CAPITAL REGIONAL DISTRICT, VICTORIA B.C.
CORE AREA LIQUID WASTE MANAGEMENT PLAN
SLUDGE MANAGEMENT OPTION STUDY

Harlan G. Kelly	Larisa Hutcheson	Al Gibb	David Harper
Dayton & Knight Ltd.	Capital Regional District	Dayton & Knight Ltd.	Westland Resource

ABSTRACT

As a key component in the Capital Regional District (CRD) Core Area Liquid Waste Management Plan (LWMP) plan development, the CRD prepared a Sludge Management Options Study in 2004 to investigate and select best practicable options for handling and treating primary and secondary sludges from the possible future Macaulay Point and Clover Point wastewater treatment facilities.

Beneficial uses evaluated included land spreading for fertilizer value (on forest and agricultural land), disposal at the local landfill, dedicated landfill disposal, direct distribution and marketing, use in municipal gardens and roadside landscaping, and production of energy and products.

Treatment options investigated included anaerobic digestion, in-vessel composting, alkaline stabilization, thermal drying, and thermal destruction. These options were expanded during the study and organized into six categories for evaluation:

KEYWORDS

Treatment of and Beneficial Use of Biosolids, Capital Regional District, Victoria B.C.

INTRODUCTION

Approval of the Capital Regional District (CRD) Core Area Liquid Waste Management Plan (LWMP) requires that the CRD submit a sludge management plan to the Ministry of Water, Land and Air Protection by March 31, 2005. The purpose of this study was to identify best practicable options for handling and treating sludge from the future Macaulay Point and Clover Point wastewater treatment facilities in the event that treatment is required as set out in the CRD Liquid Waste Management Plan (LWMP). This work was undertaken in conjunction with a parallel study for sludge treatment site selection that is not discussed here.

The sludge management study was assigned on September 10, 2003 and undertaken from October through January 2004. Two key workshops were undertaken, the first on October 7, 2003 to identify program goals and constraints, and the second on November 19, 2003 to assist in evaluating beneficial use solutions and treatment solutions for the Macaulay Point and Clover Point sludge.

Limitations to the study included:

a) a study period of less than 50 years but in accordance with the CRD Liquid Waste Management Plan (100 years is typically used for facility requirements of this magnitude);
b) the consideration of sludge production from the Macaulay Point and Clover Point planned treatment facilities only (the Saanich Peninsula WWTP will contribute a significant fraction of sludge generated in the CRD and should in future be considered in all long term beneficial use plans);
c) other necessary sludge management goals not addressed in this study include public education, source control, continued research and investigation on solutions and liaison with the regulators to achieve more sustainable legislation; and
d) the uncertainty of the timing for treatment.

The study was developed in several steps, including conclusions and recommendations for the beneficial use solutions for treated biosolids and options to treat the primary and future secondary sludges from Macaulay Point and Clover Point treatment facilities.

The beneficial use options to be investigated were set out in the study terms of reference; these were land spreading for fertilizer value (on forest and agricultural sites as well as use for mine and gravel pit reclamation), disposal at Hartland landfill, dedicated land disposal, and direct distribution and marketing. The beneficial use options were expanded and categorized during the study to include energy production and manufactured products.

The treatment options to be investigated as set out in the terms of reference were anaerobic digestion, in-vessel composting, alkaline stabilization, thermal drying, and thermal destruction. These options were expanded during the study and organized into the categories of biological treatment; chemical treatment; thermal reduction (gasification and thermal oxidation such as fluidized bed incinerator); destruction (deep well injection and wet air oxidation); co-digestion (composting with wood waste), and water reduction (thermal drying).

The beneficial use and treatment categories were examined for feasible options; infeasible options were discarded if they were found to be inappropriate for the CRD or if there were inadequate resources available in the CRD or locally to support the option. For the purposes of this study, the options were developed for a short to mid term time period, 2010 to 2025, and a long term period of 2026 to 2045.

At the October 7, 2003 workshop CRD staff selected the key program goal that the interim and long term sludge management solutions will be sustainable by reflecting social, economic and environmental values in waste management. Eleven to fourteen specific constraints for the evaluation of the respective beneficial use and treatment solutions were also identified. The primary goals and constraints were developed from the initial list of evaluation criteria set out in the study terms of reference (i.e., environmental impact, potential impact on neighbours, technical viability and effectiveness, ease of implementation, and indirect economic impacts).

The options were initially screened by the consulting team using the goals and constraints developed at the October 7, 2003 workshop. A second workshop including CRD staff and the

Engineering Liaison Committee (ELC) was held on November 19, 2003 to assist in evaluating the options. At the November 19, 2003 workshop, CRD engineering staff and the ELC members identified the relative importance of the goals and constraints, and the degree to which each beneficial use option and treatment option satisfied each goal and constraint. This evaluation was used to provide the local understanding needed to complete the evaluation by the study team.

The CRD sludge characteristics were assumed to be typical of a domestic wastewater source, and the levels of contaminants were anticipated to be within allowable regulatory limits to produce Class A biosolids. The risk regarding the introduction of pharmaceuticals and personal care products (PPCP) into the biosolids was assumed to be acceptably low; however, the potential for contamination by metals and complex organics both illustrates the need for the CRD to continue to be proactive in carrying out source control and public education programs.

The B.C. Provincial OMRR (2002) regulations for treatment and use of biosolids (treated sludge) identify requirements for Class A and Class B treatment, as well as the requirements for the protection of public health and the environment when undertaking beneficial use solutions. The regulations were included in the constraints for the treatment categories and for the beneficial use categories being considered in this study.

BENEFICIAL USE OPTIONS

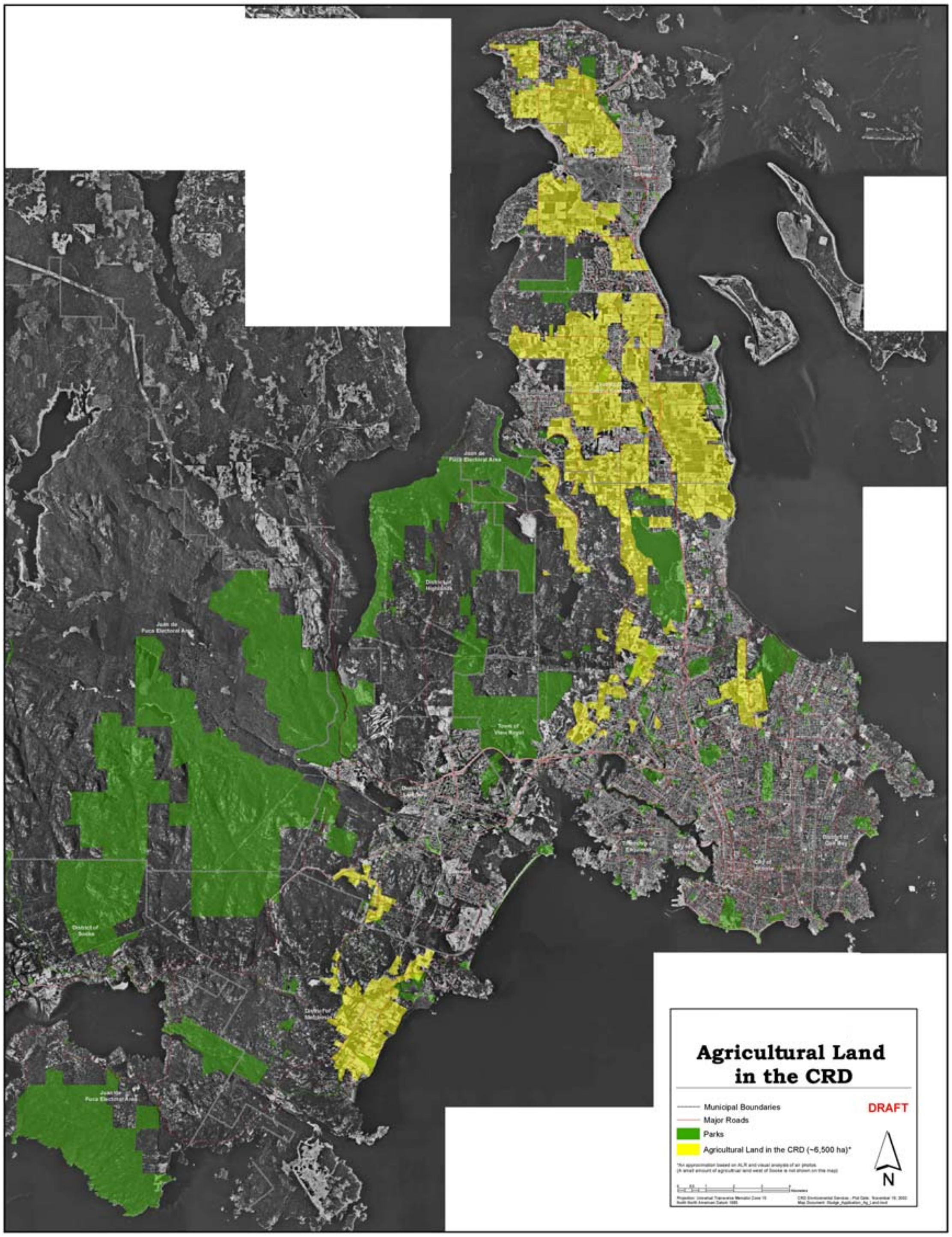
Beneficial use was identified as the driver to selection of the treatment process, because in most cases the regulatory requirements associated with the various beneficial use options contain specific requirements for treatment. The advantages and disadvantages of each beneficial use option are summarized in Dayton & Knight Ltd. (2004) report entitled Core Area LWMP Option Study for:

a) agricultural land spreading, forest land spreading, mine reclamation,
b) distribution and marketing of manufactured construction products,
c) distribution and marketing of compost and topsoil, and
d) energy production.

The advantages and disadvantages of disposal at Hartland landfill are also given. Tables A-1 and A-2 provide a summary of beneficial use and treatment options and are attached as Appendix A for convenience. The advantages and disadvantages of each option were used in the evaluation to select the preferred option(s).

Land spreading criteria were selected for conservative application limits and life cycle loadings. The projected forest agronomic application area requirements varied from about 2,000 ha to over 50,000 ha depending on the treatment solutions selected for a 2010 to 2045 study period. This was well within available supply of forest soils, especially for anaerobic digestion treatment and primary treatment needs. These requirements also included a large safety factor for forest use and application rates.

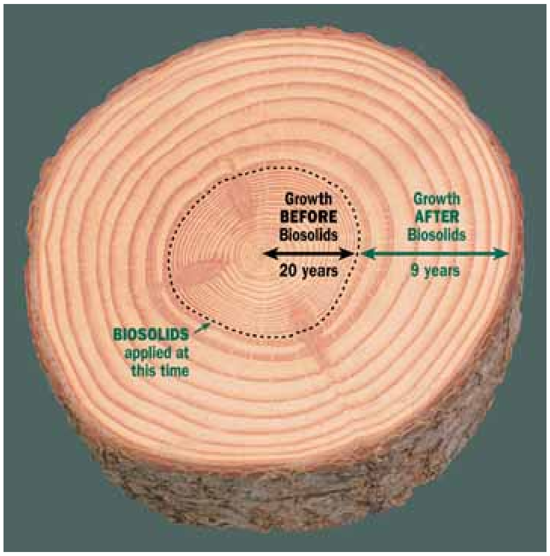
The preferred agronomic application rates were lower for agriculture than forest soils but the percentage of usable land was higher for agriculture, and consequentially land area requirements for agricultural use were lower, varying from about 1,200 ha to 40,000 ha, depending on the treatment solutions selected for a 2010 to 2045 study period. This was greater than current available agricultural land supply within the CRD for all treatment solutions other than reduction (incineration). Consequently, application to agricultural soils, while an important component that should be used (where land spreading is a preferred option) should be considered as a partial solution only. Figure 1 illustrates the agricultural and park base for the Victoria area.



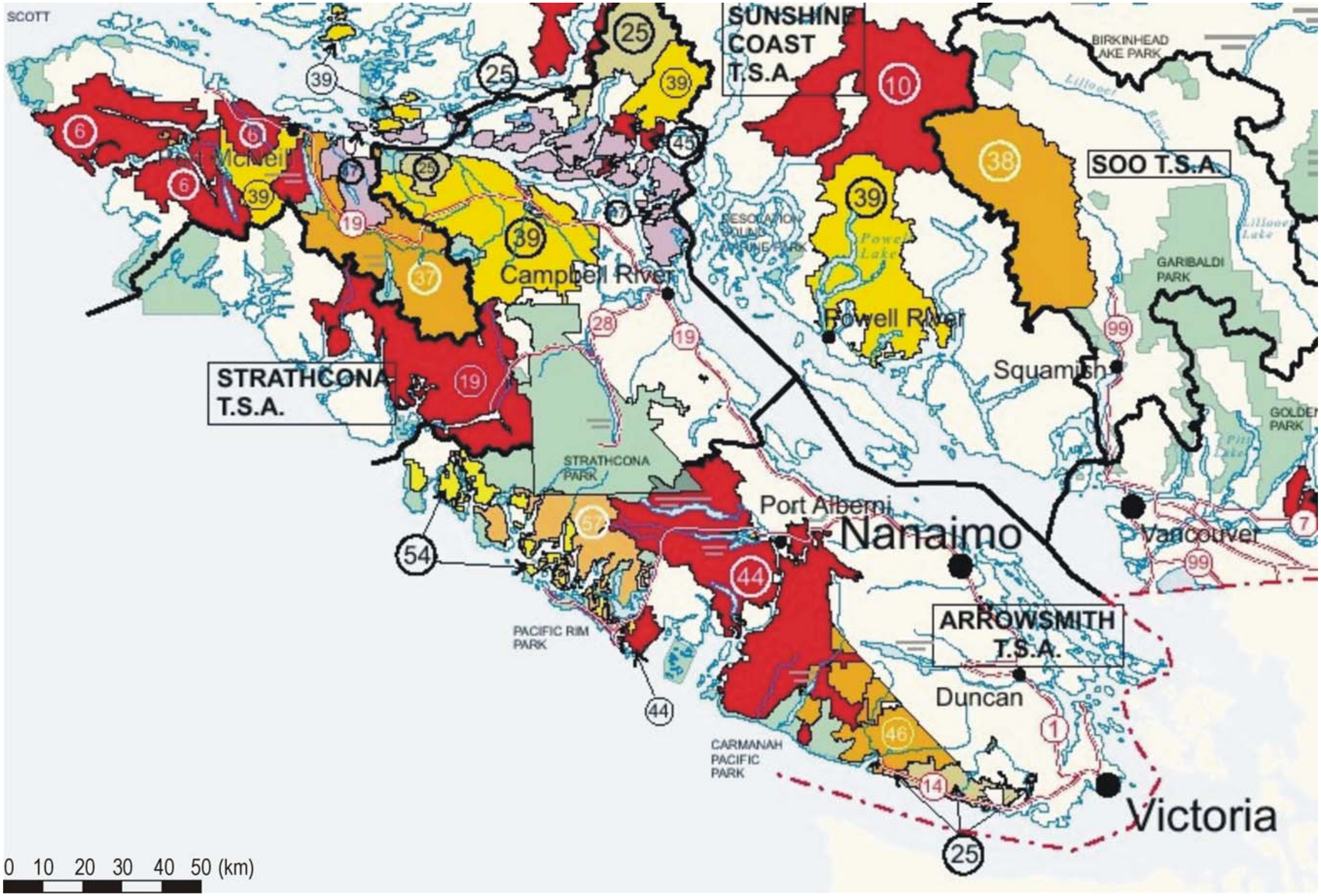
Agricultural Land in Capital Regional District, Victoria, B.C. Figure 1

The preferred beneficial use solution was found to be land spreading of anaerobically digested biosolids. Land spreading would have a lower cost than the other beneficial use options, and it would have significant environmental benefits, such as improved soil fertility and water holding capacity. Anaerobic digestion prior to land spreading would reduce the volume of solids by 40% to 50%, would greatly reduce odour potential, and treatment prior to land spreading would be necessary in any case to meet regulatory requirements.

Land application to forest sites was identified as the highest priority with application to agricultural sites as second highest priority, due partly to limited land availability for agricultural applications. There is an extensive land base of potential forestry application sites within and near the CRD. In addition, forestry sites would generally be more remote from residential areas, and would therefore have a lower impact on neighbours than agricultural applications (i.e., odours and truck traffic). Forestry sites can generally accept higher biosolids application rates than agricultural sites. Further, agricultural applications are generally restricted to certain times of the year by crop planting and harvesting schedules, while forestry applications are only restricted by climate considerations. On the other hand, agricultural sites generally have a relatively low cost for biosolids application, due to flat topography and ease of access. Both forestry and agricultural applications would be feasible, although both would require extensive public and stakeholder education and consultation. Figure 2 illustrates the land base for forestry in the regional district.



The change in tree ring spacing shown in this cross section resulted from the application of biosolids. Source: King County Department of natural Resources, Seattle, WA



Note: TSA means Timber Supply Area **Figure 2**
Tree Farm Licenses Vancouver Island and Lower West Coast

The King County (Seattle area) biosolids forestry land application program has been operating successfully using dewatered biosolids since 1991. Problems encountered have mainly been associated with public resistance (concerns over metals and hazardous chemicals, prescription products, and odours). Despite extensive scientific research elsewhere addressing many of these issues, local demonstration projects were needed to address public concerns. In addition, alliance with local support groups, large landowners, and credible organizations (such as the local university) were an important consideration. These problems have now been resolved, and the program is operating successfully. Public open houses are still conducted periodically. These were initially well attended, but attendance has dwindled over time.

King County, Seattle, WA,
Loading Flinger with Dewatered Biosolids from Portable Bunker

King County, Seattle, WA,
Application of Dewatered Biosolids with Flinger in Forest Areas

King County, Seattle, WA
Inspecting Improved Foliage after Applications of Biosolids

Mine site and gravel site reclamation were found to be not currently feasible within or outside of the CRD, since suitable mid or long term sites could not be identified within reasonable trucking, pumping or barging distance. Landfill cover could be a future partial solution, but would not be available until the landfill closed, and in any case would not offer a significant beneficial use requirement.

The remaining beneficial uses in order of preference were market distribution and commercial sale (compost), energy production, and production of manufactured products. This order of preference was based mainly on economic considerations (i.e., the cost of producing the marketable product versus the potential for cost recovery). The potential market and regulatory requirements for producing compost would be relatively straightforward compared to manufactured products. Treatment for producing manufactured products (i.e., drying or incineration) would involve complicated mechanical processes that would require substantial energy inputs. Energy recovery would have a high potential for reducing treatment costs for anaerobic digestion (combustion of digester gas), and this option could be implemented at the time of constructing treatment facilities. Manufacture of compost and manufactured products such as construction materials would be more suitable for implementation in the future, provided that a long-term market could be identified.

The Hartland landfill is currently filling at 190,000 m^3/year with municipal solid waste (MSW) including cover. The 30 hectare site would allow over 50 years filling capacity. If untreated sludge were added to the landfill, it would occupy 1/3 of the landfill volume, and could reduce the landfill capacity for MSW by about 15 years. In any case, disposal at the Hartland landfill would not constitute beneficial reuse, unless landfill gas were captured for energy recovery. This option was identified as an emergency standby solution, and was strongly recommended for this purpose.

If a monofill for dedicated land disposal were used that was separate from the Hartland site, about 88 ha of additional site would be needed, assuming trenching or dyking construction, for the 2010 to 2045 sludge volume. This would not be feasible even if treatment were used to reduce the mass and volume of sludge prior to disposal.

TREATMENT OPTIONS

The advantages and disadvantages of each treatment option studied are summarized in Dayton & Knight Ltd . (2004) report as:

a) biological treatment using anaerobic digestion,
b) chemical treatment using alkaline stabilization,
c) composting,
d) thermal reduction using fluidized bed incinerators, and
e) water reduction using convective rotary driers.

Sludge conveyance to the biosolids facility was shown to be best accomplished through trucking of dewatered sludge (30% primary and 15% secondary solids). Trucking of liquid sludge was found to be uneconomical, and pumping of liquid or thickened sludge was not practical or economical. Barging, while appropriate for beneficial use and treatment sites on the northwest coast, would require double handling and cause odour and aesthetic impacts near the treatment facilities at Clover and/or Macaulay Points. Barging was not identified as feasible for the short or mid term, but it could be revisited at a future date. (Secondary treatment may or may not occur at Macaulay Point and is unlikely to occur at Clover Point. The options study took the conservative approach on the highest possible sludge production and assumed secondary sludge may be produced from the total wastewater flow from both facilities.)

Risks were evaluated using a risk matrix, with risk reported as the product of a probable failure and the relative cost of failure. All beneficial use and treatment options were evaluated for risk, and where options did not meet an acceptable risk, they were eliminated from further consideration.

As mentioned earlier, the identification of the preferred biosolids use solutions governed the selection of the preferred treatment solutions, such that biological treatment (anaerobic digestion) was identified as the most preferred treatment, allowing the selected beneficial use solution of forest site application. Anaerobic digestion is a well-proven technology that is widely used worldwide. Advantages of anaerobic digestion include relatively low area requirements, ease of containing odours, moderate life cycle costs (net present value), and the potential for energy recovery (digester gas). In addition, anaerobic digestion can be designed to produce a high quality (Class A) treated product that is suitable for use in publicly accessible areas. There would be some visual impact associated with the digester domes, but this could be softened through proper architecture. Source control of contaminants discharged to the sewer collection system would be necessary to maintain a high quality product.

The remaining treatment solutions in order of preference were chemical treatment using thermal-chemical or alkaline stabilization, composting (i.e., co-digestion with other biodegradable waste such as wood chips), incineration (thermal oxidation using the fluidized bed process), and water reduction by heat drying. All of these processes are capable of producing products that can be used to improve soil structure and fertility. The products of incineration and heat drying can also be used to manufacture construction products (bricks, aggregates, etc.).

Chemical treatment (alkaline stabilization) of sludge would be feasible as a treatment solution but was not the number one choice, partly due to economic considerations (costs for lime added during treatment and increased product volume for disposal or reuse). In addition, alkaline stabilization would have no potential for energy recovery. Since the CRD already has chemical stabilization at the Saanich Peninsula plant, and the volume produced will form a significant fraction of the biosolids generated within the CRD, this alkaline product could form part of the Sludge Management Plan for the region, and it could be directed to the acid agricultural soils as a component in the preferred beneficial use land spreading option. This would need further study.

As described earlier, the production (and marketing) of compost was reserved for future consideration, due mainly to higher costs for treatment compared to anaerobic digestion, and unknown local market potential for the product. The volume of product (compost) would also be greater than for anaerobic digestion, due to the addition of bulking agents (e.g., woodchips) in the composting process. Composting operations can generate significant odours if not managed adequately as well as extra truck traffic (due to delivery of the bulking agent). No energy recovery would be feasible during composting, although anaerobic digestion of sludge prior to composting would allow energy recovery, as well as reducing product volume and odour potential. The site selected for the preferred treatment option of anaerobic digestion should be large enough to incorporate composting operations (and/or manufacture of construction materials) in future.

STORAGE CONSIDERATIONS

Temporary (90-day) storage of treated sludge on the treatment facility site was included in the cost estimates for treatment. Temporary storage at the site of beneficial use might also be required on a case-specific basis. B.C. regulations (OMRR 2002) allow up to nine months storage at biosolids land application sites, provided that the storage site is located at least thirty metres from a water course or domestic water source, and is stored in a manner that prevents escape of the biosolids (e.g., using berms or other works). In addition, the biosolids must be covered from October 1 to March 31, if the storage site is located on Vancouver Island. Costs for storage at beneficial use sites would depend on site location and other site-specific factors (e.g., amount of biosolids used at that site, required duration of storage, odour control needs, etc.), and would have to be evaluated on a case-by-case basis.

COSTS FOR TREATMENT AND BENEFICIAL USE

The costs for the CRD Sludge Management Plan treatment and beneficial use options are summarized in Tables A-1 and A-2.

Capital costs for treatment included site development, processing equipment, structures, site work (piping, roads, etc.) and special construction. Operations and maintenance costs included labour, power, fuel, and chemicals, known unit costs, and annual repair and equipment costs. A cost allowance for temporary (90 day) storage of treated sludge at the treatment site was also included. Life cycle costs were based on 2010 as the present worth year, at a 6% discount rate and a 20-year investment. No depreciation allowance was assumed. The life cycle cost or Net Present Value (NPV) was presented as an investment made in 2010 to pay all stages of development to 2045 (reported in 2004 dollars). All beneficial use and treatment options were cost estimated on this basis. All options were evaluated for odour management, and costs for odour control were allowed relative to the odour potential.

The costs for the preferred beneficial use option of land spreading (including costs of biological or chemical treatment and forest or agricultural spreading facilities) were estimated at about $700 to $1,200 per dry tonne, which reflected a life cycle cost range of $120 million to $154 million. Capital investment not including land cost was about $50 million for the 2010 to 2025 period, assuming primary treatment only, and about $80 million for the 2025 to 2045 period if secondary treatment were added. The treatment site requirements would be about 10 hectares, which would allow for addition of compost or dryer facilities at a later date to add further dimension to the flexibility of the treatment solution.

The costs for landfill disposal would be low (compared to land spreading) if a monofill site could be found. The monofill solution would be less than $1,000 per dry tonne, reflecting a life cycle cost of about $105 million. More likely, however, the solution would include co-disposal at the Hartland landfill, and if the cost of the landfill disposal at $100/wet tonne were continued, the unit cost per dry tonne for landfill disposal would vary from $1,250 per dry tonne for anaerobic digestion to $1,750 per dry tonne for chemical treatment. This reflected a range in life cycle cost of $165 million to $205 million; this high cost reinforces the recommendation to use the landfill as a standby solution only. Because of the closed end nature of the landfill, it should be reserved for emergency needs only.

RECOMMENDATIONS

Recommendations for the CRD Sludge Management Plan include:

1. Select the beneficial use category of land spreading, with forest application as the primary goal and agriculture and urban application as the secondary goal for use of the treated Macaulay and Clover Point biosolids.

2. Undertake additional studies to determine the availability of suitable forest and agricultural biosolids application sites.

3. Select thermophilic anaerobic digestion as the treatment process, and identify a ten hectare site; this will allow the introduction of composting for future beneficial use. Alternatively, addition of a drying process could be added in future.

4. Select landfilling at Hartland landfill as the emergency or temporary solution to provide a safety measure for lost opportunities in landspreading.

5. Develop beneficial options for commercial sale, energy use, and manufactured products where appropriate over the study period. Energy recovery through combustion of

anaerobic digester gas can be used from the outset to reduce the operating costs of the treatment facilities. For future distribution and marketing of the product(s) of treatment, composting of anaerobically digested biosolids with other biodegradable products such as wood chips is the preferred approach, followed by manufacture of construction products (bricks, aggregates, etc.) using dried or incinerated biosolids.

6. Maintain or augment the existing chemical treatment option at the Saanich Peninsula WWTP for use in agricultural land applications and landfill cover application.

7. Undertake a parallel program that includes the following components:

    a) education programs focused on the value of beneficial use programs;
    b) support of research in health and safety and environmental matters concerning the collection system, the selected beneficial use and treatment solutions;
    c) expand source control program as required based on research findings above; and
    d) contact with business leaders, health officials and government agencies (B.C, Ministry of Health, and B.C. Ministry of Water Lands and Air Protection) to enhance and guide the program.

REFERENCES

Dayton & Knight Ltd. (2004), Core Area LWMP, Sludge Treatment and Disposal, Capital Regional District, Victoria, B.C., June 2004.

OMMR, 2002, Organic Matter Recycling Regulation, Province of British Columbis, Order 084, February 4, 2002

APPENDIX A

TABLE A-1
2010 TO 2025 CRD SLUDGE MANAGEMENT PLAN COST

Beneficial Use	Treatment	Cost $M			Cost per dry tonne
		Capital	O&M	NPV 2010-25	
Land spreading (fertilizer)[1]					
a) Forest Soil	Biological Treatment, Anaerobic Digestion	$48.22	$2.20	$73.47	$995
b) Agricultural	Chemical Stabilization, Thermal-Chemical	$36.83	$3.89	$81.47	$1,081
	Chemical Stabilization, Alkaline	$38.61	$3.80	$82.24	$1,091
	Biological Treatment, Anaerobic Digestion	$48.06	$2.12	$72.37	$960
Landfill[1]	Landfill (no treatment), Monofill CRD Sludge Landfill	$35.41	$1.39	$51.30	$681
	Chemical Stabilization, Thermal-Chemical, Hartland Landfill	$36.08	$5.89	$103.63	$1,375
	Chemical Stabilization, Alkaline Hartland Landfill	$37.86	$6.16	$108.48	$1,440
	Biological Treatment, Anaerobic Digestion, Hartland Landfill	$47.56	$4.18	$95.50	$1,267
Commercial Sale and Soil Conditioner[2]	Co-Digestion (in vessel compost)/ Anaerobic Digestion	$67.50	$3.11	$103.17	$1,369
	Water Reduction (heat drying)/Anaerobic Digestion	$72.39	$5.96	$140.74	$1,869
Energy[2]	Landfill (no treatment), Monofill	$35.41	$1.39	$51.30	$681
	Biological Treatment, Anaerobic Digestion	$48.22	$2.20	$73.47	$995
	Reduction (fluidized bed incineration)	$51.81	$7.30	$135.53	$1,798
Manufactured Products[2]	Reduction (fluidized bed incineration)	$51.81	$7.30	$135.53	$1,798
	Water Reduction (heat drying)/Anaerobic Digestion/Melting Furnace	$98.29	$9.46	$206.77	$2,744

1 Land spreading and landfill costs include facility and site application costs.

2 Commercial sale and soil conditioner, energy and manufactured product costs include only facility costs; costs for marketing, program development, distribution and other are assumed to equal the revenue.

TABLE A-2
2025 to 2045 CRD SLUDGE MANAGEMENT PLAN COST

Beneficial Use	Treatment	Cost (million $)			Cost per dry tonne
		Capital	O&M	NPV 2010-25	
Land spreading (fertilizer)[1]					
a) Forest Soil	Biological Treatment, Anaerobic Digestion	$80.67	$4.47	$121.67	$733
b) Agricultural	Chemical Stabilization, Thermal-Chemical	$68.33	$11.00	$147.39	$1,080
	Chemical Stabilization, Alkaline	$71.73	$12.21	$153.82	$1,176
	Biological Treatment, Anaerobic Digestion	$80.24	$4.23	$119.57	$715
Landfill[2]	Landfill (no treatment), Monofill CRD Sludge Landfill	$146.00	$2.20	$105.43	$951
	Chemical Stabilization, Thermal-Chemical, Hartland Landfill	$65.94	$18.36	$189.69	$1,536
	Chemical Stabilization, Alkaline Hartland Landfill	$69.34	$21.39	$206.40	$1,748
	Biological Treatment, Anaerobic Digestion, Hartland Landfill	$78.93	$12.81	$165.77	$1,254
Commercial Sale and Soil Conditioner[3]	Co-Digestion (in vessel compost)/ Anaerobic Digestion	$136.93	$10.68	$193.99	$1,441
	Water Reduction (heat drying)/Anaerobic Digestion	$128.55	$10.57	$229.40	$1,387
Energy[2]	Landfill (no treatment), Monofill	$146.00	$2.20	$105.43	$951
	Biological Treatment, Anaerobic Digestion	$80.67	$4.47	$121.67	$733
	Reduction (fluidized bed incineration)	$92.35	$14.12	$222.39	$1,412
Manufactured Products[2]	Reduction (fluidized bed incineration)	$92.35	$14.12	$222.39	$1,412
	Water Reduction (heat drying)/Anaerobic Digestion/Melting Furnace	$174.73	$17.28	$337.64	$2,072

1 Land spreading and landfill costs include facility and site application costs.

2 Commercial sale and soil conditioner, energy and manufactured product costs include only facility costs; costs for marketing, program development, distribution and other are assumed to equal the revenue.