ORGANIC WASTE COLLECTION: A BUSINESS OPPORTUNITY IN VANCOUVER

by

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Abstract

The waste management industry in Canada is undergoing a number of changes that place emphasis on materials recovery and recycling. Paradigms are shifting towards closed-loop systems that minimize environmental damage and extract value from waste materials. This paper focuses on the potential for business opportunities in organic waste management in Vancouver, BC, with particular regard to the recovery of food wastes.

An overview of the waste management industry in Vancouver in its present state is discussed to assess the competitive landscape and identify key success factors to profitability. Next, there is a discussion of waste reduction philosophies that outline strategies and techniques for meeting new waste management objectives. A series of interviews gauging demand for an organic waste collection service was conducted with various stakeholders to provide a content analysis. Lastly, a number of business opportunities are identified and accompanied by a proposed operational model.

The term "sustainability" has become a platform for change in many organizations, but it is also being used as a differentiation strategy that serves a real customer base. Organic waste collection and processing as part of a waste diversion program may be a suitable method of meeting this demand. This study has indicated that although there is much interest in organic waste diversion programs, profitability may be limited if not elusive. An in-depth operational model merits further investigation.

Keywords: Waste Management; Municipal Solid Waste; Waste Diversion; Compost; Integrated Resource Management

Dedication

This essay is actually the culmination of a two-year journey of personal exploration. On the advice of a career professional, it was suggested that I pursue a skill set that better showcased my inherent talents and would lead me towards a path of self-fulfilment and satisfaction. Hence I began the MBA program with the Segal Graduate School of Business at Simon Fraser University.

We knew that I would be busy as a full-time student, part-time employee, and part-time husband, but we really had no idea how challenging it would be. We couldn’t have; I alone had not grasped the magnitude of the time commitments, self-discovery and mental fortitude required to make the most of this learning experience!

I wanted the opportunity and I took it, but not without sacrifice from my closest friends, distant family, and most importantly my wife. Without her hard work, support, and commitment to helping me realize the completion of this program, this dream couldn’t have come true.

I thank you my love and best friend, Wendy.

Acknowledgements

Many of the ideas in this paper were presumed and based on assumptions until the credibility and verification of industry-related personnel could substantiate them. In addition to the academic research conducted, these accounts of current attitudes and market sentiments lend credit to the conclusions made and subsequent recommendations. I would like to thank each individual who so generously donated me their time in order to talk about the nature of their business, industry, customers and business models.

I was sincerely surprised at how difficult it was at times to find subjects and arrange stakeholder interviews surrounding organic waste management issues. It is for this reason I would like to extend my personal gratitude to the following list of people:

Christian Beaudrie, Outreach Coordinator for UBC Waste Management. I first requested a tour of UBC's in-vessel compost facility in the summer of 2009. I was never actually able to take the tour, but Christian provided a detailed interview and subsequent discussions and information about UBC's organic waste management program that transcended other ideas in this paper. His experience was extremely helpful in conceptualizing the operational models described within.

Chris Underwood, Manager of the Solid Waste Management Branch of the City of Vancouver's Engineering Department. At a time when Metro Vancouver was in the unstable position of negotiating the final terms of a proposed organic waste collection program, Chris was took the risk of discussing program objectives and

strategic departmental goals with me. Particularly when other members were more heavily involved in the process, Chris made the time to talk rather than simply passing me along to another checkpoint in a large system.

Emmanuel Prinet, Executive Director of One Earth and

Patricia Chartrand, Strata Council President for Station Place. Representatives of property management groups were extremely difficult to come by. Many phone calls were left unreturned and a number of "promising leads" fell through in multiple instances. The property management perspective was key in gauging suitability and strategic validity of a significant target market in this paper. Although much more research is required, the initial results obtained were promising and informative.

Andre LaRiviere, Executive Director of The Green Table Network Vancouver. While my correspondence with guest relations and marketing personnel representing restaurants in Vancouver was generally brief, Andre took time to explain to me the issues that had arisen during his relations developed with numerous food outlets. Andre is a former chef and restaurant owner, and was able to lend valuable perspectives that may otherwise have been missed.

Jonathan Williams, Sr. Sales Representative of Smithrite Disposal and

Joe Rajotte, District Manager and Vice President, BC of BFI Canada. Considering the competitive nature of waste hauling in Vancouver, I was fortunate to be able to speak to each of these gentlemen about market share, their operations and partnerships. In return, I hope that each sees that organic waste hauling could be a viable area for expansion of operations in the not too distant future.

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Glossary

DLC	Demolition, land clearing, and construction
EPR	Extended producer responsibility
GHG	Greenhouse gases (notably carbon dioxide, methane and nitrous oxide)
GVRD	Greater Vancouver Regional District
HHW	Household hazardous waste
ICI	Industrial, commercial and institutional
IRM	Integrated resource management
Leachate	A mixture of water and dissolved solids produced as liquids pass through waste and collect at the bottom of a landfill. This may contain a variety of toxic compounds and pollutants.
MES	Minimum efficient scale
MSW	Municipal solid waste

Nuisance waste	Material accepted at landfills that requires special consideration, documentation, handling or disposal.
Organic waste	Carbon-based, biodegradable waste originating from plant or animal sources. This matter is capable of decay or decomposition by other living organisms.
Vector	Any animal or living thing that can serve as vehicle for disease transmission. This may include vermin (e.g. rats, racoons, etc.) and insects (e.g. flies).
Vermicompost	A humus-like soil amendment (compost) that is produced using worm castings
VLF	Vancouver landfill
VSTS	Vancouver south transfer station
WM	Waste management

1: Introduction

1.1 Purpose and Scope of Analysis

This report is an exploration of the potential for business opportunities in organic waste management within the city of Vancouver, British Columbia. To provide context to the discussion, a brief description of waste management (WM) systems and their relevance is addressed in the introduction. In order to appreciate the WM industry in Vancouver in its current state, Porter's Five Forces analysis is used to describe the players and how competitive forces are shaping the strategies being executed in the different segments of the value chain.

Trends in the WM industry are changing and there is an increasing imperative to divert or reduce the amount of waste being produced. An examination of waste reduction strategies and the philosophies behind them is explored in order to showcase the potential for new WM business models, with particular focus on organic waste. To validate underlying assumptions in these models, a series of interviews with stakeholders and potential customers within the value chain was conducted. The qualitative data obtained from these interviews is discussed and then summarized.

One of the report's key objectives was not only to identify business opportunities, but also to evaluate the ease with which they could be initiated and implemented. A number of options in organic waste management are mentioned and their merits are compared and contrasted, based on key selection criteria. These selection criteria are then used to discuss proposed operational models for the collection and processing of organic waste. The findings of the report and analysis of business opportunities are then summarized in the conclusion.

1.2 What is Waste?

Waste can be regarded as any material that is unwanted by its producer once its value has been exhausted. Often this material is the by-product of a production process such as sawdust from a timber processing plant, or the packaging associated with the safe delivery of a consumer good through retail channels. Wastes can be solids, liquids, gases, all of which can be further classified as hazardous or non-hazardous materials. The physical and chemical properties of waste are commonly used for categorization by source, i.e. residential, industrial, commercial, and institutional. Classification also occurs by composition: paper, metal, glass, organic, electronic, etc.

Municipal solid waste (MSW) is a mixture of various types of waste produced from residential and non-residential sources within a given region or district. In most cases MSW does not include industrial hazardous wastes and is handled and separated at the point of collection. This report will focus primarily on MSW generated within the province of British Columbia (BC), specifically the Greater Vancouver Regional District (GVRD).

1.3 The Importance of Waste Management Systems

The production and consumption of materials inherently generates waste and can be regarded as a by-product of human activity and population growth. The challenge of waste management is faced by all societies and a positive correlation has been associated between increased consumption and rising incomes (Orians and Skumanich, 1995).

Statistics Canada's "Human Activity and the Environment" (2005) shows consistent Canadian GDP growth from 1996 to 2002 and an increase in solid waste generation over the same period. Some of the factors cited include the trend of fewer people per household consuming basic goods (e.g. furniture, toiletries, etc.), increasing per capita consumption, a change in consumer preferences towards disposable convenience items (e.g. food, cleaning products, diapers, etc.), and obsolescence of consumer goods (e.g. clothing items, electronics, etc.).

If we accept that governments, including Canada's, wish to increase the standard of living for their people, we must expect that this will increase consumption patterns. As consumption increases more waste is produced, thus it is paramount that societies develop effective methods of waste disposal. This is important for a number of reasons:

- The improper disposal of hazardous materials presents obvious safety concerns to citizens who may or may not be aware of the presence of that waste, and the extent of damage that it can cause.
- The timely removal of waste can minimize the attraction of unwanted pests or vectors that are drawn to the scent or sight of organic matter, namely plant and animal materials. This also reduces the risk and incidence of disease transmission.
- Waste is unsightly and odours and other by-products can be unpleasant.
- Waste removal maximizes efficiency of space allocation in densely populated areas.

1.4 Traditional MSW Processing Methods

As defined in Statistics Canada's Waste Management Industry Survey (2008), typical methods of waste processing include:

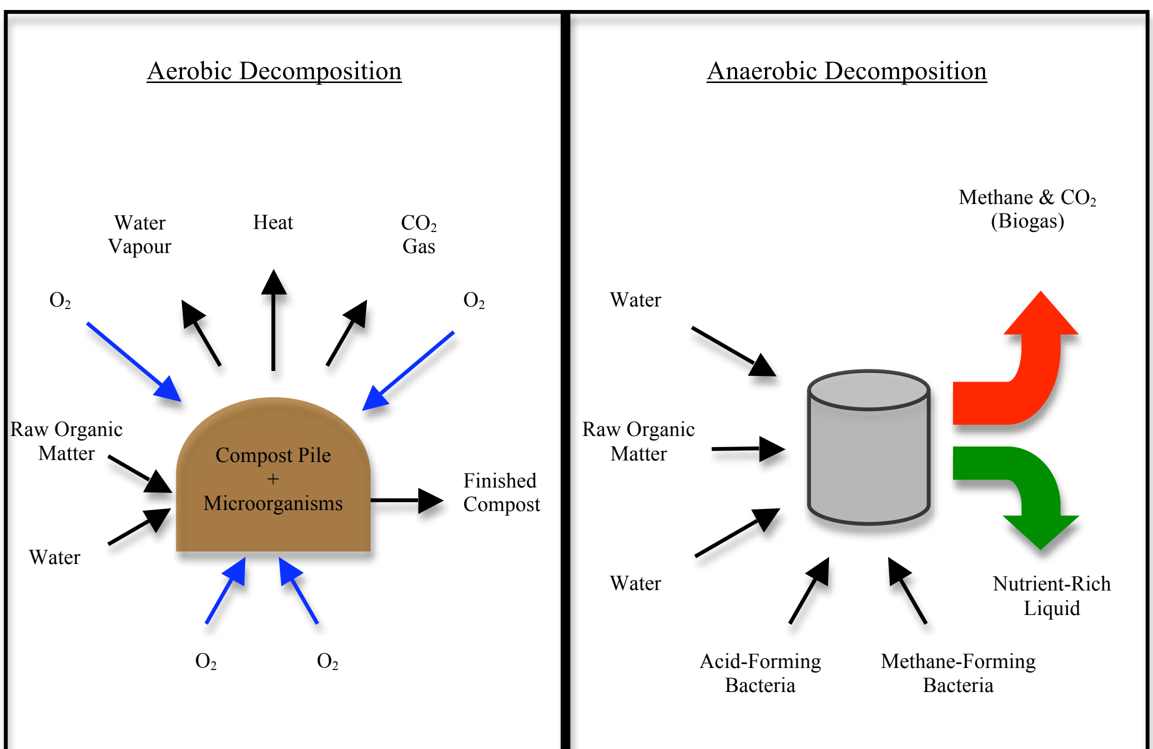
> Composting – an aerobic biological treatment process used most frequently in Canada at this time for management of biodegradable residential wasted such as leaf and yard waste or food wastes.
>
> Recycling – the process whereby a material (for example, glass, metal, plastic, paper) is diverted from the waste stream and remanufactured into a new product or is used as a raw material substitute.
>
> Incineration – in the context of waste, refers to the burning of waste. Most jurisdictions in Canada consider incineration to be disposal.
>
> Sanitary landfill – a site, on land, that is used primarily for the disposal of waste materials. The contents of landfills can include garbage that is not processed, and also residual material from processing operations (recycling facility residues, incinerator ash, compost residues, etc.).

MSW can generally be segregated into two categories, hazardous and non-hazardous. Hazardous materials require special handling, disposal and containment, but for the scope of this report we will focus on the processing options available for non-hazardous materials.

Composting

Organic matter, or plant and animal-based materials, decompose under controlled conditions in the aerobic biological process of composting. The process allows for nutrient recovery and the production of a humus-like material, most commonly used as a soil amendment. In the GVRD most materials that are composted are leaves and yard trimmings such as grass clippings and the branches of small shrubs. Waste is collected by municipal workers or private contractors from both residential and non-residential sources, and delivered to processing facilities. Alternatively, organic matter can also be broken down using the process of anaerobic digestion. The main difference between the two methods being that anaerobic conditions mean a controlled environment in the absence of oxygen resulting in the production of 'biogas', essentially a mixture of methane and carbon dioxide. This method is more commonly used in processing municipal liquid waste where slurries of excreted animal matter can be processed efficiently (e.g. animal manure collected from farms or municipal sewage treatment plants). Figure 1 contrasts the two methods.

Figure 1. Aerobic Vs. Anaerobic Digestion in Organic Matter Decomposition



Recycling

Concerns over pollution generated from landfills and incinerators in the 1980s and 1990s lead to the creation of waste disposal alternatives and particular interest in recycling (Statistics Canada, 2005). Recycling is the process where materials (e.g. glass, metal, plastic, paper) are diverted from commingled MSW and reused to create new products or used as substitutes to raw materials in manufacturing processes. In addition to extending the capacity of existing landfills, recycling provides the benefit of reducing the extraction and production of new materials, significantly decreasing the environmental impact of using virgin resources to make new products. This effect has been documented in multiple studies such as Williams' (Statistics Canada, 2005), demonstrating that paper production from recycled materials uses less energy, yields reduced solid waste, and creates fewer air and water emissions.

Incineration

Incineration is the destruction of materials by burning however this describes a wide range of practices. In terms of waste management, mass burn systems, refuse-derived fuel systems and other modern types of incinerators using pollution control devices are commonly referred to as "waste to energy" systems. While incineration can effectively reduce the total volume of waste, the emission of pollutants into the air and its resultant impacts on health and the environment has raised a number of contentious issues. While it is a common WM practice in some countries where landfill space is scarce, incineration is less common in Canada.

Landfill

When waste materials cannot be handled or reused in any of the previously listed processing methods, or if those materials are not diverted from the waste stream they are disposed of within a landfill. Simply put, landfill is the disposal of waste on the earth's surface and is the most common method of WM in Canada. The contents of the landfill may also contain residual material from processing facilities (i.e. recycling residues, incinerator ash, compost residues, etc.). Today's landfills are an improvement from old-style dumps and have improved features designed to protect the environment and account for effects on human health. This includes components such as liners that help trap leachate and gas recovery systems that help limit environmental exposure to emissions (i.e. methane).

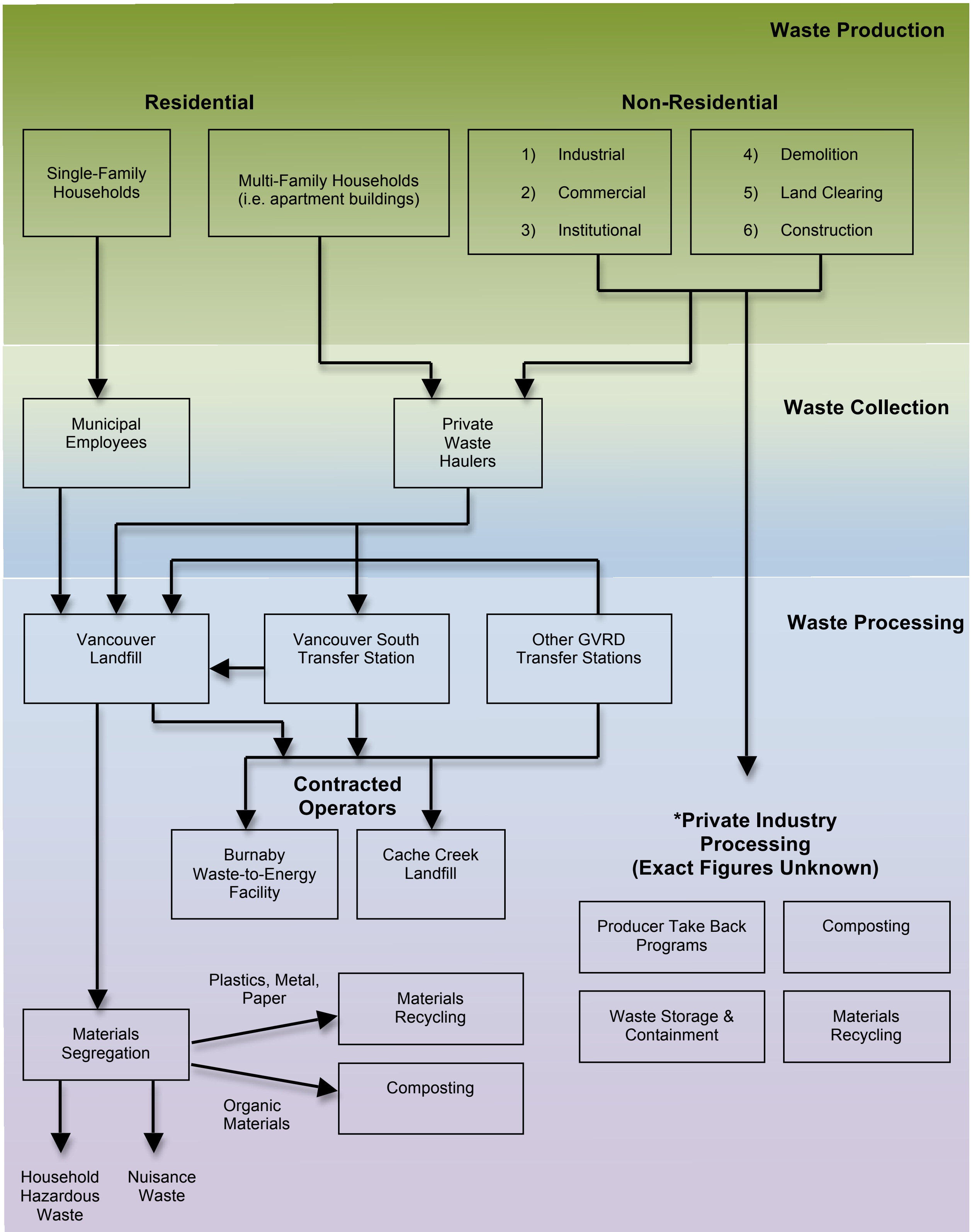
2: The Waste Management Industry in Vancouver

Municipal solid waste (MSW) is generally regarded as any material for which the generator has no further use. The management of these materials subsequently involves disposal, recycling or composting at both private and public facilities. In Canada, responsibilities for MSW management are shared between multiple jurisdictions. Municipalities handle the collection, diversion and disposal of MSW from residential sources. Provinces provide the mandate for the movement of wastes, licensing of generators, carriers and treatment facilities and extended producer responsibility (EPR). The Federal government is responsible for international agreements, the transboundary movements of hazardous and non-hazardous waste and recyclable materials, the Fisheries Act and the Canadian Environmental Protection Act (CEPA 1999). MSW management services are provided directly by municipal governments (i.e. the city or regional district) or WM boards or commissions that coordinate service provision. As a secondary source, private enterprises can be contracted by local governments to provide particular WM services (e.g. landfill operation, recycling facilities, refuse pick up, etc.). Private firms can also directly participate in arrangements with clients for various WM services, such as agreements with apartment complexes or industrial operations.

Figure 2 shows the value chain of the MSW management system in Vancouver. Waste that is produced is generated in residential and non-residential sectors. Each of these categories can be further divided to reflect the markets served, which in turn has a direct bearing on how that waste is managed. Once collected, commingled waste is either taken directly to the Vancouver Landfill (VLF) or it is separated and processed, or relocated via the Vancouver South Transfer Station (VSTS). In some cases MSW may entirely bypass waste haulers and be brought to processing facilities by residential and non-residential sources alike. This is most common with wastes recovered in producer take back programs and recyclable or compostable materials.

By using a framework of the five forces that shape competitive strategy made famous by Michael Porter (1979) the various elements of the value chain will be discussed. In addressing these forces, it will become clearer what aspects of the WM industry in Vancouver are attractive and hold the potential for new businesses to emerge.

Figure 2. The MSW Value Chain in Vancouver



*Note: For the purposes of this report private industry processing will not be addressed.

2.1 Rivalry among Competitors

In 2006, a total of 231 businesses generated $766 billion in revenues in British Columbia (Statistics Canada, 2008). A number of these businesses were based in Vancouver, as well as throughout the province. The vast majority of those WM companies are haulers that provide collection and disposal services, although some firms have integrated into aspects of processing as well. In order to adequately discuss the WM industry and the competition within it, each system component will be further broken down into waste collection activities and waste processing activities.

Waste Collection

While it is widely recognized that municipal employees of the City of Vancouver serve the residential sector, this service is limited to single-family residences, and a select few small apartments and commercial properties. This model differs from many of the other municipalities within the GVRD that contract private firms to manage waste collection for their cities/regions. Multi-family dwellings (i.e. apartments, condominiums, etc.) are served by private waste haulers, contracted by building owners and property management groups. The number of companies that remove non-hazardous MSW in this segment are few and competition is relatively low. Industry growth has been slow but steady, and waste hauling services generally lack differentiation apart from diversity in the types of waste managed (e.g. recyclables, commingled waste). A number of these companies are large nation-wide firms (in some cases international) such as Waste Management, BFI, and the Super Save group. Others are smaller community or regionally based enterprises (e.g. Smithrite Disposal Ltd.). In a personal correspondence with Joe Rajotte of BFI Canada (2009), he claimed that his company controlled approximately 15% of market share. As one of the moderately sized hauling operations in the GVRD, this finding is consistent with the idea that market share is divided amongst few firms. In order to minimize the number of trips necessary for disposal between servicing customers, highly specialized trash compaction and high volume storage vehicles are used in collection. Fuel, maintenance and labour are high fixed costs that pose a challenge to service delivery models that might be provided by smaller companies.

There is however, a second category of waste for the residential sector that has a slightly different landscape; the removal and disposal of items listed as “banned and prohibited” from the Vancouver Landfill (VLF) or Vancouver South Transfer Station (VSTS) (see Appendix A). Often these hazardous or oversized items are difficult to transport and so a specialty market has emerged to manage the handling of such wastes. This setting is much more competitive because collection schedules are infrequent, vehicle size can vary greatly and the personnel required can be few and prices negotiable. In contrast to conventional operators, there is greater differentiation in services offered, determined by the type of waste being disposed of (e.g. concrete, wood wastes, etc.). In addition to residential needs, firms operating in this space tend to service smaller projects in the industrial, commercial and institutional sector (ICI) as well as the demolition, land clearing and construction (DLC) sector, capitalizing on niche opportunities for specific waste streams. Due to the ease with which both residential and non-residential markets can be served, there are a high number firms operating and few if any switching costs. Cumulatively, these factors mean that growth in the residential sector alone is very slow, but exit barriers are low.

Table 1. 2004 Regional Tonnages and Diversion Rates by Sector in Vancouver

	Tonnes Disposed	Tonnes Recycled	Tonnes Generated	Diversion Rate
Single-Family Residential	453,050	368,040	821,000	45%
Multi-Family Residential & ICI	654,050	402,590	1,056,630	38%
DLC	369,600	702,860	1,072,460	66%
Product Stewardship (EPR)		122,410	122,410	
TOTALS	**1,476,700**	**1,595,900**	**3,072,600**	**52%**
Tonnes Per Capita	0.69	0.75	1.44	

Source: Underwood, 2007

Waste collection in the non-residential sector is handled exclusively by private haulers. Table 1 clearly shows that between the ICI and DLC sectors, the amount of waste disposed of is not only sizeable but presents a significant target market for private waste haulers that are able to serve these markets. Although there are a large number of firms competing to handle smaller quantities of waste from medium to small sized organizations, there are relatively few companies that can handle large volumes of waste for collection. These few must also compete with industrial firms that have developed their own capacity to transport their own waste to disposal facilities, as this integration becomes an inevitable consequence of operations over time. Depending on the amount, frequency and type of waste produced, collection may be outsourced to firms, or handled by the producers themselves as a means of minimizing costs and recycling by-products. Again, the high fixed costs of specialized capital equipment combined with high exit barriers and low switching costs indicate that rivalry within this segment of the market is moderate to high.

In summary, rivalry amongst competitors for waste collection in Vancouver is dependent on market segment. In the residential sector, competition is generally low except when dealing with the removal of specialized items and hazardous wastes, where it may be viewed as moderate. For non-residential markets however, competition is moderate to high with more firms fighting over a slowly growing market.

Waste Processing

Due to high capital costs and strict enforcement of waste sector policies, crown corporations usually operate waste processing facilities throughout the province of British Columbia. This holds true in the GVRD where Metro Vancouver is responsible for Vancouver's waste processing and adherence to MSW management policy (e.g. the Environmental Management Act). Metro Vancouver is actually the representative body of four separate corporate entities operating under the one name (see Appendix C). This includes the municipalities comprising the GVRD as well as several boards that are responsible for delivering essential utility services such as sewage treatment, recycling and garbage disposal, and other mandates.

Metro Vancouver operates six transfer stations within the Lower Mainland where MSW can be dropped off for a fee, charged to residents, businesses, waste haulers and contractors alike. Once the waste has been screened for hazardous materials and recyclables, it is forwarded to one of three locations: the Cache Creek Landfill, the Metro Vancouver Waste-to-Energy Facility (located in Burnaby) or the Vancouver Landfill. At first glance it may seem as though all waste processing participants are divisions or representatives of Metro Vancouver. However, upon closer inspection there are a few players in this environment with very specialized roles. The City of Vancouver owns and operates the VSTS and the VLF, while the other transfer stations remain the responsibility of Metro Vancouver. The Waste-to-Energy facility while owned by Metro Vancouver, is actually operated by a private firm called Montenay Inc. Similarly, the Cache Creek Landfill is operated by Wastech Services Ltd. under contract to the GVRD (i.e. Metro Vancouver). Lastly, there are a number of private businesses that have developed the capacity for materials storage, recycling and composting, although in most cases this is for personal usage and is a means of cost reduction. For the purposes of analysis we will exclude these private enterprises as their waste management exercises tend not to be for enterprising commercial purposes (see Figure 2 note).

In manufacturing and production systems waste disposal and transport represent costs, which should be minimized whenever possible. That said, increased waste production is not an intentional growth objective for suppliers thus waste processing has been a slow growth industry. If and when waste production increases, firms look to develop internal WM capabilities as a means of cost savings. Capital assets are very specific to waste processing methods, investment is extremely costly and exit barriers are very high. Even firms that manage waste processing operations are spared the financial risk of having to own those facilities, as is the case with the arrangement between Metro

Vancouver and the operators of the Burnaby waste-to-energy plant and the Cache Creek landfill. As such, the industry is not very attractive and competition is very low.

2.2 Threat of Entry

With nearly 150 waste management businesses serving the GVRD, it would seem as though barriers to entry in the industry are very low. The vast majority of enterprises are waste haulers that are differentiated by the region that they serve and the types of waste that they collect. The waste processing landscape is very different though, and poses a set of conditions that are quite distinct from collection.

Waste Collection

With the market fragmented into residential and multiple non-residential sectors, economies of scale play a significant role in terms of the segments that can be adequately served. In order to secure large contracts for multiple residents, businesses or large or frequent waste volumes, new entrants must have the collection equipment and sufficient personnel to be able to meet demand. While this is difficult in multi-family, ICI, and DLC sectors, it is much more feasible for specialized goods in the single-family market (e.g. home appliances). Urban sprawl and the rise in small-scale home renovation projects have created a market for MSW haulers that manage mixed industrial waste streams consisting of commingled waste with both hazardous and non-hazardous materials, and items prohibited from landfills. With low capital requirements, no switching costs and little necessity for product differentiation, barriers to entry are low for haulers that handle low volume, specialized goods with varying collection frequencies. Legislation regarding the transport of non-hazardous wastes is also relatively lax so this has not been a substantial deterrent either.

Entry is much more difficult in the multi-family and non-residential sectors where incumbent firms are entrenched by factors such as the experience curve, benefiting from logistical operational efficiencies gained over time, and access to major customer bases and relationships forged. In some cases these larger haulers can provide varied collection services for different waste streams (e.g. recyclables, organic waste, etc.) that new entrants cannot at the same cost efficiencies, thus further discouraging entry.

Waste Processing

In contrast to collection, the threat of entry to waste processing and storage is much more straightforward. The substantial capital expenditures associated with the equipment involved in incineration, composting, recycling, and landfills, in combination with the amount of it required to achieve a scale of minimum efficiency, makes the threat of new entrants low. Legislation at multiple levels of government for waste storage and processing to meet environmental standards, particularly in urban areas, also make this market unattractive to prospective enterprises. It should be mentioned though that as social concerns heighten about the environmental effects of WM practices, some differentiation is beginning to take place in waste processing methods. Although this is beginning to be addressed by small-scale solutions, practices like composting are gaining traction as favourable methods and may result in increased competition.

2.3 Threat of Substitutes

Waste Collection

The number of substitutes available for WM companies is low for a multitude of reasons. First, there are few alternate options available to MSW removal, especially in urban areas. The constraints of space limit the amount of waste that a given property owner can manage effectively within their boundaries, unless many of the materials consumed can be recycled or composted onsite. To resolve this issue for constituents, municipal governments designate land for the purpose of collection, sorting, amalgamation and transportation to landfills or materials processing facilities. A possible solution would be to have individuals transport their own waste on their own time, at their own expense, but this is also unattractive. Fees imposed at the VLF and VSTS make waste disposal costly at volumes beyond a maximal level, but more importantly the transportation costs (e.g. fuel, vehicle maintenance and insurance, etc.) make this option seem ridiculous when compared with the efficiencies gained by using municipal or private waste hauling services.

The exception to previously mentioned instances are the cases where the volume of waste produced is so large and/or frequent that it is more cost efficient for the organization to bear the delivery costs themselves, as is done in some ICI firms. Where applicable, some firms may choose to develop on-site processing capacity of materials using processes like composting.

Waste Processing

Environmental regulations imposed by multiple levels of government also limit where, when and how MSW can be stored. Waste can be comprised of hazardous and non-hazardous materials and with exposure to the elements, broken down into smaller, more problematic components over time. For example, leachate is the water by-product that is formed from percolating through permeable materials, carrying substances in solution or suspension. This is of particular relevance in landfills given the great variety and composition of the wastes present. Disastrous environmental consequences can occur if by-products such as leachate are not adequately contained and managed effectively. Methane gas and odours are also formed in waste piles and landfills when organic materials are not given sufficient access to oxygen for decomposition. These waste by-products are important aspects of why there are few viable alternatives to the collection and removal of MSW.

A second approach commonly seen is for ICI firms to develop strategic partnerships where possible, to accept their wastes as inputs for other products. This is observed in wood products processing companies that dispose of their wood by-products (e.g. sawdust and chips) to companies creating products like pressed logs (for fireplaces) or to landscapers to generate a soil amendment like mulch. Even if suppliers are charged a fee for disposing of their waste (tipping fee), as long as this cost is less than that charged by the waste processor (i.e. VLF, VSTS), or the costs of developing and operating WM options in-house, the fee is regarded as a relative bargain. It is fortunate in cases where MSW can be reused or recycled, but in most instances waste must be processed at some point and there are few substitutes for these processes short of hoarding materials.

2.4 Bargaining Power of Suppliers

Key assets to the operation and functioning of each segment of waste management vary greatly. As such, the profile of suppliers to each group will be discussed and the relative bargaining power of each addressed.

Waste Collection

The most valuable assets in any MSW collection operation are its vehicles. The durability and capacity of the vehicles are the defining characteristics of a fleet, and determine the operating capacity of an operation. These vehicles are essentially heavy-duty trucks with massive encapsulated payloads, many with compaction equipment integrated into their design. Luckily for waste haulers, there are many manufacturers making vehicles suited for the industry, and a number of OEMs that have the ability to develop capacity to create heavy machinery vehicles. It must also be noted that for smaller-sized operations pick-up trucks are often used, as are assorted container storage vehicles and trucks of various design. Waste haulers have a number of options at their disposal including vehicle manufacturers in North America and abroad (e.g. China). It is relatively unlikely that there is a credible threat of integration into WM activities by vehicle manufacturers due to the vast difference between the product produced (i.e. vehicles) and the nature of the service provided (collection logistics).

To provide WM services, operators require labourers in addition to equipment and collection vehicles. These blue-collared workers are assigned the tasks of loading the vehicles and driving them. As such, labourers are unskilled and wages can be competitively priced at market rates. Furthermore, the increased privatization of residential solid waste collection services, in conjunction with compulsory competitive tendering, has helped increase labour efficiency in this industry, reducing both operational costs and wage pressures from comparative union-paid salaries. This effect has been documented throughout Canada, the U.S.A and in the United Kingdom (McDavid, 1985; Szymanski, 1996). Thus, the menial nature of the work involved for waste collections staff, in addition to the low probability of integration from vehicle suppliers, equates to a situation where suppliers for this industry have limited power.

Waste Processing

Due to the systemic nature of this waste management discussion, it is interesting to note that the suppliers to the waste processing industry are in fact waste collection services, and indirectly, the waste producers themselves. The high capital costs of developing waste processing infrastructure are a significant deterrent to entry (discussed in section 2.1.2) however the threat of integration is a real possibility as evidenced by the large multinational organization Waste Management Inc., which operates a number of transfer stations, landfills, waste-to-energy plants and other processing-related services throughout North America in addition to waste collection operations. Although it has been able to do successfully, the company's exploits come with the caveat that few firms possess the organizational resources that it does, allowing it to leverage operational and management competencies into waste processing activities.

This type of encroachment has not yet occurred in Vancouver, with the exception of the City of Vancouver's control over its municipal collection service, as well as the operation of both the VSTS and the VLF. This may be related to the fact that Metro Vancouver manages waste processing as part of its overall WM mandate for an entire region, thus eliciting greater efficiencies of scale in processing for all its municipalities. In doing so, the numerous waste haulers in the GVRD are left with very little power against the few processing facilities in Vancouver. While collection services and waste producers – particularly in the ICI and DLC sectors – could theoretically develop their own processing and storage capabilities, this is extremely costly and therefore prohibitive in most instances. With few competitive alternatives in the region, waste suppliers are left in a weak position.

2.5 Bargaining Power of Customers

Waste Collection

As previously discussed, there are relatively few waste processing centres for the City of Vancouver. The Burnaby waste-to-energy facility, Cache Creek Landfill and the VLF handle the vast majority of waste managed. While there are facilities that manage recyclable waste and composting, they are limited in number and the activities of the private sector are largely restricted to individual operational capacity, on a per-organization basis. For the most part processors are concentrated and definitely control market share. These conditions make for very powerful "customers".

Residents of single-family homes are actually fortunate that the City of Vancouver is the only provider of waste collection services. While residents have little power to control what pricing they are offered, real costs are masked and subsidized, and are arguably less sensitive to price fluctuations – tiered pricing is based on the amount of waste disposed of by volume (selective sizing of waste bin used) – and it is part of a bundled amount paid in the form of municipal taxes for multiple utilities and services.

Waste Processing

A relatively new and interesting focus in this industry is the idea of generating customers for waste by-products in the traditional sense of the concept. Waste-to-energy processing concepts allow some value to be retained from MSW because landfill systems can be designed to recover methane gas, which can ultimately be processed to generate electricity. In 2007 a recovery rate of approximately 67% was attributed to landfill gas produced at the VLF. Of the recovered portion, 76% was directed to beneficial use and the remaining portion flared. Alternately, the waste-to-energy facility in Burnaby incinerates about 20% of the Lower Mainland's garbage into 900,000 tonnes of steam, which is converted to electricity and sold to BC Hydro as energy after meeting operational needs.

Recyclable materials such as cans and bottles have also demonstrated value to producers who have established a business model that facilitates materials recovery. While this model derives some benefit from end-of-life consumer products, it should be noted that one of the largest institutions in this arena, Encorp Pacific (Canada) is a federally incorporated, not-for-profit, product stewardship (self-described) corporation. The VLF also collects a variety of other materials annually including scrap metal, tires, waste oil, and various appliances. Contracted professionals then periodically remove these materials for recycling at other facilities.

Alternatively, organic materials diverted from landfill can be composted to produce a nutrient-rich soil amendment. While all organic material can theoretically be used to generate compost, municipal collection of leaves, grass clippings and yard waste provide the greatest volumes to generate a finished marketable product.

The idea of generating energy products and recycling materials of municipal waste by-products is somewhat novel in municipal systems. In any case waste processing operations are few in number and they control the vast majority of output from waste collection companies and producers alike. Switching costs are very high and alternatives are few and far between. Ultimately, "customers" of waste processing facilities in Vancouver are in a very weak position.

2.6 Summary

It would appear as though there are a number of identifiable key success factors that create value in the WM industry in Vancouver. For each market sector these factors will be discussed and how they are used by incumbents to hold a dominant position, or manipulated by new entrants to generate profitability.

Waste Collection

There are 3 key success factors that determine profitability and longevity in the waste collection portion of the value chain. These are 1) access to distribution channels; 2) the ability to operate at economies of scale and 3) service differentiation in the type of waste collected.

Given the relative simplicity and availability of the equipment used in waste collection operations, the first success factor is access to distribution channels. Securing waste disposal services is a given part of initiating both residential and non-residential operational settings. Once established, it is difficult to displace incumbent relationships because most product offerings are relatively homogenous, with the exception of hazardous or specialized goods. Although seemingly obvious, access to distribution channels and customers are critical in achieving the next key factor, economies of scale.

In order to establish profitability, the associated transportation costs with collection schedules must be balanced with enough waste removed to bring down the per-unit costs of disposal. Scale economies are key in large, profitable waste collection firms. Collection service pricing must be competitive as there are many firms available and this effectively creates a price ceiling. Additional pricing pressure is applied by the fact that the City of Vancouver also offers collection service for a limited number of multi-family dwellings and small businesses. The cost of this service is likely undervalued or subsidized by other revenues, as the MSW program operates at an annual net loss (see section 2.6.2).

Without securing large volumes of waste via numerous contracts, the other key success factor in collections would be product differentiation. By focusing on a particular type of waste (e.g. hazardous liquid chemicals), a focus strategy serves a narrow market segment and limits the number of competitors. Further supporting this model would be government legislation that requires specific containment regulations for the transport of such waste, although this would likely have direct implications on the capital requirements for the equipment and methods used in operations.

In summary, a targeted approach to narrowly defined waste collection markets is attractive with relatively modest capital requirements; however, competition is high suggesting low profitability. In order to improve earnings, greater capital is required but distribution channels must be secured and a significant customer base established. This is difficult to achieve without dramatically increasing the range of waste streams collected at lower prices, while managing to displace established customer relationships.

Waste Processing

Similar to waste collection, 3 key success factors have been defined for establishing profitability in waste processing. These are 1) meeting capital requirements; 2) the ability to operate at economies of scale and 3) the influence of government policy.

Undoubtedly, the most significant and obvious success factor of waste processing is the ability to meet capital requirements. Operational requirements of processing facilities demand complex containment and process engineering layouts. These assure functionality, but more importantly workplace and environmental safety as well as additional fail-safe measures in the event of unforeseen disasters and accidents. Traditionally, it has been viewed that in order to generate profitability or at least mitigate losses, processing must occur on a large scale although models such as integrated resource management are challenging this notion (Wilsenach, Maurer, Larsen, & van Loosdrecht, 2003). Lack of “customer” power may also help to explain why firms within the ICI and DLC sectors develop their own waste processing capability when producing frequent or vast quantities of MSW. The ability to recycle outputs becomes a cost minimization strategy as a means of mitigating losses due to WM expense rather than a means of achieving profitability. In fact there may be some doubt as to the profitability of this industry at all. Evidence from the City of Vancouver’s recent operations supports this idea.

Table 2. The City of Vancouver's Annual MSW Operations

(As of December 31, in $000s)

Year	SW Fees	SW Expenditure	Net Profit (Loss)
2007	40,388	46,569	(6,181)
2006	42,790	45,316	(2,526)
2005	38,629	46,457	(7,828)
2004	36,970	37,792	(822)
2003	35,592	29,882	5,710

Source: City of Vancouver annual reports, 2004-2007

Revenues for the city's MSW collection service are generated from annual utility fees paid per household dependent on the size of garbage container used, although the service has been operating at a net cost since 2003 (see table 2). Historically low prices for waste disposal and processing have created a climate void of what the real costs of WM are, thus industry profitability is low, if attainable at all. Similarly, the City of Vancouver sells its compost product at the VLF and this operation has not always proven profitable. Most recently, the 2008 composting program operated at a net cost of $384,000 (City of Vancouver Engineering Services, 2008).

The last success factor in waste processing would be the influence of government policy. The industry is heavily regulated at federal and provincial levels depending on where the waste originates and where it is ultimately stored or recycled. This has serious implications on both incumbents and new entrants and leaves firms vulnerable to changes in standards and safety regulations. These changes would likely have grave implications on capital infrastructure and/or operations and make the ownership and management of such assets a significant risk.

In closing, the substantial capital requirements to achieve economies of scale render waste processing a very expensive proposition for a limited number of potential firms. These firms are most likely to be large organizations with the capital and resources to leverage in an effort to integrate from different areas in the value chain (i.e. collection and niche waste stream processing). In addition to ensuring safety and quality outcomes, high capital infrastructure costs may help explain why Metro Vancouver owns all of its facilities but the operation of Cache Creek and the Burnaby waste-to-energy facility are able to be operated by private enterprises. Large national and international organizations such as Waste Management Inc. may possess the resources required to enter this space, but may still find it profitable and less costly to operate processing facilities without the burden of financing the associated capital costs. Finally, the threat of changes in government policy and additional controls also contribute to an uncertain and thus unappealing environment for potential new entrants.

3: Waste Reduction

In an age of international trade and commerce, resources and packaging circulate between communities at an astounding rate. The idea that people could stop generating any waste whatsoever may seem ludicrous, but halting growth rates if not tapering back the amount of waste disposed may indeed be possible. Manufacturers are beginning to re-examine the long-term implications of the components used in their products, and the end-of-life processes associated with these materials. A number of focused strategies have emerged that target not only waste reduction, but the reuse and recycling of materials so that value may be extracted in a continuous loop or cycle. The following section will discuss a number of these concepts and how waste reduction has lead to the recovery of valuable materials, bringing into question the conventional perception of "waste" itself.

3.1 The Zero Waste Imperative

The concept of zero waste can be described as a general philosophy and goal in which products and processes are redesigned such that discarded materials become resources for others to use (Zero Waste International Alliance, 2009). By managing manufacturing practices and changing lifestyles to systematically avoid and eliminate toxic waste and materials, resources can be conserved, recovered and in many cases recycled. A complete definition as created by the Zero Waste International Alliance can be found in Appendix B. The philosophy behind the concept of Zero Waste is the idea that resource systems observed in nature are cyclical, and waste by-products generated ultimately become inputs at another stage in the cycle. In contrast, many human processes related to industrial systems are linear and result in the creation of persistent or toxic materials that negatively impact ecological environments when destroyed or disposed of. Not only are linear systems damaging to their surroundings, but they are often inefficient and costly when waste materials transport, disposal and storage are factored in as well as the procurement of new resources to replace those squandered.

In 2002 the Regional District of Kootenay Boundary and the Regional District of Nanaimo began public education initiatives touting elements of zero waste philosophy. After years of watching other communities in B.C. subsequently adopt elements of zero waste goals to implement local programs and services, the GVRD directors voted to adopt this new WM philosophy in 2006 (Recycling Council of British Columbia). This initiative was executed through public education, and activities promoting both producer and user responsibility practices. In 2007 the Metro Vancouver Board adopted the Zero Waste Challenge, an integrated strategy as part of the GVRD's Solid Waste Management Plan (Metro Vancouver). The proposal was a concerted effort to reduce the growing volume of MSW in the district by minimizing waste generation, investigating region-wide composting programs and increasing the list of recyclable materials banned from the garbage. New programs and initiatives that support the goals of the Zero Waste Challenge are continually being developed and are generating improvements to existing services delivered by individual municipalities.

3.2 Waste Diversion

Waste diversion is a general term that is used to describe waste that has been diverted from disposal, typically MSW. Diversion includes all materials processed by recycling or reused at an off-site recycling or composting facility. The term however, is not used for diversion carried out separately by producers through deposit-return schemes or other EPR-based programs.

Waste diversion statistics can often be understated or misleading because producers who choose to process their wastes on-site have excluded their materials from municipal waste streams entirely and thus are never recognized at any point in the system. This is often the case with producers who compost organic materials on-site, particularly the vast majority of the agricultural sector. Producers and private firms that specialize in the management of agricultural waste generally manage dead livestock, crop residues, and manure from farms. In many instances this may be handled on-site. Also, most of these businesses are not classified as part of the waste management industry (Statistics Canada, 2008).

Municipalities have used the term “waste diversion” to develop programs, policy and regulatory instruments as part of comprehensive WM strategies. Essentially waste reduction is comprised of two major premises: increased recycling of materials (including composting) and reduced materials generation, which may be implemented in the form of reduced packaging. Participation in waste diversion programs such as newspaper recycling may be regarded as a proxy for gauging public response to diversion programs. Currently the GVRD diverts approximately 55% of all of the MSW created in the region. Alternatively, households and communities that operate their own backyard compost systems may not provide reliable data but are contributing to waste diversion efforts.

3.3 Extended Producer Responsibility

Extended Producer Responsibility (EPR), formerly referred to as Industry Product Stewardship, is a waste reduction strategy that extends the responsibility of manufacturers and distributors of consumer goods across the life cycle of their products. This is particularly relevant at the post-consumer stage once usefulness has been exhausted and materials must be discarded. In shifting financial responsibility for managing waste generation from government to producers, organizations are forced to not only recognize, but also internalize the costs associated with safe and adequate materials disposal. This encourages producers to develop economically sound recycling systems and to create products that generate less waste (Fishbein, Ehrenfeld, & Young, 2000) (Zero Waste International Alliance, 2009). At the discretion of producers, costs of waste treatment and disposal can now be incorporated into product pricing. In doing so, a market setting is fostered where the environmental impacts of a product are truly reflected and consumers can make purchasing decisions accordingly.

In recent years EPR has been increasingly incorporated into elements of environmental policy in Canada. Producers may adopt EPR guidelines voluntarily or as a result of government regulations, like in the case of the Prince Edward Island's lead acid battery take-back program. The program was introduced in 1993 in an effort to eliminate their contamination of landfills and reduce lead emissions by preventing their incineration. In removing lead acid batteries from the waste stream and recycling them at licensed facilities, regulations ensure the proper storage and disposal of the hazardous materials present in the battery. Retailers must charge $5 on new battery purchases unless an old battery is returned within 30 days. This incentivizes consumers to discard their batteries through retail outlets where enforcement of program regulations can be carried out (Environment Canada, 2006).

EPR programs have proven particularly useful in the WM of materials with toxic elements such as batteries, packaging wastes, electronics, used paint, waste oil and other items. Two attractive aspects of EPR are that companies can view these programs as opportunities to recover high-value inputs and a chance to show that their industry is financially responsible. From a strategic standpoint, it may even be advantageous for firms to take part in the discussion of how WM processes can be facilitated rather than become subject to them once government agencies mandate private enterprise's involvement. Currently two types of policy instruments are being used to implement EPR: take-back programs focusing on physical responsibility for the product and economic instruments in which producers assume financial responsibility for product disposal (Statistics Canada, 2005).

a) Take-back Programs

Take-back systems make producers responsible for providing methods of reclaiming their products after they have been used. Systems can be mandated by government bodies and supported through funding and promotion such as PEI's lead acid battery take-back program. An alternative approach however, is to have broader programs for multiple products such as consumer electronics retailers that accept old cellular telephones, used batteries, obsolete appliances, etc.

b) Economic Instruments

EPR programs can often impose levies to share the systemic financial burden and encourage customer participation for programs. Fees may be implemented in the form of deposit-return systems (used in glass and plastic bottle purchases), advance disposal fees (used in the purchase of plastic bags from some retailers and groceries), and material subsidies or taxes.

3.4 Integrated Resource Management

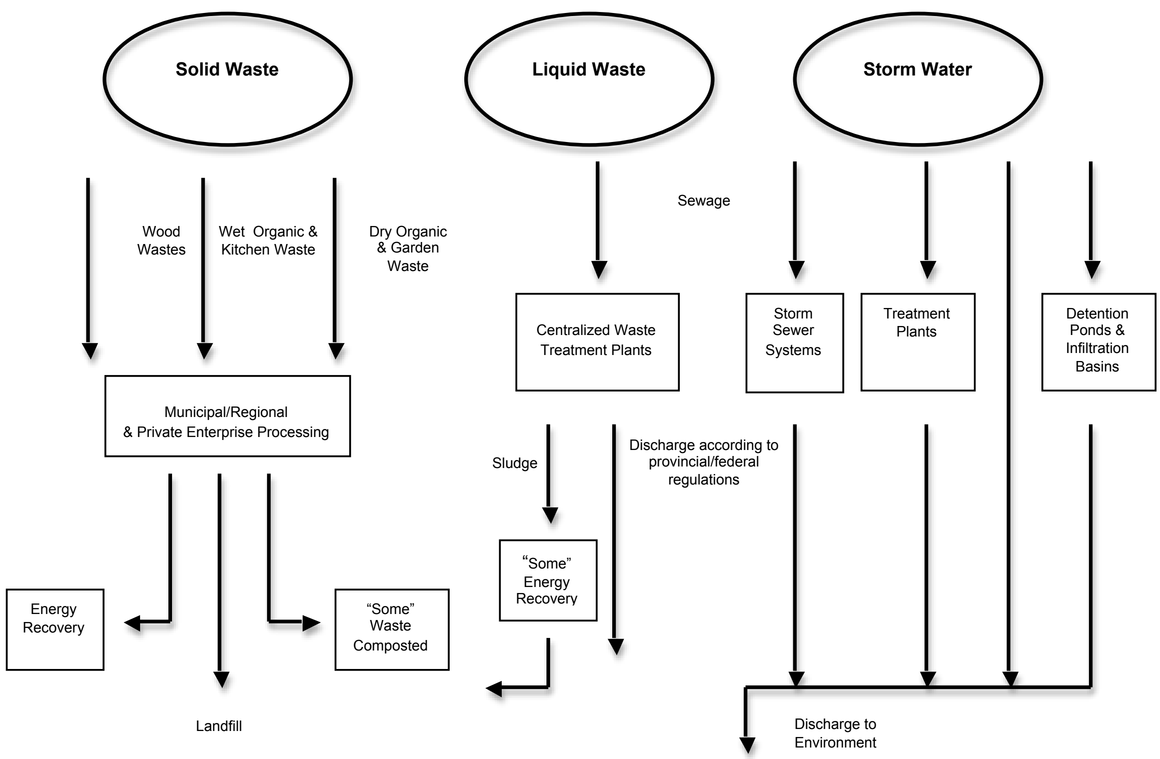
Integrated Resource Management (IRM) is a waste management strategy that combines the processing of various waste streams into a unified approach, optimizing resource recovery thus generating value. IRM is an extension of principles generated from Integrated Water Resources Management (IWRM) ideals, and the belief that although water is used as a waste transport vehicle, its value may still be captured post-processing. As a matter of sanitation, wastewater treatment has historically been prioritized in the development of urban centres. Centralized treatment is often managed by government bodies such as a municipal water board (Wilsenach, Maurer, Larsen, & van Loosdrecht, 2003). In response to commitments made in the Western Climate Initiative and the BC Energy Plan, a report was commissioned in 2007 to investigate the applications of IRM in British Columbia. The report sought to address the potential contributions of IRM to the provincial climate change agenda, and proved to be a useful guide in explaining the potential for IRM in Vancouver.

Traditional Waste Management Systems

To appreciate the differences between IRM concepts and conventional WM requires a brief discussion of traditional waste management. In most of BC's municipalities tap water is used once and then discharged as waste or sewage. Sewage is transported to a centralized processing facility where it is treated and discharged in accordance with environmental regulations. Drinking water, wastewater, storm water and MSW systems each have their own infrastructure and for the most part are managed independently of each other. Although these systems operate separately, it is important to note that there is overlap between them with interrelated impacts. For instance, potable water becomes wastewater the moment it leaves the tap and goes down the drain. Rather than reuse or recycling of that water, the result is an increased demand for the "single-use" model as populations increase. This increases costs in turn as departmental budgets must be increased to provide an adequate supply of drinking water. These costs are significant once the entire investment of water capture, storage, purification, delivery and heating are factored in. Rainwater or other forms of wastewater could potentially be reused and recycled, reducing energy consumed earlier in the preparation process.

A significant contribution to the problem is the fact that in the traditional approach waste solids and water are managed in three separate streams: MSW, liquid waste and storm water (see Figure 3). Municipal solid waste can include wet organic waste in the form of food scraps and dry organic wastes such as garden and wood materials. These two sources are often handled independently adding infrastructure costs for each system. While some of this material is composted, very little energy is recovered except from modernized facilities that are equipped to recover methane gas. The remaining material is disposed of in landfills. Sewage is piped to waste treatment plants and subsequently discharged to the environment. In some municipalities, facilities are able to convert energy from sludge but emphasis is placed on cost controls to adhere to environmental regulations. Lastly, storm water is directed to storm sewer systems, treatment plants or directly to the environment. In some cases, minor processing occurs via release through detention ponds or infiltration basins.

Figure 3. Traditional Management of Waste Streams



Although the intent of the traditional approach is to place emphasis on minimising costs while abiding by existing regulations, the result is a system that usually increases costs to taxpayers compared with what could be achieved through reuse and recycling (Wilsenach, Maurer, Larsen, & van Loosdrecht, 2003). In addition, traditional MSW practices require energy inputs at multiple levels while producing methane and other GHG emissions resulting in an inefficient cycle with energy losses.

IRM processing techniques (Treatment Technology)

Where IRM differentiates itself is in the integration of processing methods to efficiently manage the treatment of the three waste systems: solids, sewage and storm water. In doing so, resources are recovered and value can be maximized. Perhaps one of the marked differences in IRM is that wastewater and solid wastes are actually viewed as resources, thus making an argument for recovery of their value. In attempting to manage the processing of both waste streams simultaneously, energy and water recovery are achieved from effluent and MSW processing. In order to implement IRM treatment technology, processing plants would need to be greater in number and smaller in size, creating a decentralized model; a stark contrast to most present-day facilities.

A table outlining the potential uses of the components of a municipal waste system is available in Appendix D. Based on the reuse of these various components, a number of energy recovery strategies begin to emerge. These energy recovery strategies from systemic wastes include:

1. Energy Capture from Heating & Cooling
2. Anaerobic Digestion for Biogas Production
3. Gasification for Syngas
4. Recovery of Metals

Energy Capture from Heating & Cooling

Using heat pump technology energy can be extracted and used in heating and cooling buildings within close proximity of processing. Heat pumps are commonly used in residential housing and operate on the same principle as refrigerators and air conditioners. Although heat is normally captured from outdoor air or ground-source piping, treated sewage can be piped within the processor's facility or to nearby commercial buildings. One of the most attractive aspects is that they can yield four units of heat energy for every unit of electrical energy consumed. Conversely, once the heat has been obtained from the effluent it is cold enough to be used to support or replace refrigeration and other cooling systems. However, in order to fully realize the benefits of lower operating costs it is necessary that heating/cooling pipes do not have to travel very far in order to distribute the energy throughout the system. Again, an emphasis would need to be placed on a decentralized facilities model where treatment plants are located in proximity to clusters of commercial buildings that may directly benefit. These systems are already in place in B.C.; the Whistler Waste Water Treatment Plant, one of the legacies of the 2010 Olympic Winter Games is currently in operation (Resort Municipality of Whistler, 2010).

Anaerobic Digestion for Biogas Production

Anaerobic digestion is the process whereby microorganisms break down organic matter in the absence of oxygen. As a by-product of the biological activity, methane and carbon dioxide are produced. In large sewage treatment plants it is common for sludge to be processed in this manner with the resultant gases commonly referred to as biogas. This biogas is then burned to generate heat and electricity and in many cases used by the plant itself, reducing operational energy demands. The raw biogas generated can be upgraded to methane of natural pipeline quality through further processing, on par with natural gas (Corps, Salter, Lucey, & O'Riordan, 2008). As a building block molecule, methane can also be converted into methanol, ethanol and longer-chain hydrocarbons used as transportation fuels or blended with gasoline (Taylor, Anderson, D'Este, & Noceti, 1997). Further applications of biogas include burning in cogeneration plants, and even buses and cars.

Equipment designed to stabilize and control the biological processes involved in anaerobic conditions (e.g. temperature, pressure, etc.) are commonly known as biogas digesters. As part of a typical sewage treatment facility, digesters are limited to processing sludge. In an IRM model digesters accept sewage sludge in addition to all other streams of wet organic waste including food scraps and other kitchen waste. Digesters used in Europe currently process sludge, farm waste and manure, food factory waste and solid organic waste collected from households. Countries such as Sweden even go so far as to grow maize as a dedicated energy crop for this process (Lantz, Svensson, Bjornsson, & Borjesson, 2007).

Apart from biogas and recovered water the residual matter produced or digestate, is very high in inorganic materials (metals, minerals and other contaminants). In Sweden, residues from digesters that are restricted to wet organics and feedstocks are used as a soil amendment or fertiliser in agricultural applications. Although, due to concerns about the presence of heavy metals and other undesirable substances, the decision to segregate sewage digestate has been made as a matter of food safety. In biogas production systems a large amount of digestate is generated and this disposal method also provides a suitable and practical means of coping with residual matter (Berglund, 2005). In the IRM study conducted by Corps *et al* (2008), digestate produced is added to dry organic waste (e.g. wood waste) and converted into syngas, a different form of fuel.

Gasification for Syngas

The decomposition of organic solids at high temperatures under anaerobic conditions results in gasification. Long-chain molecules (e.g. cellulose) break down into a mixture of hydrogen, methane, carbon dioxide, and carbon monoxide. The synthesis gas produced, or syngas, is combustible although not suited for storage (Corps, Salter, Lucey, & O'Riordan, 2008). Syngas can be burned for heat or used in a cogeneration operation, yielding both heat and electric power. The Association of Power Producers of Ontario (2005) tout the multiple benefits of cogeneration as being: a process that is fundamentally more energy efficient compared with conventional turbine power generation and the decentralized nature of the processing plants reduces transmission losses and holds facilities to higher environmental standards. Even at conservative estimates of energy conversion, electricity production from syngas gasification has proven profitable, with the additional benefit of being able to sell excess energy sold to the municipal power grid (Corps, Salter, Lucey, & O'Riordan, 2008).

Recovery of Metals

Once heat in an IRM system has been diverted and resources extracted, the remaining digestate material is ash. Metals are bound but cannot readily leach into the environment, making it useful as a road base or potentially valuable for refining mines once combined with mineral ore (Corps, Salter, Lucey, & O'Riordan, 2008).

With energy, water, and minerals being recovered from such varied processes, there is definitely a role for IRM in B.C. That said, the amount of expertise required to build and operate such a facility could likely imply substantial financial and intellectual capital requirements. While these are not insurmountable obstacles, they are definite barriers to entry and pose considerable challenges to a decentralized model.

4: Stakeholder Interviews

In order to better understand the issues involved with a proposed business model in Vancouver, a series of unstructured interviews was conducted with stakeholders in the organic WM value chain. The views captured are intended to be representative attitudes of competitors and customers in two key target waste production markets in residential and non-residential sectors. The following section will summarize the salient points of those conversations and attempt to establish common themes from each party's experiences and market concerns.

4.1 Vancouver City Council

Perhaps the biggest competitive threat to a commercial organic waste collection service is the MSW program currently provided by the municipal government, i.e. the City of Vancouver. At present Metro Vancouver is the entity responsible for MSW management in the GVRD although in actuality, it represents four separate corporate bodies:

1. Greater Vancouver Regional District (GVRD)
2. Greater Vancouver Sewerage & Drainage District (GVS&DD)
3. Greater Vancouver Water District (GVWD)
4. Metro Vancouver Housing Corporation (MVHC)

Metro Vancouver is a federation of 22 municipalities (including Vancouver), one electoral area, and one treaty First Nation, operating as a corporate entity under provincial legislation (see Appendix C). Mayors, councillors, and other representatives act as directors on larger boards that deliver regional services, planning and political leadership on behalf of each local authority. The main areas of planning and regulatory responsibility are regional growth, utilities, air quality, and parks (Metro Vancouver, 2009). Core services provided to municipalities include planning and management of drinking water, sewerage and drainage, and solid waste. Regional parks and affordable housing are other services that are provided directly to the public.

For the purposes of this report we will continue to focus on MSW management in the City of Vancouver, or the GVRD where applicable. Our first discussion takes place with Chris Underwood, Manager of the Solid Waste Management Branch of the City of Vancouver's Engineering Department on October 13, 2009.

Why Doesn't Vancouver Currently Collect Kitchen Wastes?

For many years there have been rumours circulating the GVRD that the City of Vancouver was in preparation to implement a curbside organic waste collection that would include kitchen scraps (e.g. fruit and vegetable peelings). The municipality currently operates a yard trimmings collection service that accepts various types of organic yard waste (e.g. leaves, grass clippings, etc.) but excludes food residues. In June of 2009, CBC News reported that Metro Vancouver had signed an agreement with Fraser Richmond Soil & Fibre Ltd. to expand their current yard waste-processing program. Two questions that immediately came to mind were: why hadn't this occurred sooner; and when will the proposed program be implemented?

According to Chris the collection infrastructure for such a program in Vancouver is already in place, the biggest holdup has been the issues of a) where to store the waste; b) how to process it and; c) who would process it? With each of these issues come many significant implications on capital and infrastructure requirements to support current capacity, and population growth. Although the City of Vancouver has established waste reduction targets, "at the present time there are no solutions readily available in the private sector at the required or anticipated volumes of organic waste that could be collected." Up to this point, this has been the biggest limitation of program implementation. "A proposed system must be scalable as well, to be able to accommodate increased loads over time as public education programs influence compliance and organic waste diversion rates rise."

The City of Vancouver had conducted much preliminary research to locate enterprises that possess the requisite infrastructure to feasibly meet current demands, what capacity limitations they would face and a proposed fee structure. Ideally, acceptance of organic waste would be free as it is an input for processing companies that generate a marketable finished product as an output (i.e. compost, fertilizer, biogas, etc.). Current WM practices dictate however, that processors receive what is referred to as a tipping fee, a charge levied on waste upon disposal at recycling and processing centres. "Given the 90,000 properties that the City of Vancouver is committed to, it has been a serious and time-consuming endeavour to make arrangements for a system that can meet the needs of all interests that need to be serviced (implying the provision of processing capacity for non-residential sectors as well)." This is further confounded by the notion that implementation in Vancouver alone is not practical; obligations to the remaining municipalities within the GVRD as part of the mandate of Metro Vancouver, must also be considered and their needs planned for. One aspect of planning that has been in development and execution has been a pilot project in a given area of the city, as well as the analysis and interpretation of its outcomes. The merits of a scaled program based on a pilot study had to be adequately analysed, documented and interpreted in order to produce a proposal for an organics collection system on a wider scale. Although the pilot had not been widely touted or advertised, it was in progress.

Details of the Organics Collection Service Being Planned

Although planning was at an undisclosed stage of progress and negotiations were still underway with the processing facility - neither of which Chris could comment on in detail – he stated: “in a best case scenario the City of Vancouver’s organic waste collection program would begin within 8-12 months.” At this time the only customer-base served would be single-family households, which is consistent with their current demographic for other municipal waste collection services. The upper limitation to expanding this customer base would be the availability of equipment, the increase of which would drastically drive up capital costs of the program. “The city does not have the resources to start collecting from the commercial sector” and thus counts on the private enterprise to service the needs of ICI groups. “While collection may not be feasible, the city is concerned with at least securing processing capacity for 1) single-family households; 2) multi-family households, and then; 3) the commercial sector. Realistically, it is not possible to have this type of processing capacity immediately but improvements can be made over time. Negotiations with Metro Vancouver’s current processor of organic waste (yard trimmings, etc.) have discussed additional capital improvements to be able to accommodate dedicated food waste processing capability but this implies increased capital costs to manage anticipated increases in vector concerns." The long-term view will be to provide processing capability for all sectors to meet the needs of as many of the GVRD's municipalities served as possible.

Processing concerns aside, there would be no changes to current collection services for each municipality. Contracted waste removal companies would see their contracts remain intact because this infrastructure is already in place to collect yard trimmings. For clarity's sake, the City of Vancouver's situation is unique in that collection is not contracted out to a private firm but performed by civic employees. This has managed to remain a cost efficient option, the one exception being 2500 properties (approximately) in the multi-family sector where the City of Vancouver has contracted a private firm to manage MSW collections on their behalf. The bins currently provided by the City of Vancouver in the yard trimmings collection service are also compatible with present infrastructure. The wheeled carts are specifically designed to be emptied using a mechanical arm attached to collection trucks. Food waste would simply be added to these bins for weekly pick up, thus maintaining operational speed, safety and efficiency. Carts and trucks for a fourth stream of materials (recyclables, garbage and yard trimmings at present) would be costly and further extend planning timelines. There is also the concern that gas emissions from another fleet of vehicles collecting waste are an undesirable by-product of the service.

When asked about the role that customer education would play, Chris was adamant that this would be an integral part of an implementation program. "Whenever a significant change is made to the MSW program, education is a big part of successful change and this requires a number of resources." These resources could presumably include leaflets and flyers distributed to homes describing what the new materials to the organics collection program include, as well as prohibited materials. A brief description about the impetus for the program and a few encouraging words so that people are inspired to increase program compliance over time. Perhaps even some tips to help control odours and prevent vector issues would be included in the printed media.

What Happens to the Waste After it is Collected?

Waste sorting would occur at the processing site directly after collections, or via the transfer stations currently operated in the GVRD. Contract details were still in progress with the proposed processing firm, and there were still many uncertainties about the tolerance levels of contamination in citywide organics collected. Although a systemic approach can mitigate contamination problems, the risks and consequences of exceeding processor's contamination levels were two important areas still being examined. While contamination by paper and plastic might result in nuisance and inconvenience, the presence of metallic objects is often more damaging to machinery and thus costly. This is a common concern amongst compost operators and can result in additional costs as a result of equipment damage, repair, and downtime.

In the initial phases of recruitment contractors were informed of the expectation of processing a mixed stream of organic materials. Proposals requested a wide variety waste including meat and dairy products but not diapers or other 'higher level' materials, as is the case in organics collection systems in cities like Toronto. Chris stated that the quality of the finished compost can be diminished and requires a more capital-intensive processing capability. The fact that the "majority of organics material collected is yard waste, not food waste," (based on weight and volume) allows for improved consistency in the final product. At this time the proposed program would initially take fruit and vegetable peels but exclude meat, fish, and dairy products. "It is hoped that future capital improvements will allow these items to be included in the waste stream, but until such time the City of Vancouver will still actively encourage the use of backyard composters to accommodate the overflow."

The proposed model would have the processing facilities retain ownership of the resultant compost to be made available for sale at their own discretion. This would allow them to retain revenues, but also render them liable for the expense of marketing and promotional costs. When I asked whether the GVRD had thought about developing its own processing capacity rather than outsourcing it to a private firm, I was told "it was an option that was under consideration." "However, before an argument would be made for developing 'in-house' organics processing capability, final contract offers from private firms would have to be compared to see what option was most cost efficient." It is my assumption that the expense of developing the infrastructure required for processing would make this option unattractive; the costs associated with land acquisition alone would make the choice prohibitive.

The opportunity to speak with a representative of the MSW collection service brought forth many issues that reflect the interests of the numerous stakeholders that governments are accountable to. Once public input and debate have occurred, plans may proceed to documenting in detail what a proposed system would look like and how it would work. These matters of due diligence ensure fiscal prudence as well as increase the chances of sustaining such a program and achieving compliance from constituents. In order to adequately meet the needs of the residents in the GVRD while allowing for growth and changing population dynamics, much research must be conducted and visionary planning take place. While governments may not be best suited to manage all aspects of a MSW system, this leaves much potential for burgeoning private enterprises to fill niche locations in the value chain.

4.2 Property Management

One Earth is a non-profit research and advocacy group based in Vancouver, BC. The group promotes social and ecologically sustainable initiatives related to production and consumption by engaging in research activities and policy advocacy. Emmanuel Prinet is the Executive Director of One Earth and co-author of the "Eco-strata guide: A green guide for multi-family dwellings in Metro Vancouver". Emmanuel is also a former strata council member in a high-rise apartment building in Vancouver, as well as the founder of a sustainability committee within the complex. Patricia Chartrand is the Strata Council President for Station Place, a condominium in downtown Vancouver. Together, their insight on the policies of the strata council and the WM practices within their building was helpful in understanding the likelihood of having an organic waste collection service implemented in multi-family dwellings.

Who is responsible for waste management in an apartment building/condominium?

Typically a strata council is responsible for coordinating the WM activities for a given building. In the absence of a stratum, a building manager may act as a representative reporting directly to a property management group. Some, but not all, strata councils work with property management (PM) companies to manage the various maintenance and facility issues in a building. “Few people have the time to devote completely to building management issues (repairs, cheque writing, etc.) due to full-time employment and other commitments.” Patricia reported that her strata council uses Vancouver Condominium Services for their PM needs. These services include finding insurance for the building, dealing with trades people, negotiating prices and quotes, and they also have a list of service providers (i.e. WM companies) from which to draw upon.

In Vancouver, WM companies are contracted to collect waste from buildings that are multi-family dwellings. While this could not be answered explicitly, it is presumed that a PM group might sign a contract with WM group to provide collection services for multiple properties, resulting in secured business for the WM group and a reduction in fees for the PM group. In this particular instance, 2 different companies are used for garbage and recyclable materials. Given the wide number of private collection companies available, not all companies are able to provide the same array of services covering all waste streams.

The costs for WM in a building are a portion of monthly fees billed by the strata corporation to all residents. The council drafts an annual budget, and it is voted on at an annual general meeting. If an organic waste collection program were to be suggested, a line item would be added for it under WM, or recycling/organics to be incorporated into the monthly fee. Fees paid per resident are a representative proportion of the total cost based on the total square footage of the property. Emmanuel has quoted his current fees at approximately $480/month. He went on to elaborate however that there is an economy of scale based on the number of units occupying the same or similar ecological footprint, i.e. a neighbouring building that is twice as tall likely produces only a marginally greater volume of garbage, thus may be paying less in monthly fees on a per unit basis. In other words the greater the residential density, the less the monthly strata fees paid.

Challenges to the feasibility of organic waste collection in condominiums

One of the biggest and most obvious problems for many apartment-style dwellings is where to locate the waste facilities. In many instances the storage rooms are quite small and space for an additional waste stream is limited. Currently three large waste collection bins/dumpsters are available for garbage and then there are a number of smaller bins for recyclable materials. "Residents must take garbage and recyclables down an elevator to a parkade and walk up a flight of stairs in order to reach the waste storage area. This poor design for facility access can be perceived as a hassle and increasing an additional waste stream may add to the frustrations of an inadequately designed waste disposal system." Potential sites of a centralized collection receptacle for organic waste have been discussed in Emmanuel's building however, a proposed outdoor location on a second floor, common-area balcony brought a host of concerns. A consideration with any outdoor location, this particular site happened to be south facing and would have significant exposure to the sun. With the increased heat, particularly in the summertime, acceleration of the decomposition process would be a legitimate concern as would be the accompanying odour and leachate fluid produced with it. A shed would have to be built to house the container thereby alleviating this concern, but this would also bear visual and aesthetic consequences, especially for those facing that side of the building.

With many food waste collection programs come perceptions of the influence of vectors, i.e. fears of attracting rats and other rodents. Properly managed, these elements can easily be mitigated but education amongst residents is key in ensuring their participation and program adoption. Emmanuel describes residential attitudes towards sustainability initiatives as "generally quite supportive", although this comment is highly subjective at best. The attendance at the sustainability committee meetings usually consists of about 12 individuals from a total of 70 units in the building. Also, support of sustainability-focused proposals such as energy retrofits, have come in the form of unanimous votes at the annual general meeting. Although this particular strata council has even gone so far as to implement a by-law imposing a $50 fine for non-compliance with current recycling regulations, there is still evidence of those who cannot or will not change their wasted disposal behaviour. Cooperation is variable at times and by-law enforcement is difficult and confrontational. As such, compliance must be fostered through education and residents' willing participation in source separated waste disposal programs.

An Overall Theme about Implementation

The conversation with Emmanuel described great potential for the implementation of organic waste collection in an apartment setting however it was clear that much effort would be required in order to achieve a high level of satisfaction in implementation. Based on his own grassroots efforts to enact other sustainability-focused programs, "…implementation requires much more thorough follow-up; making sure that people are recycling; posting letters (throughout the building), etc…" and other activities to ensure a complete transition to new habits. Therein lies the challenge however; this type of follow-up has required more time than he has been able to provide. "Changes just require support and someone to take on the leadership role." While Emmanuel is able to champion sustainable change and divert his efforts towards the framework of multiple projects, he admittedly does not think that the implementation of a building-wide organic waste collection program is attainable by his efforts alone. He has helped establish a program that recovers the property's yard trimmings for collection from the City of Vancouver although the initiative taken was from the residents, and not instigated by the municipality. In other words, organics collection in multi-family dwellings, even for yard waste, is not a venture that the municipal government is actively pursuing, although the service is being offered.

There are seventy units present in Emmanuel's building and five commercial units on the main floor. This situation is representative of a high-density population creating a significant amount of waste in a relatively small area, typical to Vancouver. Even though the waste production system is not easily visible, the effects of its ecological footprint are of equal consequence. Admittedly, not all strata council members and property management interest groups may be as concerned about sustainability policy as Emmanuel, but he does represent a market in this city of concerned citizens looking for new solutions to old problems. In fact not only is this market looking for new methodologies but also the leadership to help implement these solutions, best provided by private enterprise if not by government services.

4.3 Food Service Enterprises

The production of organic waste from residential sources has been discussed as a target market for a collection service. As described in the WM value chain, another other major market of waste producers is the commercial sector, but particularly food service enterprises. It is estimated that there are hundreds of food service businesses in Vancouver including cafes, coffee shops, restaurants, and bars. Hence, it seemed logical to approach a number of these businesses to discuss the potential for an organic waste collection service. This included representatives from the restaurants Joey's, Earl's, the Cactus Club and Andre LaRiviere, the founder of Green Table; an industry organization dedicated to improving sustainable practices within the food and restaurant industry.

Is there Interest in Organic Waste Collection in the Restaurant Business?

Perhaps surprisingly, many of the restaurants that were interviewed already had organics programs in place or had franchises that were engaged in pilot projects. Andre explained that many food service businesses, particularly larger organizations, are in the process of incorporating sustainability practices into their operations. Organics waste collection and processing are just a few activities that are part of an overall strategic plan. Often processes that conserve energy, water and waste also reduce expenditures. Environmental benefits can be achieved while at the same time cost savings are incurred. "There are additional branding benefits as well: half of these restaurants want to use 'green' labelling as a strategic marketing tool to appeal to an ecologically-minded consumer, while the other half sincerely want to be good corporate stewards." Joey's claims that the organic waste composting program that they are considering implementing could manage as much as 60% of the waste currently produced at their locations. In fact one of the challenges they have been facing is the operational implementation of the program across their locations not only in British Columbia, but in Alberta and Manitoba as well. In attempting to be an industry leader Earl's has already partnered with a local company and has an organics collection program in place. The restaurant would not comment on the name of the firm however they did say that the same company was responsible for the removal of their other recyclable materials.

Unfortunately none of the participants were willing to disclose specific financial details about the cost of waste removal services for organics or other waste streams. The Cactus Club was kind enough to explain that this was due to the "highly competitive" nature of the industry, but went on to qualify that they were members of the Green Table network and that "…an investment in preserving our environment is extremely important (to them)." Joey's offered that the costs that they had been quoted were based on bin size and weight, the frequency of pick-up and the number of bins used, which is typical for the commercial sector (i.e. weight and frequency). They estimated that an organics pick-up service would take place 2-4 times per week, using 2-3 sixty-four gallon totes, depending on customer turnover and location.

4.4 Waste Haulers

To round out the organic waste collection service discussion, I was fortunate to speak with Jonathan Williams, Senior Sales Representative of Smithrite Disposal and Joe Rajotte, District Manager and Vice President, British Columbia of BFI Canada. Given the competitive nature of the WM and collections industry in the Lower Mainland, I was happy to be able to extract the information that I did out of each of them, although they were careful to keep any customer information as vague as possible.

Is there a current demand for organic waste collection in the GVRD?

Whereas BFI does not provide organics collection for any of its customers, Smithrite currently does. A source-separated organics program is in place where customers are provided with 32-64 gallon totes and serviced by front-end loading trucks as well as dump trucks. Although it was not clear how long this service has been available, it was initiated by customer's request and not by procured by Smithrite. BFI claimed that while it currently does not have customers in the GVRD using such a service, it did 15 years ago in Vancouver. Joe went on to explain that the biggest challenge from the WM provider's side is finding an appropriate processing facility. Storing the material even temporarily is not an option due to space and odour constraints, which also happen to be two of the most significant challenges for processors as well.

Smithrite disposes of organic waste at Westcoast Instant Lawns, a turf and topsoil producer located in Delta, British Columbia. An arrangement has been made that a tipping fee is charged to the company that amounts to 20-30% less than that charged at the municipal transfer stations, thus reducing a key operational expense. An interesting conversation with Joe revealed that BFI was aware that other WM companies (such as Smithrite and Superior Waste Recovery) were using Westcoast's services, however, he also knew that Westcoast had been caught operating without valid waste processing permits on a number of occasions in recent years. For that reason, BFI had purposely avoided their services as a matter of good business practice and stated "the corporation (implying a directive from a higher authority) would not allow engagement in 'such' practices." This may have something to do with the fact that as a larger operator BFI would be less likely to risk their wider reputation by operating with unscrupulous organizations in order to marginally save on costs. By comparison though, smaller operators might assume the risk to spare operational costs, as they would likely be competing on price. This is supported by Jonathan's comments that the costs associated with frequency of service made organics collection economically undesirable, but it was being provided instead as part of a wider product offering to satisfy existing customers.

Concerns about an organics service

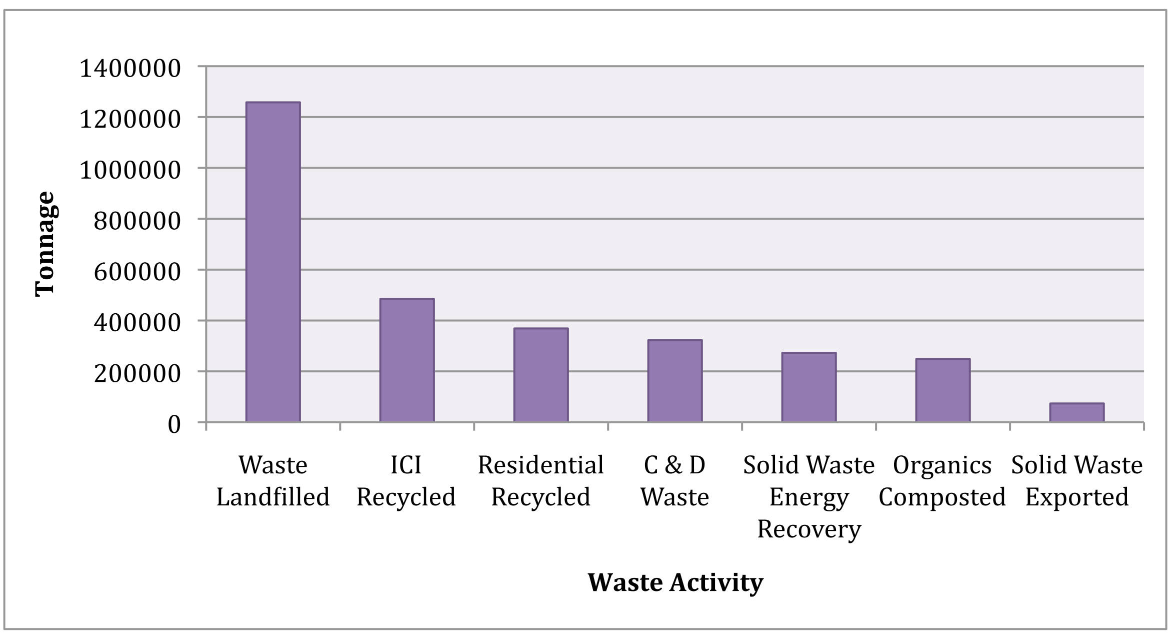
Kitchen scraps are largely fruit and vegetable peelings and contain a high percentage of water. Given that tipping fees are based on weight, organic material can pose significantly greater expense per volume of waste collected than compared with other MSW. As evidenced by Smithrite's experiences, this makes organics collection generally undesirable unless the increases in operational costs can be adequately reflected in service pricing. In addition, the decaying nature of organic matter presents the problem of odours, particularly in response to heat. In food-service environments where large amounts of organic waste are generated, offensive odours simply cannot be tolerated for any length of time. This increases collection frequency thus driving up fuel and associated transportation expenses. In order to meet increasing consumer demand, WM companies may need to develop new operational or pricing models that adequately handle organic waste in a cost-efficient manner.

It was clear from the conversation that Smithrite was not actively pursuing the expansion of organics collection. By extending their collection service to another waste stream customers were kept happy and relationships maintained. BFI also collects other waste streams such as paper and cardboard as part of their recycling services. While touting the integrity of their business, BFI also stated that "proper" processing of materials was also of concern, implying that their competition might be more concerned with the most cost-effective method of disposal post-collection rather than what happens to the materials once they have been obtained. This may not necessarily be the case; Smithrite was definitely concerned with the composition of the waste and maintaining a level of zero contamination. According to Jonathan, the organics processing facility was unforgiving about costly penalties imposed for non-biodegradables mixed with the expected organic waste. “Zero contamination is essential,” he reiterated on more than one occasion. While neither participant was able to give approximate figures on what market share was occupied in waste management or organic WM, BFI claimed to have approximately 15% of MSW collection services in the GVRD. It was agreed however that there are very few competitors currently involved in organic waste collection, affirming the potential for increased competition.

5: Business Opportunities

British Columbians have long been concerned about environmental issues. When offered the "classic choice" between jobs and protecting the environment in a study performed in 1997, 60% of BC respondents chose protecting the environment (Blake, Guppy, & Urmetzer, 1997). The study reported that although high, this number was actually down from a previous National Election survey performed in 1988 where BC residents responded overwhelmingly in favour of environmental protection at a rate of nearly 84%. Therefore, it comes as a bit of a surprise that an organic WM solution has not yet been provided for the residents of Vancouver where a substantial amount of MSW is produced annually as shown in Figure 4.

Figure 4. Waste Management Activities in the GVRD

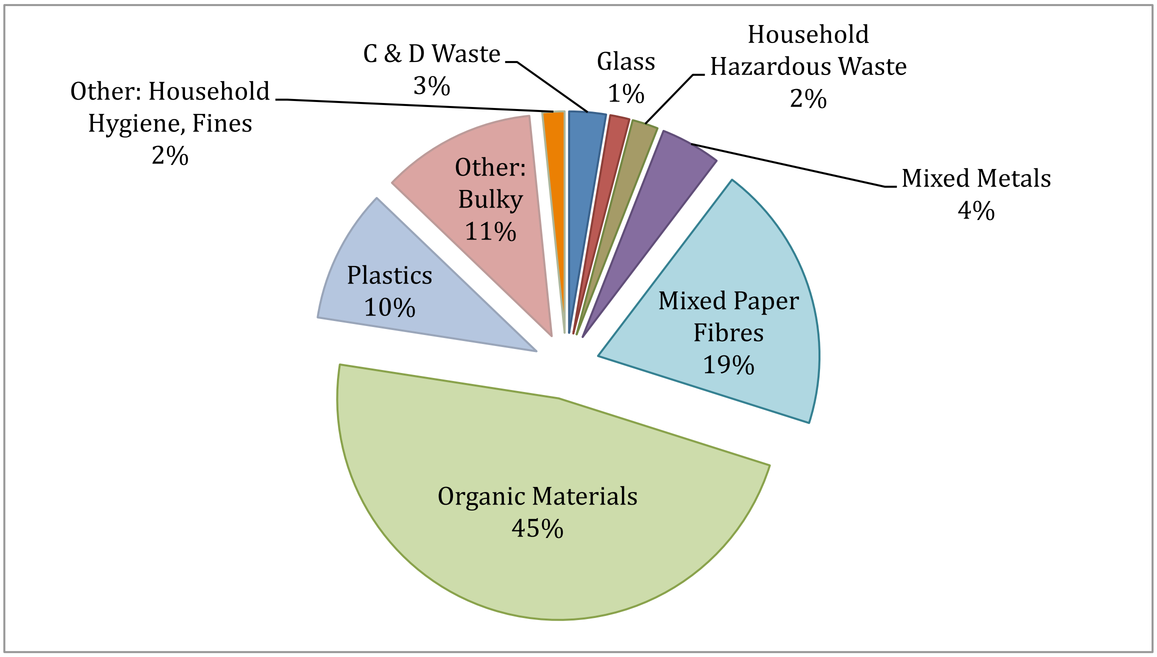


Source: Recycling Council of British Columbia, 2006

Of those materials disposed of in landfills we can see that a significant proportion of the waste is comprised of organic matter (Figure 5). While organic materials as defined by the Recycling Council of British Columbia includes wastes that are not typically composted (e.g. rubber, textiles, leather, etc.), there is still room for a reduction in the amount of organic matter contributing to this waste stream. In fact, the amount of compostable organics accounts for 21.3% of the total composition of landfilled waste, or just under half of the organic materials pictured (Underwood, 2007).

Metro Vancouver has openly admitted they do not have the full complement of resources required to adequately meet the WM needs of all sectors. This is consistent with other aspects of public services, however, in this particular case there are a number of opportunities for private enterprise to fill the gaps in the waste management value chain targeted for organic matter. The most plausible and profitable choices will be considered in the following section.

Figure 5. Composition of Landfilled Waste



Source: Recycling Council of British Columbia, 2006

5.1 An Organic Waste Collection Service

The province of Nova Scotia has had a ban on organic materials entering landfills since November of 1998. As part of a revolutionary approach to solid waste-resource management strategy, municipal governments were forced to re-think and re-tool their MSW management systems to find viable solutions to manage and prepare for this change. Curbside collection programs have also been implemented in large cities across the country, Toronto, Ottawa, and Edmonton to name a few.

Metro Vancouver has endorsed composting as a sustainable method of processing organic waste. This approach is part of a larger initiative targeted at diverting waste from landfills. Before waste can be processed though, an adequate collection network must be established with sufficient infrastructure to facilitate recurrent service and transportation from producers to processing sites. The municipal government will be implementing its curbside collection program of food waste for single-family homes in the City of Vancouver at some point in the year 2010. Nevertheless, a clear solution has not been identified for two substantially large segments in the Vancouver area. The two markets that have been identified by this study are residents of multi-family dwellings, and waste producers operating within the ICI sector.

5.1.1 Residential Apartments (High/Low-Density)

A 2008 report by Statistics Canada (Elliottt, 2008) showed that the provinces that had the highest participation rates in composting also had the highest percentages of households that have both yard and kitchen waste collected at the curb. Simply put, when residents have the option of having their organic waste hauled away, a higher percentage of them compost. This implies that if the necessary infrastructure were in place residents would likely be complicit in participation in such a program.

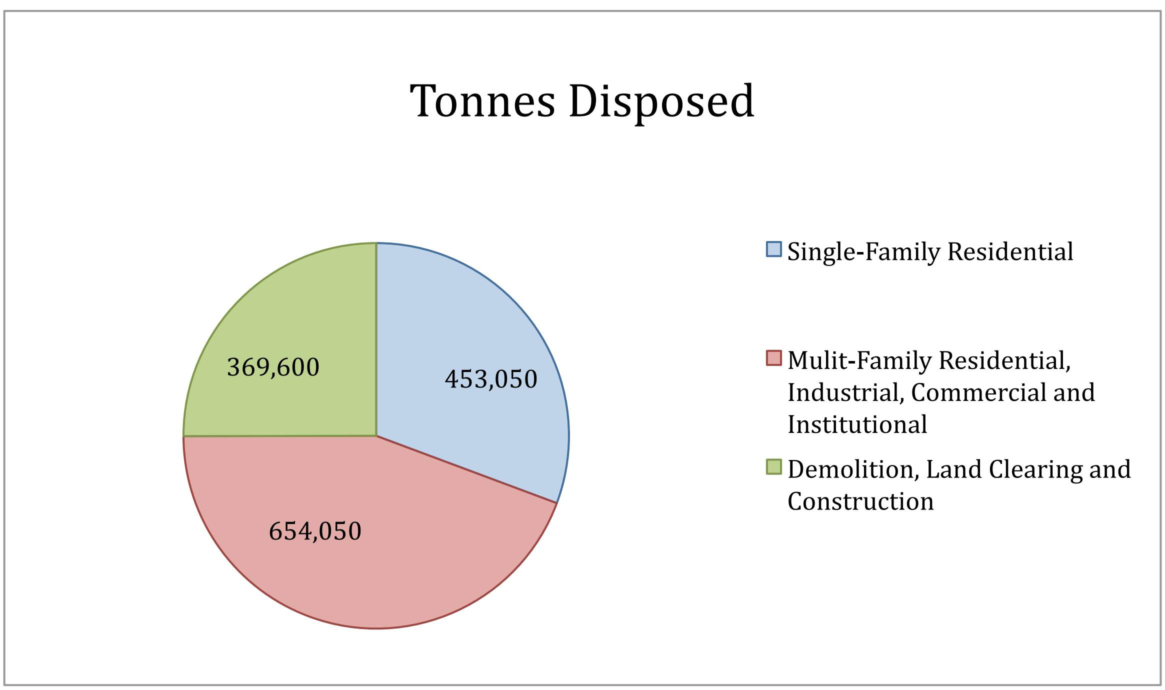
The same study also demonstrated that participation in year-round composting tends to be higher in those provinces that have improved access to curbside collection. Although composting can be done year-round, the biological process slows down in cold weather. The discomfort of increased exposure to inclement weather coupled with increased compost cycle times are just two more reasons that make composting for apartment residents an inconvenient option. Instead, a service could be provided that would collect organic waste from a centralized location at an apartment building, similar to how garbage and recyclable materials are collected at present. These collection services are typically contracted to private companies so another waste stream supporting source-separated organics would not pose a drastic change to residents' current behaviour.

5.1.2 Non-Residential Sources of Waste (Commercial and Institutional)

The ICI sector annually produces the majority of MSW in Vancouver (Figure 6). Although its composition is quite different from residential sources due to the nature of the industries involved, there are a number of targets within this group where dramatic waste reductions can be made, specifically in the institutional and commercial sectors.

Amongst commercial operators in the GVRD, we can further divide groups of interest into one of three categories: food retailers, restaurants and food processors. Within these groups lies the greatest potential to remove a steady stream of organic waste on a regular basis.

Figure 6. 2004 Disposal Rates (by sector) in the GVRD



Source: Underwood, 2007

Retailers

Retail grocers come in various sizes of operations. There are the independent establishments of small to medium size, and then there are the large or “big box” stores which usually belong to a chain of other franchises. Many retailers in Vancouver are involved in programs that donate edible food waste to social programs that feed marginalized groups such as the homeless or distribute it to food banks, yet there still remains a portion of waste that is unfit for consumption. These inedible products can include baked goods, produce, meat, fish and dairy products that are damaged, tainted, or items not sold before their best before dates. As such they must be disposed of and providing organic waste removal would be a viable alternative.

Grocery stores and produce markets turn over large amounts of inventory on a recurring basis. Foods with limited preservatives and packaging present a challenge in that these items need to be removed on a timely basis, limiting exposure to elements that accelerate the decomposition process (heat, oxygen, etc.). While large volumes collected from numerous locations could present systemic challenges to a food waste collection service, food retailers provide an easy and perceptible area as a target market.

Food service businesses

Vancouver is home to hundreds of food service businesses. There are cafes, restaurants, bars, bistros, and numerous types of eateries throughout the city. The 2006 Food Diversion Report notes that many small and medium-sized restaurants perceive that they have less food waste because in many cases foodstuffs are purchased on a daily basis. This limits waste by minimizing the amount of spoiled food, and discounted pricing (i.e. daily specials) is a secondary operational tactic of extracting value from items that are edible but not "freshly made". Despite that fact, the report also observed a perception that food waste removal companies would not consider restaurants if there were insufficient quantities to make service cost effective. This was however unsubstantiated, through interviews with waste removal companies (The Vancouver Food Policy Council, 2006).

Undoubtedly, not all food establishments produce enough waste to make collection service profitable. Although given the vast number of food services and the diversity in size of operations and franchises, there is an appreciable market that is worth further investigation. While pricing, billing, and service may traditionally be applied in a model that deals with a WM company and customer on a one-to-one basis, billing and service options could easily be modified. A revamped model could potentially have a cartel of restaurants pay a pooled fee for service within a given district or neighbourhood, effectively lowering the costs for all participants while increasing the overall inclusion rate of waste collection program. Such conglomerates already exist in the city to unite communities and achieve common goals; two such examples are the Kitsilano 4th Avenue Business Association and the Yaletown Business Improvement Association. By strategically framing the removal of organic waste as a collective concern and a matter of social responsibility, a greater number of businesses could participate in a collection service at a minor increase in marginal costs to their existing operations.

Food Processors

While the exact number of food manufacturers operating in the GVRD is unclear, it is known that there are many catering businesses of various sizes as well as formal and informal preparation kitchens servicing groups of people for public services such as shelters and school cafeterias in addition to commercial enterprises (e.g. banquet halls, hotels, etc.). Like other sectors discussed, industrial food processors also generate edible and inedible food waste. Smaller processors feel as though the aggregate waste produced is too little to warrant efforts to establish diversion programs (The Vancouver Food Policy Council, 2006). Although this may pose an operational if not a billing challenge to service provided, an opportunity exists to collect this waste stream being produced. Respondents to the Food Diversion Report (2006) claimed that there is much incentive for processors to set up their systems (i.e. cost, regulations, feel good factor, etc.), but a commercial enterprise specializing in organic waste collection could easily fill this gap. A creative billing option might be to have the City of Vancouver subsidize a portion of service costs to help achieve overall waste diversion targets. Arguably this may complicate existing WM service delivery models, but the City of Vancouver already provides waste collection services for a select number of commercial properties, so the idea would not be unprecedented.

Finally, "food processors" in a wider context might include daily labourers, and employees that consume food while at work (still industrial and commercial sectors). This overlooked contingent that often spends 40+ hours per week (on average) in the employment setting, still manage to consume variable amounts of organic materials and produce food waste and unfinished or leftover table scraps, albeit in smaller amounts compared with previously mentioned markets. In any case food processing, whether on an individual or commercial basis, generates another source of organic waste matter that may be collected.

Similar to the "group billing" option previously proposed for food service businesses, a reworking of a typical operational model may be in order to implement a successful service in an office setting. This idea is not unique and is being employed by the Cadillac Fairview Corporation Ltd., one of the largest owners and managers of commercial real estate in North America. As part of their "Green At Work" plan, one of the pillars of the program "Waste Management" seeks to "generate zero waste" by implementing waste minimization, waste management, and Reduce, Reuse, and Recycle practices. As a part of this mandate organic recycling (as it is termed in their program) was introduced for food court tenants in 2004 and for office tenants in early 2009. It is presumed that waste management services are billed into leasing costs or monthly service fees paid by all tenants. Recognizing its responsibilities as a major commercial waste generator, Cadillac Fairview has been praised for its perspective on developing management systems to meet environmental commitments (Ontario Waste Management Association, 2006). Nevertheless, these systems are supported by waste management service providers that are able to meet the needs of such a significant customer. Given the number of bank-owned buildings, office towers and other forms of commercial real estate in Vancouver's downtown core alone, the ICI sector merits some investigation as a potential market.

5.2 Organic Waste Processing

A commercial enterprise collecting waste could be regarded as the "low hanging fruit" of a WM system. Some of the tougher challenges arise when disposal and storage concerns are raised. Although waste processing undoubtedly implies increased capital expenditures for property, plant and equipment, it is the next logical step in the value chain. New WM models like waste-to-energy and IRM have redefined the notion of waste though. Current thinking changes the paradigm of value, and materials that have historically been considered worthless are now raw materials for end products. These ‘end products’ are marketable and as such, the transformation of organic waste may now be viewed as a value added process. The various methods of materials recovery will be described so that a complete picture of processing options and their merits can be discussed.

5.2.1 Composting

As described earlier, composting is the aerobic breakdown of organic materials into a soil-like product called humus. The process uses microorganisms (i.e. bacteria and fungi), worms, and insects that consume the organics consisting of carbon and nitrogen, producing heat as a by-product. Facilitation of the composting process is relatively uncomplicated. In order to maintain aerobic conditions materials must be exposed to air periodically by agitation, and a relative degree of moisture/humidity maintained. Other factors that can be controlled for process optimization are temperature, size of particulate matter, frequency of agitation and the carbon-to-nitrogen ratio of the waste involved. The more actively these variables are controlled, the faster decomposition can occur.

Another method of composting that is growing in popularity is vermicomposting, where worms’ consumption of organic material generates nutrient-rich manure commonly known as worm castings. A variety of worms can be used to generate the humus-like material but the red worm (Eisenia Foetida) is the most popular. There has been much discussion about the quality of worm castings and the difference in nutrient profile compared with microbial decomposition (Dickerson, 2001). While the matter is seemingly trivial, the final quality of compost produced has direct implications on target consumers, thus affecting marketing and pricing strategies. Having said that, one noteworthy difference in the two production methods is that vermicomposting cannot accept the same range of materials, namely meat and dairy products. If such waste contamination occurs, the worms cannot consume those materials and they putrefy over time. This has obvious systemic implications on odour and other aspects of production, causing problems.

As a method of extracting value from post-consumer organic materials, composting provides a number of benefits. Diversion of bio-waste from landfills reduces the amount of leachate and odour produced on-site, and limits the amount of methane produced thus preventing escape of the harmful greenhouse gas into the atmosphere. Diversion by composting also helps alleviate concerns of limited landfill space constraints. Lastly, compost is a valuable, renewable resource that adds beneficial nutrients to soils without the need for fertilizers or other costly inputs. Quality compost can be used on an individual basis for household planting needs, or on a much greater scale for institutions with landscaping requirements or soil remediation projects.

5.2.1.1 Custom Composting Solutions

Due to the relative simplicity of the process, many Canadians practice composting on an individual basis, often using a receptacle in their backyards. The City of Vancouver has offered compost bins to homeowners and residents for a number of years. Initially they were given away for free as part of the overall waste diversion strategy, but in recent years a fee of $25 has been implemented. This however, is only one of many options that have become available to conscientious consumers seeking to take initiative in what is widely believed to be a sustainable and ecologically beneficial practice.

A relatively new market has emerged, providing a variety of products specifically designed for organic waste storage, transportation, and home composting. Websites such as composters.com offer product lines of home composting solutions such as tumblers that rotate, facilitating compost turnover, and compartmentalized compost bins. Historically odour has been the greatest concern regarding indoor storage of organic waste for temporary containment (e.g. under the sink) but smaller, conveniently sized bins have now been designed with charcoal filters that allow oxygen exposure to organic materials while mitigating offensive smells (NatureMill Inc.). There are also organic waste digesters, designed to handle higher proportions of moisture and wet matter, as well as companies that sell microbial additives that accelerate decomposition and balance pH (Pasternak, 2006). Granted, some home solutions are better suited for single-family dwellings than they are for apartment or condominium-style buildings, but providing a complete line of composting solutions would allow access to a wider market.

Retailing custom solutions for home composting is one option but the manufacturing of these products would also be a potential business opportunity, assuming that adequate market validation was established to warrant production in or near the GVRD. Centralized and coordinated distribution of composting products is also a slight variation of this option that would allow for significantly fewer operational costs compared with mass production.

5.2.1.2 Large-scale Solutions

The most feasible option for processing organics in a commercial setting is to use a method that provides a “large-scale solution”. This allows for collection of waste from a larger group such as a community or institution, as well as providing a means for expansion of operations to meet increases in capacity over time. Typical constraints to operational size are the availability of land, the machinery available or desired, the quality of compost that can be produced, and the capital available to establish operations.

A prominent issue in dealing with mass processing of organic waste is the storage and containment of aggregate waste. Organic matter typically has moderate to high moisture content, promoting accelerated decomposition and odour as a result. Odours and moisture are attractants to vectors that scavenge for food sources (e.g. rats, bears, etc.) and provide prime location for reproduction and proliferation of flies and insects. Common to all large processing facilities are the infrastructure costs of providing adequate animal barriers, odour mitigation equipment or processing methods that can manage these factors within a short time of receipt of the waste.

There are a number of ways of managing throughput of organic wastes and generating compost. Although the biological process can be manipulated in a myriad of ways, the three most common methods are static pile, windrow and in-vessel systems. The merits of each system will be discussed below.

Static Piles

The most basic of all composting methods is the static pile, where organic matter is mounded into a pile and turned over at regular intervals. This technique can be extremely low-tech and implies very low capital costs in comparison to other methods.

Systems also range to high-end models where suction or blowing apparatus is used to draw air into the matter to promote oxygenation. Piles can be aerated vertically and/or horizontally, where they are spread over a greater breadth. By increasing the surface area there is greater exposure to air placing less demand on aeration tubes and decreasing processing time.

Aeration in static pile systems can be inconsistent and therefore, these systems can have tendencies toward odour and vector problems. Another concern is that a substantial amount of space is required in order to process the waste, and this system requires batch-style processing opposed to a method of continuous production. This effort can be labour intensive in a system where overall processing efficiency is at the lower end of the spectrum.

Windrows

A windrow system is a slight variation of the static pile where large trenches are dug in the ground and lined with a material that prevents leachate from comingling with the surrounding ecology. Some windrows offer a static process but the majority include a regular schedule of turnover to facilitate aeration promoting decomposition. Even when machinery is involved, the windrow process is labour-intensive. Adequate and frequent mixing of the elongated pile ensures aerobic processes are prevalent however anaerobic bacteria still produce variable quantities of greenhouse gases and odours. These by-products can be minimized with frequent turnover but this further increases the labour profile of operations.

In recent years the application of gore covers to windrows have provided increased efficiency and functionality to these systems. Gore, the manufacturers of the breathable waterproof material Gore-Tex®, has developed an industrial grade tarp with an integrated membrane designed specifically for sheltering compost windrows. This cover allows the passage of carbon dioxide through the membrane while containing odours, humidity and retaining heat. The cover also repels water from the external environment allowing for internal control of moisture levels and optimizing biological activity. Piles can be covered at will using an unwinding device effectively transforming a static pile into an in-vessel system. The company goes so far as to claim that this product can eliminate the regulatory requirements for an enclosed facility applicable in some jurisdictions (Net Zero Waste, 2009). In any case, the Gore Cover when used in combination with its blower unit and drainage/aeration troughs provide an intelligent design complimented by the reduced costs of an outdoor system.

Because of the ample land requirements of both static piles and windrow systems, these methods are suitable in rural settings such as farms but can be very costly in locations where space is at a premium. The obvious benefit of these systems is that facility costs are dramatically reduced because operations and processing can occur in an open-air environment. While these low-tech methods of WM suggest that they may involve the lowest capital costs of any suggested operation, the overarching long-term labour costs combined with land costs could negate this benefit in the long run when applied to an urban setting such as Vancouver.

In-vessel composting

In-vessel composting systems are a new adaptation of industrial technologies applied to organic waste management. These systems allow for continuous loading of materials into a fully enclosed environment that controls all the variables governing microbial decomposition while dramatically reducing odours and GHG production. There are vermicomposting systems such as Sustainable Agricultural Technologies Inc.'s Worm Wigwam that are flow through systems; additionally, aerated static piles with the incorporation of removable covers such as the Gore™ Cover (mentioned previously) are also referred to as in-vessel systems. Although these systems may be regarded as in-vessel methods due to their potential for continuous throughput, for the purposes of this discussion these systems will be excluded because the principles of those technologies has already been addressed.

Modern in-vessel composting uses metal tanks, tunnels or concrete bunkers that regulate and closely monitor temperature, airflow and humidity creating a "bioreactor" of sorts. What makes these types of systems attractive is the dramatic reduction in compost production time. Companies such as Transform Compost Systems located in Abbotsford, BC claim a production turnaround time in as little as 4 to 8 weeks (Transform Compost Systems), compared with the naturally occurring biological process that can take much longer (depending on waste composition). What is particularly attractive about processing in a completely enclosed environment is that all types of organic waste can be processed including meat and dairy products that contain higher proportions of fat, which lengthens the decomposition process. In contrast, many processors find these products unfavourable in static pile and windrow operations, although theoretically those methods can tolerate animal materials.

Additional benefits to this method are the complete elimination of vector concerns once bio-waste has begun processing within the system. Leachate management occurs through the systemic recycling of water and flexible design options make the system scalable allowing for changes in production time and waste volume. With all of the features present in such a system however, the equipment costs are relatively when high compared with other processing methods.

5.2.2 Biogas Production

In theory the opportunity for biogas production is readily available but in practice there are a number of hurdles that must be overcome before a feasible operation could be situated in or near Vancouver, let alone the GVRD. It may be difficult for such a system to be remotely profitable, or at least the amalgamation of many systems and regulatory bodies would need to heavily subsidize costs in order to achieve a return on investment with a break-even point projected well into future years. The sheer nature of the capital investment required for plant development and infrastructure to produce, distribute and utilize biogas necessitates a considerable minimum efficient scale of production (MES). While this is not necessarily a complete deterrent, implementation of this system presents a number of challenges.

On-site production of biogas has worked well in agricultural settings (i.e. farms) where vast quantities of waste are produced daily in the form of animal manure, crop residues, and other organic matter. In an urban setting though, it is difficult to imagine how such a system could safely be implemented in a cost-effective manner for smaller waste volumes. Companies such as Onsite Power Systems Inc. claim that for a food processing plant generating 125 tons daily of process solid waste and suspended solids in wastewater, the cost of building a conventional facility would be $3.5 million USD (Onsite Power Systems Inc.) and provide a straight ROI in approximately 3 to 4 years. The products generated are biohydrogen and biomethane which could be kept separate, or mixed together to operate standard internal combustion engines, and presumably heat the immediate processing location and surrounding structures. While smaller-scale operations can be observed in many developing nations - particularly in Southeast Asia - pollution standards, electricity and waste management legislation make application of this technology in Vancouver difficult. Retrofitting is costly and integrating WM and energy systems in existing structures make this operative model unlikely and difficult to justify. Perhaps as IRM techniques improve and modularity is applied to new designs, efficiencies can be gained such that smaller scaled operations could be applied to individual buildings or small clusters of facilities. For now though, technology on a small-scale seems a significant distance in the future.

While it may be true that biogas is a clever method of capturing value from organic matter, the supplementary production methods are better suited to materials with a high liquid content and less towards MSW. These critical inputs have direct implications on the types and sources of waste provided for a biogas production facility. A constant uninterrupted stream of organic material would need to be secured in sufficient volumes that carbon and nitrogen requirements could be satisfied for gas production. While MSW sources could be provided through partnerships with WM companies and competitive pricing offered for tipping fees, this may not provide enough material for a facility to operate at MES. Liquid manure and sewage would be potential options for additional inputs however transportation and handling of these materials poses other problems; namely regulatory compliance issues, storage, infrastructure (e.g. the development or re-routing of piping) and other capital costs. Processes can be further complicated by the coordination of multiple regulatory standards (i.e. waste transport, energy production and distribution, etc.) across multiple jurisdictions and potentially conflicting legislation (i.e. municipal and provincial). Zoning by-laws within urban areas may also play a role in restricting where a potential facility could be located.

Assuming that these concerns could be quelled, the initial investment in a biogas facility would be quite substantial. The 2008 Integrated Resource Management Phase I Study Report directly addresses the issue that:

> The risk of time, and hence cost, overruns during construction is significantly smaller for small $10 million plants occupying 300m^2 (approximately 3,300 square feet) than for a single plant occupying several hectares costing several hundred million dollars. In addition, the lessons learned in building the first small plants can be applied beneficially to the remaining installations (Corps et al., 2008, p. 47).

Ironically this comment is listed as one of the potential benefits for the business case for IRM in British Columbia, although it could be interpreted as a sure warning to organizations that dare venture into this industry and the costly errors that could be made along the way.

Another complication is that the production of useable methane and or syngas requires specialized systems and infrastructure developed and maintained by highly qualified personnel (e.g. engineers, systems technicians, etc.) in multiple disciplines. A labour profile particular to this type of enterprise would likely add additional costs to an operational model. Other “unique” costs may be those affiliated with the disposal of by-products of syngas production, liquid tar and solid char (Wang, Weller, Jones, & Hanna, 2008). While the quantities of these materials vary with improved processing and higher gas yields, disposal of these waste by-products could pose significant additional operational expense.

Lastly, while biogas production is an exciting energy opportunity, sadly the infrastructure is barely in place to adequately utilize it to its full capabilities. Lantz *et al* (2007) discuss the incentives and barriers affecting the utilisation of biogas in Sweden and its greatest potential there is as a vehicle fuel currently used in buses, distribution trucks and passenger cars. Ten percent of biogas produced there is used for this purpose, although the country's biogas production accounts for 0.3% of its total energy use. One of the suggested strategies is to use the natural gas grid for biogas distribution, although this would require additional syngas processing and thus, additional operational costs. That said, access and input into the natural gas distribution system in this city or this province would imply even further cost.

Biogas production is a great option from a resource utilisation perspective but much research needs to be done before it can be viewed as an attractive option for organic MSW processing in Vancouver. This is unfortunate because the technology provides the benefits of reducing landfill needs and reduced air pollution, and properly managed biogas does not contribute to climate change. While this may not yet be a secure or lucrative value proposition for enterprising firms, it might be an opportunity better suited for a crown corporation or large, established conglomerate.

5.3 Compost Sales

It has been established that organic waste collection would be the simplest business opportunity, but waste processing is the real bottleneck in the industry. Once a suitable method of processing has been found the next logical conclusion is to market and sell the resultant product. Having discussed the trials of biogas production and sales, the remaining alternative is the sale of compost. Because of its nutrient dense properties, the soil amendment can be sold as a fertilizer or conditioner of sorts, for use in agricultural and horticultural markets.

Compost sales are likely an important form of revenue generation as part of an overall operational strategy in organic waste processing. It is difficult to find historical reports of retail sales data for compost and this may partially be due to the fact that in many cases composting operations run by municipal governments distribute compost at no direct cost to the community at large. Also, the act of composting is referred to organic waste recycling by different bodies in the WM industry, further confounding figures. Susan Antler, long-time Executive Director of the Composting Council of Canada explains that,

> While establishing markets for the finished compost has never been a slam-dunk, a consistent, high quality product and the continued reliability of supply source have been keys to successful compost sales strategies. For many, the development of markets has taken at least three years, requiring investments in growth trials and sampling (versus giving the product away), as well as recipes and procurement specifications (Antler, 2008, p. 22).

The marketing and sale of compost may indeed involve its own challenges. Of the 32% of businesses in Canada that actually sold their compost generated in 1998, nine out of ninety facilities used an outside broker to manage product sales; the others either gave it away or used it for on-site purposes (Antler, Composting Grows Stronger). Additionally, Antler states “transportation costs and undeveloped markets are the two most frequently sited barriers to marketing compost products.” Sales generated from these facilities ranged over a variety of price points spanning $20 to $30 per tonne. In order to remain somewhat competitive with programs that give their compost away for free, market prices are driven down to lower levels. This only reinforces the notion that organic waste must be processed in high volumes in order for operations to remain profitable.

The one caveat is that niche markets may exist for compost sales dependent on the quality of compost produced. For instance there is some evidence to support the idea that worm castings (vermicompost) may be richer in many nutrients than typical microbial compost (Dickerson, 2001). That said, nutrient profile testing could validate the constitution of superior product, thus fetching higher market prices due to differentiation in quality. The author of *The Practical Guide to Compost Marketing and Sales*, Ron Alexander, echoes this sentiment:

> …compost can be processed so that it is appropriate for use as a soil amendment, turf topdressing, mulch, erosion control media, etc. It can be further refined into a growing media component or nutrient source, or blended to allow for its use in a variety of creative applications. Because of compost's incredible versatility, the best application for a particular product – thus the end users who can best use it – is determined by the characteristics it possesses. When marketing a particular compost product, sell to its strengths (characteristics) – the product can't be everything to all people, and it is a sure recipe for problems to try to be (Alexander, 2004, p. 25).

Alexander's work has demonstrated that different market segments use compost for different purposes, and these groups have varied priorities and reasons for using specific products. With such variation available in the market, it may be advantageous to have finished compost marketed and sold to multiple groups based not only on market price and volume, but the stage of compost maturity as well. This would definitely have operational implications though, specifically with regard to determining the length of time for compost curing.

5.4 Summary

Waste Collection

With so many options available for exploiting elements of the waste management value chain, a focus on organic waste allows the incorporation of a differentiated service strategy combined with other key success factors determining profitability. A simple collection service can be initiated at relatively low cost and access to distribution channels can be established in the multi-family residential sector, where there is presently little to no competition. Although there are firms that provide this type of service in the ICI sectors, they are few and there is much room for market growth. As mentioned earlier in chapter 2, securing these distribution channels is key in obtaining economies of scale over time. Furthermore, data exists to support the efficiencies gained by having private enterprises engage in waste collection.

It has been many years since McDavid (1985) described the increasing privatization of residential SW collection services in Canada. Citing substantial productivity differences McDavid noted that Canadian municipalities, including West Vancouver and Richmond, were able to achieve significant cost savings by contracting private firms for MSW collection. The presence of numerous private firms was also noted as a key element of periodic competition in tendering of contracts. This has lead to the streamlining of unionized operations in municipalities that continue to service their own MSW collection, through practices such as reduction of crew sizes or decreasing the number of routes serviced. Competitive bidding has also generated benchmarks for comparison with existing collection costs, and provided better cost-information for public officials. In some cases this has lead to the creation of mixed public-private systems within municipalities. In 2008 private enterprises transported 65% of the total amount of MSW collected in Vancouver between the VSTS and the VLF (City of Vancouver Engineering Services, 2008). This means that the current WM system is reliant upon private firms for the collection of two thirds of the city's MSW produced, although this is not surprising given the large number of residential apartments in Vancouver in combination with the extensive list of unsuitable materials for garbage collection (see Appendix A). If the market for waste collection seems attractive, then perhaps there is potential for waste processing ventures as well.

Waste Processing

To determine the most attractive solution of the processing options mentioned in this chapter, we will refer to the key success factors identified in chapter 2. An additional consideration will be the amount of labour required in each enterprise, as this has direct consequences on operations and the ability for new entrants to compete on a smaller scale. Table 3 shows a comparison of each of the methods discussed using these parameters.

Table 3. A Comparison of Proposed Waste Processing Business Opportunities

	Labour Requirements	Capital Requirements	Economies of Scale	Influence of Government Policy
Processing				
Retail/Distribution of Custom Compost Solutions	Very low	Very low	No	Very low
Static Pile Composting	Moderate	Moderate	Yes	Moderate
Windrow Composting	Moderate	High	Yes	Moderate
In-Vessel Composting	Low	High	Yes	Moderate
Biogas Production	High	Very high	Yes	High

Although the retailing and distribution of custom/home composting equipment is not technically a processing option per se, the table shows that it may the option with the lowest amount of financial risk. That said, it may also be the least profitable as these retail products are generally limited to single-family home environments for small-scale waste processing. Waste storage and container-type solutions under this category are easily displaced by cheap substitutes and this does not solve the problems of "where does the waste go and who will transport it there?"

Focusing on actual waste processing, we can see that the effect of government policy is greatest in biogas production. The merits and constraints of an IRM processing operation, discussed earlier, also dictate that initial capital outlay is very high and product utilization at present is very low, emphasizing a need to prove the market. Labour requirements in this type of operation are also very high, but this may be overcome in time due to experience curve effects. With WM trends moving more towards materials recovery and closed loop systems, nutrient and water recycling are a natural extension of this concept. Biogas sales in conjunction with IRM are a great opportunity in theory, but in practice such an operation has many hurdles to overcome.

The vast capital requirements for biogas production and sales automatically render this type of venture best for an energy or utilities company that would be able to leverage existing resources. Regulatory restrictions would need to be carefully adhered to in order to implement the necessary piping and infrastructure to connect a production plant to other facilities let alone develop natural gas infrastructure. Given the applications of natural gas compared with biogas, upgrading and conversion of biogas would be a must. Although initially expensive, this investment would allow for competitive sales of biomethane in gas markets. Given the water recovery and heavy metals and contaminant capture involved in an IRM process, there is good reason to suspect that such a business would be eligible for government subsidization or a contractual operating relationship with Metro Vancouver.

Static piles and windrow composting seem somewhat attractive due to their moderate labour profiles and relative simplicity of operations, but it must be noted that these facilities require substantial amounts of land to be able to manage raw organic waste, compost production, and finished compost storage. Not only would the land required be expensive in an urban area such as Vancouver, but also the open-air aspects of operations are unfavourable and impractical.

The last and best-suited processing method for Vancouver is the use of an in-vessel composting system. Continuous throughput allows organic waste to be processed in a continual manner, which makes for ease of operational planning and scaling in response to the volume of waste received. Initial waste containment immediately alleviates all vector concerns and once processing has begun, labour requirements are minimal. Some expertise is required for equipment maintenance and operation however, the biggest hurdle may be the initial capital outlay for the purchase of the equipment. Although this is a significant investment, the in-vessel technology is what surmounts the issues of economies of scale and government regulations that limit processing location. While land is obviously still required to maintain and operate the machinery, a comparatively smaller footprint is required than that of static piles and particularly windrows.

The low barriers to entry in waste collection suggest that if such a business were to be established for organic waste, it would not be long before competition was an issue. Identified earlier in the paper through interviews and assessment of the entire value chain, waste processing is the real bottleneck in the organic waste management industry. For this reason I would suggest that the best way to ensure competitive positioning in the industry would be to integrate a collection service with an organic waste processing operation, specifically an in-vessel composter. Revenue streams would be two-fold, comprised of waste collection service billing and ultimately, sales of the resultant compost. In time, such a firm could opt to accept organic waste streams from other collection services, and a third revenue stream could be generated from the tipping fees levied. This would provide the necessary competitive insulation required to achieve economies of scale at a greater rate than potential rivals, and ensure domination in this niche area of waste management.

6: Operational Models

It is difficult to conceptualize what some the business opportunities look like in organic waste management without discussing a theoretical model of operations. Without having exact figures or estimates to lend credence to financial models, some of the salient points can still be discussed to provide a framework of what considerations must be regarded when procedures are designed for prospective operations.

6.1 Organic Waste Collection

A centralized collection bin would be best suited for organic waste removal in a residential setting, similar to those currently used for garbage collection and recyclable materials. As such, it would be kept in the same location for ease of resident access. This bin would likely be a 64-gallon plastic tote equipped with a charcoal filter to allow for airflow while filtering out odours. Smaller bins (1.5-2.5 gallons) would be provided for each resident that wished to participate in the program. This size is small enough to be kept underneath a kitchen sink or another discrete location in a small apartment. Periodically residents would transfer the contents of the smaller bins to the centralized collection bin, as they do with other waste streams. The centralized bin, likely kept in a dark or shaded area, would then be emptied or replaced one to two times per week depending on volume and odour.

A similar system would be used for non-residential organic waste collection to establish uniformity of operations. Multiple 64-gallon bins would be used instead of one giant centralized container. Having the same style of bin for all pick-up locations would standardize collections and allow for the use of one type of collection vehicle. Obviously the number of totes used and the collection frequency would depend on the volume produced in given operation (i.e. food processors and restaurants would have greater requirements). Based on figures quoted from Jonathan Williams of Smithrite Disposal, collection at a typical restaurant would be daily, if not every second day. With such a high collection frequency, these enterprises would likely form the core customer base of the ICI sector.

Collected waste would be disposed of at a centralized processing centre or location where it could be amalgamated and screened for contaminants. At this point collection bins would be cleaned and deodorized if necessary. If disposal is to take place at one of the municipal transfer stations in the GVRD, elimination of contamination is critical in limiting fines. Smithrite was adamant that these penalties are even worse and costly with private processing companies such as Westcoast Instant Lawns. It should be noted that at municipal transfer stations reduced tipping fees can be negotiated and dumping processes expedited for commercial waste haulers. This is particularly relevant for services focussed solely on collection and no further processing.

6.2 Organic Waste Processing

Given the number and magnitude of costs associated with MSW collection (labour, transportation, equipment, etc.) the concept of minimum efficient scale places a determinant role in all aspects of operations, particularly the size of a processing facility. This notion is confirmed by Metro Vancouver's lengthy process and difficulty in sourcing a partner large enough to provide waste processing capacity for all of the

GVRD's residents. Granted, the GVRD needs to service 22 municipalities whereas a business meeting the needs of Vancouver residents could be considerably smaller. However, the property costs associated with being located closer to the city must be balanced against space utilisation in a given operation.

The benefits and drawbacks of on-site versus off-site processing will be discussed to give a picture of what these models might look like, and hopefully indicating a preferred solution in the process.

On-site Organic Waste Processing

The idea of imposing a decentralized business model where waste processing is accomplished directly on-site is attractive for many reasons. The most obvious being reduced transportation costs, which in turn reduces the ecological footprint of operations. Touting the sustainability of the operation could further prove to be an effective branding strategy, because fewer GHG emissions are generated. Bulk waste collected would be transferred a short distance to a processing unit (i.e. composter) which requires less labour-time involved on a per unit (or contract) basis. Once processing has been initiated, machinery takes care of the front-end of processing while finished product must be tended to, removed or moved to a finishing location. Regular equipment maintenance would be required as well, which could potentially detract from time savings gained from reduced transport to a centralized location.

The downfall to this model is the high initial capital outlay required to operate multiple locations simultaneously. Batch processing achieved by collecting large volumes of waste from multiple sites permits economies of scale to be achieved, thus reducing total operational costs per subscribed unit. It would be difficult to convince strata corporations and PM groups that on-site processing is a worthwhile investment unless there were substantial cost savings in landscaping materials used (e.g. mulch or compost). Without seeing quantifiable data on expenses incurred or approximate amounts of compost generated, this is difficult to completely assess.

Very few apartment-style buildings or businesses have the space to practically allocate a composting operation on site. Assuming that the space hurdle could be overcome, fewer have the landscaping requirements on the property to necessitate the use of the compost produced. Space is at an even higher premium in urban areas and as such, on-site composting is not a recommended option for businesses in Vancouver at this time. Where on-site models have worked have been community gardens and organizationally subsidized programs to meet WM goals secondary to revenue generation, however, as a primary goal this model is not commercially viable.

Off-site processing

The better of the two options, off-site processing is a more practical operations model for organic waste processing in Vancouver. A centralized location implies a more labour-intensive collection process, but the efficiencies gained in bulk processing are worth the expense.

Materials disposed of at a facility would go through a conveyor-type method of pre-processing including: shredding, metal collection, manual extraction and trommel screens to reduce the size of particulate matter. The organic material is then conveyed to a mixer where a desired material is used to amend moisture content. The University of

British Columbia’s Waste Management program currently operates an in-vessel composter (manufactured by Wright Environmental Management Inc.) and mixes 2 parts wood chips for every 3 parts of organic waste. Jonathan Williams (Smithrite) confirmed that restaurant and food waste is the most dense type of garbage due to it’s high moisture content and as such, wood chips provide a suitable dryness to help balance the moisture and nutrient contents in the resultant compost. Christian Beaudrie, Outreach Coordinator for UBC Waste Management, states that the wood chips acquired to operate the compost machine come from a local wood products manufacturer in the Lower Mainland (name withheld) that pays lower tipping fees to dispose of the material at UBC than it would at alternate locations. This arrangement not only provides key organic materials to produce quality compost, but the pricing structure also subsidizes a portion of operational costs.

Of the composting options available, the in-vessel method was determined to be the preferred method of processing. In particular the in-vessel systems designed by Wright Environmental Management Inc. (Wright Inc.) seemed to provide a number of benefits: contained leachate through water recirculation, complete odour containment, negligible methane release, and adjustable processing time. Because all aspects of microbial decomposition (oxygen, moisture, temperature) can be manipulated in a controlled environment at all times, the composting process is accelerated to an impressive 10-14 day retention cycle within the in-vessel system (14 days at UBC)! When the compost is removed from the machine at the end of the retention cycle it must then be left to mature.

Maturity and stability are terms that often used to describe the rate of decomposition occurring within compost. Stable compost refers to a product that is not undergoing rapid decomposition and whose nutrients are slowly released into the soil (Wu, Ma, & Martinez, 2000). This is an important determinant on the potential impact of the compost material and nitrogen availability in soil. Unstable, active compost can actually leach nitrogen from surrounding soil and in some cases cause plant death. If stored improperly or left unaerated, unstable compost may decompose anaerobically, generating odour. Compost maturity and stability are important factors that have a direct bearing on all composting operations and affect product cycles. Turnaround time directly affects operations in that storage space must be made available for maturation. The California Integrated Waste Management Board (2003) suggests that, "…typically, compost is stored between 30 to 120 days to further stabilize." The WM operation at UBC finds that a two-month curing time post-processing, meets their functional compost needs. Although the exact maturity time for a proposed operational model would depend on what type of product was being created for target markets (as discussed in section 5.3), it is suggested that the curing time would be approximately the same length as UBC's model, i.e. 60 days. This would imply that the composting facility have adequate space for the unloaded compost to be spread with enough area to aerate and mature for the necessary 60 days, in a continuous cycle. Upon completion of maturation the compost would be ready for sale and distribution.

6.3 Compost Sales

To address the issue of transportation costs raised in section 5.3, marketing strategies would focus on compost sales and distribution to gardening centres and landscaping projects primarily within Vancouver and secondarily throughout the GVRD. A marketing campaign would focus heavily on the notion that the compost was produced from organic materials sourced from within the community and transported a minimal distance, emphasizing the diminished ecological footprint used to make a sustainable product. Having said that, compost sales also add another layer of complexity in operations because the product would need to be bagged and transported to local distributors and retailers. To minimize these costs, a portion of the processing facility could be devoted to retail sales although this may limit customer exposure to the product. This could be remedied through increased marketing to strategic segments such as local community gardening groups, landscaping companies, etc.

It would be hoped that as waste collection volumes increased over time, processing volumes would necessitate larger sales contracts. A number of markets within the GVRD have been identified where this demand could be satisfied, such as the numerous soil remediation projects for contaminated land (e.g. heavy metals) and brownfields – “abandoned, vacant, derelict or underutilized commercial and industrial properties where past actions have resulted in actual or perceived contamination and where there is an active potential for redevelopment" (British Columbia Ministry of Environment). One of the more recent notable projects was the restoration of Pacific Place on the north shore of False Creek, serving parcels such as David Lam Park, Andy Livingston Park, and Creekside Park. With other large volume customers, waste could be hauled directly off of the compost processing site, limiting the expense of transportation. However, facility design would have to accommodate increased traffic and loading area(s).

7: Conclusion

While it is difficult to measure consumer interest in sustainable methods of WM, let alone their willingness to pay for it, the results of the 2007 GfK Roper Green Gauge Report gives us some insight into consumer attitudes. Based on their answers respondents were segmented into five groups ranging from “apathetics” to “true blue greens”. The results showed that as many as 66 percent of respondents are “seriously concerned about the environment” ranging from environmental fence sitters who buy “green” only when it suits their needs, to the “true blues” (30 percent); those who were most likely to walk the green talk through activism and purchasing. The remaining groups comprised 33 percent of the total respondents and were generally disinterested in green issues or were not concerned enough to take any action (Lim, 2009). The survey results suggest that roughly two thirds of people are concerned enough about the environment to consider the merits of a waste management business that could divert organic materials from landfills.

As discussed in section 5, Blake *et al* (1997) have demonstrated the long held view in British Columbia that there is a sincere interest of environmental issues and their relavence. Additionally, BC’s introduction of the Organic Matter Recycling Regulation in 2002 points to provincial leadership as well as a climate of cabinet support to achieve strategic objectives in line with provincial mandates. This evidence reinforces the idea that Vancouverites want new solutions to old waste management problems. Interviews conducted with property management stakeholders highlighted the necessity for continued and sustained leadership as prerequisites for sustainability-focused programs in a multi-family household setting. It is my belief that this leadership is desired in other sectors too, including institutional, commercial and industrial sectors.

Emmanuel Prinet's (One Earth) comments about follow-up and implementation point to a need for planning and control activities supplied in an organizational context. These activities are typically provided by businesses to ensure operational functioning and can be categorized as four key overlapping activities (Slack, Chambers, & Johnston, 2007):

a. Scheduling: When to do things
b. Loading: How much to do
c. Sequencing: In what order to do things
d. Monitoring and Control: Are activities going to plan?

These four activities are critical to ensuring the management and implementation of an operational plan and require significant time and effort to ensure successful program execution. It is for these same reasons that private enterprises like property management groups are contracted to help strata councils ensure the delivery of essential building services. Similarly, when governments cannot tend to all aspects of a society's needs for safety and critical functioning, private industry exploits these opportunities to provide benefit. It is my belief that now is an opportune time for private enterprise to fill multiple gaps in the value chain of waste management in Vancouver, with specific regard to organic waste.

In addressing the best opportunities to add value in the current WM system, I had hoped to clearly find the best operational model that existed for managing organic waste.

Research in the early stages of the project quickly demonstrated that the bottleneck in the current system is waste processing. This is also the biggest gap in the industry with respect to organic waste. While it is difficult to simultaneously exploit all aspects of the value chain, there are significant synergies to be achieved from being able to do so. Distinctive branding built on the foundations of a sustainable, closed-loop solution is one major benefit, but this also provides a great source of competitive insulation. Waste production occurs in every conceivable market segment and this translates to many accessible customer bases. Exclusive partnerships with PM groups in the residential sector are one attractive possibility, but group-pricing strategies in the ICI sector are worth further exploration too.

Energy generation and recovery of multiple resources in IRM are fantastic ideas, but there are far too many hurdles and unanswered questions to make this an attractive option for organic waste processing in Vancouver at this point in time. In addition to the issues already addressed, current provincial building codes discourage the IRM approach by requiring discharges to sewers, separating organic solid waste with resource recovery and not supporting water reuse (Corps, Salter, Lucey, & O'Riordan, 2008). IRM demands drastic changes in current thinking and will likely require a significant time before regulatory bodies can adjust accordingly. There is also the element of public reaction to decentralised sewage treatment. NIMBYism or the (Not in my back yard) reaction is an anticipated community reaction that has been observed with comparatively “safe” technologies such as waste-to-energy incinerators. In time public support may be garnered but without it, these concepts are doomed to fail.

The idea of on-site waste processing faces similar public education challenges, although decentralized waste management also bears capital costs that restrict the size of markets through a limited customer base. As techniques become more proven and systemic advantages are gained further along the learning curve of modularized waste processing, decentralization may show potential for increased adoption.

Finally, my preferred solution is an organic waste collection service combined with off-site processing using an in-vessel composter. Although start-up costs associated with vermicomposting techniques are lower, in-vessel operation generates lower labour costs over time and dramatically reduces processing time, thus decreasing the length of product turnover and the sales cycle. Compared with IRM, initial capital costs are much lower but land and equipment are still significant concerns for new entrants. Scalability however, is a bigger concern and the operation must have the ability to expand capacity to reach MES and profitability! A suitable strategy would be to establish a relationship with Strata councils working with the same property management group to gain a foothold with waste collection in a series of buildings. Once a routine schedule and operational methodology were established, it could be scaled for additional properties and sectors.

In any case, competitive advantage still remains in waste processing though. Even if agreements are made with other waste haulers, the ability to control compost processing and adjust tipping fees accordingly allows for protection from other challengers. Lastly, additional revenue can be generated from the sales of locally produced compost. This would make for a charming and identifiable marketing story for a regional customer base.

Final Thoughts

There was a common theme throughout the discussion of all of the available methods of organic waste processing. Landfill is quickly becoming an antiquated method of managing many waste materials, particularly when there is value to be extracted. Whether this value is enough to generate economic rents on a consistent basis remains to be seen. This may help to explain why governments at multiple levels fund many waste management processes and various elements of the value chain. That said, the research also showed that many governments have also seen cost savings from the inclusion of private firms in waste management systems (McDavid, 1985) and that there is room for further growth of competition. It is my sincere hope that firms with the experience, conviction and entrepreneurial spirit will seize the opportunity to fill these gaps in the waste management value chain in Vancouver and divert organic waste from landfills.

Appendices

Appendix A: Materials Banned & Prohibited from Metro Vancouver Disposal Sites

The following is a list of materials that Metro Vancouver has deemed “Banned & Prohibited” at municipal disposal facilities according to the Solid Waste and Recycling section of their website (www.metrovancouver.org). This is either because there are existing programs set up for these items or the materials are hazardous to waste collection workers, the public and the environment.

Banned Materials:
Beverage containers (all except milk cartons)
Containers made of glass, metal or banned recycled plastic (1, 2, 4 & 5)
Corrugated cardboard
Green waste
Recyclable paper

Prohibited Materials:
Agricultural waste
Automobile bodies and parts
Barrels or drums in excess of 205 litres (45 gallons) whether full or empty
Biomedical waste
Dead animals
Electronics and electrical products
Excrement
Gypsum
Hazardous waste
Hospital office waste
Inert fill materials including soil, sod, gravel, concrete & asphalt (exceeding 0.5 m^3 per load)
Lead acid batteries
Liquids and sludge
Oil containers, oil filters, paint products, solvents and flammable liquids
Metal household or commercial appliances
Pesticide products
Pharmaceuticals
Radioactive and reactive waste
Refuse that is on fire, smouldering, flammable or explosive
Refuse that would cause undue risk of injury or occupational disease to any person at the disposal site that would otherwise contravene the *Occupational Health and Safety Regulations*
Tires
Any Single object weighing more than 100 kilograms or measuring more than 2 metres (in size in any direction)
Any other refuse that the Manager considers unsuitable for handling at the disposal site

Appendix B: A Definition of Zero Waste

The Zero Waste International Alliance established a definition of the "Zero Waste" concept on November 29, 2004. According to the organization, "This is intended to assist businesses and communities in defining their own goals for Zero Waste" (Zero Waste International Alliance, 2009, para. 1).

> Zero Waste is a goal that is ethical, economical, efficient and visionary, to guide people in changing their lifestyles and practices to emulate sustainable natural cycles, where all discarded materials are designed to become resources for others to use.
>
> Zero Waste means designing and managing products and processes to systematically avoid and eliminate the volume and toxicity of waste and materials, conserve and recover all resources, and not burn or bury them.
>
> Implementing Zero Waste will eliminate all discharges to land, water or air that are a threat to planetary, human, animal or plant health.

This is the goal we are striving for. Measures of success in meeting this goal are outlined in the Zero Waste Business Principles and the Global Principles for Zero Waste Communities. Businesses and communities that achieve over 90% diversion of waste from landfills and incinerators are considered to be successful in achieving Zero Waste, or darn close.

Appendix C: Governing Bodies Responsible for Municipal Services in the Greater Vancouver

Metro Vancouver manages the delivery of essential utility services, such as drinking water, sewage treatment, recycling and garbage disposal on a regional basis. Strategic and long-term objectives are met by managing and planning growth and development, while protecting ecological interests.

Metro Vancouver encompasses four separate corporate entities listed below:

1. Greater Vancouver Regional District (GVRD)
2. Greater Vancouver Sewerage & Drainage District (GVS&DD)
3. Greater Vancouver Water District (GVWD)
4. Metro Vancouver Housing Corporation (MVHC)

The GVRD consists of:

- Abbotsford (with respect to the provision of park services only)
- Anmore
- Belcarra Bowen Island
- Burnaby
- Coquitlam
- Delta
- Electoral Area A
- Langley City
- Langley Township
- Lions Bay
- Maple Ridge
- New Westminster
- North Vancouver City
- North Vancouver District
- Pitt Meadows
- Port Coquitlam
- Port Moody
- Richmond
- Surrey
- Tsawwassen
- Vancouver
- West Vancouver
- White Rock

The GVS&DD is comprised of:

- Burnaby
- Coquitlam
- Delta
- Electoral Area A
- Langley City
- Langley Township
- Maple Ridge
- New Westminster
- North Vancouver City
- North Vancouver District
- Pitt Meadows
- Port Coquitlam
- Port Moody
- Richmond
- Surrey
- Vancouver
- West Vancouver
- White Rock

The GVWD is responsible for:

- Anmore
- Burnaby
- Coquitlam
- Delta
- Electoral Area A
- Langley City
- Langley Township
- Maple Ridge
- New Westminster
- North Vancouver City
- North Vancouver District
- Pitt Meadows
- Port Coquitlam
- Port Moody
- Richmond
- Surrey
- Tsawwassen
- Vancouver
- Village of Belcarra
- West Vancouver

The GVRD is the sole shareholder of the Metro Vancouver Housing Corporation

Appendix D: Components of Municipal Waste and Their Potential Uses

The Capital Regional District (CRD) data provided was obtained from the Macaulay and Clover Point Wastewater and Marine Environment Program 2003 Annual Report, in care of Wilsenach *et al* (2003).

Item	Mass/Year (CRD Data)	As a resource
[1]**Organic Solid Waste**	Approx. 82,000 tonnes/year of wet organic waste (including sewage sludge) and 100,000 tonnes/year of dry organic waste	Wet organic waste can be diverted to a biogas digester to produce methane for vehicles. Dry organic waste can be diverted to gasification to produce electricity.
Water	99.95% 38 billion litres/year	Process water, Irrigation Creek restoration Aquifer recharging
Oil & Grease	5,000 tonnes/year	Biodiesel, biomethane for vehicles
Suspended Solids Measured directly as Total Suspended Solids		Biomethane for vehicles.

Dissolved Organic Materials	8,000 tonnes/year	Biomethane for vehicles. Synthesis gas for cogeneration.
[2]**Dissolved Salts, Minerals** E.g. Ammonia, Phosphorous, Potassium, Calcium, Nitrogen.	5,000 tonnes/year	Potential fertilizers, which can displace and reduce environmental impacts of manufactured fertilizers.
[3]**Dissolved Metals** E.g. Arsenic, Barium, Cadmium, Chromium, Copper, Cyanide, Iron, Lead, Magnesium, Manganese, Mercury, Nickel, Silver, Tin, Zinc.	200 Tonnes/year	Potential for recovery through gasification of sewage sludge.
[4]**Chemicals of Emerging Concern** This family of chemicals includes Endocrine Disrupting Compounds (EDCs) such as phthalates from landfill leachate and pharmaceuticals.		As far as possible, these chemicals must be reduced or eliminated from our environment at source, (for example, by treating leachate from the Hartland Landfill). Treatment must be designed to destroy as many of these chemicals as possible.

[5]**Heat Energy**	Approximately 2.23 million GJ/year	District heating and cooling, which can displace fossil fuels used for heating. Benefits include reduced greenhouse gas emissions and reduced air pollution. 30% of the region's homes, or 15% of the region's total building energy requirements.

[1] The volume of wet and dry organic waste is estimated by from CRD reports of the tonnes of waste received at the Hartland Landfill and CRD waste composition studies. Other volumes of dry organic waste are estimated from other sources including BC Hydro.

[2] Some of these materials occur naturally in our water supply, while others derive from commercial processes and human waste.

[3] Some of these materials occur naturally in our water supply, while others derive from piping, commercial processes, human waste, and household products.

[4] Even in minute quantities, these compounds can cause gender changes in marine life. Recent research shows that dilute doses of EDCs are more problematic than concentrated doses, and that trace levels of different EDs can cause synergistic effects which are far more harmful than individual contaminants.

[5] In winter, fresh water comes to homes in Greater Victoria at 7˚C but leaves significantly warmer. Even after dilution in the winter with water that infiltrates sewage piping, water at the existing outfalls averages 17˚C during the winter months.

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