) and the sensitivity of the economic analysis will be assessed on this basis.

3 Targets

3.1 Overview

The GHG analysis approach described in Section 2 did not explicitly discuss GHG targets for either the specific elements of the wastewater system or for the Program as a whole. For the GHG analyses described in Section 2.2, different alternatives/strategies/scenarios for specific elements of the Program are assessed relative to one another. But there is the question of GHG targets and what might be required and appropriate for the CRD Program. The following sections explore this topic area.

3.2 Nuances of Carbon Neutral

As discussed previously, the CRD has already stated an implied target for GHG emissions for the Core Area Wastewater Management Program: carbon neutrality. “Carbon neutral” is a popular phrase – in fact, Oxford American Dictionary’s 2006 Word of the Year (*The Washington Times*, November 14, 2006) – and many definitions exist. However, the Provinces *Bill 44 – 2007 Greenhouse Gas Reductions Target Act* (passed in November 2007) definition of carbon neutral captures its two key themes: (i) minimizing GHG emissions and (ii) net (i.e. reduce) GHG emissions that occur to zero through emission offsets.

On the basis of this definition, it can be seen that a carbon neutral status can, in theory, be achieved for any project or program: the question comes down to how much the owner needs to spend to offset unavoidable emissions. In this context, a target for the overall CRD Program could be to design the strategy such that the unavoidable emissions, and associated offset costs, are reduced to their lowest level. However, there may be a cost to achieve such a status that in turn needs to be balanced against the remaining offset cost. The work described in Section 2.2, through incorporation of the potential costs of GHG emissions into the economic analyses, implicitly considers the costs to “offset” unavoidable emissions and thus provides this balance.

A more challenging question relates to unavoidable emissions and whether a wastewater management program on a CRD scale can be designed to be a zero GHG emitter and thus without the need for any “external” offsets. Again, the analyses described in Section 2 provide information to answer this question.

3.3 Regulatory Perspectives

While minimizing GHG emissions is a theme, setting GHG targets suggests the establishment of measurable and thus quantifiable parameters. Targets could be set based on regulatory requirements or on the basis of CRD policy that reflects its values.

Consider here the regulatory aspect. The Province's *Bill 44 – 2007* does not presently contain GHG emission reduction targets for public sector organizations (PSO) (e.g. local governments) outside of the Provincial government. For such PSO's, the Bill requires annual reporting on actions and plans taken to minimize GHG emissions. As a related aside, it is important to note that such requirements are applied "corporately", meaning they consider GHG emissions associated with all PSO operations. In the context of a local government such as the CRD, the corporate emissions would consider those generated by all utility operations, including, for example, potable water supply and solid waste management in addition to wastewater management. Local governments could examine their services as a whole and develop strategies to achieve the reductions, beginning with those that are most cost-effective and minimally impact service.

The Province has also tabled *Bill 31 – 2008 Greenhouse Gas Reduction (Emissions Standards) Statutes Amendment Act*, 2008. This legislation, if and when enacted, would give the Province the means to develop regulations that could include specific reduction targets for GHG emissions from waste management facilities that, supposedly, could include wastewater management systems. The Province has issued a *Landfill Gas Regulation Policy Intentions Paper for Consultation (May 2008)* that focuses on GHG emissions from landfill operations, where this regulation is intended to come into effect in January 2009. However, nothing similar for wastewater systems has been proposed by the Province at this time.

Similar to the Province, the Federal government has not introduced legislation/regulations that specifically target the wastewater sector. The *Regulatory Framework for Air Emissions (April 26, 2007)* specifies mandatory emission reduction targets, but applies only to major industrial sectors.

3.4 Policy Considerations

Based on the current absence of specific regulatory drivers, the CRD has the opportunity to consider its own GHG emission targets, at least in the near-term, for the Core Area Wastewater Management Program. In this circumstance, such considerations would be applicable to CRD policy decisions of its own choosing.

Possible Approaches and Challenges

Two approaches could be considered for use in developing GHG targets, the first being establishment of an absolute GHG emission target expressed, for example, in terms of an annual mass (t CO_2e/yr) or unit mass (t CO_2e/ML of wastewater treated). The second approach involves emission reductions, expressed as a percentage, achieved relative to some baseline condition.

At this point in time it is reasonable to suggest that the first approach is premature in the context of the wastewater management industry. While wastewater management-related GHG research reaches back several decades, the information generated by this work is extremely limited (e.g. Barton and Atwater (2002) provide a comprehensive summary on one specific GHG topic, as an example). It could be pragmatically stated that only in the past two to three years has the global wastewater industry begun to give the GHG subject serious consideration and, as a result, a higher volume of new information is only now coming available.

The second approach, dealing with relative emission reductions, also has its challenges. As noted in Ministry of Community Services and Community Energy Association (2008), "… not all infrastructure projects will lead to net GHG emission reductions". This has lead to categorizing projects/programs that either (i) provide an actual, absolute reduction in GHG emissions relative to existing systems and infrastructure or (ii) will increase net GHG emissions *relative* to existing systems and infrastructure but would provide lower emissions relative to a "business-as-usual" project or program. In the context of wastewater management systems, the same available information constraints that hamper the first approach also impede this second approach. These constraints are illustrated in the following example.

An Illustrative Example

The significance of these information constraints is best illustrated by an example, using a relatively large service population that is generating 100 ML/d of wastewater. Sophisticated wastewater treatment systems at this scale require in the order of 350 kWh of electricity to treat 1 ML of wastewater (e.g. City of Edmonton 2003). The carbon intensity of electrical power generated/supplied in British Columbia is approximately 37 g CO_2e/kWh (Sahely et al. 2006, BC Hydro 2005). Using these values, the annual energy-related emissions associated with supplying power for wastewater treatment is approximately 470 t CO_2e/yr.

Now consider the potential GHG emissions associated with discharging nitrogen-bearing effluent to the environment. Effluent nitrogen can be converted to nitrous oxide (N_2O), a powerful GHG with a global warming potential (GWP) approximately 300 x carbon dioxide (CO_2) (IPCC 2006), by microorganisms in receiving water bodies under certain conditions. The IPCC (2006) methodology currently assumes, as a default value, that 0.5% of effluent nitrogen is converted to N_2O in receiving bodies. Assuming effluent that contains 15 mg N/L of nitrogen, and using the above values, gives annual effluent-derived GHG emissions of about 1,300 t CO_2e/yr. The effluent-derived GHG emission is almost three times larger than the energy-derived GHG emission in this particular example. As a result, in this example, any improvements in treatment energy efficiency would be rendered practically insignificant when considering emissions that more comprehensively encompass the facilities total carbon footprint. These values also demonstrate the importance of defining the boundary that contains the analysis.

Continuing with this example, the IPCC acknowledges the large uncertainty in the N_2O emission factor, which is dependent on the type of water body receiving the effluent (e.g. stream/river, estuary, etc.) and the physical, chemical and biological processes within this system. In addition, a major contribution to the uncertainty is that "… insufficient field data exist to improve this factor" (IPCC 2006).

This example is not intended to be representative of the CRD situation, but it illustrates the challenges facing the wastewater industry in the general realm of GHG emission and carbon footprint analyses and, specifically, the establishment of GHG targets for wastewater management systems.

Targets or No Targets?

The preceding discussion has argued that it would be premature for the CRD to set specific GHG targets, in either an absolute or relative form, for the purposes of planning the Program at this time. However, the CRD is well positioned to include potential GHG emissions in its decision-making for the Program. The analyses described in Section 2 will provide the CRD with the information needed to make informed decisions on key elements of the Program while considering carbon footprint implications.

Over time, as more industry information becomes available and regulatory approaches evolve, it may become possible to set specific GHG targets in the future once Program elements are implemented. The targets will have to be defined carefully within boundaries where realistic and defendable analysis assumptions can be used.

4 Summary

The Core Area Wastewater Management Program is being developed at a very unique time in history, where climate change and GHG emissions have emerged as important community values. The CRD has an exciting opportunity to capitalize on its situation by integrating carbon footprint considerations into its fundamental wastewater strategy decision-making. To this end, this Discussion Paper describes how the CRD can generate information to feed into its decision-making activities.

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