

Biosolids Master Plan

Final Report

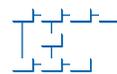


Hamilton

Prepared for

The City of Hamilton
Public Works Department
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Executive Summary

Through a Master Planning approach under the Municipal Engineers Association's (MEA) Municipal Class Environmental Assessment (Class EA) process, a long-term strategy for the environmentally sustainable, reliable, and cost-effective management of the City of Hamilton's biosolids was identified.

The Master Planning approach included input from the City, stakeholders, the public, and the City's consulting team. A City Technical Steering Committee (TSC) and a Stakeholder Advisory Committee (SAC), comprising a wide range of participants, were involved throughout the project. Two Public Information Centres were held during the project to solicit public input into the decision making process.

Currently, the City contracts the disposal of its biosolids, which are a product of wastewater treatment after stabilization and dewatering, by way of land application through a contractor. Increasingly stringent regulations and limitations in land availability at critical times have negatively influenced the sustainability of the land application approach. Periodically, limitations in the ability to land apply the biosolids results in long term storage or landfilling of the biosolids.

A review of a long list of alternatives was completed using background documents provided to the TSC and SAC together with formal evaluation criteria. The short listed alternatives that were selected through this evaluation included increased biosolids stabilization and/or thermal oxidation (incineration). A further review of the short-listed alternatives was completed. Through a rigorous evaluation of these alternatives, it was concluded that thermal oxidation/reduction (incineration) of the biosolids was the preferred alternative for the long term planning period. This management alternative was recommended together with continued biosolids stabilization using anaerobic digestion and cogeneration of heat and electrical power using by-product methane gas prior to the dewatering and thermal oxidation process. This recommendation met the objectives set out for the Master Plan.

This Master Plan Report summarizes the planning approach, the evaluation of alternatives, the recommendations made, and the cost implications.

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1.0 INTRODUCTION

The City of Hamilton is located on the western shore of Lake Ontario. In 2001, the Cities of Hamilton and Stoney Creek, the Towns of Ancaster, Flamborough and Dundas, and the Township of Glanbrook, were amalgamated to form the new City of Hamilton. The population of the new City is just over 500,000. Hamilton is a combined residential, commercial, institutional and industrial city and is home to McMaster University and Mohawk College.

Hamilton has three wastewater treatment plants (WWTPs) that serve the wastewater treatment needs of the community. The Main Street WWTP, located in Waterdown, and the King Street WWTP, located in Dundas, service populations of approximately 5,500 and 40,000, respectively. The Woodward Avenue WWTP is located in Hamilton and services a population of approximately 380,000. Liquid sludge from the Waterdown WWTP and Dundas WWTP is transported to the Woodward Avenue WWTP (**Figure 1**), blended with the sludge produced at the Woodward Avenue WWTP and anaerobically digested. Digested sludge, called biosolids, is dewatered using centrifuges and applied to agricultural land, stored temporarily at the Power Grow Systems Facility in Niagara Region, or on some occasions landfilled.



Figure 1 Aerial View of the Woodward Avenue WWTP

The current average annual dry solids production at the Woodward WWTP is approximately 12,500 tonnes/year. For perspective, this is equivalent to 95 grams of dry solids produced per m³ raw sewage treated, and 81 grams of dry solids produced per capita serviced.

The City of Hamilton required the development of a long-term strategy for management of their biosolids in an environmentally sustainable, reliable, and affordable manner. To this end, the City retained Hydromantis, Inc. and XCG Consultants Ltd. with input from other specialists and the public to evaluate feasible biosolids processing options and end uses to determine the most appropriate long-term management strategy.

1.1 Objectives

Through a Master Planning approach under the Municipal Engineers Association's (MEA) Municipal Class Environmental Assessment (Class EA) process, a long-term strategy for the environmentally sustainable, reliable, and cost-effective management of the City's biosolids is identified.

The biosolids management evaluation was divided, as follows, into 17 Technical Memoranda (TM) to address the key objectives of the biosolids management strategy:

TM 1	Current Status of Biosolids Management in Hamilton
TM 2	Projected Future Biosolids Quantities
TM 3	Current Land Application Practices
TM 4	Current and Evolving Trends in Biosolids Management
TM 5	Current and Projected Biosolids Management Practices in Ontario Communities
TM 6	Regulatory Review
TM 7 - TM 15	Biosolids Management Options
TM 16	Evaluation Criteria
TM 17	Evaluation of Short Listed Alternatives and Selection of Preferred Alternative

These Technical Memoranda are referred to extensively in this summary report. Further details and copies are provided in **Appendix A**.

1.2 General Wastewater Treatment and Biosolids Management Processes

In general, wastewater treatment entails two output trains, liquids and solids. The liquids train is discharged from the treatment plant to a body of water as “treated effluent” and is regulated by the Ministry of the Environment (MOE) under site specific Certificates of Approval (C of A). In this case, the receiving water body is Hamilton Harbour. The solids train is treated producing a by-product known as “biosolids”. Currently, mechanically dewatered biosolids generated by the City of Hamilton are utilized as a soil amendment or beneficial soil additive for agricultural land application. The average annual dry biosolids production (excluding the moisture content) at the Woodward Avenue Wastewater Treatment Plant (WWTP) is approximately 12,500 tonnes/year of dry solids or approximately 50,000 wet tonnes/year including the moisture content, representing a total of 1,200 to 1,250 truck loads per annum from the WWTP. This quantity would be expected to increase to between 1,850 and 2,050 truck loads per annum at the endpoint of the 30-year planning period if the status quo is retained.

Biosolids must be managed in an environmentally sustainable, reliable, and cost-effective manner and are subject to stringent Provincial and Federal regulations. Historically, the City incinerated its biosolids up until 1996 when the infrastructure refurbishment necessary for the old multiple hearth incinerators to meet regulatory requirements was deemed cost-ineffective when compared to land application. Since 1996, biosolids generated by the City of Hamilton have been utilized as a soil amendment or soil additive in agricultural land application.

1.3 Problems and Opportunities

1.3.1 Biosolids Management Issues and Sustainability

The management of biosolids land application is increasing in complexity. Recently implemented Provincial legislation (e.g. Nutrient Management Act [NMA]), competition for land from other municipalities and other nutrients (e.g. manures to land), continuing concerns with certain biosolids constituents levels (metals and pathogens) and biosolids odour contribute towards limiting the future land bank available to the City for the

spreading of biosolids. Off-season and inclement weather storage costs, increasing transportation distances and stringent approval requirement for securing land are further complicating and increasing the risk of the application process. In addition to the above-mentioned pressures, one of the major elements to sustaining this alternative is the dependence on a volunteer farmer base which has proven difficult to secure and maintain because of application timing logistics, including land already in crops, other nutrient loads on agricultural land, and neighbour odour concerns. During off-season or times of inclement weather, when land application is not feasible, or when biosolids storage is precluded, the City's contingency plan through its contractor, was to store biosolids at the Power Grow facility in Niagara Region, or dispose of them to landfill.

The following is a list summarizing the emerging issues which limit the sustainability of a biosolids land application program:

- Recently implemented Provincial legislation (i.e. the Nutrient Management Act) has reduced and limited the future land bank available to the City for the spreading of biosolids onto approved agriculture lands.
- Increased regulated requirements for biosolids storage (i.e. 240 days) for off-season and inclement weather.
- Continuing concerns with certain biosolids constituents levels (i.e. metals, pharmaceutical residuals).
- Increased risk of utilizing the contingency disposal option of land filling. This is a result of off-season or times of inclement weather when land application is not feasible, or when biosolids storage is precluded.
- Competition for land from other municipalities.
- Securing agriculture lands from farmers and the reliability of retaining approved lands is difficult considering the land is obtained through a volunteer basis.
- Biosolids odours are generally problematic at the WWTP and the sites of application.
- Limited land application contractors to service the City.

- Increasing transportation distances to available lands.
- Historical stringent Certificate of Approval (C of A) requirements for land approvals.
- Increased concerns from the community of negative impacts land application of biosolids can pose to the environment.
- Increased expectation from the community as a result of improved technology, to treat biosolids to a higher standard.

The overall sustainability of this management approach, especially over the medium- to long-term, is tentative and uncertain. While the City's experiences with land application over the past 11 years have been generally positive, opportunities to continue the program are limited, due primarily to the growing constraints of increasing regulation and decreasing land availability within reasonable transport distances. To better meet existing commitments, accommodate future growth, and address regulatory requirements, a Biosolids Master Plan (BMP) was developed for the City of Hamilton to identify the preferred management strategy for the next 30 years.

1.3.2 Preview of Master Plan Recommendation

During the review of a long list of alternatives, two recommended management solutions were presented to and supported by the BMP's Stakeholder Advisory Committee (SAC) evaluation scoring:

- Land application of Class "A" biosolids (US EPA term to define a higher stabilized product) and/or
- Thermal oxidation or reduction (incineration).

These recommendations were presented to the public at the Phase 2 Public Information Centres in September 2006. The options were well received, and the constraining issues (decreasing available land base, trucking cost, green house gas emissions, odour, metal and pathogen concerns) associated with continuation of the present land application program and any potential 'Class A' production program were acknowledged by the public. Recent significant advances in thermal reduction technology served to increase the public's perception of its viability and application.

The preferred BMP management strategy was finalized through further assessment of the recommended alternatives. Considering that each of the alternatives is likely to be located at the Woodward Avenue WWTP site, (except in the event of storage facilities related to possible land application programs, which due to the size would need to be sited elsewhere in the City), it is imperative that the biosolids handling solution arising from the BMP be effectively incorporated into the overall plant footprint.

1.4 Master Plan Approach

The City retained the services of Hydromantis, Inc. and XCG Consultants Ltd. who, together with input from other specialists, the Stakeholder Advisory Committee and the public, evaluated feasible biosolids processing options and end uses to determine the most appropriate long-term management strategy for the City.

The Stakeholder Advisory Committee was comprised of staff from relevant City departments (Health, Regulatory, etc.), industry health and safety representatives, biosolids and consultant specialists, academics and interested members of the public. The Ministry of the Environment, the agricultural practitioners and neighbouring municipalities where Hamilton biosolids are applied and City Council were represented on the SAC. The SAC assisted in the preparation of alternatives screening criteria and evaluation and scoring of the alternatives.

A Master Plan, as framed by the MEA's Municipal Class EA, encompasses a two-phase process with problem/opportunity identification in Phase 1, and alternative solutions/strategies identification, evaluation and the selection of a preferred solution/strategy in Phase 2.

Public consultation is an important component of the process to meet the EA requirements. During Phase 1 of the BMP, discretionary Public Information Centres (PICs) were held in March 2005 at three locations to engage the public in the problem/opportunity definition process. A second round of PICs was held in September 2006 during Phase 2 of the study and offered further opportunity for the public to participate and provide input to the alternatives selection.

1.4.1.1 Legal Implications

Each of the recommended alternatives has specific regulatory/legal implications that stem from the responsibility that the City carries with respect to the production and the regulated management of its biosolids.

Wherever the City's control over the process is contracted out of the City's facilities there is a risk of contract default. Further, for any alternative wherein there is a dependence upon the contractor for land application compliance, there are risks of spills and contamination. Ultimately, however, responsibility for appropriate biosolids management lies with the City.

Under the thermal reduction alternative, other regulations associated with emissions will require compliance; however, proper design, sampling and monitoring can ensure that compliance will be met. Emissions criteria have been addressed by other municipalities in Ontario (e.g. Regions of Peel and York, City of London) with the satisfactory meeting of regulatory requirements by their thermal facilities.

A number of policies, regulations and statutes pertain to this document, namely:

- Nutrient Management Act
- Federal Fertilizer Act
- Ontario Regulation 347 – Waste Management
- Interim Compost Guidelines (MOE)
- Canadian Council of Ministers (CCME) Compost Guidelines
- Water and Waster Master Plan Policy Paper endorsed by Council on May 11, 2005 (refer to PW05050)
- Places to Grow Legislation
- Greenbelt Protection Act
- Safe Drinking Water Act
- Environmental Assessment Act
- Environmental Protection Act
- Source Water Protection Act

1.4.2 Consultation Process

An extensive public consultation program was undertaken for the BMP. The following summarizes the public consultation process which took place during the development of Phases 1 and 2 of the Biosolids Master Plan:

- Notice of Commencement and Advertising for Members of the Stakeholder Advisory Committee, September 2004
- Stakeholder Advisory Committee Meeting #1, February 25, 2005
- Public Information Centres #1, March 7, 2005 (Glanbrook Municipal Service Centre (MSC), March 8, 2005 (Dundas MSC) and March 10, 2005 (Stoney Creek MSC)
- Stakeholder Advisory Committee Meeting #2, June 28, 2005
- Stakeholder Advisory Committee Meeting #3, June 7, 2006
- Public Information Centres #2, September 19, 2006 (Stoney Creek MSC), September 21, 2006 (Woodward Public School)
- City Council presentations in April and August 2007.

Appendices B, C and D provide copies of key consultation documents.

1.4.2.1 Stakeholder Advisory Committee (SAC)

A Stakeholder Advisory Committee (SAC) was convened and consulted at key points through the process. As part of the advertisement for the Notice of Commencement, an invitation was extended to any parties interested in being a part of a stakeholder group. No responses were received from the advertisement. City staff, in turn, issued Letters of Invitation to groups/committees and parties that were felt would have an interest in being on the SAC. The composition of the SAC was as follows:

- City of Hamilton:
 - Public Works, Waste Management Division
 - Public Works, Water and Wastewater Division, Compliance and Regulation Section

- Public Health Services
- Agricultural and Rural Affairs Committee Representative
- County of Haldimand
- Ministry of the Environment
- Environment Hamilton
- Hamilton Industrial Environmental Association
- Public Member at Large
- Councillor David Mitchell, Ward 11

The SAC met on three occasions through the project (see below). Meeting announcements were made in advance. The presentations to the SAC, lists of attendees, meeting locations and meeting notes are provided in **Appendix C**. Relevant SAC written communications are provided in **Appendix C**.

Consultative communications to explore potential strategic cooperative opportunities and initiatives were undertaken throughout the BMP process with the following entities:

- The Regional Municipality of Peel
- The Regional Municipality of Halton
- The Regional Municipality of Niagara
- Hamilton/Niagara Wasteplan
- Terratec
- N-Viro

Documentation related to these consultations is provided in **Appendix C**.

1.4.2.2 Public Information Centres

Public Information Centres (PICs) were held in Phase 1 at three City locations during March 2005 and in Phase 2 at two City locations during September 2006. Notices for each PIC were placed on the City website and in the Hamilton Spectator (**Appendix B**).

The first PIC engaged the public in the identification of the problem/opportunity for biosolids management. The second PIC presented long term biosolids management alternatives and invited public input for the development of the preferred alternative.

Appendix B provides the presentations for each PIC, brochures provided, the signed-in attendees at each PIC and written input from the attendees.

1.4.2.3 Regulatory Agencies

Regulatory agencies and relevant Ministries were notified and consulted throughout the BMP process. The notification mailing list and records of correspondence are provided in **Appendix B**. Feedback has been supportive of the Master Plan and the Master Planning process.

1.4.2.4 Technical Steering Committee

The TSC membership included members from the City's Public Works Water and Wastewater Division, including Mr. Chris Shrive (City Project Manager), Mr. Dan Chauvin, and Mr. Jim Harnum.

1.4.2.5 Consultant Project Manager and Team

Mr. Joe Stephenson, Hydromantis, Inc. was project manager and Mr. Mike Newbigging, Hydromantis, Inc. was alternate project manager. Key staff specialists from Hydromantis, XCG and Malcolm Pirnie were provided. In addition, Dr. Mel Webber and Dr. Tom Bates, both soil and crop specialists with a complete understanding of the issues surrounding biosolids application to land, were an integral part of the consultant team.

1.4.3 Public Works Committee and Council

The documentation describes the *Preferred Biosolids Management Strategy* produced following the technical assessment described above and through further application of the SAC's criteria and evaluation screening process on the recommended biosolids management strategies. The recommended strategies and an approach to their further evaluation were presented to the City's Public Works Committee in March 2007 through an Information Update Subsequent to further evaluation, the resulting preferred BMP management strategy was brought before the Committee of the Whole for approval in August 2007. Related documents and presentations are provided in **Appendix D**.

1.5 Environmental Assessment for the Combined Sewer Overflow and Woodward Avenue Wastewater Treatment Plant (WWTP) Expansion

Phase 3 of a concurrent Schedule C Environmental Assessment process for the Combined Sewer Overflow and Woodward Avenue Wastewater Treatment Plant (WWTP) Expansion (the Woodward WWTP Expansion) is ongoing. Considering that any alternatives are likely to be located at the Woodward Avenue WWTP site, (except for any storage facilities which due to the size would need to be sited elsewhere in the City), integrative detailed design of the preferred BMP alternative and its footprint may be studied in collaboration with that project to ensure that future plant expansion processes are adequately sized and configured. It is imperative that any biosolids handling solution arising from the BMP be effectively incorporated into the overall Woodward Avenue WWTP footprint.

2.0 WASTEWATER TREATMENT AND CURRENT STATUS OF BIOSOLIDS MANAGEMENT

The City of Hamilton is served by three Wastewater Treatment Plants (WWTP), Woodward Avenue WWTP, Waterdown WWTP and Dundas WWTP. The average wastewater flow rates treated at each of the facilities are presented in **Table 1**. The Dundas and Waterdown facilities are small relative to the Woodward facility, together totalling approximately 5% of the flow treated by Woodward. A detailed discussion of the current status of the City of Hamilton's biosolids management is provided in **Appendix A** (Technical Memorandum 1).

Table 1 Treatment Capacity of Hamilton's Wastewater Facilities

Facility	Average Day flow* (m ³ /d)	Fraction of Design Capacity (%)
Dundas WWTP	15,326	84
Waterdown WWTP	2,877	106
Woodward Ave. WWTP	345,587	84
*: Average of 2002 and 2003		

2.1 Wastewater Treatment Plant Descriptions

A brief description of the Dundas, Waterdown and Woodward WWTPs is provided in this section. The Woodward Ave. WWTP is by far the largest WWTP in the City and handles the solids generated at all three City facilities.

2.1.1 Dundas WWTP

The Dundas WWTP is located in the former Town of Dundas (now part of the City of Hamilton) and services a population of approximately 40,000 people. Final treated liquid effluent is discharged to Cootes Paradise via Desjardin's Canal. A picture of the Dundas WWTP is shown in **Figure 2**.



Figure 2: Dundas WWTP

Preliminary treatment of the raw sewage consists of screening and grit removal. The wastewater is dosed with ferrous chloride for phosphorus removal and is split between two process trains referred to as Plant A and B. The design capacity of Plant A and B are 6,100 m³/d and 12,100 m³/d, respectively. Both Plants A and B treat wastewater in the same manner: primary sedimentation, followed by aerobic biological treatment and secondary clarification. Disinfection of each plant's effluent with gaseous chlorine occurs on a seasonal basis from May 15 to October 15. Following disinfection, effluent from Plant A and B is combined. A tertiary sand filter polishes the combined effluent prior to final discharge.

Grit and screenings removed from the raw sewage are transported by truck to the Glanbrook Landfill. Waste activated sludge (WAS) produced in the aeration tanks is pumped back to the headworks of the WWTP and co-thickened in the primary clarifiers. Settled sludge from the primary clarifiers is currently pumped to an on-site, covered holding tank. The tank has a volume of 713 m³. The sludge is trucked to the Woodward Avenue WWTP for further processing.

2.1.2 Waterdown WWTP

The Waterdown WWTP is an activated sludge process with tertiary treatment. It has a rated capacity of 2,720 m³/d, is located in the former Town of Waterdown (now part of the City of Hamilton) and services a population of approximately 5,500 people. Final treated liquid effluent is discharged to Grindstone Creek. **Figure 3** shows a picture of the Waterdown WWTP.



Figure 3: Waterdown WWTP

Preliminary treatment of the raw sewage consists of screening and grit removal. Wastewater is dosed in the grit chamber with ferrous chloride for phosphorus removal and is subsequently split between two process trains referred to as Plant A and B. Both Plant A and B treat the wastewater in the same manner: primary sedimentation, followed by aerobic biological treatment and secondary clarification. Disinfection with gaseous chlorine is practiced year round on the secondary effluent from each Plant. Following disinfection, effluent from Plant A and B is combined. A dual media filter comprised of sand and anthracite polishes the combined effluent prior to discharge.

Grit and screenings removed from the raw sewage are transported by truck to the Glanbrook Landfill.

Waste activated sludge (WAS) from the aeration tanks is pumped back to the primary clarifiers and co-thickened with the primary sludge. Settled sludge from the primary

clarifiers is currently pumped to an on-site covered holding tank. The tank has a volume of 370 m³. The sludge is later trucked to the Woodward Avenue WWTP for further processing.

2.1.3 Woodward WWTP

The Woodward Avenue WWTP is a conventional activated sludge process. Solids treatment consists of waste activated sludge thickening, anaerobic digestion, and dewatering. The Woodward Avenue WWTP has a rated capacity of 409,000 m³/d, is located in the City of Hamilton and services a population of approximately 380,000 people. Final treated liquid effluent is discharged to Hamilton Harbour via Red Hill Creek. **Figure 4** shows the influent pumping station at the Woodward Ave. WWTP.



Figure 4: Woodward Avenue WWTP

Preliminary treatment consists of screening and grit removal. The influent raw sewage is dosed with ferrous chloride in the influent channels for phosphorus removal. Following preliminary treatment, the flow is directed to primary clarifiers. Primary effluent is split between two secondary treatment trains, referred to as the North and South Plants. The North Plant provides two-thirds of the total treatment capacity of the plant (273,000 m³/d), while the South Plant provides the remaining one-third of the capacity (136,000 m³/d). Both Plants treat the primary effluent in the same manner: aerobic biological treatment followed by secondary clarification. Gaseous chlorine is used to disinfect each Plant's secondary effluent, occurring on a seasonal basis from May 15 to October 15. Following disinfection, effluent from the North and South Plant is combined and discharged to Hamilton Harbour via Red Hill Creek.

Grit and screenings removed from the raw sewage are transported by truck to the Glanbrook Landfill. Scum from the primary clarifiers is removed by skimmers, concentrated, and sent to a landfill. The raw sludge is pumped to the primary digesters. Waste activated sludge from both the North and South plant is pumped to three gravity belt thickeners (GBT).

Sludge from the Dundas and Waterdown WWTPs is discharged from the trucks to a sump and pumped directly to the primary digesters.

All sludge is treated by anaerobic digestion in two stages. A total of 8 digesters exist on-site for sludge stabilization; however, not all digesters are in service. Following the recent conversion of a secondary digester to a primary digester, the North Digester Complex consists of 3 primary digesters and 1 secondary digester. The South Digester Complex consists of 2 primary digesters and 2 secondary digesters. Each digester has a diameter of 32 m and volume of 8,050 m³. The primary tanks have fixed covers, are mechanically mixed, and operate under mesophilic conditions at a target temperature of approximately 35°C.

Following digestion, the biosolids are dewatered using centrifuges. Pumps transfer biosolids from the holding tank to each dewatering unit. Belt conveyors transfer the dewatered biosolids cake to storage.

Dewatered biosolids are stored temporarily in live bottom bins at the Woodward Avenue WWTP prior to transport off site. Dewatered biosolids are stored off-site at the Power Grow Systems Facility in Niagara Region. The storage facility is currently leased and operated by Terratec (a subsidiary of American Water Services Canada Corp. or AWS) and provides an area of 6.6 ha that is approved by the Ministry of the Environment for storage, transport, processing, and composting of non-hazardous waste. Storage of the biosolids occurs during the winter months and when the biosolids cannot be land applied.

2.2 Biosolids Production Rates

The mass of solids transported from the Dundas and Waterdown WWTPs to the Woodward WWTP is presented in **Figure 5**. The Dundas WWTP contributes 3.95 dry tonnes/d of solids to the anaerobic digestion system at the Woodward Avenue WWTP. This represents 4.4% of the total solids. The Waterdown facility contributes 0.75 dry tonnes/d or 0.9% of the total and the Woodward facility contributes 84.5 dry tonnes/d or 94.7% of the total. The Woodward value was estimated and is higher than the reported value. There were inconsistencies when a biosolids mass balance was completed, but the estimated value is considered representative of the actual production.

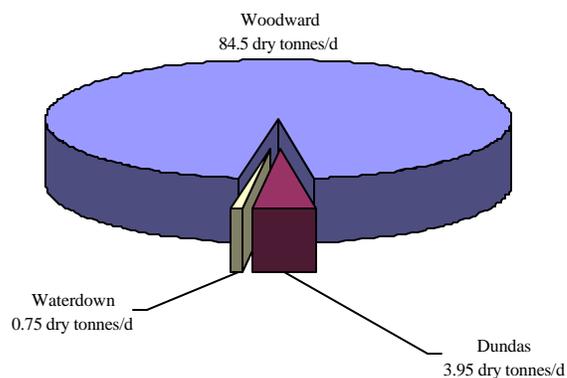


Figure 5: Source of Solids From Hamilton's Three WWTPs

After anaerobic digestion and dewatering of the biosolids, the annual average dewatered biosolids production is approximately 54,000 wet tonnes per year (based on the Annual Operating Reports for the Woodward Avenue WWTP for 2002 and 2003). The reported two-year average total solids (TS) concentration in the dewatered cake was 23.2 percent dry solids, and the volatile (VS) concentration was reported as 52 percent of the TS. Based on the 2002 and 2003 haulage reports, the average dry solids production is approximately 34.6 tonnes/day or 12,629 tonnes/year.

3.0 REQUIREMENTS FOR BIOSOLIDS MANAGEMENT IN ONTARIO

In Ontario, both federal and provincial regulations apply to the management of biosolids. The applicable regulations are dependent on the technology being utilized; however, since biosolids are considered to be waste and waste is a Provincial responsibility, most of the regulations that apply to biosolids are Provincial. Biosolids may be governed in part by federal regulations if they are processed to a saleable product. For example, in the case of alkaline stabilization, the product, if it meets certain criteria, may be governed under the federal Fertilizer Act. A detailed regulatory review is provided in **Appendix A** (Technical Memorandum 6).

In order to operate a facility, approvals must be obtained, including approvals for activities such as construction, discharge to air, discharge to water, land application to approved sites, transport of materials and operation of a facility. In Ontario, biosolids are generally regulated by the Environmental Protection Act (EPA), the Environmental Assessment Act (EAA), the Nutrient Management Act and the Ontario Regulation for Waste Management (O. Reg. 347). Federally, the Fertilizer Act is mostly applied to products derived from biosolids.

Currently, anaerobically digested biosolids from Hamilton are applied to agricultural land. In order to apply, biosolids must meet quality standards, including digestion time and temperature, and metal concentrations. A total of eleven heavy metals are required to be monitored. The regulations dictate maximum application rates, frequency and preclude application if soil conditions do not meet certain criteria (e.g. soil metal concentrations cannot exceed prescribed levels). Application restrictions are also dictated depending on the agricultural crop and the time before crop harvest. The land on which biosolids may be applied must be approved by the regulators through a Certificate of Approval process prior to biosolids application. In addition to biosolids and land standards, the biosolids hauler and spreader must meet specific reporting criteria. If the biosolids cannot meet the prescribed criteria and no other treatment is available, the biosolids must be taken to a landfill or incinerated.

If biosolids are composted and are to be applied to land, the resulting product must meet the Ontario compost guidelines. The guidelines include maximum permissible metal

concentrations and minimum process treatment conditions (e.g. minimum temperature for a minimum time). If multiple influent streams are used to create the compost, each of the streams must meet the compost guidelines.

With some technologies, such as alkaline stabilization, the biosolids are treated to an extent that they are considered a product that may be registered under the federal Fertilizer Act. This product may be classified as a fertilizer or more commonly as a soil amendment. To be classified as a fertilizer, in addition to other criteria, claims with respect to nutrient value must be verified. Whether the product is classified as a soil amendment or as a fertilizer, it must meet standards including maximum metal and pathogen concentrations

4.0 PROJECTION OF FUTURE BIOSOLIDS QUANTITY

To estimate future biosolids production leaving the Woodward WWTP, it is necessary to estimate the population served and a per capita sludge generation rate. Details on the projection of future biosolids quantity are provided in **Appendix A** (Technical Memorandum 2).

4.1 Population Projection

Using data provided by Ontario's "Places to Grow" Strategy and current and aggressive annual growth rates, future populations were determined. The Strategy provided a current and an aggressive population projection, each with the same base population of 510,300 people in 2001 for the entire City of Hamilton. The wastewater treatment serviced population for Woodward Avenue WWTP is included in this base population, with the additions of surrounding communities that are not serviced by the plant. For 2031, the current growth scenario projected a total population of 658,900 and the aggressive growth scenario projected a total population of 700,700. From these populations, a current and an aggressive annual growth rate were determined to be approximately 1.0% and 1.2%, respectively.

Using the current and an aggressive annual growth rate determined above, corresponding population projections were determined for the projected servicing populations up to 2035. In 2003, the population serviced by the Woodward Avenue WWTP was determined to be 380,000 from the City's GRIDS (Growth Related Integrated Development Strategy) data. This servicing population was the starting point for each population projection. **Table 2** contains the projected population serviced by the Woodward Avenue WWTP based on the current and aggressive growth rates. These growth scenarios are used to project flows and sludge generation for the plant.

From 2010 onward, the serviced population includes the residual population from Dundas and Waterdown above and beyond its WWTP's serviceable population limit of 50,000 population equivalent (PE).

Table 2: Project Serviced Population

Year	Projected Service Population	
	Aggressive Growth Rate	Current Growth Rate
2003	380,000	380,000
2005	389,500	387,500
2010	415,200	407,800
2015	450,700	437,300
2020	490,500	470,500
2025	535,600	508,200
2030	587,000	551,500
2035	646,300	601,700

4.2 Quantities of Biosolids

Raw, primary and waste activated sludge from Dundas, Waterdown and Woodward Avenue are processed into biosolids at the Woodward Avenue WWTP in anaerobic digesters. The biosolids are dewatered and a contractor, Terratec Environmental, removes them off-site for land application. A review of the 2001, 2002 and 2003 Summary Reports for the Biosolids Recycling Program by Terratec Environmental was performed. The annual amount of biosolids removed from Woodward Avenue was established and is shown in **Table 3**. Based on an average biosolids production rate of 56,859 wet tonnes/year and a service population of 380,000, the biosolids production rate is 0.150 wet tonnes/year/capita.

Table 3: Biosolids Production Per Capita

Year	Woodward Service Population	Biosolids Production (wet tonnes/yr)	Biosolids Production Per Capita (wet tonnes/yr/capita)
2001	380,000	62,000	0.163
2002	380,000	53,386	0.140
2003	380,000	55,190	0.145
Average		56,859	0.150

The biosolids production rate of 0.150 wet tonnes/year/capita in combination with the projected service population was used to establish future biosolids production rates. The results are shown in **Figure 6**. At current growth rates, the biosolids production rate is estimated to be 94,230 wet tonnes per year in 2035. This is a 54% increase from the

estimated 2005 production rate. At aggressive growth rates, the biosolids production rate is estimated to be 100,900 wet tonnes per year in 2035. This represents a 64% increase from the estimated 2005 production rate.

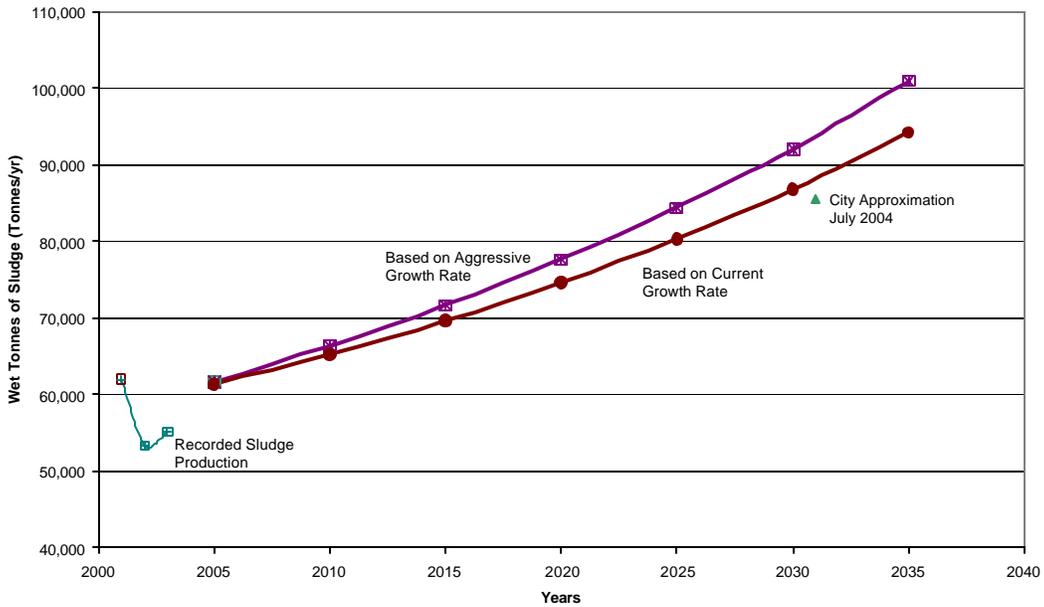


Figure 6: Projected Annual Sludge Production Rates

5.0 FACTORS INFLUENCING FUTURE BIOSOLIDS MANAGEMENT THROUGH LAND APPLICATION

The factors affecting the land application of biosolids include the quantity and quality of biosolids to be applied and the land available for biosolids application. Discussions regarding the factors influencing the future biosolids management through land application are provided in **Appendix A** (Technical Memorandums 3 and 7).

5.1 Biosolids Quality

The biosolids quality considers historical metals and nutrient levels in Hamilton's biosolids.

5.1.1 Metals Content

The MOE Guidelines for Land Application (1996) specified criteria for application on agricultural land for anaerobically digested sewage biosolids that was based on the ammonium plus nitrate nitrogen (plant-available nitrogen) to metal ratio. The MOE Guidelines (1996) also specified maximum metal concentrations for dewatered sewage biosolids that may be applied at rates up to 8 tonnes per solids per hectare per five years.

The Ontario Regulation (O.Reg. 267/03) made under the Nutrient Management Act (NMA, Bill 81) specifies the maximum biosolids application rate for land application as a function of the concentration of regulated metals. Depending on the concentration of the regulated metals, the maximum biosolids application rate is 8 tonnes/ha over a five-year period (8T standards), or 22 tonnes/ha over a five-year period (22T standards).

Table 4 summarizes the metal content in the biosolids from the Woodward Avenue WWTP. In 2002 and 2003, the biosolids samples satisfied the MOE Guidelines (1996) for dewatered sewage biosolids, and the 8T standards under the NMA. The average concentrations of molybdenum and selenium exceeded the 22T standards in 2002 and 2003. The biosolids are, therefore, limited to application rates of 8 tonnes/ha over a five-year period as opposed to the higher application rate of 22 tonnes/ha over a five-year period. This restriction increases the area of land required for land applying Hamilton's biosolids.

Table 4: Metal Content In Hamilton Biosolids

Metal Concentration (mg/kg TS)	Woodward WWTP (digested biosolids)		Max. Concentration for Agricultural Land Application ⁽³⁾	
	2002 ⁽¹⁾	2003 ⁽²⁾	8T Standard ⁽³⁾	22T Standard ⁽⁴⁾
Arsenic	3.9	6.0	170	75
Cadmium	4.3	8.5	34	20
Chromium	215	175	2,800	1,060
Cobalt	5.0	8.4	340	150
Copper	714	577	1,700	760
Lead	121	98	1,100	500
Mercury	0.5	1.0	11	5
Molybdenum	40.0	41	94	20
Nickel	43.0	40	420	180
Selenium	14.6	19	34	14
Zinc	931	871	4,200	1,850

Notes:

1. Based on average values (January to July) reported in the 2002 Biosolids Utilization Program Audit (CH2M Hill, 2003). Metal concentrations were analyzed monthly in the digested biosolids.
2. Based on average values (May to December) reported in the 2003 Biosolids Utilization Program Audit (CH2M Hill, 2004). Metal concentrations were analyzed monthly in the digested biosolids.
3. 8T Standard: Maximum Metal Concentration in Material to be Applied up to 8 Tonnes per Hectare per 5 years (Table 1, Column 3, NMA, 2002, and Table 1, Column 4, MOE Guidelines, 1996).
4. 22T Standard: Maximum Metal Concentration in Material to be Applied up to 22 Tonnes per Hectare per 5 years (Table 1, Column 2, NMA, 2002)

5.1.2 Nutrient Content

The previous land application guideline (1996) specified a maximum application limit for nitrogen (ammonium and nitrate nitrogen) from anaerobically digested sewage biosolids of 135 kg N/ha over 5 years for agriculture land. No application limit for phosphorus was specified. The application rates for potassium and other nutrients, as well as organic matter contents were determined on a case-by-case basis.

In the NMA, nitrogen and phosphorus application rates are based on site-specific agronomic and crop removal balance. Indexes for nitrogen and phosphorus would be completed to limit nitrogen and phosphorus applications.

The characteristics of the biosolids from the Woodward WWTP are summarized in **Table 5**. The solids and nutrient levels are considered typical. What could potentially limit the application of biosolids to agricultural land is the application of the Nutrient Management Act Phosphorus (P) Index. The P Index will restrict applications on soils with high

available soil phosphorus concentrations. Annual biosolids applications will be restricted to the crop phosphorus requirement where soil phosphorus concentrations exceed 30 mg/L.

In 2004, three (7.3%) of the 41 application sites for Hamilton biosolids had available soil phosphorus concentrations exceeding 30 mg/L. In 2002, two (4.1%) of the 48 application sites exceeded 30 mg/L, and in 2003 no sites exceeded 30 mg/L. It is common for available phosphorus in Ontario soils to exceed 30 mg/L and the resulting decrease in biosolids application rates will mean increasing land requirements through the planning period.

Table 5: Quality of the Dewatered Biosolids Produced at the Woodward WWTP

Parameter	Woodward WWTP	
	2002 ⁽²⁾	2003 ⁽¹⁾
TS (%)	23.9	22.4
VS (% of TS)	52	52
TKN (as N) (% of TS)	4.3	3.9
Ammonia (as N) (% of TS)	0.6	0.8
Phosphorus (TP as P) (% of TS)	2.7	3.0
Potassium (K as K) (% of TS)	0.5	0.5
Faecal Coliform (CFU/g TS)	Not reported	1,003 ⁽³⁾
Notes:		
1. Based on 2003 Biosolids Utilization Program Audit for the Woodward Avenue WWTP (CH2M Hill, 2004). Values are typical values estimated by CH2M Hill except for TS, TKN, and TP which are based on the 2003 average (CH2M Hill, 2004).		
2. Values based on 2002 average from January to July (except VS and Faecal Coliforms) (CH2M Hill, 2003).		
3. 2003 average of monthly geometric means. The sample location was not reported (i.e. unclear whether samples are digested or dewatered and/or on wet/dry basis) (CH2M Hill, 2004).		

The NMA specifies that *E.coli* counts in biosolids must not exceed 2×10^6 CFU per gram total solids dry weight for land application. Historically, *E.coli* has not been sampled, as it was not required under the previous MOE Guidelines (1996). The reported geometric mean density of faecal coliform in Woodward biosolids was 1,003 CFU/g TS. Based on the faecal coliform density, it is anticipated that the *E.coli* density would satisfy the NMA requirement.

Biosolids characteristics may change in prolonged storage due to precipitation, freezing/thawing, evaporation, volatilization and biological activity. In general, ammonia nitrogen concentrations may decrease after storage due to volatilization. Also, the TS and nutrients may decrease slightly with time.

5.2 Land Inventory

The land base available for Hamilton biosolids application within 50 km of the Woodward Avenue wastewater treatment plant was determined. This area is depicted in **Figure 7** and includes the following regions, counties and townships: Hamilton, Halton, Brant, Niagara, Haldimand, and the Townships of North Dumfries in Waterloo Region and Puslinch in Wellington County. The sections of Peel Region and Metropolitan Toronto falling within the area were assumed to be built-up and non-agricultural; therefore unavailable for Hamilton sewage biosolids application and were not included in the land base calculation. A substantial portion of the radial is Lake Ontario water surface which further reduces the potential biosolids spreading area available to the City within its radius.

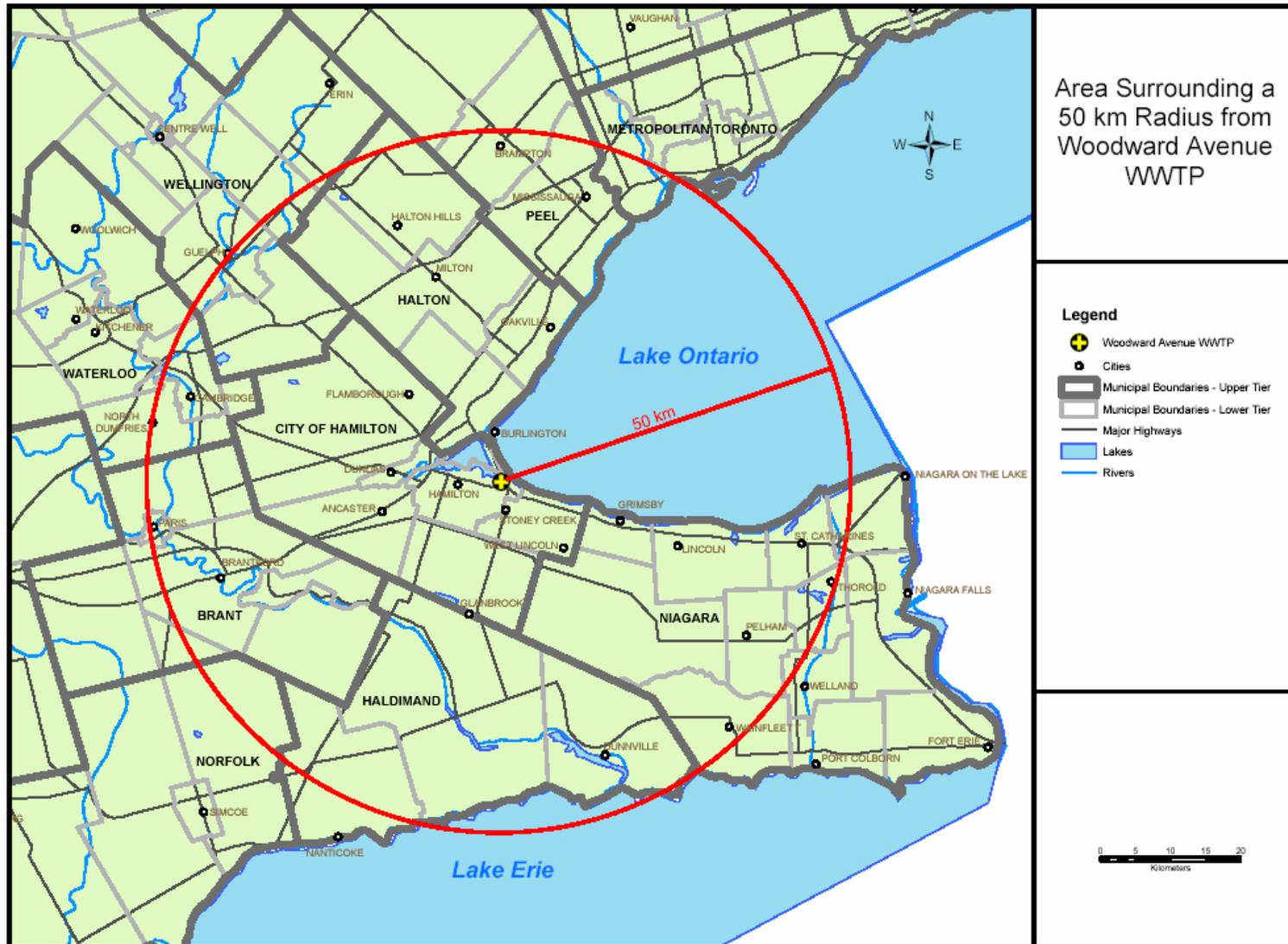


Figure 7: Land Base Within 50 km Radius of Hamilton

5.2.1 Land Availability for Biosolids

Agricultural land where crops are grown is considered the only land available for biosolids application. Prior to the available agricultural land being used for biosolids application, there must first be allowances made for manure application, setbacks (residences, watercourses, wells and other protected areas), and land not suitable for biosolids application. Of the estimated 733,366 ha of field crop area within 50 km of Hamilton's Woodward plant, it is estimated that 277,860 ha or 38% of the land could potentially be used for biosolids application. Since biosolids may be applied on specific lands only once in every five years, the actual potential land area is 55,752 ha ($277,860 / 5$). Based on an application rate of 8 tonnes of dry solids/ha, the required land area to accommodate the biosolids production in 2035 is 2,709 ha or 4.9% ($2,709 / 55,752$) of the presently available biosolids application area.

The City of Hamilton itself is estimated to have only 8,549 ha of land per year available for biosolids application. Based on current biosolids production rates 1,545 ha or 18% would be required to manage current biosolids production. Assuming no change in availability, 32% of available land would be required to accept the 2035 biosolids production.

Nine jurisdictions including Hamilton are located within 50 km of Hamilton. Their present biosolids production is 152,232 tonnes dry solids / year and they are expected to produce 230,298 tonnes dry solids in 2035. If all of the current biosolids produced were land applied at an application rate of 8 tonnes dry solids/ha, 19,029 ha of land or 34% ($19,029 / 55,752$) of the potentially available land each year would be required. At the estimated 2035 production rates, 52% of the available land each year would be required.

Since not all of the current biosolids production in the nine jurisdictions is spread on the 55,752 ha of available land, the actual land requirements would be lower. If the City of Toronto and Peel Region apply no biosolids in the 50 km radius of Hamilton, the other jurisdictions apply a proportion of their biosolids approximately equal to the proportion of their land included in this area and the pattern of biosolids management does not change significantly over time, the amounts of biosolids land applied in this area in 2035 were estimated at 61,391 tonnes dry solids/year. At an application rate of 8 tonnes dry

solids/ha, 7,674 ha of land or 14% (7,674 / 55,752) of the potentially available land each year would be required to manage the 2035 biosolids production.

Changes in livestock numbers and hence the amount of land needed for manure application over the next thirty years are difficult to predict but are expected to decrease due to loss of land for urban development. This in turn, will reduce the amount of cultivated field cropland available for biosolids application.

These calculations indicate that a large percentage commitment of land would be required within the 50 km radius. This is a significant limitation in the continued and sustainable ability to spread biosolids on land for the 30-year planning period, particularly in further consideration of the basis of securing volunteer farmers offering their lands for application.

6.0 CRITERIA FOR ASSESSMENT OF BIOSOLIDS MANAGEMENT ALTERNATIVES

The criteria to evaluate biosolids management options were developed to reflect the issues associated with the social, environmental and economics of alternatives as they apply to the Hamilton condition. The criteria for the alternatives evaluation were based on the initial criteria developed and with input received from the TSC and Stakeholder Advisory Committee. Background to the various options was provided in Technical Memorandums (TMs) developed for and reviewed by the TSC and SAC. The documentation in TMs 1 through 6 (**Appendix A**) assisted the project team (TSC & SAC) in defining the problems and opportunities in developing a long-term strategy for the environmentally sustainable, reliable, and cost-effective management of the City's biosolids. The remaining nine TMs provided details on each of the alternative biosolids management technologies for consideration in the Master Planning process. The TSC and SAC reviewed the TM content, provided input on biosolids management alternative evaluation criteria and participated in the selection of a short list of preferred solutions. These documents (TMs 7 to 15, **Appendix A**) each described and assessed in detail a particular biosolids management technology available for consideration by the City and SAC as viable options or as components of an overall preferred management strategy for the next 30 years.

Table 6 summarizes the long list of alternatives for biosolids management reviewed for Hamilton, and the comparative distinction and end-use or final disposal for each.

The proposed *Evaluation Criteria* process was described in TM 16 (**Appendix A**) and utilized by the SAC to evaluate the long list of alternative technologies. The alternatives were evaluated with respect to the natural environment, social environment, technical considerations, and financial implications. These criteria reflect the principles of the City's Triple Bottom Line (TBL) and Vision 2020 sustainability policies. **Figure 8** shows the main categories for the evaluation and each category's weighting. Each category had a number of sub-criteria with a weighting factor.

Table 6: Long List of Alternatives Considered

Biosolids Management Alternative	Comparison to the Current Program	End Use/Disposal	Dominant Regulation(s)	Risk
Land Application of Class 'B' biosolids	Status Quo	land/landfill	NMA, O. Reg. 267/03	insufficient land base levels of metals and other constituents
Class 'A' Stabilization (specific enhancement to digestion)	Pathogen and odour reduction	land/landfill	Fertilizer Act (NMA if not sold as fertilizer)	insufficient land base levels of metals and other constituents
Composting and co-composting	Pathogen and odour reduction	land/landfill	CCME and MOE Compost Guidelines (NMA if not sold as fertilizer)	insufficient land base levels of metals and other constituents
Alkaline Stabilization	Pathogen and odour reduction; soil acidity correction	land/landfill	Fertilizer Act NMA if not sold as fertilizer)	insufficient land base levels of metals and other constituents
Thermal Drying	Pathogen and odour reduction; volume reduction	land/landfill or other products	Fertilizer Act NMA if not sold as fertilizer)	insufficient land base levels of metals and other constituents
Incineration or co-incineration	Complete oxidation, sterilization and maximum volume reduction	ash/landfill	O.Reg. 346, 347 and 419/05	stringent control of air emissions required for CFCs
Landfill	Diversion from land application to landfill	landfill	O. Reg. 347	direction away from organics to landfill
<p>Notes:</p> <p>Class 'A' and 'B' denote a US EPA terminology for the degree of biosolids stabilization. In Ontario, the equivalent to Class 'B'; is mandated under the NMA. Composting, alkaline stabilization, thermal drying are capable of producing a US EPA Class 'A' product under the auspices of composting regulations or the Fertilizer Act.</p>				

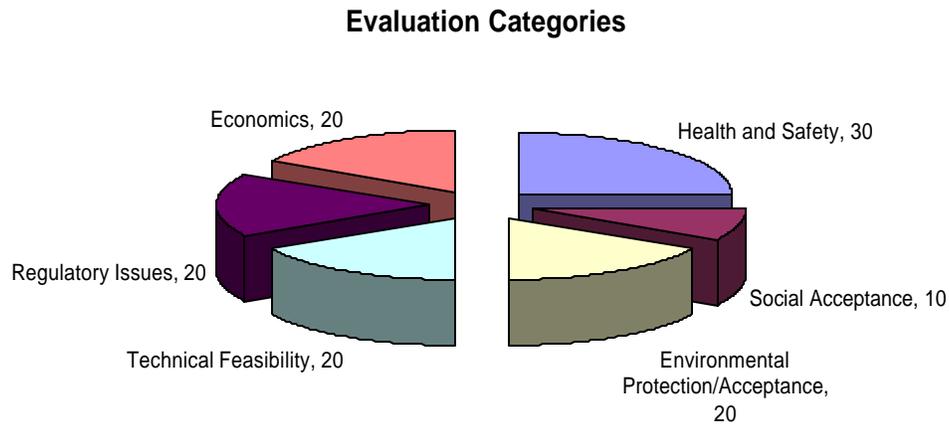


Figure 8: Main Evaluation Categories and Weighting Factors (Total = 120)

The evaluation criteria matrix referenced the values of Vision 2020, sustainability and the City’s ‘triple bottom line’ of environment, society and economy.

The TSC and SAC reviewed, analyzed and evaluated the various options for biosolids. The results were compiled and the project team met to collectively discuss the results of the evaluation and gain a consensus on the short list of options to be vetted through the public. These recommended solutions were presented to the public at the second round of PICs.

General comments and issues raised by the TSC and SAC were recorded and reviewed and responses provided. A listing of these responses can be found in **Appendix C**.

7.0 ASSESSMENT AND SELECTION OF BIOSOLIDS MANAGEMENT ALTERNATIVES

The TSC and SAC reviewed, analyzed and evaluated the options presented for long-term biosolids management. The results were compiled and the project team met to collectively discuss the results of the evaluation and gain a consensus on the short list of options to be vetted through the public. The project team ranking for alternative plans, based on the criteria above, is summarized in **Figure 9**. The figure indicates the technologies reviewed in each TM. This ranking is relative, and highlights those technologies that rank higher than others, and would therefore be more appropriate for Hamilton.

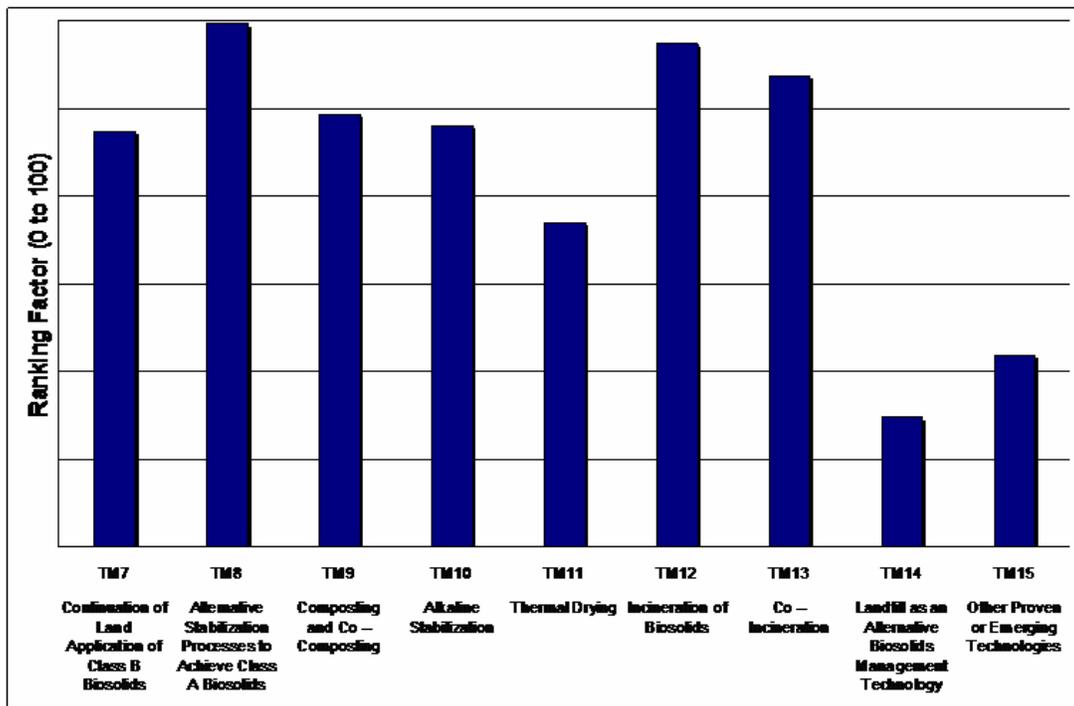


Figure 9: Stakeholder Advisory Committee (SAC) Ranking Factoring for Alternative Biosolids Handling Plans

The recommended solutions, together with the analytical rationale, are summarized in TM17 (**Appendix A**). These recommended solutions were presented to the public at the second round of PICs. Of particular note is the recommendation to not proceed with the

current practice of land applying Class ‘B’ biosolids (i.e. US EPA designation). This recommendation is supported by the fact that from a Triple Bottom Line (TBL) perspective, biosolids can be treated to a higher level (Class ‘A’ US EPA designation) thereby minimizing environmental and social risks as they relate to odour generation and pathogen reduction. Emerging technologies were deemed effective in small pilot applications but unproven in broad wastewater applications. Landfilling of biosolids was dismissed as a prime alternative as it was considered contrary to the waste diversion policy.

The overall net present value (NPV), that is the capital and 30-year O&M costs, for each alternative is summarized in **Figure 10**.

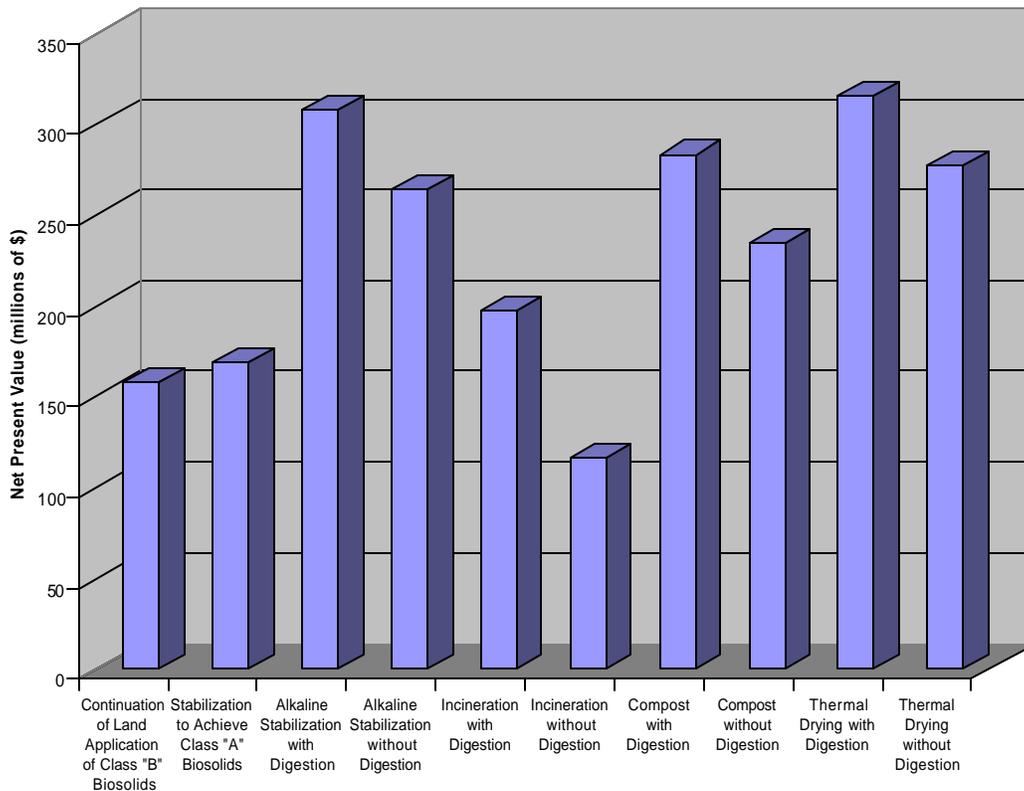


Figure 10: Summary of Net Present Value for Long-List of Alternatives

The project team’s short list recommended that the City undertake any one, or a combination of two approaches: the production of a ‘Class A’ stabilized product (a US Environmental Protection Agency [EPA] reference for an enhanced level of odour and

pathogen reduction as compared to standard stabilization processes) for further land application, and/or thermal oxidation/reduction (incineration) of the biosolids. A number of comments/concerns were raised concerning the short-listed alternatives (and other alternatives as well) and these are summarized in **Appendix C**. Comments/concerns were raised specifically for the Class “A” production (US EPA designation) and thermal reduction. These concerns and responses are summarized as:

7.1.1 Class “A” Production

1. **Question:** *It is not clear to me if the biosolids applied to soil are treated to get rid of pathogens and metabolizable contents in all cases -* **Answer:** Current stabilization methods at the plant (i.e. anaerobic digestion) reduce pathogens in the biosolids. The equivalent to Class “A” product would be pathogen free.
2. **Question:** *The label should reflect the monitoring of the sludge and give levels of heavy metals, any dangerous chemicals, and the summarized results/conclusions and recommendations of toxicity and mutagenicity/carcinogenicity tests. This is not something negative; it would not only be safe practice but also increase the market value of the sludge. If we have to compete for land to apply the sludge, competitiveness becomes an asset –* **Answer:** Sewage biosolids represented for sale in Canada as a soil amendment / conditioner are regulated by the CFIA (Canadian Food Inspection Agency) under the federal Fertilizers Act and must be labelled. The label implies a sampling / monitoring strategy and represents a quality guarantee. All products must comply with maximum heavy metal concentrations defined in TM4.

7.1.2 Thermal Reduction

1. **Question:** *I agree with the general trend, not to incinerate or send biosolids to landfill -* **Answer:** Given recent improvements in incinerator technologies, a general trend away from biosolids incineration may be neither justifiable nor practical. ‘Incineration’ is the broad traditional reference to the burning of material to ash in the presence of air. The development of combustion technologies employing a broad range of controlled specific conditions (for example, with pure oxygen [gasification], flameless [pyrolysis], under pressure, or in a vacuum) has led to the application of ‘thermal conversion’ technologies which may still be generally referred to as incineration (conversion to ash), actually have increased combustion efficiency and, together with greatly improved stack control technologies, have significantly reduced process emissions. The need for management of ash residuals, however, remains.
2. **Question:** *I do not favour incineration because unless it is complete, emissions can be a health problem, and even if incineration is complete, the CO₂ produced contributes to global warming, the S and N oxides can be toxic, and heavy metals in the air are undesirable –* **Answer:** Recent incinerator technologies are much improved over previous ones and emissions from a properly designed and

operated modern biosolids incinerator present no significant human or animal health risk.

Numerous comments/concerns were raised with respect to biosolids quality for land application in terms of heavy metals which relates to all of the land application alternatives, these comments are summarized in **Appendix C**.

The following provides a summary for the short-listed alternatives.

7.1.3 Class 'A' Production

Class 'A' biosolids, as defined by the US EPA, have substantially lower pathogen content and can typically be less odourous than Class 'B' biosolids; two qualities that realize a greater level of regulatory standard and public acceptance. Equivalent to Class 'A' biosolids can be land applied with reduced site restrictions. In Ontario, these materials would need to be registered under the CFIA Fertilizer Act. **Figure 11** shows two styles of anaerobic digesters that are typical for anaerobic digestion systems.

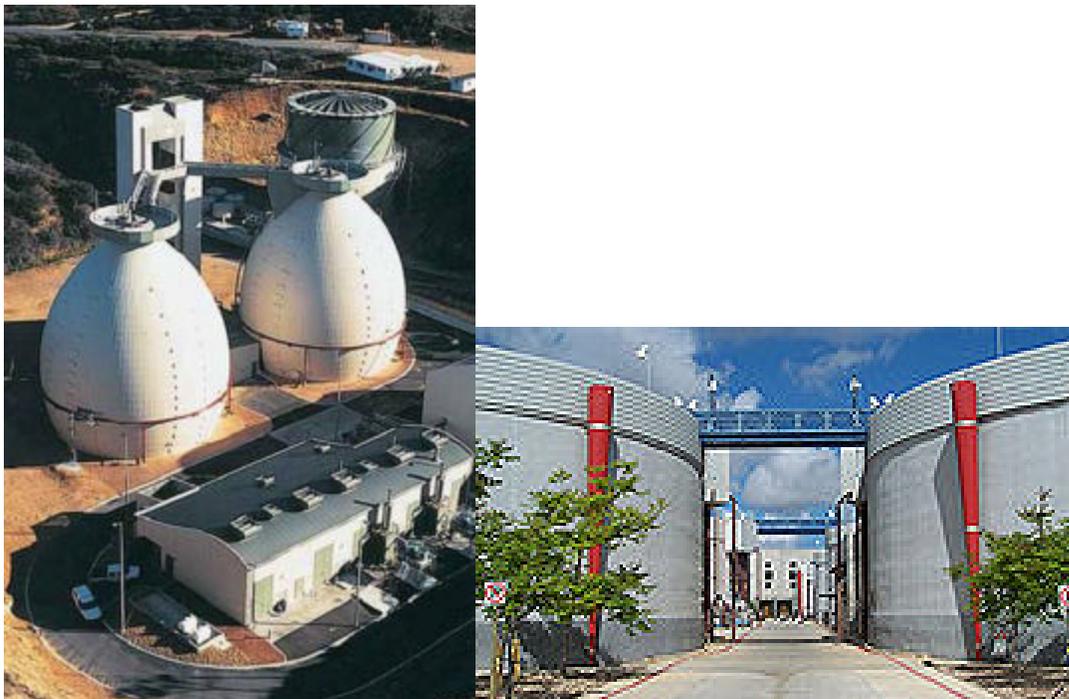


Figure 11: Photo Examples Of Anaerobic Digesters

Class 'A' biosolids product, to be further distributed by the City or through its contractor would be required to continually and consistently meet the acceptable metal concentrations set by the Canadian Food Inspection Agency under the Fertilizer Act. At

present, the City's biosolids meet those requirements for the majority of regulated metals: however, for two specific metals, molybdenum and selenium (generally found in personal care products) producing consistent and reliable levels are yet to be achieved and remain a limiting factor for marketing biosolids as a Class 'A' product. In addition, the marketing of a Class 'A' product is challenged by a lack of customer base to consistently purchase such a product. For these reasons, proceeding with marketing a Class 'A' product is not recommended and disposal would be limited to land applying to agriculture lands, with a contingency of landfill for unapplied product. This would include the limitations identified for a traditional non-CFIA product that would be registered under the NMA. In future, should opportunities for marketing a Class 'A' product arise, the cost would need to be revised.

Two Class 'A' biosolids production alternatives were identified by the TSC and SAC through the BMP process; one involving the alkaline stabilization process, and a second that would involve altering the existing digestion process at the Woodward WWTP to include enhanced treatment through temperature phased anaerobic digestion (TPAD).

7.1.4 Alkaline Stabilization

The high temperature and pH changes that occur with the addition of lime or other alkaline reagent to digested or undigested biosolids result in a sterilized and low odour product. The alkaline stabilization process can be implemented in-house or through contract. There remains a need to further manage the distribution/disposal of the end product, and a continuing requirement that the product meet the metal constituent levels as regulated for its end use as a fertilizer under the CFIA. The alternative assumes that a consistent and reliable source of lime is available as process feed through the planning period. Perhaps less controllable is the requirement to have access to low pH (acidic) agricultural soils that will benefit from the neutralizing application of the alkaline stabilized biosolids. Such soil characteristics in Ontario are typically found in the lacustrine clays of the southwest (Essex and Lambton) and Niagara regions. **Figure 12** shows two examples of alkaline stabilization facility installations.



Figure 12: Photo Examples of Alkaline Stabilization Facilities

7.1.4.1 In-House Alkaline Stabilization

This alternative would see an alkaline stabilization facility constructed and operated at the Woodward WWTP site. The treatment may be applied to undigested (high solids content) or digested sludge (lower solids content) with a corresponding lime volume addition requirement and associated operational cost. As fertilizers are applied seasonally and must be actively distributed, there would be further storage and transportation requirements (and transportation air emission issues). Further, sludge metal constituent concentrations would have to meet or exceed those stipulated by the Fertilizer Act, and any future revisions, as described above.

7.1.4.2 Contract Alkaline Stabilization

A regional alkaline stabilization plant is currently being established in Niagara through a joint venture of Walker Industries Holdings and the technology firm N-Viro, with an existing contract to take 50% of Niagara Region's sludge production. The facility has been sized to process higher volumes, and potential exists where the City of Hamilton could secure through contract the remaining capacity.

Under this alternative, a contract would be entered into with the processor and sludge would be transported from Woodward WWTP to the facility in Niagara. The City's sludge would be stabilized and then further distributed by N-Viro in accordance with the Fertilizer Act.

There are some associated risks and uncertainties: contract timeframes, contract default, facility size or process failure to handle future production volumes. These may require that the City have a well-established and definitive contingency management program.

Further, the City would need to ensure that its sludge constituent metal concentrations are maintained at or below those of present and future Fertilizer Act requirements, as described above. For these reasons, proceeding with marketing a Class 'A' alkaline product is not recommended and disposal would likely be practically limited to application to agriculture lands. In future, should opportunities for marketing an alkaline Class 'A' product arise, the evaluation would require adjustment.

7.1.5 Temperature Phased Anaerobic Digestion (TPAD)

A second method of achieving production of the equivalent of a Class 'A' biosolids product is through the process of temperature-phased anaerobic digestion (TPAD). The Woodward WWTP currently operates a mesophilic (35 to 40°C) digestion process. The TPAD process consists of thermophilic (> 55°C) digestion as a first phase, further promoting a greater decomposition and conversion of acids to methane and carbon dioxide in the subsequent mesophilic phase. The TPAD process has demonstrated high rates of pathogen kill and the ability to produce Class 'A' biosolids if configured properly. However, it would need to be verified and regulated through the CFIA Fertilizer Act.

In comparison to conventional mesophilic digestion, the TPAD process creates a higher ammonia recycle load and the requirement for a corresponding nitrification capacity being available in the liquid train at the Woodward WWTP. Alternatively, a side-stream ammonia removal process would need to be incorporated into the design of the Woodward WWTP Expansion.

The TPAD process, as compared to conventional anaerobic digestion, results in higher methane gas production. The additional gas produced through the TPAD process could be included in the gas recovery and reuse design already in place at the Woodward WWTP and currently operated by Hamilton Renewable Power Incorporated.

There remains a need to further manage distribution/disposal (including transport) of the TPAD Class 'A' end product, and a continuing requirement that the product meet the metal constituent levels as regulated and marketed for its end use as a fertilizer, or similarly as applicable for further land application.

7.1.6 Thermal Oxidation/Reduction (Incineration)

Thermal oxidation/reduction is a process for sludge management that destroys the organic matter present in the sludge. Combustion releases the heating value of the organic matter in the sludge through rapid high temperature chemical reactions, and reduces considerably the volume and weight of solid residuals (ash) for ultimate disposal, resulting in greatly reduced transport and disposal requirements. Depending upon temperature, this process can destroy or reduce trace organic materials. **Figure 13** shows examples of this technology.



Figure 13: Photo Examples Of Fluidized Bed Incinerators

The City, using multiple hearth technology, incinerated its biosolids up to 1996 when the process infrastructure refurbishment necessary to meet regulatory requirements was deemed cost-ineffective. Fluidized bed incineration is now the state of the art technology and the type considered for most new sludge incineration installations. There are currently a number of biosolids thermal reduction systems in Ontario, including at the Lakeview (Peel), Highland Creek (Toronto), Duffin Creek (York), and Greenway (London) WWTPs.

Either digested or undigested sludge may be incinerated. There is a greater net fuel consumption for digested solids relative to undigested solids. Cogeneration use of digester methane production would further offset the costs associated with digestion incineration. Heat and energy recovery processes can also be considered in this application, and as a result of recently announced provincial initiatives related to

renewable energy, the opportunities to generate electricity utilizing thermal reduction technologies were analyzed.

Air emissions criteria for an incinerator installation are a major consideration in the selection and cost of the incinerator system. The emissions resulting from the incinerator system operation are monitored by regulatory agencies. Technologies to control emissions are now readily available, proven, and are further designed and implemented to meet or exceed regulatory requirements. Emissions criteria have been well addressed by other municipalities in southern Ontario with the satisfactory meeting of regulatory requirements by their thermal facilities.

Unlike municipal solid wastes, wastewater biosolids generally have comparatively low levels of persistent organics and provide a more consistent feed product which in turn ensures a better control of the overall incinerator process. For wastewater biosolids, the incinerated ash is assessed as non-hazardous waste and typically may be disposed of at a municipal landfill. Opportunities exist to also utilize the ash generated in cement manufacturing and road construction, although this is not common.

There have been recent significant technical improvements in the thermal reduction process. The presence of facilities in southern Ontario provides local expertise in the practice. The public has historically expressed concern with thermal reduction alternatives; however, the operating experience of these local facilities can be referenced to provide information to those less comfortable with the concept of thermal reduction.

7.2 Additional Issues for Short-Listed Alternatives

Based on the short-listing to a “Class A” stabilized product (i.e. US EPA designation) and/or a thermal reduction process, a further evaluation was undertaken that assessed:

- Impact on current co-generation process (“Class A” biosolids)
- Air emissions (thermal reduction and hauling)
- Potential energy from waste (EFW) (thermal reduction)

These issues are reviewed and presented in TM17 (**Appendix A**). A summary of each item follows:

7.2.1.1 Impact on current co-generation process

The current co-generation system (known as HRPI) was evaluated for the following scenarios:

- Current anaerobic digestion continues,
- Chemical Enhanced Primary Treatment (CEPT) was practiced using the current anaerobic digester system,
- “Class A” biosolids were produced using the TPAD technology and no CEPT was practiced.

Relative to the current operating configuration, the CEPT option has a greater digester gas production rate which increases the revenue (electricity plus heat recovery) in the HRPI system by approximately 4%. With the TPAD option, gas production is even greater and the revenue increases by 20%. The benefit of this additional capacity is lost since, in order to recover this energy, an increase in co-generation capacity is required, the current thermophilic digesters must be upgraded and there will be an increase in digester operating cost. The potential benefit to producing “Class A” is not considered in this economic analysis (e.g. does not consider public acceptance). For all three scenarios, the cost of operating the digestion process is greater than the co-generation revenue.

The co-generation process has the potential to obtain a higher dollar value for electricity produced based on government incentives. At 11 cents/kWh instead of the current contract 7.5 cents/kWh, the net revenue for the baseline conditions would increase significantly, and under this condition co-generation has a positive economic value even if further processing is undertaken (e.g. incineration).

7.2.1.2 Air Emissions

Air emission quantity and quality for the current land application process was compared to incineration. Comparisons were made for greenhouse gas emissions (GHG) and Criteria Air Contaminants (CACs). GHG emissions were estimated for thermal oxidation (incineration) and the land application alternatives. Air emissions for land application were only estimated for trucking. For the land application alternatives trucking air emissions are only one of the air emission sources from these alternatives.

For the case of CACs, biosolids trucking produces lower emissions than thermal processing. This is a result of the relatively small quantities on sulphur and nitrogen compounds in refined engine fuels. The CAC emissions for either alternative were compared to the reported emissions in the City of Hamilton. The comparison indicated that the emissions, although different from each other, are minor components in terms of the entire City emissions (<0.04%).

7.2.1.3 Potential energy from waste (EFW) for thermal reduction option

Energy from waste (EFW) incineration takes advantage of the heated emissions from an incinerator to generate steam and electricity with a steam turbine. Excess heat may potentially be used for space heating or processes requiring heat in the plant. This evaluation reviewed EFW facilities in the United States and the United Kingdom. Generally these facilities used dewatered undigested sludge as fuel for an incinerator. **Table 7** provides a summary of the size, dry sludge production and electrical production from three facilities reviewed. Generally, the facilities are large due to the high capital and O&M costs associated with the EFW systems. Electrical production does not supply all of the energy requirements for the incineration process. For example, the Beckton WWTP uses natural gas for start-up and during operations that approximately equals (in dollar terms) 1/3 of the electrical energy produced. A schematic of a thermal reduction energy from waste system is shown in **Figure 14**

Table 7: Summary of EFW Facilities Reviewed

Plant/Location	Flow Treated (MLD)	Sludge Generated (TDS/day)	Power Generated (MW/d)
St. Paul, Minnesota	719	63	120
Beckham, UK	1210	259	150
Crossness, UK	700	85	50

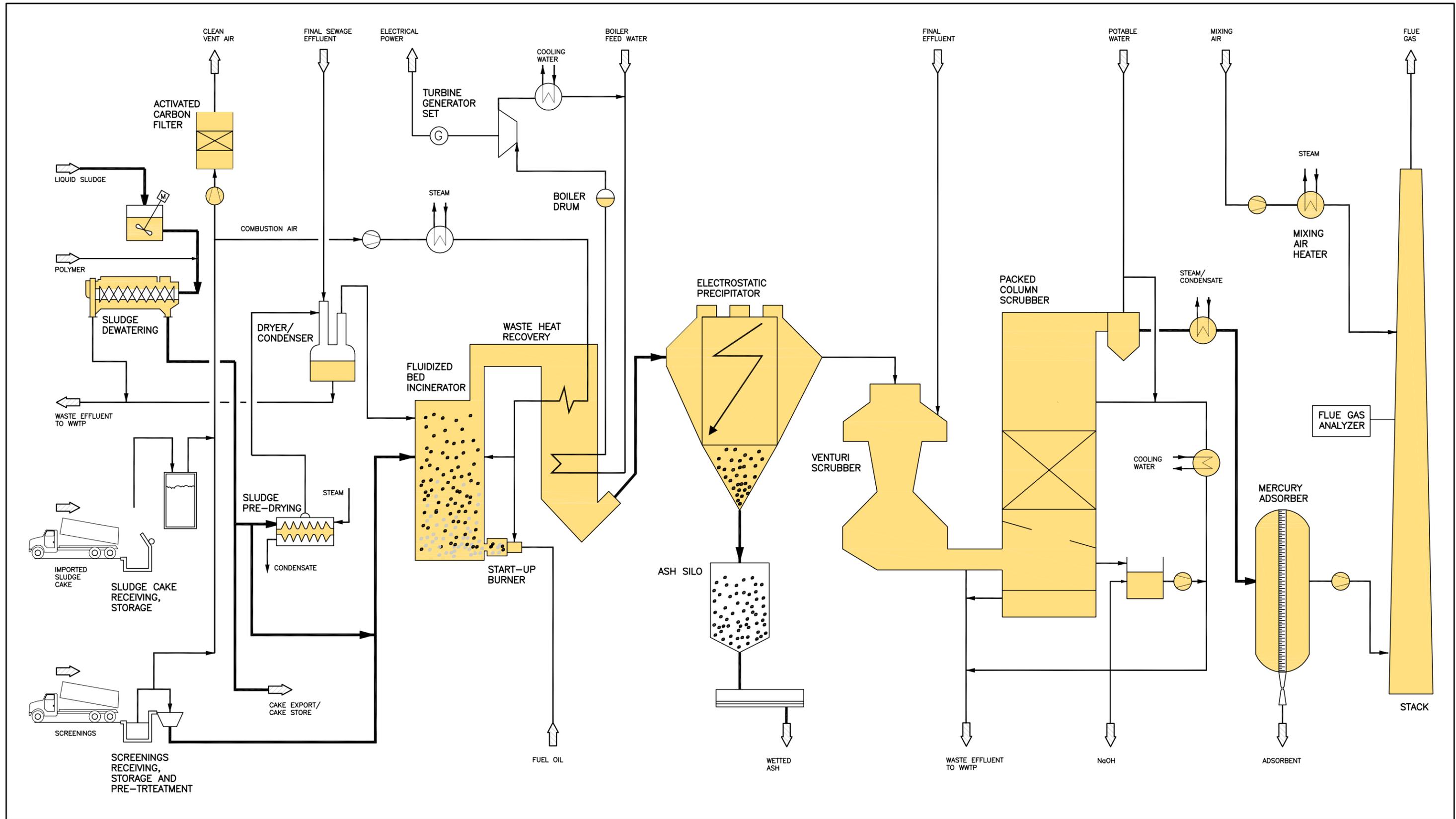


Figure 14

SCHEMATIC LAYOUT OF INCINERATOR WITH ENERGY FROM WASTE RECOVERY

7.3 Review of Short-Listed Alternatives

A review of the short-listed alternatives was completed based on the “triple bottom line” principles and criteria of environment, society, and economy. A qualitative analysis was conducted to identify the effects of the short-listed alternatives on environmental and societal issues. This review is provided in TM17 (**Appendix A**).

The security and reliability of available land on which to apply equivalent Class ‘A’ or ‘B’ biosolids (US EPA designation) has the greatest negative potential to influence these options, due to increasingly restrictive regulations, public and industry opinion, and land availability. A major influence is the ability to consistently generate a biosolids or fertilizer that is acceptable for land application; however, land application can be beneficial as a soil amendment and nutrient source, especially in a reclamation or remediation situation, or on acidic soils. Land application is a major concern to major municipalities in Ontario due to the lack of available land at the right time for biosolids application and the paucity of a volunteer farm base.

Locating an incinerator, and the associated public concerns, will have the greatest influence on the incineration alternative. Noise and emissions abatement measures (enclosures and odour controls) would need to be employed at the incinerator and associated equipment to mitigate the impacts of these emissions to plant workers and neighbours in the vicinity of the WWTP. The incinerator can be sized to provide 100% contingency for all biosolids if/when other end-uses are temporarily or permanently unavailable.

The economics of the short-listed alternatives were determined based on the potential for continued co-generation of electricity from digester gas and the potential for energy from waste (EFW) from the incinerator process. A summary of the cost evaluation is provided in TM17 Table 9 (**Appendix A**). The results are summarized in **Figure 15**, with multiple options for the incineration alternative (with digestion, co-generation and/or energy from waste).

The incinerator options are compared to two Class “A” biosolids options for land application: TPAD and alkaline stabilization. Alkaline stabilization has been compared

with and without digestion and co-generation. The results indicate that the alkaline stabilization alternative is the most costly option for Hamilton, with or without digestion/co-generation. The Class “A” TPAD option compares closely with the incinerator options, although it is generally higher cost than most incinerator options.

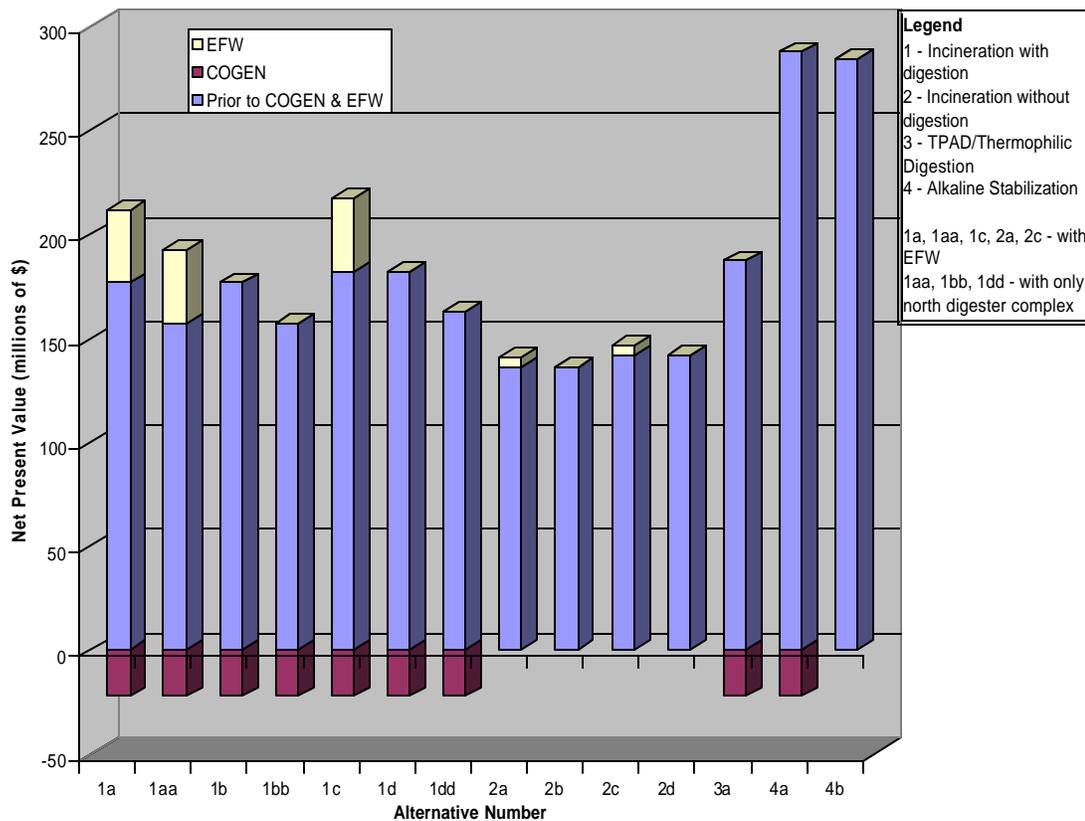


Figure 15: Summary of Economic Evaluation of Short-Listed Alternatives

The incinerator options with digestion are higher than those without digestion by about 20%. The incinerator options with digester/co-generation and EFW are the highest cost, generally over 30% above similar options without digestion/co-generation.

The option to operate only the north digester complex (NDC) with EFW is the least costly. The incinerator options without EFW result in a premium of about 10% for the continued digestion/co-generation option, slightly less than 10% if only the north digester complex is operated. This difference (i.e. incineration with or without digestion/co-generation, but no EFW) is well within the band of uncertainty of the conceptual estimates. Therefore, continued digestion with incineration as a preferred biosolids

management alternative is recommended as it provides for backup disposal options in the unlikely event of an incinerator shutdown and continues to generate electricity from digester gas onsite.

7.4 Selection of the Preferred Alternative

Based upon the thorough analysis of the short-listed alternatives, continued anaerobic digestion coupled with thermal oxidation (incineration) is the recommended and preferred alternative for the biosolids management planning period.

This alternative meets:

- The City's triple bottom line criteria.
- Provides long term control of biosolids management for the 35-year planning period with the most confidence.
- Maintains the benefit of anaerobic digestion using the Woodward Avenue WWTP north digester complex that may be continue to be applied to land as a backup.
- Provides the benefit of continued electrical power production and digester heating with the cogeneration process recently initiated.
- Results in maximum reduction of the solids volume and a sterilized end product.

Section 7.1.6 provides a description of the preferred thermal oxidation (incineration) process.

8.0 IMPLEMENTATION PLANNING

Implementation of the preferred alternative(s) is the primary goal of the Biosolids Master Plan. The implementation must include an environmentally sustainable, reliable, and cost-effective management strategy. This section describes the preferred alternative and its implementation.

8.1 The Preferred Alternative

The selected preferred alternative is thermal oxidation/reduction (incineration) preceded by continued anaerobic stabilization and cogeneration.

The actual implementation depends on many factors including final City and environmental approvals, scheduling and funding. A detailed design, specification and approvals process is recommended to facilitate the tendering and construction of the various projects. Assuming that thermal reduction of the biosolids is implemented with complete backup, it is likely that demolition of the old incinerator building may be required. This should be analyzed at detailed design for certainty and for constructability. This is critical with respect to the future expansion of the Woodward WWTP.

To complete planning, detailed design and approvals will likely require 2 to 3 years, depending on the level of approvals ultimately required. Construction and commissioning will take 3 to 4 years. The overall period from planning to commissioning is, therefore, 5 to 7 years. Thus, it is essential to retain existing City and contractual services for management of the biosolids prior to and up to the commissioning of the selected alternative. Depending on the progress of the private Liberty Energy EFW facility, it may become a temporary alternative contingency in the interim period in lieu of or combination with continued land application or land filling.

A simplified analysis of the estimated cash flow for capital and operating cost for the selected alternative is provided in **Figure 16**. The project may require Phases 3 and 4 of the Municipal Class EA process to be completed.

Figure 16. Implementation Schedule - Biosolids Management Strategy Preferred Alternative - Thermal Oxidation (Incineration)

Task	2005\$	Year																				
		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Planning																						
Biosolids Master Plan - Current	300,000																					
Master Plan Updates (5-year intervals)	600,000																					
Biosolids Management Strategy Renewals under the NMA	100,000				*																	
Continued Biosolids Contract Operation Until Implementation of Thermal Oxidation	19,110,000																					
Strategy Implementation																						
Technology Review & Phase 3 and 4 Class Environmental Assessment, if needed	250,000																					
With Continued North Digester Complex																						
Design and Specifications with Approvals, Tendering & Award	3,010,000																					
Existing Digester Improvement Capital	6,500,000																					
Construction and Commissioning	56,790,000																					
Continuing Operations and Maintenance (Incinerators & Digesters)	90,700,000																					
Cogeneration Net O&M After Energy Recovery	(22,400,000)																					
Annual Capital (\$ 2005)		100,000	100,000	200,000	125,000	2,428,333	2,303,333	2,303,333	15,697,500	15,497,500	14,197,500	14,197,500	-	200,000	-	-	-	-	-	200,000	-	-
Cumulative Capital Cost (\$ 2005) to Year 2035	67,550,000	100,000	200,000	400,000	525,000	2,953,333	5,256,667	7,560,000	23,257,500	38,755,000	52,952,500	67,150,000	67,150,000	67,350,000	67,350,000	67,350,000	67,350,000	67,350,000	67,350,000	67,350,000	67,550,000	67,550,000

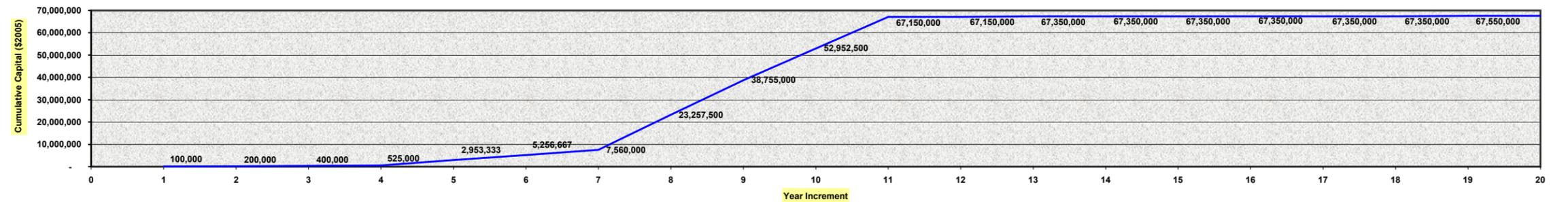


Figure 16 shows the cost of the existing biosolids program until the preferred alternative is fully commissioned through to 2025. Costs are reported in 2005 dollars. Future capital cost should be adjusted for materials and construction inflation. Costs include the City growth for the planning period, contractor mark-up (12.3%), engineering and non-construction costs (20%), capital cost contingency (15%), planning level contingency (35%), and inflation to midpoint of construction (10%).

8.2 Contingency Planning

The Master Plan has included capacity and complete backup with a duplicate thermal oxidation unit. In the event that a backup unit is not provided for the selected alternative, then another contingency plan will be required for sludge management.

The retention of anaerobic digestion and dewatering capacity, with continuous optimization, will enable the City to potentially continue to produce biosolids that may be land applied or landfilled as contingency. Depending on the private incinerator proposal progress by others (i.e. Liberty Energy), this could provide another contingency option for the interim period.

Land application as a contingency would require continuous planning to ensure that facilities (e.g. trucking, storage, application equipment) and approved acreage, are available when required. It is important to note that land requirement and availability and trucking volume is a major concern regardless of the degree of biosolids stabilization provided. Due to the complexity of this continuous backup contingency, the implementation of the selected alternative backup facility, that is a duplicate thermal oxidation unit, is preferred.