Feasibility of and Suggested Methods for Operating a Compost Facility at the UBC Farm

Erik Toren

University of British Columbia

APBI 497

January 14, 2014

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Abstract

The purpose of this directed study was to determine the feasibility of operating a compost facility on an existing 12m x 24m concrete pad located at the UBC farm. Composting methods and processes were examined to maximize the productivity of the space available and to promote biological conditions for the production of safe, high quality finished compost. Once it was determined that a safe end product could be produced using waste generated at UBC, economic feasibility was assessed. An approximate budget for an on-farm compost facility is included. Outlined in this paper are the specific regulations that pertain to the operation of an industrial compost facility on the UBC farm, and the criteria that must be met in order to produce the highest quality compost using materials generated on the UBC campus. This report also gives specific suggestions and methods as to how these regulations can be followed and criteria met.

Composting Methods

The Canadian Organic Matter Recycling Regulations (OMRR) accepts three methods of composting; turned windrows, static aerated piles (S.A.P) and in-vessel systems. Turned windrows and static aerated pile systems were explored for this facility.

The S.A.P system uses perforated pipes below the base of a compost pile to force air into the material, giving the operator greater control over oxygen and moisture levels. A system of sensors within the compost pile could be used to detect oxygen, moisture and temperature levels, automating the composting process and providing optimum conditions for microorganisms. Pile size can also be increased as more oxygen can reach the center of the pile (Richard, *Oxygen Transport*, 1996), increasing total facility capacity. Forcing oxygen into the material means that piles require less frequent manual turning than windrow composting. Total end nitrogen can be maximized by less frequent turning. Ammonia (NH_3) can volatize when exposed to open air, and is lost from the system as a gas (Bonhotal, 2007). Ammonia that is retained within the pile can then be converted into plant-available nitrate (NO_3) (Aldrich, 2006), increasing nutrient quality of finished compost. The composting process in S.A.P systems is generally slower than in windrow composting, and care must be taken to expose all material to the high-temperatures in the core of the pile (Bonhotal, 2007). Although a relatively slower process, static aerated piles then provide greater control over factors affecting the composting process and have the ability to produce a finished product with higher nutrient content.

With turned windrow systems, pile size is generally smaller and turning is more frequent (Bonhotal, 2007) to ensure that optimum oxygen levels are maintained within the pile. Frequent turning does mean that more of the material is broken down by the physical movement of machinery, and is exposed to thermophillic temperatures at the center of the pile. This can translate into a quicker overall composting process and more efficient destruction of pathogens and weeds, but lower total nitrogen (Bonhotal, 2007) in the finished compost. Turned windrows are used by most commercial compost facilities because of the relatively quick processing time. However, unless specific windrow turning machinery is used, manual turning using a front-end loader can be labour intensive. Compost produced by this method also may require longer curing times to produced a high-quality finished product, that is, compost that supports thriving microbial communities.

Both methods have their advantages and it may be possible to combine the two to optimize efficiency and finished compost quality. Turning piles during the thermophillic phase to incorporate oxygen can disrupt microbial colonies, forcing them to expend energy re-colonizing and extending the decomposition process (Bonhotal, 2007). Using forced aeration to maintain optimum oxygen levels during the thermophillic stage could allow for larger pile volumes and greater overall capacity of the facility. Turning and mixing of material more frequently than standard S.A.P systems before and after the thermophillic stage is likely necessary to create a more homogeneous mixture and to hasten the composting process.

Mitigating Potential Issues

Public perception of this compost facility would be imperative to its success. Concerns of odor problems and animal attraction are usually associated with compost facilities, especially when located in an urban setting such as the UBC farm.

Enclosing or simply covering this facility will depend on weighing the benefits of either option, discussed further in the **Operation** section of this paper. An enclosed facility should help mitigate the problem of attracting birds and rodents, major problems associated with outdoor facilities. Enclosing the facility should also help with potential noise concerns. Grinding machinery will likely be the main source of any noise concerns. Noise monitors could be used to assess if machinery would pose any issues for the surrounding South Campus community.

Odor problems can be controlled by passive biofilters. The enclosed facility would capture any gaseous emissions and pump them through an external filter to mitigate odors and to provide a safe working environment inside the facility. Finished compost biofilters have been shown to effectively treat all odors associated with composting (Richard, *Odor Treatment*, 1996). Nick Hermes, a former UBC graduate student has developed, although currently on a small scale, a biofiltration system that uses layers of gravel, wood pellets, zeolite and finished compost to neutralize odors associated with indoor composting (Hermes, 2012).

Identified Compost Feedstock at UBC

UBC Food Waste

During 2011-2012 and 2012-2013, 431 and 496 tonnes of food waste including soiled paper were collected from various compost bins on the UBC campus, B. Fraser (Personal Communication Nov, 12, 2013). The bins were located in all food service outlets, Totem and Vanier residence cafeterias, Scarfe, the Forest Science Center, Macmillan Building, CIRS, International House, Brock Hall, UBC Childcare Center and various others (UBC Building Operations, 2009). As compost collection increases with the UBC Zero Waste Action Plan, annual food waste collection is predicted to increase to 1300 tonnes (Fraser, 2013). This material will include pre and post consumer food waste, napkins, paper towels, paper plates and cups. Currently, most public compost bins are contaminated with >1% uncompostable materials (Fraser, 2013), the exception being UBC food services. This will likely continue to be an issue for years to come as the public adjusts to proper compost bin use. UBC waste management currently trucks the majority of UBC food waste to the Harvest Power compost facility in Richmond. The disposal fee for uncontaminated (<1% contamination) food waste is $40/t while contaminated (>1% contamination) is charged $80/t. The majority of UBC food waste is disposed of at a cost of $80/t.

Food waste provides relatively nutrient-rich compost feedstock and is generally host to many beneficial species of bacteria and fungi needed to start the composting process.

Animal Bedding

The UBC Center for Comparative Medicine (CCM) produces approximately three tonnes of waste animal bedding in the form of wood shavings every ten days, totaling ~110 tonnes of material every year, G. Gray (Personal communication, October 1, 2013). UBC Waste Management currently trucks this waste to Sumas Environmental Services in Burnaby at a cost of $800 per tonne.

The majority of waste bedding comes from rodents, birds, reptiles and rabbits, with a small proportion of bedding from primates, swine and sheep. Primate bedding is autoclaved and certified to be sterile before being added to collection bins. All bedding contains some fecal matter and urine, and is free of level 2, 3 or 4 pathogens as described by Health Canada, contains no hazardous materials, and contains no dangerous goods or substances G. Gray (Personal communication, September 30, 2013). The CCM wood shavings would require no further grinding or chipping before being mixed into the compost material.

Animal bedding is listed as suitable for creating Class A compost under Schedule 12 of the OMRR. However, because the animal bedding from the UBC CCM may contain fecal matter from U.S imported swine, this material falls under disposal regulations outlined by the Canadian Food Inspection Agency (CFIA). The proposal to compost animal bedding at a UBC compost facility is currently under review by representatives from the CFIA. The District Veterinarian, Dr. Amrinder Brar must verify that no other animals, besides U.S swine, imported to the UBC CCM are under CFIA regulations. From earlier discussions with Dr. Brar, it is likely that UBC CCM animal bedding will be given permission to be used as compost feedstock. This paper will be amended once a final decision is reached by the CFIA.

According to UBC Risk Management, there are no identified risks relating to the handling, transportation or storage of this bedding, as long as the composting of this material meets with CFIA approval, N. Levit (Personal Communication, December 19, 2013). A representative from the CFIA would need to visit both the UBC CCM and the compost facility for approval.

UBC Plant Operations Yard Waste

Yard waste, as described in the OMRR, consists of "clean and untreated wood waste, or non-food vegetative matter resulting from gardening operations and landscaping" (Organic Matter Recycling Regulations, 2002). Yard waste generated at UBC consists mostly of fall leaves, grass clippings and tree branches. As compost feedstocks, grass clippings are a readily degradable source of nitrogen feedstock while fall leaves and wood debris provide carbon necessary for complete decomposition. Chipped wood debris can also provides structure and porosity when mixed with dense, wet compost material.

UBC Plant Operations currently collects and stores waste material for future use on campus. Tub grinders are rented periodically to mulch materials for landscaping purposes on campus. At present, it does not appear that an alternate method of disposal for yard waste is required. However, it may be the case that finished compost would be more desirable in some landscaping applications than crude mulch. If this were the case, it would benefit both parties if UBC Plant Operations sent yard waste to be composted in exchange for finished compost.

During the 2011/2012 and 2012/2013 years, the amount of yard waste generated at UBC was 293 and 133 tonnes respectively (Fraser, 2013). Unfortunately the collections data is limited to these two years, and there does not appear to be any clear reason for the considerable variation amount of material collected between the two years. Volume, nutrient content, moisture content and type of yard waste material will also change seasonally. This variation enforces the fact that a compost facility must be able to adjust its pile recipes with changes in material availability and volume in order to continue to compost efficiently.

Factors Affecting Decomposition Efficiency

Reaching and sustaining temperatures of 55°C within the compost pile as outlined in Schedule 1 of the OMRR is necessary for the destruction of potential pathogens, and is ultimately what will result in a safe end product. The heat generated in the pile is attributed to the metabolism of microorganisms affected by the "degradability and energy content of the substrates and the availability of moisture and oxygen" (Ryckeboer, 2003). The rate and completeness of decomposition is influenced by any factor that affects this microbial activity. With this in mind, the role of the compost facility operator is then to create favourable environments for aerobic microbes by mixing piles with proper carbon and nitrogen ratios, and maintain optimum oxygen, moisture, pH and temperature levels throughout the process in order for rapid and complete decomposition.

Explained below are the influences of oxygen, moisture, temperature, pH level and the carbon to nitrogen ratio during the composting process, as well as how measurements of these factors can indicate problems within the pile.

Oxygen

The decomposition of organic material by bacteria and fungi in the presence of oxygen produces carbon dioxide and water as byproducts and as a result should, theoretically, produce no offensive odor. Factors such as: excess moisture, inadequate porosity and excessive pile size (Richard, 1996) reduce oxygen levels throughout the pile, resulting in anaerobic conditions and odor.

Pile size is the major determinant of oxygen flow within the compost matrix. Oxygen enters the pile through convection currents caused by hot air rising from the center of the material (Richard, 2003). If the pile is too large, the weight of material above the core will crush pores needed for fresh air to enter the pile, resulting in dense, anaerobic sections and release of odor. Thorough mixing or forced aeration is essential to disrupt dense sections of material and redistribute moisture in order to maximize air-flow into as much of the pile as possible.

Moisture

Accurately measuring compost moisture content should be prioritized when designing monitoring systems and schedules. Moisture affects microbial growth, oxygen transport, temperature control and can lead to both anaerobic conditions and dormant microbes. Bacteria and fungi require thin biofilms to survive and secrete digestive enzymes; at a moisture content below ~30%, these microbes can become dormant and the composting process will stop (Ryckeboer, 2003). When the moisture content rises above ~65% (Ryckeboer, 2003), oxygen transport slows dramatically as water fills the majority of pores needed for gas exchange and leads to anaerobic conditions within the pile. Higher moisture content can also lead to lower temperatures within the pile as heat released from decomposition is absorbed by the vaporization of water (Rogstrand, 2003). Consistent moisture content of 50%-60% by weight (Ryckeboer, 2003) is considered ideal for microbial growth while retaining adequate porosity for gas exchange within the compost pile.

Carbon to Nitrogen (C:N) Ratio

The rate of decomposition is most influenced by the initial carbon to nitrogen ratio of the decomposing substrate (Prescott, 2013). In a managed compost system, an initial C:N ratio of 25-35:1 (Ryckeboer, 2003) is optimum for rapid and complete decomposition. In essence, bacteria and fungi require no more than 1 unit of nitrogen for every 25-35 units of carbon they consume (depending on the species). A high C:N ratio (>35:1) where nitrogen becomes a limiting element, will result in an incomplete compost process (some material will not be decomposed). If instead the nitrogen content is too high, (<25:1) microorganisms will transform excess nitrogen into ammonium, which can be lost from the system by leaching or ammonia volatilization (Jones, et al. 2007), a major contributor of odor problems.

It is important to emphasize that the ratio of carbon to nitrogen should be interpreted as the *relative availability to microorganisms* of carbon and nitrogen. A high surface area of all compost material is critical for allowing fungi and bacteria greater access to nutrients. There is, however, a balance between increasing the surface area of materials by grinding or shredding, and using materials large enough so as to not reduce pile structure and porosity. The C:N ratio is also an indicator of compost maturity and nutrient availability, which are discussed in later sections.

pH

The pH of a compost pile is both a factor and an indicator of conditions within the material. During a normal aerobic composting process, pH should be self-regulated following the pattern of an initial dramatic drop to approximately 5.0, and a gradual rise to 7.0 – 7.5 (Ryckeboer, 2003). Bacteria responsible for the majority of decomposition have a pH range of ~7.0 – 8.0 (Prescott, 2013) in which they can survive. Once colonized, these bacteria release enzymes that keep the pH relatively neutral throughout the process. (Ryckeboer, 2003).

A drop in pH can provide indication of inadequate oxygen, or abundance of moisture leading to anaerobic conditions. Anaerobic bacteria produce acetic acid as a byproduct, substantially lowering the pH of the pile (Wichuk, 2010) inactivating aerobic bacteria and release methane and other gasses, causing odor issues and increasing greenhouse gas emissions.

Temperature

Microbes responsible for aerobic decomposition survive and metabolize within a temperature range of ~10-70°C (Wichuk, 2010). Although high temperatures (55°C) are required for the destruction of potential pathogens in the compost material, temperatures above 70°C can denature beneficial microbes (Ryckeboer, 2003). Temperature must be monitored to prevent the pile from becoming too hot, and to follow the temperature profile which will provide information about which stage the composting process has reached.

Typical compost systems have a temperature profile characterized by an initial increase to thermophillic temperatures (40-55°C), a sustained high-temperature period (45-65°C) and a subsequent decline to near-ambient temperatures (Wichuk, 2010). Measuring temperature at 0.5m above the base of the pile should give accurate core temperatures (Rogstrand, 2003). A return to ambient temperatures is the result of decreased microbial activity, indicating that active composting is complete (all material has been decomposed), or that unfavorable conditions within the pile have prematurely slowed or stopped decomposition. Changes in temperature should then prompt the operator to investigate oxygen, moisture and pH levels to assess if the change is indicating process completion or caused by poor conditions.

Dedicated monitoring equipment capable of accurately measuring oxygen, moisture, pH, carbon to nitrogen ratio and temperature will give operators the required information to ensure the composting process is working efficiently. Tracking this data will also be invaluable to future student research projects.

Finished Compost

Assessing Maturity

After the initial pathogen reduction criteria found in Schedule 1 of the OMRR have been achieved, Schedule 2 outlines two sets of conditions, either of which must be met before Class A compost can be considered complete for land application or sale.

Condition 1 states that compost must be maintained at an average temperature of 45°C for 14 days, after which the C:N ratio must be between 15-35:1.

Condition 2 states that after a 21 day curing process of piles measuring no less than 3m wide x 2m high with a moisture content between 30-60% and an ambient air temperature between 5-30°C, finished compost must:

A. Have a C:N ratio between 15-35:1
B. Not rise more than 20°C above ambient temperature when measured at a depth of 60cm from the surface.

These conditions are in place to ensure the composting process is complete, preventing compost from being sold or applied while active decomposition is still taking place. In addition, the curing phase promotes microbial re-colonization after being inactivated by high temperatures. However, there are several factors that are not discussed in the OMRR and that could result in misleading temperature and C:N ratio measurements, resulting in a false assessment of compost maturity.

As decomposition takes place, carbon is lost as carbon dioxide while nitrogen is generally conserved in the bodies of microorganisms (Aldrich, 2006). Theoretically, the C:N ratio should decrease and become constant as decomposition progresses and completes. As previously discussed, an optimum initial C:N ratio of the compost mix should be between 25-35:1 (Ryckeboer, 2003). It is possible then, that an optimum initial C:N ratio will always register as an acceptable final C:N ratio (15-35:1) according to the OMRR. It is therefore important to accurately measure the initial and final C:N ratio in order to compare. However, it is also not assured that there will be a measurable decrease in the C:N ratio during the course of composting. For instance, nitrogen fixation by bacteria within the material may lower the C:N ratio before all available carbon is used. Also, at a basic pH (7.5), the loss of carbon in the form of carbon dioxide and nitrogen as NH_3 are concurrent (Wichuk, 2010) meaning that the C:N ratio may remain unchanged throughout composting.

Temperature is used in conjunction with the C:N ratio to eliminate some of the aforementioned variability in assessing compost maturity. The OMRR takes into consideration moisture content and pile size when evaluating temperature of finished compost. However, pH, oxygen levels or previously extreme temperatures could all lead to constant, neutral temperatures falsely indicating maturity. As described previously, any of these factors can slow or stop microbial activity, lowering the temperature of the pile before decomposition is complete.

Using the factors that could affect both the C:N ratio and temperature of a compost pile, an example of a misleading diagnosis of compost maturity could be as follows:

> A compost pile with an initial C:N ratio of 30:1 underwent the majority of its decomposition at a neutral pH of 7.5 and as a result the C:N ratio remained unchanged. During this time, the material experienced temperatures above 70°C, denaturing decomposing microbes before all available nutrients were consumed. The temperature dropped, indicating that all available nutrients had been consumed and the compost was ready to cure. After 21 days of curing, the C:N ratio was measured at 30:1 and the temperature was 10°C above air temperature, attributed to thermal insulation of the pile.

Using the general OMRR guidelines, this compost pile could be considered mature even though decomposition was not complete. Many combinations of factors could lead to misleading assessments of compost maturity. It may be beneficial to remove many of the variables associated with large-scale compost piles and test material under ideal lab conditions such as the Dewar Self Heating test. This is a standardized test with controlled oxygen, moisture, pH, and vessel size (Wichuk, 2010). An increase in vessel temperature over a few-day period is related to microbial activity and therefore compost stability.

Compost Quality

Many factors will influence the quality of finished compost. Some factors such as ambient temperatures or different microbial populations within the pile are out of the operators' control. Others, like turning frequency and initial C:N ratio can be managed. Depending on the proposed end-use for finished compost, it may be desirable to alter these management practices.

Frequent turning can accelerate the stabilization of compost material, meaning less working time on the pad. It can also lead to lower nitrogen levels in the end product, as nitrogen is lost as gaseous ammonia (Bonhotal, 2007). Generally, however, the nutrient quality and quantity will be determined by the feedstocks and the amount of leaching that occurs. With a covered facility, leaching should not be of major concern and nitrogen, phosphorus and potassium levels should remain relatively high (Bonhotal, 2007).

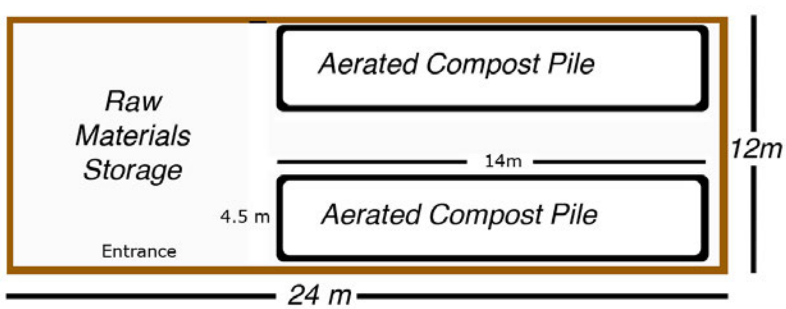
A finished compost with a C:N ratio of less than 20:1 is defined as a fertilizer, while a compost with a C:N ratio above 30 is defined as a soil amendment (Rogstrand, 2003). The difference between these products is that fertilizer will add a net positive amount of plant available nitrogen, while soil amendment retains plant available nitrogen for slow release (Rogstrand, 2003). Mixing a compost pile with a lower initial C:N ratio can help (although not ensure) a lower final C:N ratio if a fertilizer is desired. However, this definition only takes nitrogen into consideration as a source of nutrients. Elements such as potassium and phosphorus should also be measured to fully understand the effect on soil fertility or to avoid over-fertilization and nutrient leaching.

In addition, the curing phase of composting will have a profound effect on finished compost quality. Curing, or maturing the compost promotes microbial re-colonization after high temperatures inactivate most beneficial soil microbes. The dynamic relationship between soil microorganisms and plants promotes biological pest control, nutrient release and plant growth (Neher, 2013). In this respect, curing will have a direct effect on compost quality. Neher et al. (2013) discuss the effects of various recipes and methods on biological communities on finished compost. A longer curing process will certainly increase the variety and abundance of microbes within the compost, but will influence facility management and decrease annual capacity. During the summer months when leaching due to rainfall is of least concern, it may be possible to cure compost outside the facility. This could allow for increased facility capacity, and may enhance the colonization of beneficial microorganisms in the finished compost due to airborne spores.

Operation

The 12m x 24m concrete pad can be configured in numerous ways to accommodate a compost facility. A covered, open-sided facility would provide ample space for windrow turners to maneuver from pile to pile, and advantage of natural airflow. Temperature control may be harder to maintain and if odor issues do arise, gaseous emissions may be harder to contain. However, every step to prevent odor issues should be of higher priority than mitigating potential issues. Enclosing the facility may limit the choice of windrow turner, as they must be able to work within the confines of the facility. Temperature control and biofiltration may be easier in an enclosed facility. The number and dimensions of windrows, machinery used to turn them and the time required to complete the composting and maturation process will affect annual production.

The diagram below offers one configuration of windrows using the option of an enclosed facility. Other possibilities could be to form three piles running the 12m width of the facility, increasing total annual capacity by 50t. This option would require an open-sided facility for windrow turner movement.



With pile dimensions of 4.5m wide x 2.5m high x 14m long (Rogstrand, 2003) (Paul, 2013), total volume of each pile would equal ~79m^3.

Pile volume = 0.5 (Base x Height) x Length

The optimum bulk density of a windrow compost pile (maximizing use of materials while providing adequate porosity) was found to be 640 kg/m^3 (Rogstrand, 2003). It is reasonable to assume that a density of 640 kg/m^3 is obtainable from the proposed UBC feedstocks of food waste, yard trimmings and wood shavings. By using the calculated bulk densities of these materials in **Table 1**, 640 kg/m^3 falls within the medium-high range for food waste and yard trimmings.

Material	Density		
	Low	**Medium**	**High**
Food Waste	343	514	1029
Yard Trimmings	150	450	900
Animal Bedding (Wood Shavings)	250	300	350

Table 1: Bulk densities of proposed material (Environmental Protection Agency Victoria, 2013)

Multiplying the bulk density of material (640 kg/m^3) by the assumed pile volume ($79m^3$) gives an approximate value of ~50 tonnes of material per pile. The proposed configuration of the concrete pad allows for two 14 meter long, ~50 tonne windrows to be housed within the facility at one time. A processing time of 6-8 weeks is recommended for each pile to reach the thermophillic stage and to allow for all material to be exposed to the high-temperature core, J. Paul (Personal communication, July 2, 2013). According to Schedule 2 in the OMRR, compost must be "cured" for a further 21 days (and meet the criteria outlined in section 2 of schedule 2) after active composting has finished. Division 3, Section 26 also states that this curing must occur on a covered, impermeable surface to prevent leaching of nutrients into groundwater. This means that curing would have to take place inside the facility, postponing the formation of a new pile for at least 21 days. Using this timeframe, 10 ~50 tonne piles could be processed in this facility each year, totaling approximately 500 tonnes of material. However, subsection 4 of Division 3 also states that curing can take place anywhere if a qualified professional can demonstrate that water quality criteria is met and leachate is managed. If an alternate curing area were established, this could increase the annual capacity of the facility by ~200 tonnes.

Space constraints will dictate what type of machinery is used to turn and mix the compost as required by the OMRR. Dedicated windrow turners capable of shredding, aerating and adding water to the compost would of course be ideal. These turners have the advantage of further breaking down the material every time the piles are turned, creating a more homogeneous particle size and encouraging quicker decomposition. Unfortunately, the space required to operate these turners is more suited to outdoor applications. A standard tractor with bucket-style loader would be sufficient to initially move and mix compost.

Each pile of finished compost should be tested for fecal coliform levels, presence of heavy-metals and final C:N ratio. Additional tests for potassium and phosphorus could be ordered to evaluate the "N.P.K" value of the compost. This would help the operator differentiate compost based on its nutrient value in addition to N, and determine how finished compost should be used, either as a fertilizer or soil amendment.

Forming Compost Piles Using Appropriate Recipes

Table 2 lists the C:N ratios for materials identified as compost feedstocks at UBC, which should serve as a guideline for the "recipe" of a compost pile.

Material	Average C:N Ratio (weight to weight)	C:N Ratio Range	Average Moisture Content
Food Waste	15:1	14-16:1	70%
Animal Bedding (wood shavings)	475:1	200-750:1	35%
Yard Trimmings (tree trimmings/ leaves/grass)	48:1	28-67:1	45%

Table 2: C:N ratio and moisture content for common materials (Natural Resource, Agriculture and Environmental Service 1992) (Richard, *Moisture content,* 1996)

The C:N ratio in yard trimmings (grass, leaves, trees and shrubs) will vary depending the proportion of greenery to woody debris throughout the year. Lower C:N ratio are associated with Spring and Summer, the higher ratios would be expected with materials collected in Fall and Winter. Moisture content will also vary, and would need to be determined before mixing. For the purposes of this paper, the average C:N value of food waste is used in all calculations as either extreme would not greatly affect results. The average C:N ratio of animal bedding (475:1) is used in all calculations as the only variability should be small changes in the amount of animal excreta found in the material. C:N ratio for yard waste is based on the combined average of tree/shrub trimmings, grass and leaves. **Table 3** Provides three examples of appropriate recipes for 50 tonne piles based on values for these materials found in **Table 2**.The highlighted combination is used for annual capacity calculations in order to accommodate composting all of the UBC CCM animal bedding produced each year (~110 tonnes). Mixtures with lower C:N ratios were calculated to promote nitrogen-rich finished compost.

Material	Tonnes		
Food Waste	35	30	28
Yard Waste (Excluding Grass)	1	9	4
Animal Bedding	14	11	18
C:N	**26:1**	**28:1**	**25:1**

Table 3: Possible pile recipes and C:N ratios

The following calculation was used to determine appropriate pile recipes (Natural Resource, Agriculture and Environmental Service 1992).

$$C:N = \frac{Q_1(C_1 \bullet (100-M_1))+Q_2(C_2 \bullet (100-M_2))+Q_3(C_3 \bullet (100-M_3))}{Q_1(N_1 \bullet (100-M_1))+Q_2(N_2 \bullet (100-M_2))+Q_3(N_3 \bullet (100-M_3))}$$

Q_n = mass of each material
C_n = % carbon
N_n = % nitrogen
M_n = moisture content

Using the highlighted compost pile recipes above, **Table 4** estimates the total amount of waste that could be composted at this facility.

Material	Annual Tonnes
	Annual # of Piles: 10 (Curing area inside facility)
Food Waste	310
Yard Waste	30
Animal Bedding	110

Table 4: Approximate annual waste utilized by the compost facility.

Food waste composted at this facility could amount to 24% of the 1300 predicted tonnes (Fraser, 2013) of food waste generated at UBC by 2016. Animal bedding composted at this facility would amount to 100% of all bedding generated at the UBC CCM.

End Uses

Mass loss from the composting process can be anywhere from 30%-50% (Bonhotal, 2007). This would result in approximately 250-350 tonnes of finished compost available for use. The UBC farm would likely be able to use the majority of the compost produced at this facility depending on nutrient quality and crop requirements. However, the UBC farm soils are high in plant-available phosphorus; the phosphorus levels in finished compost could dictate or limit the amount of compost applied to the UBC farm. UBC Plant Operations could potentially utilize 300-400 tonnes of compost annually, according to Greg Thrift, UBC head gardener. Any surplus could be sold or donated to community and school gardens or sold to the public. However, it is unlikely that there would be an excess of finished compost.

Budget

Investment	Capital Costs	Operational Costs	$/Tonne
Building/installation	$200,000		
Equipment	$60,000		
Monitoring System	$10,000		
Fuel		$2,600	
Hydro		$2,000	
Maintenance		$9,600	
Labour		$43,456	
Testing		$4455	
Total Capital Cost	**$270,000**		
Total Operational costs		**$62,111**	
500 Tonne Production			
Food Waste Savings ($80/T x 310T)		-$24,800	
Animal Bedding "Revenue" ($800/T x 110T)		-$88,000	
Cost/tonne Factoring in Potential Revenue			**$0.00**
Surplus From Animal Bedding Revenue			**$25,889**

Building and Installation:

The building and installation cost for this facility was taken from a static aerated pile facility of similar size, built in Agassiz, B.C by Transform Compost (Paul, 2013). This fully enclosed example was used to estimate construction costs if this option was chosen for a UBC application. An open-sided facility would likely cost less than this particular facility.

Seabird Island Compost Facility, Agassiz B.C (Paul, 2013)

Equipment:

Monitoring equipment would include soil moisture, oxygen and temperature probes, and data logging computers. The UBC School of Population and Public Health offers some equipment such as data loggers, noise monitors, indoor air quality monitors and gas monitors that could be used by this facility. Soil monitoring probes like the Vegetronix VH400 Soil Moisture probe and THERM200, $50/ea (www.vegetronix.com) and the ICT Soil Oxygen Meter, $7400 (www.ictinternational.com) would be suitable for this application.

There are a variety of grinder and screener manufacturers, and machinery can generally be purchased used. The type and size will vary, but the tub grinder and movable screener at the Agassiz facility are examples that would be appropriate and are shown below.

Tub grinder with 80hp tractor (Paul, 2013)

Portable screener (Paul, 2013)

Labour:

At least one non-union Level 3 technician is proposed to operate this facility. Pile management and monitoring is ongoing, while the larger task of forming and turning piles is less frequent. Student interns, volunteers, or farm staff could provide assistance during periods of forming or turning. Another dedicated Level 3 technician would add $43,456 to the annual operating cost, leading to a cost of $32.75 to process each tonne of material.

Testing:

Fees were based on ten separate tests for fecal coliform levels, total organic carbon, total organic nitrogen and all heavy metals outlined in the quality criteria of Section 4 in the OMRR. Maxxam Analytics in Burnaby B.C provided the quote for lab testing fees, which is included in **Appendix 1**. . The fees represent testing each pile after the curing process and before application to ensure it meets Class A compost criteria. The attached quote does not include testing each pile for available phosphorus and potassium, but the cost is reflected in the budget. Maxxam charges $77.00 for each additional test for available nutrients.

Fuel / Hydro / Maintenance:

Diesel fuel was estimated at $50 per week for a front-end loading tractor. Hydro bills for were estimated at an annual 11,000kWh. Maintenance on equipment was estimated to be $800 per month.

Cost Savings and Potential Revenue:

The compost recipe highlighted in **Table 3** was used when calculating the tonnes of animal bedding and food waste that could be processed annually. Revenue from accepting UBC CCM animal bedding was based on charging the CCM their current bedding disposal fee of $800/t. Cost savings from accepting UBC food waste was based on the $80/t tipping fee charged to UBC for organic waste containing >1% contamination by Harvest Power in Richmond. UBC food waste disposal savings of $24,000 were not included in potential revenue. However, it is reasonable that UBC waste management could contribute to operational costs. UBC Plant Operations would also see cost savings by sending material to a UBC compost facility, however, more research is needed to determine their budget for dealing with yard waste.

With an annual throughput of 500 tonnes, potential revenue from accepting a disposal fee for waste animal bedding could amount to $27,079. The relationship dynamics between the compost facility, UBC farm, the UBC Sustainability Committee and the UBC Center for Comparative Medicine would dictate how this surplus would be allocated.

Conclusions

The method of composting recommended is a combination of turned windrows and forced aeration to promote thorough mixing and breakdown of material and to allow for greater control of oxygen, moisture and temperature within the pile. Enclosing the facility will meet the requirements of the OMRR and allow for greater control of noise, odor and visual pollution.

Collecting the disposal fee for the UBC CCM waste animal bedding is what will allow this facility to operate without a deficit. Accepting a smaller disposal fee of $700, for instance, may make an agreement with the UBC CCM and a farm compost facility amicable. UBC Waste Management would be integral in transporting any material to the facility, and any concerns they may have will need to be addressed.

It is important to reiterate that the annual capacity of this facility has been estimated on the basis that all compost piles decompose effectively and completely within the recommended timeframe of 6-8 weeks and cure to maturity in the minimum 21 days as required by the OMRR. C:N ratios, moisture contents and volumes have all been calculated from the best available data, but these values must be determined for the specific material used before forming a new pile. These specific values will change the estimated annual capacity of this facility. There are, as mentioned, many factors that can negatively affect aerobic microbes within the compost pile, delaying completion of the process. If a UBC farm compost facility were built, agreements with UBC Waste Management, UBC Plant Operations and the UBC CCM would be needed and measures in place to arrange for alternate disposal of organic waste in case of unforeseen problems with the compost system.

However, there are certain benefits to operating a compost facility on the UBC farm. Composting at the farm could eliminate at least 32 trips to Richmond or ~960km and the emissions that are associated with them by UBC Waste Management trucks. The UBC farm and UBC Plant Operations would benefit from the steady supply of finished compost. Depending on nutrient quality of the compost, the UBC farm could see cost savings from decreased fertilizer purchases.

An accessible compost facility could serve as a laboratory and learning opportunity for students across a wide variety of disciplines and the general public. Proposals for further student research products are included at the end of this paper.

The success of any composting program rests on the ability for individual compost bins to collect a pure, minimally contaminated stream of organics. Those using these bins, UBC students, faculty and residents must be educated to the point where composting basics and consequences of adding non-compostable materials are known. Without this basic knowledge, the greatest contributors to the success of a composting program will remain unconsciously ignorant of their actions. Simply sending away our organic waste may perpetuate the thought that compost collection bins are the last step in the food system.

What happens to what I throw away? Where does it go? Why does it matter? These questions seldom run through the mind of students as they dispose of waste materials. Refuse bins continue to act as an anonymous receptacle, which absolves us of any accountability for what we throw in. A UBC farm compost facility could serve as a visible representation to the aforementioned questions.

Further Questions and Research Opportunities

Talk to UBC hygiene regarding transport and handling of material in an enclosed facility. Tariq Din. Health and Safety Manager. 604-822-1885

A specific quote is needed for enclosing the existing concrete pad and cutting aeration piping into concrete flooring. The quote used in the budget may be accurate, but should be cross-referenced.

Discuss the logistics of transporting UBC food waste, yard waste and animal bedding to a farm compost facility

Explore various facility configurations to maximize throughput and ability to deal with various volumes of material throughout the year.

Look into the cost and feasibility of small-scale self-propelled windrow turners such as the Backhus Windrow Turner.

Test piles 2.5m high x 4.5m wide should be constructed from animal bedding, food waste and yard waste. Time to completion, nutrient value, and presence of any pharmaceuticals should be monitored and tested to evaluate the quality of compost that could be expected from this facility.

Student Directed Studies Possibilities and Examples:

Applied Science students: Research possible odor mitigation technologies, track changes in compost efficiency with regards to changes in methods and recipes.

CEEN students: Assess possibility of heat capture system from composting facilities for use in adjacent greenhouses etc.

Microbiology students: Develop an understanding of how microbial communities are influenced by different composting methods and recipes.

Occupational and Environmental Health students: Determine any occupational hazards from working in an enclosed compost facility.

Land and Food Systems students: Develop and assess education and awareness strategies for reducing contaminants in food wastes.

Graduate Student Project: Document and monitor microbiological changes during the curing process of finished compost; does cured UBC compost suppress soil borne root pathogens?

Applicable Sections of The Organic Matter Recycling Regulations

The Regulations that follow apply to the production of Class A compost, taken from the Canadian Organic Matter Recycling regulations (2002). Regulations that applied only to Class B compost, Class A Biosolids, Class B Biosolids and Biosolids Growing Medium have been omitted.

Division 5 — Class A Compost

Process and quality criteria
Section 12

(1) In this section, **"untreated and unprocessed wood residuals"** means clean wood from lumber manufacturing, and includes shavings, sawdust, chips, hog fuel, ground mill ends and land clearing waste which has been ground with the majority of the greenery removed and no soil present.

(2) Compost that is produced solely from yard waste or untreated and unprocessed wood residuals, or from both, and that meets the requirements of all of the following, is Class A compost:
- (a) Schedule 1, Pathogen Reduction Processes;
- (b) Schedule 2, Vector Attraction Reduction;
- (c) Column 1 of Schedule 4, Quality Criteria.

(3) Compost that is not solely produced from yard waste or from untreated and unprocessed wood residuals and that meets the requirements of all of the following is Class A compost:
- (a) the requirements of subsection (2) (a) to (c);
- (b) Schedule 3, Pathogen Reduction Limits;
- (c) Schedule 5, Sampling and Analyses — Protocols and Frequency;
- (d) Schedule 6, Record-keeping.

(4) Class A compost must be derived only from organic matter[1].

(5) Biosolids used as feedstock for the production of Class A compost must not exceed the standards for Class B biosolids set out in Column 3 of Schedule 4.

Section 13

Class A compost may be distributed with no volume restriction.

Listed below are Schedules 1-6 and Schedule 12 as referenced to in Process Quality and Criteria of Class A Compost. Outlined in these schedules are the materials allowed and conditions that must be met during the compost process in order for the end product to be classified as "Class A" and therefore allowed to be distributed without volume restrictions.

[1] In subsection 4, "organic matter" refers to materials in Schedule 12

Schedule 1

Pathogen Reduction Processes
Section 1

The pathogen reduction requirements listed in section 2 (a) to (g) of this Schedule must be met before or at the same time as the vector attraction reduction requirements set out in sections 1 to 3 of Schedule 2.

Section 3

The pathogen reduction requirements for Class A compost listed in section 4 (a) to (c) of this Schedule must be met before the vector attraction reduction requirements listed in section 2 (a) and (b) of Schedule 2.

Section 4

One of the following pathogen reduction processes specified in paragraphs (a) to (c) is required to produce Class A compost:

(a) the windrow composting method whereby organic matter is processed in a windrow involving periodic aeration and mixing of the windrow, with a temperature of not less than 55º Celsius maintained for at least 15 days and not fewer than 5 turnings of the windrow made during the high temperature period to promote uniform exposure of the compost to thermophilic temperatures;

(b) the static aerated pile composting method consisting of a compost process involving mechanical aeration of the compost pile, with the compost pile insulated and a temperature of not less than 55º Celsius maintained throughout the compost pile for at least 3 consecutive days;

(c) the enclosed vessel method consisting of a confined compost process involving mechanical aeration of compost under controlled environmental conditions, with a temperature of not less than 55º Celsius maintained for at least 3 days during the composting process.

Section 6

The director may provide approval for an alternative process on a specific basis if the director is satisfied that the alternative process in that case will provide a Class A compost equivalent in quality as that produced by the process described by section 4 (a) to (c).

Schedule 2

Vector Attraction Reduction

Section 2

One of the following vector attraction reduction processes are required for Class A compost:

(a) Class A compost must be treated in an aerobic process for 14 days or longer. During that time, the temperature of the compost must be higher than 40° Celsius and the average temperature of the compost must be higher than 45° Celsius. After the vector attraction reduction process is completed the carbon to nitrogen ratio of the compost must be greater than or equal to 15:1 and less than or equal to 35:1;

(b) Class A compost must be retained in curing piles for at least 21 days. After the 21 day period, the carbon to nitrogen ratio of the Class A compost must be greater than or equal to 15:1 and less than or equal to 35:1 and must not re-heat, upon standing, under the following conditions:

> (i) compost is aerated and formed into a pile no smaller than 3 metres in diameter and 2 metres high with compost having a moisture content between 35 percent and 60 percent;
>
> (ii) the pile must be formed in a location where the ambient temperature remains in the range of 5° to 30° Celsius;
>
> (iii) 3 days after the pile has been formed, the temperature of the compost is measured at a depth of 60 cm into the pile from the outside surface of the pile;
>
> (iv) the compost must not re-heat upon standing to greater than 20° Celsius above ambient temperature.

Section 3

If one of the above vector attraction reduction methods cannot be met, then a test method or treatment process specified in protocols approved by the director, may be used as an alternative means of showing that vector attraction reduction has been achieved.

Schedule 3

Pathogen Reduction Limits

Section 1
Fecal coliform levels must be determined to be < 1 000 MPN per gram of total solids (dry weight basis) for Class A compost (not produced from yard waste alone).

Section 3
For Class A compost (not produced from yard waste alone), 7 representative samples must be taken

(a) from every 1 000 tonnes dry weight, or
(b) once per year, whichever occurs first.

Section 4
The required fecal coliform levels must be met in all 7 representative samples.

Section 5
Fecal coliform levels for Class A compost (not produced from yard waste alone) must be met either before, or at the same time as, the vector attraction reduction requirements are met.

Section 6
Fecal coliform levels must be met and vector attraction reduction methods must be complete before Class A compost is prepared for distribution

Schedule 4

Quality Criteria

Section 1

Substance concentrations, expressed in μg/g dry weight must not exceed the limits set out in the following table:

	Column 1
Substance	**Class A compost**
Arsenic	13
Cadmium	3
Chromium	100
Cobalt	34
Copper	400
Lead	150
Mercury	2
Molybdenum	5
Nickel	62
Selenium	2
Zinc	500

Section 2

Retail-grade organic matter[2] and managed organic matter must have:

(a) foreign matter content less than or equal to 1 percent dry weight, and
(b) no sharp foreign matter, such as glass or metal shards, in a size and shape that can cause injury.

[2] "Retail Grade Organic Matter" refers to Class A compost

Schedule 5

Sampling and Analyses — Protocols and Frequency

Section 1

All required analyses for Class A compost that is not solely produced from yard waste must be carried out at intervals of:

(a) at least every 1 000 tonnes dry weight of organic matter, or
(b) once per year

whichever occurs first[3].

Section 3

Analyses must be in accordance with the procedures described in "British Columbia Laboratory Methods Manual: 2003 — for the Analysis of Water, Wastewater, Sediment, Biological Materials and Discrete Ambient Air Samples", (2003, Ministry of Water, Land and Air Protection), or by suitable alternate procedures authorized by a director.

Schedule 6

Record-keeping

Section 1

Temperatures and retention times must be monitored and recorded each working day during the production of Class A compost (not solely produced from yard waste).

[3] These are minimum regulations. Sampling should be done for every "batch" before application

Section 2

Temperature and retention time records must be kept at the facility for at least 36 months and must be made available for inspection by an officer, or sent to a director or an inspector or officer authorized under the *Agricultural Land Reserve Act*, the *Soil Conservation Act* or the *Forest Land Reserve Act*, upon request.

Section 3

The results of analysis required by this regulation must be kept at the facility for at least 36 months after the production of Class A compost (not solely produced from yard waste)

Section 4

The results of analysis must be made available for inspection by an officer or sent to a director or an inspector or officer authorized under the *Agricultural Land Reserve Act*, the *Soil Conservation Act* or the *Forest Land Reserve Act*, upon request.

Section 5

The land application plan signed by a qualified professional as required by Division 1 of Part 3 of the regulation must be kept at the facility, or kept by the registered owner of the land application site, for at least 36 months after application and must be made available for inspection by an officer, or sent to a director or an inspector or officer authorized under the *Agricultural Land Reserve Act*, the *Soil Conservation Act* or the *Forest Land Reserve Act*, upon request.

Schedule 12

Organic Matter Suitable for Composting

Section 1

Only the organic matter in the following table may be composted into Class A compost:

Table — Organic Matter Used for Composting

Column 1 — Organic Matter	Column 2 — Constituents of Organic Matter
animal bedding	animal bedding derived from straw, paper, hog fuel, wood chips, bark, shavings or sawdust.
biosolids	stabilized municipal sewage sludge resulting from a municipal waste water treatment process or septage treatment process which has been sufficiently treated to reduce pathogen densities and vector attraction to allow the sludge to be beneficially recycled in accordance with the requirements of this regulation.
brewery waste/winery waste	used or diverted grain, malt, hop flowers, berries, fruit, leaves and twigs and yeast resulting from brewing or wine making process.
domestic septic tank sludge	sludge removed from a septic tank used for receiving, treating and settling domestic sewage.
fish wastes	fish carcasses and parts from harvested wild stocks, commercial aquaculture operations and fish processing facilities. This would include offal, viscera and mortalities from fish and shellfish. It would also include faeces captured from commercial aquaculture net pens.
food waste	recyclable food for humans that has been diverted from residential, commercial or institutional sources.
hatchery waste	broken or unhatched eggs, unhatched chicks, membranes, embryonic fluids and eggshell.
manure	animal excreta from pets, animals in zoological facilities, fish held in commercial aquaculture or aquarium facilities, livestock, farmed game or poultry, this does not include the management of animal excreta (manure) on farms as defined as agricultural waste in B.C. Reg. 131/92 but does include animal excreta (manure) not included within the scope of B.C. Reg. 131/92.
milk processing waste	sludge or biomass from treatment of milk or fluid milk which has been diverted from human food consumption.

plant matter derived from processing plants	fruit, vegetable and vegetative material derived from fruit and vegetable processing plants, these are materials which have been removed from an agricultural operation and no longer fit within the definition of agricultural waste (agricultural vegetation waste) as defined in B.C. Reg. 131/92.
poultry carcasses	carcasses of domestic fowls, such as chickens, turkeys, ducks or geese, raised for meat or eggs. This would include offal and viscera as well as mortalities from fowl which died from reported "Federally Reported Diseases".
red-meat waste	carcasses of red-meat animals such as cattle, swine, sheep, fallow deer, farmed game and farmed bison.
untreated and unprocessed wood residuals	clean (non-contaminated and untreated) wood from lumber manufacture, e.g. shavings, sawdust, chips, hog fuel, ground mill ends and land clearing waste which has been ground with the majority of the greenery removed and no soil present but does not include construction and demolition debris.
whey	the serum or watery part of milk that remains after the manufacture of cheese.
yard waste	clean and untreated wood waste or non-food vegetative matter resulting from gardening operations, landscaping, and land clearing; yard waste does not include wood waste derived from construction or demolition. Neither human or animal food waste that is diverted from residential, commercial or institutional sources, nor manure, is yard waste.

Part 5
Division 2 — Construction and Operation of Composting Facilities

Plans and specifications
Section 24

(1) A discharger must have a qualified professional prepare plans and specifications for

(a) the construction and operation of a new composting facility, or
(b) any modification of an existing composting facility that results in an increase in the annual production capacity of more than 10 percent or more than 20 000 cubic metres.

(2) The plans and specifications required by subsection (1) must include, but are not limited to, all of the following:

(a) all works to be constructed on the site;
(b) design capacity of the composting facility;
(c) a leachate management plan which stipulates how leachate generated from any and all stages of the composting process will be minimized, managed, treated or disposed;
(d) an odour management plan which stipulates how air contaminants from the composting facility will be discharged in a manner that does not cause pollution;
(e) an operating and closure plan for the composting facility.

(3) The discharger must ensure that

(a) the qualified professional
  (i) affixes his or her professional seal or signature, or both, to the plans and specifications for the composting facility, and
  (ii) makes a signed statement certifying that the composting facility has been constructed in accordance with the plans and specifications,
(b) a copy of the plans and specifications for the composting facility are kept at the composting facility at all times, and are available for inspection at any time,
(c) the plans and specifications are submitted to a director upon request, and
(d) the composting facility is operated in compliance with the plans and specifications required by subsection (1).

(4) The director may request additional information with respect to the plans and specifications that he or she considers necessary for the protection of human health and the environment, and may specify particular concerns or questions that the plans and specifications must address.

Notification of operation
Section 25

(1) The discharger must, at least 90 days before beginning the operation of a composting facility, give notice in writing to

(a) a director, and
(b) the Land Reserve Commission if the composting facility is in an agricultural land reserve or forest reserve land.

(2) The notification required by subsection (1) must include
(a) the composting facility location and design capacity, name of a contact person, type of waste received, and intended distribution of compost, and
(b) a copy of a personnel training program plan that addresses the specific training needed to operate the composting facility in compliance with this regulation.

Division 3 — Leachate Management for Composting Facilities

Composting facility requirements
Section 26

(1) In this section, **"curing area"** means an area where organic matter which has undergone the rapid initial stage of composting is further matured into a humus-like material.

(2) The receiving, storage, processing and curing areas of a composting facility must comply with all of the following:

(a) be located on asphalt, concrete or another similar impermeable surface that is capable of withstanding wear and tear from normal operations and that will prevent the release of leachate into the environment;

(b) have a roof or cover, or a prepared surface, designed to prevent
(i) the surface collection of water around the base of organic matter and compost, and
(ii) run-off water from entering the receiving, storage, processing and curing areas;

(c) have a leachate collection system designed, constructed, maintained and operated to reuse leachate, or to remove leachate, from the receiving, storage, processing and curing areas.

(3) Leachate that is not collected and reused in the composting process must not be discharged into the environment unless authorized under the Act.

(4) Despite subsections (2) and (3), an impermeable surface, roof, cover, prepared surface or leachate collection system is not necessary if a qualified professional can demonstrate through an environmental impact assessment that the environment will be protected and appropriate water quality criteria satisfied through the use of alternative leachate management processes.

(5) A director may request additional information with respect to the environmental impact assessment that he or she considers necessary for the protection of human health and the environment, and may specify particular concerns, questions, standards or monitoring that the assessment must address.

Division 4 — Capacity of Composting Facilities

Capacity for organic matter
Section 27

The amount of organic matter in a composting facility must not at any time exceed the total design capacity of the facility.

Capacity for compost
Section 28

At least half of the compost stored at a composting facility must be removed annually from the facility beginning in the third year after facility start-up.

Capacity for residuals
Section 29

(1) Residuals from the composting process must

(a) be stored so as to prevent vector attraction, and
(b) be disposed of on a regular basis in accordance with the Act.

(2) Residuals that are stored at a composting facility must not at any time exceed 15 cubic metres in total.

Closure of a composting facility
Section 30

Before the closure of a composting facility,

(a) all compost must be applied or distributed in accordance with this regulation, and
(b) all unprocessed organic matter must be removed from the facility and dealt with in accordance with the Act.

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Appendix

Maxxam

PROJECT QUOTATION

Customer:	**University of British Columbia**
Address:	2329 W Mall, Vancouver, BC V6T 1Z4
Phone:	[redacted]
Quote:	
Customer Contact:	
Project Reference:	
email:	

Laboratory Performing Analysis: *Burnaby*

Date Issued: January 10, 2014 Valid Until: December 30, 2014

MINIMUM BILLING FEE OF $250.00 PER SUBMISSION APPLIES

PARAMETER	METHOD REFERENCE	MATRIX	#	UNIT COST	TOTAL
Fecal Coliforms	Mutiple Tube Fermentation, SM 9222	SOIL	10	$72.50	$725.00
Total Organic Carbon	LECO	SOIL	10	$77.00	$770.00
Total Nitrogen	LECO	SOIL	10	$77.00	$770.00
BC CSR Metals	ICPMS	SOIL	10	$65.00	$650.00
				TOTAL	$2,915.00

ADDITIONAL FEES:		
Sample Disposal Fee	Charged on a per sample basis	$2.00
Hold Fee at 4 degrees C	Samples submitted with no test request	$5.00
Archive Data Retrieval	$50 per hour	By Quote
Electronic Data Deliverables	In MS Excel spreadsheet or client-specific	No Charge

COMMENTS:

Prices listed exclude applicable taxes and are based on standard TAT unless otherwise indicated

METHOD PERFORMANCE, DETECTION LIMITS AND ENVIRONMENTAL GUIDELINES

- Unless stated otherwise, a review of the scope of work (per ISO 17025) indicates that Maxxam standard target analytes and reporting limits will meet customer requirements. Prices are quoted on this basis. Please contact your project manager for standard list of analytes.
- Dilutions due to matrix interferences may raise the RDL above criteria.

QUALITY ASSURANCE

- Maxxam has a national quality assurance program supported by dedicated, trained, full-time QA staff (at least 1 per location)
- Maxxam laboratories are recognized as Accredited Laboratories for specific tests by the Standards Council of Canada (SCC) and/or by the Canadian Analytical Laboratories Association (CALA). Scopes of accreditation for Maxxam's Laboratories may be viewed for SCC at http://www.scc.ca/en/search/palcan or for CALA at http://www.cala.ca

TURN-AROUND TIME (TAT)

- All TAT quoted is in business days.
- TAT on samples received past 3:00 pm or on Saturday begins the next business day.
- For weekend or holiday work, additional charges apply. Please contact your project manager.
- In the case of subcontracted analyses, TAT begins is based on time of receipt at the subcontractor laboratory.
- In the event of incomplete or conflicting submission information, TAT begins immediately once resolved.
- If rush service is required to meet hold times, surcharges will be charged even if standard TAT is requested.
- Surcharges are only charged for actual TAT received, not TAT requested.
- A review of Maxxam capabilities and resources (per ISO 17025) indicates that project requirements can be met, based on future workload projections. This does not constitute a performance guarantee due to variable sample loadings and instrument failure.

SERVICE	PREMIUM/ SURCHARGE
Same Day TAT	200%
1 Day TAT	100%
2 Day TAT	50%
3-4 Day TAT	25%
Standard 5-7 Day TAT	Regular Rate

The laboratory must receive advance notice of all RUSH projects. Please call your Project Manager to schedule.

CONTACTS

Contact Title	Maxxam Contact	Regarding
Account Manager	Amanda Hart [redacted]	Project setup, Quotes, etc.
Project Manager	Samantha Fregien [redacted]	Bottles, Job Status, Reports
Customer Service Manager	Rob MacArthur [redacted]	Escalations, Backup