APPENDIX A – BIOSOLIDS COMPOSTING TECHNOLOGY SELECTION AND EVALUATION

Biosolids Composting Technology Selection and Evaluation
CoW-BC-Report-FINAL-2011-05-16

City of Winnipeg
Biosolids Composting
Technology Selection and Evaluation

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1 Background

The City of Winnipeg is interested in conducting a pilot biosolids composting project. A 1.5-day workshop was held on February 2 and 3, 2011 at the Greenwood Inn & Suites, Winnipeg. Arnold Permut (City of Winnipeg) and Daryl McCartney (Edmonton Waste Management Centre of Excellence [EWMCE]) facilitated the workshop. Technology Specialists participating were John Paul (Transform Composting Systems) and Scott Gamble (CH2M Hill). Workshop participants included eleven City of Winnipeg staff and three Veolia staff. A complete list of workshop attendees is included in Appendix A.

The purpose of the workshop was to introduce composting science and engineering fundamentals influencing composting system designs. An overview of composting technologies and equipment was also presented. Based on pre-workshop discussions, four technologies were shortlisted for detailed discussion at the workshop: (1) an aerated static pile; (2) a covered aerated static pile; (3) a tunnel system; and (4) an indoor continuous flow aerated system. The workshop agenda is presented in Appendix B.

Currently, 48,000 wet tonnes of municipal biosolids are generated from the City's North End Water Pollution Control Centre (NEWPCC). The biosolids are mesophilically digested and centrifugally dewatered to achieve a total solids content of approximately 26%. The biosolids are managed through the WinGRO program, through which they are either land applied or disposed of in the Brady Road Landfill. Recent changes to the regulatory environment have resulted in significant reductions to the amount of material that can be land applied.

2 Workshop Objectives

The primary objectives of the workshop were to: (1) identify the composting method and ancillary technologies needed for full-scale implementation and in the pilot study; and (2) to provide conceptual level costs for the pilot study. Using a lecture-discussion format, the first part of the workshop provided the participants with a basic understanding of the scientific and technical principles used to guide the design and operation of biosolids composting facilities. The open discussion during this period provided the technical experts with an understanding of the key issues surrounding this project.

To assist with the technology selection process, a brainstorming session was held to generate a preliminary list of evaluation criteria. During this process, one of the technologies originally on the shortlist, the indoor continuous flow aerated system, was dropped from the list because it did not meet the criterion of being an established technology.

3 Initial Technology Screening

A wide range of composting methods and technologies are available for managing biosolids, organic wastes, and manures. Almost all of these technologies are based on the same biological processes and basic principles, but they differ in how the process and resulting nuisance conditions are controlled.

A list of potential composting methods and systems that could be applied in a pilot operation was developed by the project team, and is shown in Exhibit 1. This "long list" of options was developed based on the Team's experience as well as the research conducted for other technology assessment projects.

For this evaluation, each of the options included in the long list was subjected to an initial screening and "fatal flaw" analysis using criteria developed by the project team. These criteria included (in no particular order):

- a demonstrated capability of the technology to process biosolids;
- the appropriateness of the technology for the volume of feedstocks to be processed;
- the technology's inherent level of odour control;
- the ability of the technology to be operated year-round in Winnipeg's climate;
- previous evidence of reliable operations at a commercial level;
- the ability of the technology to meet best-management practices for pathogen and vector attraction reduction;
- the ability of the technology to produce stabilized compost in a reasonable amount of time;
- anticipated land requirements; and
- anticipated capital and operating costs.

The assessment of each technology, based on the above criteria, is summarized in Exhibit 1. Based on this assessment, a number of options were excluded from further consideration as the primary processing method at the proposed pilot facility. Those options that were considered appropriate for biosolids composting included:

- aerated static piles (with and without engineered covers);
- channel systems; and
- tunnel systems.

Exhibit 1

Initial Screening of Organic Waste Processing Options

Technology	Example System Vendors	Demonstrated capability to process Biosoilds	Space Rqmt	Appropriate for Feedstock Quantities	Inherent Odour Control (1)	Appropriate for Winnipeg Climate	Reliable Commercial Operation	Ability to Meet Pathogen & Vector Rqmt	Ability to produce stable compost (2)	Capital Cost Per Tonne of Capacity	Operating & Maintenance Cost Per Tonne
Static Pile	N/A	×	Large	Yes	Low	No	Yes	No	No	Low	Low
Passively Aerated Static Pile	N/A	×	Large	No	Low	No	Yes	No	No	Low	Low
Turned Windrow	N/A	✓	Large	Yes	Low - Moderate	No	Yes	Yes	Yes	Low - Moderate	Low - Moderate
Mass Bed (unaerated, outdoor)	Vermeer	×	Moderate - Low	Yes	Low - Moderate	No	Yes	Yes	Yes	Low - Moderate	Low - Moderate
Aerated Static Pile (uncovered, outdoor)	N/A	✓	Moderate - Low	Yes	Moderate	Yes	Yes	Yes	Yes	Low - Moderate	Moderate
Aerated Static Pile - Plastic Cover (outdoor)	Ag-Bag	✓	Moderate	Yes	Moderate	Yes	Yes	No	Yes	Low - Moderate	Moderate
Aerated Static Pile - Engineered Cover (outdoor)	Gore, ECS, MOR	✓	Moderate	Yes	Moderate	Yes	Yes	Yes	Yes	Moderate - High	Low
Aerated Static Pile (uncovered, indoors)	N/A	✓	Moderate - Low	Yes	High	Yes	Yes	Yes	Yes	Moderate - High	Moderate
Channel	Transform, IPS, Longwood	✓	Moderate - Low	Yes	High	Yes	Yes	Yes	Yes	High	Moderate
Mass Bed (aerated, indoor)	Vermeer	×	Moderate - Low	Yes	High	Yes	Yes	Yes	Yes	High	Moderate
Agitated Bed	Ebara, Sorrain	×	Low	Yes	High	Yes	Yes	Yes	Yes	High	High
Static Containers/Vessels	ECS, Naturtech	✓	Moderate - Low	No	High	Yes	Yes	Yes	Yes	High	Moderate - High
Small Agitated Containers/Vessels	Go Mixer, Big Hanna	×	Moderate - Low	No	High	Yes	Yes	Yes	No	High	Moderate - High
Large Agitated Containers/Vessels	Wright, Hot Rot	×	Moderate - Low	Yes	High	Yes	Yes	Yes	Yes	High	Moderate - High
Tunnel	Herhoff, Gicom, Christiens	✓	Moderate - Low	Yes	High	Yes	Yes	Yes	Yes	High	Moderate - High
Rotating Drum	Bedminster, X-Act	✓	Moderate - Low	Yes	High	Yes	Yes	Yes	No	High	High

Notes:
1. Criteria refers to the inherent odour control capability of the method/system and infrastructure/operating practices normally associated with that method/system. High level of control is required in order to be considered
2. Criteria is a reference to the ability of the method/system on its own, to produce stabilized compost within the residence time normally associated with that method/system.

Although they were identified as potentially suitable technologies, the tunnel and channel composting systems were eliminated from further consideration subsequent to the shortlisting processing. This was due to constructability issues and to the costs associated with running a pilot scale system using either of these two technologies. This left variations of the aerated static pile composting system to be considered for the pilot scale operation.

4 Pilot Facility Basis of Design

This section outlines the functional requirements and design criteria for the pilot facility, which have been developed by the project team based on discussions with City personnel.

4.1 Processing Facility Location

Although potential host sites have been generally discussed (e.g. NEWPCC and Brady Road Landfill), the specific location of the pilot facility has yet to be determined. The conceptual designs are thus based on the assumption that the facility would be located within an industrial subdivision or adjacent to an existing City utility facility, and be a minimum of 1,000 m from residential developments.

4.2 Biosolids Characteristics

Biosolids are currently dewatered at the NEWPCC using centrifuges. Characteristics of the dewatered biosolids cake were obtained from the City and from published literature. The key characteristics of the feedstock are summarized in Exhibit 2.

EXHIBIT 2
FEEDSTOCK CHARACTERISTICS

Parameter	Value
% Solids	22% to 26%
% Nitrogen	4.6%
% Carbon	41.2%
Carbon: Nitrogen Ratio	~9:1
Bulk Density	980 kg/m^3
Volatile Solids	75%

4.3 Facility Capacity

Composting facilities and equipment are normally sized based on peak daily or weekly processing capacities, as opposed to peak monthly or annual quantities. This is due to the potential for seasonal variations of feedstock quantities and the nature of facility operational schedules as they relate to managing odours and other nuisance conditions.

In the case of the pilot facility proposed by the City, it would be possible to closely control the amount of biosolids delivered to the composting facility, as well as the delivery schedule, by coordinating activities with other disposal/treatment options. Based on discussions with City personnel, a pilot facility capable of handling approximately 10% of the total amount of biosolids generated was selected as the basis for design. This corresponds to approximately 100 wet tonnes per week, or 5,200 wet tonnes per year. It was further assumed that a consistent amount of biosolids would be delivered to the facility on a weekly basis, and that the deliveries would be scheduled such that biosolids would arrive over a two-day period.

4.4 Preliminary Mix Design and Bulking Agent Requirements

For biosolids composting to be effective, it is necessary to add amendments high in accessible carbon to the compost "mix" in order to balance the nitrogen-rich materials in the feedstocks, thus attaining a suitable carbon to nitrogen ratio. With very wet feestocks such as biosolids, bulking agent amendments are also necessary to adjust the porosity of the mixture in order to provide sufficient interstitial channels for air movement. The most common bulking agent used in biosolids composting is wood chips. However, it may be possible to use other materials such as straw, sawdust, cardboard, and/or dried leaves. Use of a bulking agent other than wood chips may significantly change the physical properties of the feedstck recipe. The impact of these changes on the design assumptions would need to be assessed.

It is also a normal practice to recycle a portion of the oversized material screened from the finished compost back into the initial feedstock mix. In addition to acting as a microbial inoculum, this recycled material can be used to help adjust moisture levels, meet nutrient requirements, and enhance porosity.

A preliminary mix design and mass balance were prepared based on 100 wet tonnes per week of biosolids inputs, along with recycling of oversized materials from screening operations. The mix design is summarized in Exhibit 3.

EXHIBIT 3
PRELIMINARY MIX DESIGN

	Weight (wet tonnes/week)	Volume (m^3/week)
Feedstocks & Bulking Agent		
Biosolids	100	102
Bulking agent (hog fuel, ground DLC)	55	200
Recycled Compost from Screening	55	133
Mixture Characteristics		
Moisture Content		57 %
C:N Ratio		24:1
Approximate Bulk Density (after mixing)		524 kg/m^3

4.5 Compost Product Quality and Use Assumptions

Compost quality criteria have not been developed or formally adopted by the Province of Manitoba. However, it is likely that the quality criteria specified in the Canadian Council of Ministers of the Environment's (CCME's) "Guidelines for Compost Quality" would be utilized by Manitoba Conservation in assessing and regulating any new composting facilities or pilot programs.

As shown in Exhibit 4, the CCME Guidelines include specific criteria for trace elements, pathogen levels, maturity, foreign matter (including "sharps"), and organic compounds. Two sets of criteria exist within the Guidelines, which allow compost to be classified as either "Category A" or "Category B"[1]. The distinction between the two lies in differing criteria for trace elements and sharp foreign matter. Criteria for pathogens levels, maturity and organic compounds are the same for both categories. It is anticipated that compost products produced from Winnipeg's biosolids would consistently meet the CCME's Category "B" criteria. It is also possible that Category "A" criteria could be met.

Although there are no provincial requirements, compost produced in Manitoba is subject to regulation by the Canadian Food Inspection Agency (CFIA). The product quality requirements of the CFIA are generally harmonized with the CCME Guidelines. The CFIA also ensures consumer protection through its enforcement of product labeling requirements for compost products and other soil amendments and fertilizers.

In order to meet Canadian Food Inspection Agency (CFIA) requirements for compost quality, it is necessary that compost be both stable and mature. Stability is a measure of the stage of decomposition of the organic material, and is measured by reheating tests or carbon dioxide respirometry tests. Maturity is affected by stability, but more specifically is a measure of the impact of the toxicity of the compost to plants. Germination and growth tests, using cucumbers or other species, and ammonia concentrations are commonly used tests for maturity. The stability and maturity criteria in Exhibit 5 have been adopted by the project team to guide the technology selection and conceptual designs undertaken as part of this assignment.

[1] The terms "Category A" and "Category B" are specifically used in the CCME documentation. They should not be confused with, or used interchangedly with the terms "Class A" or "Class B" which are used to reference pathogen treatment levels for biosolids.

EXHIBIT 4
SUMMARY OF CCME GUIDELINES FOR COMPOST QUALITY.

	Category A	Category B	
	Maximum Concentration within Product (mg/kg dry weight)	**Maximum Concentration within Product (mg/kg dry weight)**	**Maximum Cumulative Additions to Soil (kg/ha)**
Trace Elements			
Arsenic	13	75	15
Cobalt	34	150	30
Chromium	210	NL[a]	NL[c]
Copper	400	NL[b]	NL[d]
Molybdenum	5	20	4
Nickel	62	180	36
Selenium	2	14	2.8
Zinc	700	1,850	370
Cadmium	3	20	4
Mercury	0.8	5	1
Lead	150	500	100
Pathogens [e]			
Salmonella	<3 MPN/4 g (dw)		
Fecal coliform	<1000 MPN/g (dw)		
Foreign Matter and Sharp Foreign Matter			
Foreign Matter	≤1 piece greater than 25 mm in any dimension per 500 mL	≤2 pieces greater than 25 mm in any dimension per 500 mL	
Sharp Foreign Matter	None greater than 3 mm in any dimension per 500 mL	≤3 pieces per 500 mL, 12.5 mm max dimension	
Maturity/Stability	Compost shall be mature and stable at the time of sale and distribution, shall be cured for a minimum of 21 days, and shall meet one of the following requirements: - Respiration rate ≤ 400 mg O_2/kg VS (or OM) per hour - Carbon dioxide evolution rate ≤ 4 mg CO_2-C/kg OM per day - Temperature rise above ambient < 8'C		
Organic Compounds	Composting of feedstocks with high concentrations of persistent of bio-accumulating organic contaminants should be avoided.		

[a] NL – Not listed in the Guidelines, but a limit of 1060 mg/kg may be used.
[b] NL – Not listed in the Guidelines, but a limit of 757 mg/kg may be used.
[c] NL – Not listed in the Guidelines, but a limit of 210 kg/ha may be used.
[d] NL – Not listed in the Guidelines, but a limit of 150 kg/ha may be used.

[e] Compost produced solely from yard waste must meet time-temperature criteria OR pathogen content limits. Compost produced from all other feedstocks must meet time-temperature criteria AND pathogen content limits

EXHIBIT 5
COMPOST PRODUCT STABILITY AND MATURITY INDICES USED FOR THE WINNIPEG BIOSOLIDS COMPOSTING PROJECT

Criteria	Method	Criteria
Stability Criteria:		
Reheating Potential	TMECC 5.08-D	<8°C
CO_2 Respiration	TMECC 5.08-B	<4 mg CO2/g OM/day
Maturity Criteria:		
Emergence/Growth (Cucumber)	TMECC 5.05-A	90%
Ammonia Concentration	TMECC 4.02-C	<500 ppm (dry wt)

It was assumed that the quality of the compost product produced at the pilot facility would be consistent with products produced by biosolids composting facilities in Edmonton, Kelowna and Moncton. While this product would be of a suitable quality for use in residential, landscaping, and agricultural applications, it is assumed that the product would most likely be used in controlled applications at the Brady Road Landfill site or other City-owned facilities.

4.6 Design Life

A minimum design life of five years was chosen for the major system components of the processing facility, including buildings. This design life is reflective of the pilot nature of the facility, and the potential for it to be replaced with a larger facility in the future.

4.7 Feedstock Receiving and Mixing

Due to the potential for odours, it was assumed that the pilot facility would include a completely enclosed biosolids receiving building. A single unloading position would be provided in the receiving building, and a rapid-closing overhead door (i.e. with a cycle time of less than 15 seconds) would be installed to reduce the amount of time when the doors are open, thus minimizing fugitive odour releases.

The receiving building would not be large enough to allow the biosolids delivery truck to be completely indoors while unloading. Instead, the unloading door would be opened and the truck would discharge its contents directly into a recessed floor within the building. Within the building, biosolids would be handled and moved using a wheel loader.

The biosolids would be mixed with bulking agent using a vertical auger mixing unit. The unit would be equipped with scales to allow for accurate weighing of materials and close adherence to the final mix design.

A ventilation system would be installed in the receiving and mixing building to extract interior building air and discharge it to a biofilter for odour treatment. The ventilation system would be sized based on an airflow rate equivalent to six air changes per hour. Source capture ducting would be provided over specific processing areas, including feedstock storage areas and mixing equipment. Air exchangers could be considered to keep the building warmer during the winter.

4.8 Odour Treatment

Odourous building and process air collected from within the facility would be treated using a biofilter. The biofilter would consist of a 1.5 m layer of coarse wood chip overlying a 40 mm layer of 25 mm+ washed rounded rock. A network of HDPE air distribution pipes would be embedded in the washed rock layer. The entire biofilter would be situated on a sloped concrete pad to allow for drainage and collection of leachate from the biofilter. Leachate would be directed to a low-strength leachate tank.

The biofilter would be separated into three distinct cells. The treatment capacity of each cell would be equivalent to 40% of the required total (i.e. 120% total). This allows for one cell to be taken offline (i.e. for media changes), while still providing 80% of the required treatment capacity. Each biofilter cell would be designed with an empty-bed residence time of at least 45 seconds. The total area of the biofilter would be approximately 935 m^2.

Mist scrubbers may be used immediately upstream of the biofilter to reduce particulate levels in the airstream; a high particulate load could negatively affect the performance of the biofilter media.

4.9 Receiving and Mixing Building Design

The receiving and mixing building would consist of a pre-engineered steel-frame/fabric cover building. This uninsulated building system would be specified with an ultra-violet resistant polyethylene cover. The building structure would be situated on 1 m high cast-in-place concrete foundation walls.

In the absence of an identified host site, geotechnical data is not available. For the purpose of completing conceptual designs, it was assumed that typical slab-on-grade and strip footing construction would be suitable, and that piles would not be required.

4.10 Compost Curing

After feedstocks materials have undergone active composting in the composting system, a "curing" phase is required in order to ensure that the materials meet the regulatory criteria for stability/maturity and can be marketed as finished compost.

The compost from the composting system would thus be transferred to a 4,100 m^2 outdoor windrow composting/curing pad. The composting/curing pad size was determined based on the assumption that materials would be managed in windrows that are 6 m (20 ft) wide and 2.4 m (8 ft) high that are turned with a wheel loader. A residence time of at least eight weeks is expected in order for the material to meet the stability/maturity criteria.

The working surface in the outdoor composting/curing area would consist of a compacted gravel base/sub-base designed to withstand the weight of wheel loaders and trucks. The gravel base/sub-base would be constructed overtop a geosynthetic liner that provides groundwater protection equivalent to a 1 m thick compacted clay liner with a hydraulic conductivity of $1x10^{-9}$ m/s.

4.11 Stormwater Management

Surface water from areas outside of the facility would be diverted around or away from the operating areas using ditches, swales and berms. Run-off from building roofs would be captured in underground tanks for use in the composting process and for equipment washing.

Outdoor working surfaces around the facility, as well as the outdoor composting/curing pad and product storage area, would be sloped at a minimum of 0.5% to promote drainage. Run-off from these areas would be captured through a combination of manholes, ditches and swales and transferred to an onsite detention pond.

For the purposes of this exercise, it was been assumed that the detention pond would be underlain by a geosynthetic liner and would be sized to contain run-off from a 1:25 year, 24-hour storm event. Because the detention pond will also serve as the primary source of water for fire suppression, it will also include additional capacity, or "dead storage," beyond the 1:25 year run-off water volume.

4.12 Leachate Management

The facility would include allowances for the capture of run-off, spills and liquid from floor-washing in the receiving and mixing building. Liquids would be captured in sumps and transferred via aboveground piping to a 15 m^3 aboveground insulated HDPE leachate storage tank.

This leachate would be reused during the initial mixing process as necessary to adjust the moisture content of materials. Allowances would also be made for any surplus leachate to be pumped to tanker trucks and disposed of at an offsite facility.

4.13 Staff, Administrative, and Maintenance Facilities

No staff, administrative or maintenance facilities would be incorporated into the proposed facilities; it is assumed that existing facilities at the host site would be utilized.

4.14 Compost Product Storage

Compost would be screened using a portable trommel prior to being sold or stored on site. A wheel loader would be used to move compost from the curing windrows to the screening equipment.

A 1,825 m^2 outdoor compost storage area is included in the design of the proposed facility. This footprint is based on stockpiling of all finished compost produced between October and March. The storage area size also allows for aisles between adjacent stockpiles as would be necessary for truck and equipment access.

It is anticipated that the compost would be stored in discrete piles so that inventory could be tracked using batch or lot numbers as required by federal regulations. Each stockpile would be constructed during the finished product screening stage using a stacking conveyor.

The working surface in the storage area would consist of gravel base/sub-base designed to support the weight of wheel loaders and trucks. However, there would be no geosynthetic or clay liner in this area.

4.15 Mobile Equipment Requirements

The mobile equipment required to support the composting operation is listed below. It is assumed that the facility is operated independently of other City facilities and activities, and would thus require dedicated equipment.

- Wheel loader (e.g. John Deere 644 or equivalent) with oversized (e.g. 8 yd^3) bucket.
- Vertical auguer mixer (e.g. Supreme 500T or similar; stationary or PTO with tractor).
- One portable trommel (e.g. MCB 621) with radial stacking conveyor.

5 Processing Technology Options

This section outlines the technologies and facilities that were considered for the pilot program. All facilities are based on the design criteria and incorporate the features outlined in the previous section.

5.1 Facility Option 1 – Outdoor Aerated Static Pile

This outdoor facility is based on the use of an aerated static pile composting system. A total of four composting "bunkers" would be constructed using concrete ecology blocks to enclose the composting piles. The blocks would be placed directly on top of a poured-in-place concrete pad. Equipment associated with the aeration and leachate collection from each bunker would be situated at the rear of each bunker.

It is anticipated that one bunker would be loaded each week with a wheel loader. The loading height of the bunkers would be approximately 2 m. Once the bunker was full, materials would be composted for an initial period of two weeks. Although the aeration system would be capable of operating in both negative and positive modes, it is assumed that it would be normally be run in "positive mode." A 15 to 30 cm layer of finished compost would be placed overtop each pile's surface to provide odour reduction.

After two weeks, the material would be removed from each bunker with a wheel loader and transferred to another bunker for an additional two weeks of composting. The remixing that occurs during this transfer step is necessary to ensure that all materials are exposed to the high temperatures required for pathogen reduction.

Once the second stage of the composting process has been completed, and pathogen reduction temperatures have been verified, materials would be removed from the second-stage bunkers using a wheel loader and screened to recover bulking agent for reuse.

The design of each of the bunkers would be identical, and would consist of a 12 m wide by 18 m long three-sided enclosure, a below-floor aeration system, timer and temperature feedback controlled aeration fans and associated ducting. With this sizing and configuration, there is no redundancy built into the composting system.

It is expected that the pilot facility would require a part time equipment operator (0.6 FTE) and a part-time process operator (0.4 FTE). These requirements are based on the premise that the administrative and supervisory functions would be done in association with other City facilities.

5.2 Facility Option 2 – Enclosed Aerated Static Pile

This facility is also based on the use of an aerated static pile composting system, except that the composting system would be enclosed within a building. As with the previous option, a total of four composting “bunkers” would be constructed using concrete ecology blocks to enclose the composting piles. The blocks would placed directly on top of a poured-in-place concrete pad. Equipment associated with the aeration and leachate collection from each bunker would be situated at the rear of each bunker, but within the building.

The building would consist of an pre-engineered steel-frame/fabric cover building (i.e. the same as the receiving and mixing building) and would be situated on 1 m high cast-in-place concrete foundation walls.

Operation of this system would be the same as that previously described for the outdoor aerated static pile system: one bunker would be loaded each week with a wheel loader and materials would be composted for a two-week period. After two weeks, the material would be transferred to another bunker for an additional two weeks of composting. At the end of the four-week composting process, materials would be screened to recover bulking agent for reuse.

The aeration system would be designed to operate in both negative and positive modes, but would normally be run in “positive mode.” A 15 to 30 cm layer of finished compost would be placed overtop each pile’s surface to provide odour reduction.

The sizing and design of each of the bunkers would be identical to those for Option 1. With this sizing, there is no redundancy built into the composting system.

It is expected that the pilot facility would require a part time equipment operator (0.6 FTE) and a part-time process operator (0.4 FTE). These requirements are based on the premise that the administrative and supervisory functions would be done in association with other City facilities.

5.3 Facility Option 3 – Aerated Static Pile with Engineered Cover

This outdoor facility is based on the use of an outdoor aerated static pile composting system that includes an engineered cover over top of each composting pile. The facility would include space for a total of four composting piles, each with dimensions of approximately 8 m in width and 50 m in length. The piles would be situated on top of a poured-in-place concrete pad. Equipment associated with the aeration and leachate collection from each bunker would be located at the end of each pile.

Operation of this system would be the similar to the two previously described systems. One pile would be constructed each week with a wheel loader and covered with an engineered tarp. The materials would be composted for four weeks, after which time the pile would be transferred to another location for an additional two weeks of composting. At the end of the six-week composting process, materials would be screened to recover bulking agent for reuse.

The aeration system would be design to operate only in "positive mode." Because the engineered tarp provides a degree of odour control, the 15 to 30 cm layer of finished compost overtop the piles is not necessary.

It is expected that the pilot facility would require a part time equipment operator (0.6 FTE) and a part-time process operator (0.4 FTE). These requirements assume that the administrative and supervisory functions would be done in association with other City facilities.

5.4 Conceptual Facility Cost Estimates

Order-of-magnitude construction cost estimates were developed for each of the facility options based on regional unit rates for construction costs and support equipment requirements for similarly sized facilities. A summary of the capital and equipment cost estimates for each option are provided in Exhibits 6 through 8. **These estimates do not include any costs associated with purchasing land for the facility.**

The estimated annual operating cost for each of the facilities was approximately $385,000.

5.5 Additional Considerations

5.5.1 Expansion of Facility Options 1 and 2

The bunker style ASP composting system that was used in Facility Options 1 and 2 is very amenable to expansion, and the throughput of these two facilities could be significantly increased for a relatively small incremental cost.

The capacity increase would be achieved by increasing the height of the composting piles in each bunker from 2m (6.5 ft) to 3.6 m (12 ft). Increasing the pile height in this manner, but maintaining the same bunker length and width, would allow the capacity of both the facilities to be roughly doubled (from 5,200 to 10,400 wet tonnes of biosolids per year) without changing the footprint of the associated outdoor pad or building.

The expansion would require the bunker walls to be increased from approximately 2.3 m (7.5 ft) to 3m (10 ft) through the addition of another row of ecology blocks. The aeration system associated with each bunker would also have to be redesigned to allow for a higher airflow rate. Finally, the curing and storage pads for each option, and the associated surface water detention pond, would have to be expanded.

The incremental costs for the expansion are summarized below:

- Additional ecology blocks: $20,000
- Incremental cost for expanded aeration system: $60,000
- Incremental cost for expanded curing/storage pad: $370,000
- Incremental cost for expanded surface water pond: $59,000
- Incremental cost for expanded mixing unit: $38,000

Total incremental cost: $547,000. This results in total capital costs of $4.2M and $5.8M for options 1 and 2, respectively.

5.5.2 Reversing Aeration System for Facility Options 1 and 2

The design of the aeration system in Facilty Options 1 and 2 is based on positive aeration. However, with the redesign of the aeration system piping, it would be possible to provide a system that can operate in both positive and negative modes. The redesign of the system would require additional piping and process air valves, an increase in the size of the aeration fans and the biofilter, the addition of a leachate drainage sump, and replacement of al PVC piping with HDPE piping. The incremental cost for this change for the 100 wet tonne per week system is estimated to be in the order of $300,000. Approximately 60% of this incremental cost is associated with expanding the biofilter.

EXHIBIT 6
OPTION 1 FACILITY CONSTRUCTION ORDER OF MAGNITUDE COST ESTIMATE

Description	Subtotals ($)
Land Purchase	0
Site Preparation	20,602
Exterior Yard Area & Utility Connections	179,132
Access Roadway	19,075
Receiving and Mixing Building	407,614
Outdoor Composting Pad	461,550
ASP Composting System	200,000
Vertical Mixers	200,000
Weather Station	10,000
Biofilter	82436
Surface Water Detention Pond	46,250
Windrow Curing Pad	235,270
Product Storage Pad	47,333
Subtotal	1,909,261
Contractor O/H and Margin (10%)	191,000
Probable Construction Cost	2,100,261
Contingency Allowance Based on Level of Design (30%)	630,078
Engineering and Permitting Fees	358,034
Construction Management Fees (7.5%)	204,755
Mobile Equipment	
Portable Screen	110,000
Wheel Loader	275,000
Total Probable Cost	3,678,148

EXHIBIT 7
OPTION 2 FACILITY CONSTRUCTION ORDER OF MAGNITUDE COST ESTIMATE

Description	Subtotals ($)
Land Purchase	0
Site Preparation	20,066
Exterior Yard Area & Utility Connections	172,917
Access Roadway	19,075
Receiving/ Mixing/Composting Building	1,812,830
Outdoor Composting Pad	n/a
ASP Composting System	200,000
Vertical Mixers	200,000
Weather Station	10,000
Biofilter	82,436
Surface Water Detention Pond	46,250
Windrow Curing Pad	235,270
Product Storage Pad	47,333
Subtotal	2,846,177
Contractor O/H and Margin (10%)	285,000
Probable Construction Cost	3,131,177
Contingency Allowance Based on Level of Design (30%)	939,353
Engineering and Permitting Fees	492,053
Construction Management Fees (7.5%)	305,290
Mobile Equipment	
Portable Screen	110,000
Wheel Loader	275,000
Total Probable Cost	5,252,873

EXHIBIT 8
OPTION 3 FACILITY CONSTRUCTION ORDER OF MAGNITUDE COST ESTIMATE

Description	Subtotals ($)
Land Purchase	0
Site Preparation	21,408
Exterior Yard Area & Utility Connections	181,949
Access Roadway	19,075
Receiving/ Mixing Building	407,614
Outdoor Composting Pad	524,935
Composting System + Covers	450,000
Vertical Mixers	200,000
Weather Station	10,000
Biofilter	82,436
Surface Water Detention Pond	46,250
Windrow Curing Pad	235,270
Product Storage Pad	47,333
Subtotal	2,226,269
Contractor O/H and Margin (10%)	223,000
Probable Construction Cost	2,449,269
Contingency Allowance Based on Level of Design (30%)	734,781
Engineering and Permitting Fees	403,405
Construction Management Fees (7.5%)	238,804
Mobile Equipment	
Portable Screen	110,000
Wheel Loader	275,000
Total Probable Cost	4,211,258

6 Evaluation Process

As discussed in previous sections of the report, the three facility options selected for evaluation were: (1) outdoor aaerated static pile; (2) enclosed aerated static pile; and (3) aerated static pile with an engineered cover. Key evaluation criteria were identified at the workshop using the following steps in a structured group brainstorming session: (1) list as many criteria as possible; (2) screen criteria to identify relevant criteria; and (3) rank criteria using a sticker voting technique. A total of 42 criteria were identified, with 17 of these identified as relevant criteria. The relevant criteria ranked from most to least important are presented in Exhibit 9. The remaining criteria (those screened out of the evaluation) are presented in Exhibit 10.

With the exception of costs, the relevant criteria were evaluated using relative qualitative statements by the expert team on the evening of February 2 and reviewed by the workshop participants the morning of February 3 (Exhibit 9). Cold weather tolerance was the only criterion drawing discussion from the participants. Intuitively, one would expect the enclosed facility (option 2) would be easier to operate in cold weather as compared to the outdoor facility (option 1). The expert team's rationale was that enclosed facilities are more challenging due to the handling of indoor air with high humidity levels and that the equipment used at the facilities has been proven to operate at the low temperatures experienced in Winnipeg.

Based on the overall evaluation, option 1 (outdoor aerated static pile) was considered the best option for the City of Winnipeg. This option had the lowest cost estimate, and was ranked as the best option or tied for the best option for 11 of the 15 qualitative criteria. In the rankings with respect to the four remaining qualitative criteria (water needed, nuisance controal, leachate handling, and rainfall impact), no fatal flaws were identified and it was belived these lower rankings were marginal relative to the other options.

EXHIBIT 9
RELEVANT COMPOST TECHNOLOGY SELECTION CRITERIA

		Option		
Criteria	**Sticker Voting Score**	**1. Outdoor aerated static pile**	**2. Enclosed aerated static pile**	**3. Aerated static pile with engineered cover**
Odour	18	Best odour control	Best odour control	Least odour control
Ease of O&M	16	Easiest	Moderate	Most difficult
Capital cost	15.5	$3.68M	$5.25 M	$4.21M
O&M cost	12.5	385,000	385,000	385,000
Time-frame	12	Shortest	Moderate	Longest
Cold weather tolerance	11	Most	Moderate	Least
Availability of equipment	7	Least time required	Moderate	Most time required
Scalability	6	Most	Less	Most
Water requirement	3	Most	Most	Least
System complexity	3	Least	Moderate	Most
Footprint	2	Least	Most	Moderate
Staffing	1	Similar	Similar	Similar
Nuisance control	1	Lowest	Best	Moderate
Leachate issues	1	Low	None	Low
Rainfall	0	Some impact	No impact	Low impact
Modularity	0	Yes, most flexible	Yes, least flexible	Yes
Decommissioning Cost	0	Low	High	Moderate

EXHIBIT 10
CRITERIA NOT CONSIDERED IN THE TECHNOLOGY EVALUATION

Criteria	Rationale for exclusion
Availability of bulking agents	Same for all alternatives
Biosolids quality	Same for all alternatives
Carbon credits	Same for all alternatives
Constructability	Concept captured in other relevant criteria
Equipment requirements	Similar for all alternatives
Fire safety	Similar for all alternatives
GHG emissions	Similar for all alternatives
Health & safety	Similar for all alternatives
Impact on current landfill operations	Similar for all alternatives
Maintainability	Concept captured in other relevant criteria
Marketability of product	Similar for all alternatives
Political acceptability	Similar for all alternatives
Potential owner/operator models	Similar for all alternatives
Power/energy requirement	Concept captured in other relevant criteria
Public acceptability	Concept covered in other relevant criteria
Purpose of pilot	Similar for all alternatives
Raw or digested biosolids	Similar for all alternatives
Run-on/off control	Similar for all alternatives
Seasonal challenges	Concept captured in other relevant criteria
Semi-arid climate	Concept captured in other relevant criteria
Site Preparation	Similar for all alternatives
Siting	Similar for all alternatives
Staff training	Concept captured in other relevant critieria
Throughput	Similar for all alternatives
Track record	All proven technologies

7 Summary and Conclusions

A one and a half day technical workshop was held to identify an appropriate biosolids composting facility for the City of Winnipeg. Based on a preliminary discussion held before the workshop, four options were selected for analysis; however, one of these options (an indoor continuous flow aerated system) was elimated from detailed analysis at the workshop because it was considered an emerging technology and was not ready for immediate implementation.

The three options selected for analysis were: (1) an outdoor aerated static pile; (2) an enclosed aerated static pile; and (3) an aerated static pile with an engineered cover. Two throughput rates were considered in the design: 10 and 20% of the total amount of biosolids generated per year, which corresponds to 5,200 and 10,400 wet tonnes of biosolids per year, respectively. Common design elements included the feedstock recipe, the leachate collection and storage facilities, and the ancilliary equipment needed (wheel loader, vertical auger mixer, and trommel screen). The volumetric feedstock recipe used in the design was two volumes of fresh bulking agent (wood chips) to 1.3 volumes of recycled bulking agent to one volume of biosolids. An on-site leachate storage capacity of 15 m^3 was provided for all options. Space requirements for curing and storage were also the same for all three options: 4,100 m^2 and 1,825 m^2, respectively. Operation and maintainance costs were also considered comparable for the three options and was estimated at $385,000 per year.

To process 10% of the biosolids generated annually, capital costs, excluding land purchase cost, for the three options were: $3.7M, $5.3M, and $4.2M for the respective options: an outdoor aerated static pile; an enclosed aerated static pile; and an aerated static pile with an engineered cover. The outdoor aerated static pile was also ranked the best overall alternative with respect to other relevant criteria assessed at the workshop. The incremental capital cost to process 20% of the biosolids generated annually was only $547,000 for options 1 and 2. Therefore, the capital costs to process 20% of the flow for options 1 and 2 were $4.2M and $5.8M, respectively.

Appendix A
Workshop Attendees

Name	Affiliation	eMail Address
Abercrombie, Neil	Veolia Water	Neil.Abercrombie@veoliawaterna.com
Borlase, Bill	City of Winnipeg	bborlase@winnipeg.ca
DeCraene, Dan	City of Winnipeg	dandecraene@winnipeg.ca
Drohomerski, Darryl	City of Winnipeg	ddrohomerski@winnipeg.ca
Fuga, Graham	City of Winnipeg	gfuga@winnipeg.ca
Gamble, Scott	CH2M Hill	scott.gamble@ch2m.com
Gibson, Dwight	City of Winnipeg	dgibson@winnipeg.ca
Hawley, Jeff	City of Winnipeg	jhawley@winnipeg.ca
Hestad, Jim	Veolia Water NA	james.hestad@veoliawaterna.com
Hwang, Jong, Hyuk	City of Winnipeg	jhwang@winnipeg.ca
Kuluk, Tony	City of Winnipeg	x-tkuluk@winnipeg.ca
Lundberg, Lee	Veolia Water NA	Lee.Lundberg@veoliawaterna.com
McCartney, Daryl	University of Alberta, EWMCE	daryl.mccartney@ualberta.ca
Paul, John	Transform Compost Systems	johnpaul@transformcompostsystems.com
Permut, Arnold	City of Winnipeg	apermut@winnipeg.ca
Sims, Trevor	City of Winnipeg	tsims@winnipeg.ca
Szoke, Nick	City of Winnipeg	nszoke@winnipeg.ca

Appendix B
Biosolids Composting Pilot Project
Technology Selection Workshop
2 & 3 February 2011
Greenwood Inn
Winnipeg, Manitoba

Background information

Technologies shortlisted for inclusion in workshop discussions:
1. Aerated static pile
2. Covered aerated static pile
3. Tunnels
4. In-door continuous flow aerated system

Miscellaneous issues identified for possible consideration at workshop:
- Identify a plan and needs for implementing the pilot project
- Odour generation and control
- Conceptual level cost of technologies
- Material storage and handling issues
- Markets: a quick overview will be presented. Ron Alexander may be brought in sometime in the future.
- Selected technologies must be able to operate year-round; particularly in winter (140 wet tonnes per day at 24% TS).
- Centrifuge operation.
- Potential to compost without digestion.
- Comments on the number of municipal and private operations in other jurisdictions in Canada. Identify potential ownership/operating models.
- Identification of workplace safety and health issues.

Identified outcomes for workshop:
- Cost of pilot study.
- Identify a technology and scale for pilot study.
- Create a matrix listing the advantages and disadvantages and relative cost of each technology.

DAY ONE

TIME	SUBJECT (Leader)	GOAL &/OR LEARNING OBJECTIVE
8:30	Introductions & goals of workshop (DM)	Introductions (Names, affiliations); Goals of workshop (learning objectives and outcomes of workshop, including post workshop deliverables);
8:45	Current program of co-disposal with solid waste (DD & JH).	Describe operating concerns including odour issues; List costs of current program.
9:15	Composting Process Overview & Compost Science & Principles (JP)	Understand biological composting process (e.g. high rate, secondary, curing, progression of microbial populations), the key process parameters (e.g. oxygen, moisture, porosity, temperatures) and operating ranges, and how these process parameters are managed to optimize the composting process and the infrastructure usage.
10:00	General classification of composting technologies (JP)	Understand the type of composting systems as they relate to managing and optimizing the biological process and managing nuisances.
10:15	Break	
10:45	Compost Technologies & Equipment (SG)	List and briefly describe a broad overview of technologies.
11:45	Introduce process for the afternoon	Describe the process to be used to select the technology.
12:00	Lunch	
1:00	Case studies or description of shortlisted technologies (15 minutes per technology): - Covered aerated static pile (DM). - Aerated static pile (SG & JP). - Tunnel (SG & JP). - Continuous flow aerated system (JP).	Understand material handling and equipment requirements for each technology; Understand approximate cost capital and operating costs of technologies.
2:30	Break	
3:00	Generate and select evaluation criteria (DM).	Generate list of potential selection criteria; be inclusive. Review list to ensure criterion is essential for project success; if controversial err on inclusiveness. Decide how to score each criterion; e.g. qualitative, subjective score, relative, quantitative, etc.
3:45	Preliminary ranking of short-listed technologies (DM). - rank technologies individually (sticker voting). - group discussion of findings.	Identify best solution.
4:20	Wrap up and Questions	
4:30	Day concluded	
Evening	Group dinner & facilitation team (Daryl, Scott, & John) debrief and planning for day 2.	Costing of highest ranked alternative(s)

DAY TWO

TIME	SUBJECT	DESCRIPTION
8:30	Final ranking of short-listed technologies (DM)	Finish process of selecting an appropriate technology.
9:00	Compost Utilization & Marketing (JP)	What are the various attributes and uses of compost? How is compost marketed?
9:20	Basis for design and conceptual cost estimate for selected technology (SG/JP)	List the conceptual design specifications used to cost the selected technology. Provide conceptual cost for selected technology.
10:20	Break	
10:45	Odour Control & Management (SG)	
11:15	Implementation checklist (SG)	
11:45	Workshop closing	
Noon	Lunch	
	Future training topics: - Workplace safety & health issues. - Life cycle assessment as a decision support tool. - Compost Product Standards & Analysis. - Fires at Composting Facilities - Nuisance Control. - Other.	- Health & safety issues specific to composting. - Identify emerging tools & current limitations of LCA in Canada. - Compost product standards, sampling and analyzing practices, and QA/QC programs - Fire prevention and control