Increasing Construction and Demolition Waste Diversion in Halifax Regional Municipality

A Dalhousie University Case Study

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Caption: Dismantling of Dalhousie house on University Avenue December 2011.

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Caption: C&D educational sign in front of Dalhousie house being deconstructed
1.0 Purpose

The purpose of this report is to investigate construction and demolition (C&D) waste management practices at Dalhousie University, in the region, and globally to recommend strategies for increasing diversion rates at Dalhousie and throughout Halifax Regional Municipality (HRM).

2.0 Executive Summary

A number of methods were used to gather data on constraints and opportunities for increased C&D waste diversion. Audits were conducted at campus workshops. Interviews were carried out with local experts. Peer-reviewed and gray literature was examined. Meetings were held with crews and data was collected and analyzed from campus construction and demolition projects. From this data, key findings were outlined (Figure 1) and recommendations created (Figure 2).

Figure 1: Summary of key report findings

- Demolition projects normally create 20 to 30 times more waste than construction projects.
- Due to the different recycling options available for clean and contaminated wood, it is often necessary to separate them. This is true of many other C&D materials.
- There are several sources of C&D waste at Dalhousie including campus workshops, new building construction, renovation projects, and the demolition of university houses and buildings.
- Campus workshops are producing C&D waste. Some is diverted through re-use, staff uses, recycling pick-up at the workshop, and by hauling material to the Dalhousie central C&D waste bin. A large % of the volume of this material is still currently ending up in the waste stream. Exact numbers of total annual weights need to be researched further.
- Space is often a limiting factor for the onsite storage of multiple bins on a construction, demolition, renovation or workshop site.
- During large renovation and maintenance projects, Dalhousie often hires a waste hauler to provide C&D waste bins and transport the resulting material to a recycling centre. Otherwise waste produced is collected with a truck by Facilities Management staff and disposed of at the general mixed C&D waste bin located at the Central Services Building.
- Extra costs are associated with moving a house that is two-stories high due to the necessity of dismantling and removing obstructions such as tree limbs and power lines.
- Additional costs were proposed to Dalhousie for coordinating waste removal and ensuring separation of waste materials on campus construction sites and during the deconstruction of houses. The owner currently has to bear additional costs to increase diversion rates beyond legislated standards in HRM. These costs are not standard as they relate primarily to labour costs projected by companies. These projected costs can be associated with a premium of 8 – 25% more than standard procedures.
- The largest weights found of a particular material stream in the LeMarchant Street house demolition project included clean wood, hazardous waste, treated wood, and asphalt shingles. Foundations were not included as part of this project.
- Some structures will have more value as a deconstruction project than others depending on the use and value of the material and products found inside.
- More labour and equipment costs were associated with deconstruction than demolition; however, there were fewer recycling and waste costs. The total costs for deconstruction were approximately 8% -15% more per square foot than demolition.
- Deconstruction achieved the highest rate of diversion of material from the landfill, although the demolition procedures also had a high rate of diversion because hazardous wastes were removed carefully creating a clean stream of remaining material. LEED targets were outlined in the RFP for this project. These drove the creation of a waste management plan, data collection, and reporting on targets.

**Figure 2. Summary of key recommendations**

<table>
<thead>
<tr>
<th>Dalhousie University (ICI organizations)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Install separate bins and signage for individual waste materials at campus workshops and create a campus depot area for five C&amp;D waste bins to hold recyclable wood, gypsum board, metal, plastic, and mixed C&amp;D waste at the CSB building or warehouse. Put a fence around the C&amp;D waste bins or use lockable bins.</td>
</tr>
<tr>
<td>2. Increase storage space for cut-offs in those workshops where it limits the potential for material reuse, particularly the Architecture Department woodworking shop and the Engineering Department concrete laboratory.</td>
</tr>
<tr>
<td>3. Increase the recycling of waste materials produced from renovation projects through on-site source separation and transportation to segregated waste bins.</td>
</tr>
<tr>
<td>4. Stipulate on-site separation and high recycling rates of 75-95% (not including landfill cover) for both aggregate and non-aggregate materials in request for proposals (RFP), tender documents, and contracts.</td>
</tr>
<tr>
<td>5. Stipulate through the request for proposals (RFP) or contract that 75-95% of the materials for which recycling opportunities exist will be separated on-site when possible.</td>
</tr>
<tr>
<td>6. Modify the University Green Building Policy with separate guidelines that require high diversion rates of 75-95% for all recyclable construction, demolition, and renovation materials.</td>
</tr>
<tr>
<td>7. Carry out random audits of projects to ensure diversion rates are being achieved.</td>
</tr>
</tbody>
</table>
### Government (HRM and the Province)

1. Increase opportunities for contractors to separate C&D materials at recycling centres.

2. Explore social and community programs that can combine deconstruction and value-added product creation to reduce the labour costs of deconstruction, create jobs, and produce local products such as flooring and furnishings from deconstructed material.

3. Encourage the development of new uses for construction waste and value-added uses for recycled demolition materials.

4. Conduct further study and research on how to change hazardous waste to non-hazardous waste through processes such as composting and mechanical trimming.

5. Outline clear provincial legislation on C&D waste that will encourage more high-value C&D use. Examples of policy drivers include:
   a. Bans at all provincial landfills on recyclable materials such as asphalt shingles, clean wood, and gypsum board.
   b. Mandate separation of material into clean streams at either the project site or a recycling centre.
   c. Require hazardous waste reports before demolition to ensure proper handling and to encourage the separation of hazardous waste from clean material.
   d. Use a tax on mixed waste and/or deposit funds to eliminate the economic advantage of producing mixed C&D waste

6. Work with the construction industry to develop specifications that allow the use of more recycled materials in road construction, paving, and other applications - for example 5% asphalt shingle grit in paving applications.

7. Consider encouraging the local manufacture of products with a recycled content through the application of a tax reduction or subsidy.

### All organizations

1. Promote and aim to minimize waste by design through retrofitting or the full or partial reuse of an existing building.

2. Promote and use pre-built building components as an effective means of reducing construction waste and assisting deconstruction activities when a building is renovated or taken down.

3. Support structure designs that incorporate standard sizes of materials or divisions of standard sizes in order to minimize cut-offs.

4. Use existing programs such as LEED to drive C&D diversion in projects.
3.0 Introduction

This report is divided into two sections. Section four provides information on C&D waste production at Dalhousie University and suggests recommendations for increasing reuse and recycling rates for these material streams on campus. Section five discusses current constraints and challenges to C&D waste recycling within HRM and provides recommendations for overcoming these obstacles.

The term ‘construction and demolition waste’, or ‘C&D waste’ is commonly used to describe a large number of waste materials generated from the construction and demolition of buildings and civil infrastructure. This includes materials such as:

- aggregates (concrete, bricks, asphalt, ceramics);
- asphalt shingles;
- clean wood (sawn lumber to which glues, resins, plastics or other materials have not been added);
- contaminated wood or dirty wood (engineered wood products to which glues and resins have been added such as plywood, particle board and laminated wood products as well as wood products with paints or stains applied to them);
- treated wood (infused with metals or chemicals such as coal tar creosote and chromate copper arsenate (CCA) to preserve the wood against mold and rot);
- gypsum board;
- ceiling tiles;
- insulation;
- carpet;
- glass;
- plaster;
- metals;
- plastics.

While many waste materials from these projects are the same, the quantities produced will vary greatly with demolition projects normally creating 20 to 30 times more waste than construction projects (Recycling Council of Ontario, 2006). In addition, construction waste consists primarily of offcuts from new construction materials while many demolition waste materials are worn and have been painted, fastened together or otherwise modified from their original state.

In much of the world, it has until recently been cheapest and most convenient to landfill all C&D waste. However, within the last two decades, many regions have seen the development of several factors which combined together have made the land-filling of C&D waste less desirable. These factors include the arrival of many current landfills at full capacity, the high cost of building landfills with adequate
environmental protection, public resistance to the construction of new landfills and an increased interest in reducing demand for natural resources while creating a sustainable construction industry. Together, these factors have prompted many governments and municipalities to find ways to encourage the reuse and recycling of C&D waste. Europe has led the way, with countries such as Belgium, Denmark and the Netherlands recycling more than 80% of their C&D waste by the late 1990s (Symonds & Associates, 1999). Progress has also been made recently in Canadian provinces such as Nova Scotia, where the Halifax Regional Municipality has a bylaw requiring that 75% of C&D waste is diverted from the landfill.

There are a variety of construction materials made out of wood and not all of them are easily recyclable. Increasingly, dimensional lumber (often called ‘clean wood’) is being replaced by engineered wood products (described as ‘contaminated wood’) including plywood, fiberboard and laminated framing components. Engineered wood products can be difficult to recycle due to the glues and resins they contain. Direct reuse, energy recovery and the use of engineered wood products in composts appear to be the most common options for recycling these products. If nails and other metal objects are removed, dimensional lumber can be recycled into a variety of additional products including mulch, wood pellets, particle board and wood flour. Due to the different recycling options available for clean and contaminated wood materials, it is often necessary to separate them. Wood products that have been treated with coal tar creosote or chromated copper arsenate for resistance to rot and insects cannot be recycled and must be disposed of as a hazardous waste. Therefore, the careful separation of wood waste is often necessary before these materials can be recycled.

### 4.0 Construction and Demolition at Dalhousie University

There are several sources of construction and demolition waste at Dalhousie University (Figure 3). At least ten campus workshops produce small amounts of construction waste throughout the year. In addition, larger volumes of construction waste are produced during the construction of new buildings and renovations on campus. Demolition waste is produced through renovation projects and building and house removal. While renovation projects are usually smaller than construction and demolition projects in size, they often produce significantly more waste than construction projects. A study by Franklin Associates (1998) found that renovation activities accounted for 44% of the C&D waste produced in the United States in 1996, while construction activities accounted for just 8%. Renovation activities at Dalhousie University include reroofing, the remodelling of older buildings and furniture replacement. The university also conducts demolition of existing buildings and houses to prepare sites for new construction.
Figure 3: Sources of C&D waste at Dalhousie University

4.1 Methods: Audits, interviews, meetings, correspondence and report review.

Through this study, data was gathered on a number of projects and activities at Dalhousie University and other institutions in North America.

1. **Campus Workshops Audits (construction waste):** Interviews and audits were conducted at many of the workshops on campus between July 15’th and September 15’th to gather information on the waste being produced at these locations as well as the current challenges to recycling this waste (Appendix A).

2. **Interviews (construction and demolition waste):** Valuable information was gathered through interviews with ten experts knowledgeable of constraints and opportunities for reducing, reusing, and recycling C&D waste in HRM.

3. **Meetings and Correspondence (construction and demolition waste):** took place with construction staff on a new construction site at Dalhousie (The Ocean’s Excellence Centre); LEED consultants, construction managers, demolition staff on the LeMarchant Street demolition project; facilities staff at Dalhousie University; and staff at Cornell and Rutgers University who provided insight into C&D waste recycling practices.

4. **LeMarchant Street Audit (demolition waste):** Four houses were demolished as part of a Leadership Energy and Environmental Design (LEED) building project on the Dalhousie campus. Detailed tender documents were created to request bids on three options: relocation, demolition (target of at least 75% diversion of material from the landfill), and deconstruction.
(90% or more diversion from the landfill) (Appendix B – p.27). Detailed tracking of materials was requested for the LEED process using a Material Tracking Sheet. Additional information was collected for this study including the weight and quantity of hazardous waste, salvaged material, labour costs, and time.

5. **Report Review (demolition waste):** existing reports prepared for Dalhousie University on house relocation were reviewed.

### 4.2 Findings: Construction Waste

#### 4.2.1 Workshops

While the total amount of construction waste produced at Dalhousie’s workshops each week is small, waste production from these sources is constant and becomes significant as it accumulates during the course of a year. Since only one audit was conducted at each workshop, it is beyond the scope of this study to determine precisely the volumes of C&D waste produced at Dalhousie’s workshops. However, the waste audits provided information on the specific waste materials being produced at each location (see Tables 1 & 2, p.16). The workshop interviews provided further information on the C&D waste materials commonly disposed of and constraints related to sorting and storing the sorted materials.

The workshop interviews and audits indicate that the volume of waste produced at each workshop varies significantly depending on the type of work undertaken and the space available to store cut-offs for future use. For example, Dalhousie’s Chemistry and Physics machine shops which specialize in precision tooling produce much less waste material than the Arts Centre workshop, which builds stage sets for the Theatre Department. In addition, the Chemistry and Physics workshops each have a large area available for storing cut-offs, which allows staff to save pieces of scrap wood, metal and plastic that are large enough to be used in future projects. While the central services building (CSB) woodworking shop and the Arts Centre workshop also have some storage space available for cut-offs, the Architecture woodworking shop and the Concrete laboratory have very limited storage space. Storage space at the Architecture workshop is particularly limited, consisting of a 6x8 foot closet that is 4 feet deep. The Architecture workshop staff stated that the idea of setting up a permanent exterior storage container to create additional space for off-cuts has been discussed. Many of the staff interviewed at the workshops indicated that increasing their ability to store cut-offs for future use could significantly reduce the volumes of construction waste produced.

Currently, construction waste from many of Dalhousie’s workshops is being disposed of in campus dumpsters. This seems to occur because the dumpsters are conveniently located across the campus while no system is in place for transporting this waste to the single general C&D waste bin located at the central services building (CSB). It appears that some workshops produce significantly more
construction waste than others, although this research project was not able to define the waste volumes precisely. Research conducted for this report suggests that the concrete laboratory and the Arts Centre workshop produce the highest weights and volumes of construction waste, followed by the Architecture and CSB woodworking shops. The Oceanography and Psychology workshops appear to produce less waste than the preceding workshops, but more than the Chemistry and Physics machine shops. The specific waste streams produced at these workshops are described below.

**Architecture Woodworking Shop**
The Architecture woodworking shop produces a significant amount of wood waste. Staff estimated that 100-150 Lbs of clean and engineered wood waste is generated each week and indicated that this volume could be significantly reduced if more storage space was available for cut-offs. Current storage space for cut-offs is very limited considering the number of students who use this workshop, and consists of a 6 X 8 foot closet that is four feet deep. A recycling bin for wood waste has been installed at this shop to allow for the separate collection of this material. Since there is not currently a campus-wide system for recycling this material; however, the collected wood waste is deposited in the mixed C&D waste bin at the CSB building. Approximately 50Lbs of sawdust is created per week. This is collected by a vacuum system and disposed of by facilities management staff as organic waste. Very little other C&D waste is produced at this workshop. Small amounts of plastic waste including plexiglass and plastic packaging accumulate. Metal waste from a metalworking shop within the Architecture building is also combined with mixed C&D waste from the woodworking shop. The mixed C&D waste is disposed of in campus dumpsters.

**Arts Centre Workshop**
The Arts Centre workshop has its own bin for mixed C&D waste due to the high volumes of waste produced there. Most of the C&D waste is produced through constructing and dismantling theatre sets. While efforts are being made to find second homes for the theatre sets by donating them to schools and the Habitat for Humanity organization, there is a limited demand for these sets and many
of them must be disposed of. The most common waste materials at the Arts Centre workshop are 3/4" plywood and pine framing, although these materials are reused when possible. Other common waste materials are plaster and various polystyrene foams. All C&D waste is collected in metal barrels equipped with wheels which are emptied into the Arts Centre mixed C&D waste bin when full. Sawdust produced here is collected with a vacuum system and disposed of in the C&D waste bin.

The mixed C&D waste bin at the Arts Centre workshop is emptied by a waste hauler when full. Workshop staff estimated that on average, this bin is emptied every two weeks. However, it may fill up more quickly at the end of each semester as school projects are finished. Receipts from the waste hauler show that in April and May 2011, this C&D bin was emptied five times. The total amount of C&D waste removed from this bin during the two months was 1,920 Kg and the average weight of each load was approximately 400 Kg.

Central Services building (CSB) Woodworking Shop
This woodworking shop is used by Facilities Management staff. The primary waste materials produced are engineered and clean wood cut-offs, sawdust, and wood shavings. Sawdust is collected by a Power Vac. vacuum system and disposed of by Power Vac. staff. Small amounts of metal waste are produced at this workshop including aluminum scrap and a little steel. This is disposed of in the CSB mixed C&D waste bin. Plexiglas and glass waste are occasionally produced, but amounts are minimal. Polyethylene packaging waste from this workshop is also deposited in the nearby C&D waste bin.

Chemistry Machine Shop
The workshop in the chemistry building constructs and repairs equipment used for chemistry experiments. This workshop primarily conducts small-scale precision tooling which limits the volume of waste produced. There is also a separate storage room available which allows a large number of cut-offs to be saved for future use. The construction waste disposed of consists of small pieces of engineered wood, metal shavings, plastic shavings and occasionally polystyrene foam packaging. The construction waste materials are disposed of in campus dumpsters. Due to the nature of the work undertaken here and the space available for storing cut-offs, the Chemistry machine shop produces very little C&D waste.

Concrete Laboratory
The concrete laboratory at Dalhousie University creates significant volumes of waste concrete and other construction waste. This laboratory conducts research on the use of fiber reinforced concrete and green concrete technologies in structural applications. Research activities produce concrete waste which is stockpiled by the main entrance to the workshop and periodically picked up by Ocean Contractors Ltd for recycling. When the waste concrete pile was audited, several other materials were found including scrap metal, wood, plastics and electronic waste. Engineered wood is used to create
the concrete forms and this is disposed of in campus dumpsters. Due to an increase in the number of students using the concrete laboratory, storage space is currently very limited. For this reason, wooden concrete formwork is usually thrown out after one use resulting in higher waste volumes than in the past. An increase in available storage space could reduce the large volume of engineered wood currently disposed of. Metal waste is also produced at the concrete laboratory. While larger metal scrap is stored indoors and recycled, small pieces of metal are often disposed of in campus dumpsters.

Oceanography Workshop
The oceanography workshop builds equipment for research conducted at the Oceanography Department. This workshop produces a wide variety of construction waste materials, including clean wood, engineered wood, several kinds of plastic and metal waste. Plastics used include acrylic, PVC, polycarbonate, polyethylene, fibreglass, and delron. Staff indicated that limited storage space for cut-offs makes it difficult to reduce the construction waste produced. More storage space could be created if the space was organized differently. Additional storage space would be useful for clean and engineered wood scraps and plastic scraps. Staff indicated that most metal scrap is reused by the Aquatron welding shop and that engineered wood and polyethylene are the most common waste materials produced. All disposed construction waste is deposited in campus dumpsters.

Physics Machine Shop
This workshop is quite similar to the chemistry workshop in that it primarily conducts precision machine tooling. Since the physics machine shop has a large separate room for storing cut-offs, the volume of waste produced here is minimized. Due perhaps to the storage space available to them, the
Physics machine shop staff are very careful to store any cut-offs that could possibly be used in the future. Because of the nature of the work conducted here and the space available to store cut-offs, minimal amounts of waste are produced at this workshop. Approximately 100 Kg of metal shavings are disposed of annually in campus dumpsters. Small plastic and metal scraps are also deposited in these dumpsters.

**Psychology Workshop**

The psychology workshop is used for a variety of tasks including the construction of shelves and cabinets for the Life Sciences building. The most significant waste material produced here is engineered wood, of which the majority is most likely melamine board, a composite wood board with a plastic veneer. Much of the engineered wood waste is produced through the construction of shelves and cabinets. Significant amounts of acrylic material are also disposed of at this workshop. Very little metal waste is produced here. Staff indicated that cut-offs are being used when possible. All C&D waste that is not saved (including sawdust) is disposed of in campus dumpsters. Staff mentioned they are willing to separate all recyclable construction waste produced at this workshop to increase diversion rates.

**Tables 1 & 2. Results of Dalhousie workshop audits**

* The weights shown are the contents of an average garbage can in each workshop, except for the concrete laboratory where the waste concrete pile was audited instead

* The Physics Department workshop has been omitted from these tables since an audit was not performed at this location

<table>
<thead>
<tr>
<th>Workshops</th>
<th>Clean Wood</th>
<th>Engineered Wood</th>
<th>Treated Wood</th>
<th>Metals</th>
<th>Plastics</th>
</tr>
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<tbody>
<tr>
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<tr>
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<td>gravel (weight unmeasured)</td>
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<tr>
<td>Total Weights (kilos)</td>
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</table>
4.2.2 Interviews, Meetings, and Correspondence

Since the 1990s, new structures at Dalhousie University have met higher construction standards as well as increasingly stringent guidelines for energy and water consumption. By the end of the last decade, Dalhousie had begun to seek Leadership in Energy and Environmental Design (LEED) certification for new construction projects. LEED is a green building rating system that promotes a whole-building approach to sustainability by recognizing building performance as it relates to a variety of environmental and human health impacts (Canada Green Building Council, 2012). There are four LEED certification standards including Silver, Gold, and Platinum which signify increasing levels of environmental performance. Dalhousie’s new Mona Campbell building and Life Sciences Research Institute have been designed and built to meet LEED Gold and LEED Silver standards respectively. In 2011, Dalhousie increased its commitment to sustainable construction by adopting a sustainable building policy which requires that all major building projects ( >10,000 gross sq ft) completed after 2011 be constructed to meet LEED Gold standards. The University is also setting standards for “green building design and operations in all renovation projects...from retrofits of interior building spaces and houses to major buildings.” (Dalhousie University, 2011, p. 1).

While the LEED certification process places a value on the recycling of construction and demolition wastes, the fact that both waste streams are combined during the evaluation process can actually reduce a building owner’s incentive to recycle certain materials. This situation can occur when the demolition process results in large amounts of rubble and waste diversion is tracked by weight. In this case the immense weight of the demolished concrete, brick and other rubble can ensure that C&D waste recycling rates appear to be high even if few other construction and demolition waste materials are recycled. This situation seems to have occurred during the construction of the Mona Campbell building. In this case the recycling of large volumes of demolition rubble ensured that overall recycling rates remained high even though all construction waste was sent to a recycling facility as mixed waste (A. Merrick, personal communication, February 10, 2012). With the LEED Canada Green Building Rating System, points are awarded for achievement in several categories including waste reduction and recycling. Currently, one point is awarded for recycling 50% of the waste produced during a project and two points are earned for a 75% recycling rate (Canada Green Building Council, 2010). It should be noted that the LEED rating system is flexible and recycled waste can be measured in either weight or volume. Depending on the certification level sought, it may also be possible to avoid earning points for waste recycling if these points can be earned in other categories. Suggestions are made in the discussion section on steps Dalhousie can take to ensure that a high percentage of all C&D waste is recycled during LEED projects.
Meetings and interviews with Dalhousie construction staff and local waste management experts revealed a number of key findings. To reach higher diversion rates, separating material into clean streams is important as potential reuse and recycling methods are often confined to a single waste material and do not tolerate high contamination rates (Jeffrey, 2011). As trades staff install items on a construction site excess material is often left on the ground and cleaned up after the job has been completed. There can be between five and fifteen trades groups on site at a given time. All material is usually collected together creating a co-mingled pile. To remove waste from the upper levels of a building, chute systems are connected to the building structure. Co-mingled material is often dumped into a mixed-load dumpster. On-site source separation of waste materials requires additional labour, multiple bins, careful management, and entails a higher cost than mixed waste disposal. An effective management plan for separating and removing construction waste in a cost effective manner must be developed according to the particular constraints of each project. A lack of space for multiple waste bins containing separated materials is a common constraint during urban construction projects. When space is limited, on-site waste separation becomes more complex as single material bins must be brought on site in rotation and multiple methods for collecting and disposing of separated waste may need to be adopted.

On a construction site, the source separation of waste materials for recycling purposes is normally proposed as an additional cost to the owner as it is cheaper for construction companies to send mixed C&D loads to a recycling centre due to the extra labour costs associated with onsite sorting and similar tipping fees for sorted and mixed waste. Some informants suggested that C&D recycling be coordinated by the Construction Manager instead of being left to each trades group. This coordination activity would be outlined as a separate cost to the owner. On-site source separation of C&D waste and the achievement of recycling rates above 50% currently entail substantial additional costs to the owner in HRM. However, these additional costs in comparison to standard waste management practices could be reduced or eliminated by creating a larger difference in tipping fees for sorted and mixed waste and by developing recycling industries that accept sorted C&D waste and allow contractors to avoid tipping fees altogether.

4.3 Findings: Demolition Waste

4.3.1 Renovation and maintenance

Renovation projects take place almost every day at Dalhousie University. Most of these projects are small-scale, and the waste produced is collected with a truck by Facilities Management staff and disposed of at the general mixed C&D waste bin located at the Central Services Building. Maintenance projects vary from repainting the exterior of a wooden house on campus to reroofing a large academic building. Other renovation projects include replacing the flooring of a wooden porch, remodelling a
laboratory and renovating a campus dormitory. Given the diversity found among renovation and maintenance projects, it is not surprising that a wide variety of waste materials are produced. Waste materials can vary from painted shingles, old lumber and gypsum board to light fixtures, used appliances and paint cans. During large renovation and maintenance projects Dalhousie often hires a waste hauler to provide C&D waste bins and transport the resulting waste to a recycling centre.

4.3.2 Surplus equipment and furniture

At large institutions such as Dalhousie University, surplus equipment and furnishings (hereafter termed material) are continually being replaced. While a significant portion of this waste stream used to be disposed of at C&D recycling centres, Dalhousie has recently organized a process where surplus material at one university department is sold to other departments or the general public. Pictures of the material are posted on the Dalhousie Procurement Department’s webpage and university faculty, staff and the general public can bid on each item. Preference is given to university bids in order to reuse materials on campus when possible. All university departments are required to notify the procurement department when they wish to dispose of unwanted material to facilitate the reuse of these items. While it is probable that some unwanted furniture is disposed of improperly, particularly during spring cleanups when mixed waste dumpsters are provided, this process has been highly successful at diverting used furniture and equipment from disposal. It is estimated that approximately 95% of the unwanted material the Procurement Department becomes aware of finds a second home. Broken furniture is not normally reused since Dalhousie does not currently have the resources to repair these items. Although the percentage of unwanted furniture that is broken appears to be small, it may be worthwhile to develop opportunities for fixing easily repairable items on campus.

Dalhousie University completed a substantial renewal of residence furniture during the past five years. Approximately 2,000 bedroom sets that were 30-60 years old have been replaced with new furniture. During this process, Dalhousie sought out opportunities to reuse the furniture that was being replaced by donating it to furniture banks and offering it free of charge to Dalhousie faculty and staff as well as the general public. Unwanted furniture was only advertised through the university’s online news service, but reached a wider audience by word-of-mouth. The new furniture installed in the residences is made of easily recyclable solid wood and metal. This furniture is designed so that each part can be replaced individually to avoid the replacement of whole items due to breakage.

4.3.3 Report: House Reuse

A report was conducted for Dalhousie University in 2010 on the feasibility of relocating one of the University owned houses (1234 LeMarchant) to another site on campus. The two-story house was 2458 square feet. Total costs to relocate the house three blocks away on another campus lot was priced at over three times the cost of a demolition project at well over $300,000. This did not include
the costs of renovations. Costs were associated with the existing location, the move, and the new location (Figure 4).

<table>
<thead>
<tr>
<th>Existing Lot</th>
<th>The Move</th>
<th>New Location and Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazardous assessment and contaminated soil remediation</td>
<td>Disconnect power lines</td>
<td>New foundation structure and supports</td>
</tr>
<tr>
<td>Separate the building into two halves</td>
<td>Move house</td>
<td>Reassemble house</td>
</tr>
<tr>
<td>Disconnect services</td>
<td>Municipal services (traffic control) and permits</td>
<td>Landscaping</td>
</tr>
<tr>
<td>Remove trees, chimneys, basements, ...</td>
<td>Landscaping</td>
<td>Design fees</td>
</tr>
<tr>
<td>Load house onto flat bed</td>
<td></td>
<td>Contingency fees</td>
</tr>
<tr>
<td>Landscaping</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 4.** Cost factors of relocating a two-story campus house.

Extra costs are associated with moving a house that is two or more stories in height is due to the height of power lines and dismantling complexities. Discussion with Holland College Facilities staff in PEI revealed similar findings. Staff posted an ad in the local paper to provide campus houses to any group free of charge. One story houses were removed and relocated for free by outside individuals/companies. Two-story houses were not taken and the university ended up demolishing these structures.

The relocation project planned for 1234 LeMarchant did not move ahead and the house became part of the LeMarchant St. demolition project.

### 4.3.4 LeMarchant Street Demolition Project

Four houses were taken down between November 2011 and February 2012 and will be replaced by a new mixed-use residence building. This project is registered as a LEED project; therefore 75% of the demolition waste was targeted for diversion from use as landfill cover or storage in a landfill. In addition to the LEED target, special efforts were made to study strategies that would create more jobs while achieving higher rates of diversion.

In October 2011, a tender package was released with specific bidding options for the four houses including Option A - relocation, Option B - demolition, and Option C – deconstruction (Appendix B). It was required to provide a bid price for one of the houses (1220 LeMarchant St. for deconstruction). No company provided a bid price for Option A – relocation, likely due to the factors outlined in Section 4.3.3. The quote for Option C-deconstruction was bid at approximately 20% higher than Option B -
demolition. The project moved forward with the demolition of three houses and deconstruction of the fourth house.

The LEED consultants involved in this research project played a valuable role in convening meetings to gather and double-check tracking forms and data. Additionally, they collected data for aspects of this study that fell outside the normal LEED process such as figures on labour and hazardous waste. As a result of this project, tender documents for future demolition on campus were modified and strengthened. Modifications were also made to the Materials Tracking Form (Appendix C).

Three of the four houses were demolished and the fourth house was deconstructed. Combined averages from the three demolished houses were compared to findings from the deconstructed house. Key findings include:

- Deconstruction achieved the highest rate of diversion of material from the landfill at 90% diversion excluding hazardous waste as part of the total weight or 93% diversion including hazardous waste as part of the total (Figure 3).
- The demolition option also achieved a high rate of diversion at 84% excluding hazardous waste as part of the total weight or 86% diversion including hazardous waste as part of the total. One driving factor for this high rate of diversion in the demolition of the three houses was the identification of hazardous waste. Dalhousie provides a hazardous waste report to contractors. All houses had some areas with lead paint and asbestos. Over 30% of the total weight of the house material was treated as hazardous. The care taken to remove hazardous material cleanly meant that most demolition materials were removed separately (Figure 5). Thus the clean wood framing was able to be used by Brooklyn Power for heat generation. If the lead painted wood and clean wood had been co-mingled the material would have been used for landfill cover only and would not have met LEED credits.
- The difference between the demolition option and deconstruction with this project was the hand separation of the wooden frame versus knocking it down with an excavator. This high diversion rate for the demolition option may not be achieved in other projects if there is no hazardous waste in the house or building. In addition, high diversion rates may not be met if a structure containing hazardous material is torn down in such a way that all material is co-mingled and brought to a hazardous site. Moderate tipping fees at hazardous waste landfills could encourage contractors to co-mingle loads of hazardous and non-hazardous material in order to save labour costs and time.
Figure 5. Comparison of diversion weight between deconstruction and demolition.

<table>
<thead>
<tr>
<th></th>
<th>Salvaged</th>
<th>Recycled</th>
<th>Hazardous Waste</th>
<th>Solid Waste</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deconstruction</td>
<td>5,875</td>
<td>25,303</td>
<td>15,120</td>
<td>3455</td>
</tr>
<tr>
<td>Demolition</td>
<td>1,542</td>
<td>38,369</td>
<td>15,120</td>
<td>7439</td>
</tr>
</tbody>
</table>

Figure 6. 1234 LeMarchant St. Dalhousie University being prepared for demolition December, 2011.
• Costs and revenues associated with deconstruction versus demolition the houses on LeMarchant Street were collected (Figure 7). Revenue associated with the both houses related to salvage of material including items like metal radiators, window, doors and railings. In addition, in the deconstructed house more wooden 2 X 4s were salvaged (Figure 11). In total the average amount of money associated salvage revenue was minimal. This figure may change depending on the value of material in the structure. For the house that was deconstructed, there were less tipping fee costs as the material was more separated though labour and equipment costs were higher due to the time needed to separate the material. An extra week or two of work was provided to the crew. Hazardous waste costs were the same per house as material amounts were similar. The total costs per house were approximately 8% higher for deconstruction though diversion rates were higher and employment longer (Figure 7). The extra time needed for deconstruction maybe become an issue due to the nature of timelines for building projects though in this case the extra time for deconstruction for this project was roughly a week.

• The demolition and deconstruction projects saw a similar dollar return on salvaged items although during the deconstruction project more material was salvaged for reuse by weight (Figure 8 & 9).

<table>
<thead>
<tr>
<th>Square feet</th>
<th>Costs/Revenue</th>
<th>Treated wood</th>
<th>Salvage waste (per kg)</th>
<th>Recycled material (per kg) 65-68 cents</th>
<th>Blended labour (per hour approx.) $42</th>
<th>Equipment</th>
<th>Hazardous Waste – 55 cents per kg</th>
<th>Costs per house</th>
<th>Costs per kg</th>
<th>Total kgs</th>
<th>Costs per square foot</th>
</tr>
</thead>
<tbody>
<tr>
<td>2380</td>
<td>Decon.</td>
<td>$ -</td>
<td>$ 363</td>
<td>$ 1,043</td>
<td>$ 17,123</td>
<td>$ 54,726</td>
<td>$ 7,840</td>
<td>$ 8,325</td>
<td>$ 86,971</td>
<td>$ 1.75</td>
<td>49741</td>
</tr>
<tr>
<td>3307</td>
<td>Demo.</td>
<td>$ 184</td>
<td>$ 613</td>
<td>$ 1,187</td>
<td>$ 24,857</td>
<td>$ 43,191</td>
<td>$ 3,987</td>
<td>$ 8,325</td>
<td>$ 79,971</td>
<td>$ 1.28</td>
<td>62471</td>
</tr>
</tbody>
</table>

Figure 7. Costs and Revenue associated with deconstruction and demolition of LeMarchant St houses.
Some structures will have more value as a deconstruction project than others depending on the potential uses and value of the materials and products found inside. In this case study, there were some wide boards found closer to the foundation but nothing of significant worth on today’s market (Figure 10).
The material streams with the highest weights included clean wood, hazardous waste, treated wood, and asphalt shingles (Figure 11).

Clean wood from both the deconstruction and demolition projects was primarily recycled for energy generation although wooden 2x4’s from the deconstruction project were re-used.
<table>
<thead>
<tr>
<th>Materials (in Kgs)</th>
<th>Deconstructed</th>
<th>Demolished</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wooden 2x4’s</td>
<td>5000</td>
<td>0</td>
</tr>
<tr>
<td>Base Boards</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Railings</td>
<td>25</td>
<td>0</td>
</tr>
<tr>
<td>Trim Cabinets</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>Doors</td>
<td>150</td>
<td>167</td>
</tr>
<tr>
<td>Windows</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Drywall</td>
<td>0</td>
<td>62</td>
</tr>
<tr>
<td>Furnishing</td>
<td>500</td>
<td>901</td>
</tr>
<tr>
<td>Plumbing Fixtures &amp; Trim</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Hot water heaters</td>
<td>0</td>
<td>83</td>
</tr>
<tr>
<td>Boilers and burners</td>
<td>0</td>
<td>250</td>
</tr>
<tr>
<td>Cast Iron Radiation</td>
<td>100</td>
<td>300</td>
</tr>
<tr>
<td>Electric Baseboard</td>
<td>12.5</td>
<td>17</td>
</tr>
<tr>
<td>Clean Wood</td>
<td>23000</td>
<td>33109</td>
</tr>
<tr>
<td>Metals</td>
<td>173</td>
<td>1958</td>
</tr>
<tr>
<td>Asphalt Shingles</td>
<td>1930</td>
<td>2638</td>
</tr>
<tr>
<td>Plastic Packaging</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Cardboard</td>
<td>0</td>
<td>116</td>
</tr>
<tr>
<td>Recyclables</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Paper</td>
<td>0</td>
<td>21</td>
</tr>
<tr>
<td>Waste</td>
<td>0</td>
<td>1791</td>
</tr>
<tr>
<td>Waste - Treated Wood</td>
<td>3455</td>
<td>5648</td>
</tr>
<tr>
<td>Hazardous Waste -</td>
<td>15120</td>
<td>15120</td>
</tr>
</tbody>
</table>

**Figure 11.** Kilograms of salvaged, recycled and waste materials for demolition and deconstruction.

**Key:** Yellow = salvaged, blue = recycled, black = waste

**Note.** Foundations were not included in this demolition project, but will be incorporated for onsite fill during construction. Some furnishings and radiators from the houses were reused by Dalhousie before the demolition project started so true salvage weights could have been higher.
Figure 12. Removal of asphalt shingles on LeMarchant deconstruction project (1220 LeMarchant).
4.4 Expert Interviews: Construction and Demolition waste at Dalhousie

During the expert interviews, participants were asked two questions about the reduction, reuse, and recycling of C&D waste at Dalhousie University. The two questions used and the answers received are presented below. It should be noted that some participants provided more than one comment per question while others did not provide any comments.
**Question 10.** What are the challenges to sorting and storing sorted C&D waste materials at Dalhousie University?

<table>
<thead>
<tr>
<th>Number of Experts</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Limited space for separate recycling bins and the sorting of materials</td>
</tr>
<tr>
<td>4</td>
<td>No Comments</td>
</tr>
<tr>
<td>3</td>
<td>Cost involved (due to time and labour required) is a challenge</td>
</tr>
<tr>
<td>1</td>
<td>Restrictions on using low-cost labour</td>
</tr>
<tr>
<td>1</td>
<td>Greater recognition of the importance of sorting is needed</td>
</tr>
<tr>
<td>1</td>
<td>Waste stored in unlocked dumpsters is a public hazard</td>
</tr>
</tbody>
</table>

**Question 11.** What other challenges or restrictions currently limit the reduction, reuse and recycling of C&D waste at Dalhousie University?

<table>
<thead>
<tr>
<th>Number of Participants</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>No Comments</td>
</tr>
<tr>
<td>3</td>
<td>University policies do not encourage C&amp;D waste recycling</td>
</tr>
<tr>
<td>2</td>
<td>Better knowledge of recycling markets is needed</td>
</tr>
<tr>
<td>1</td>
<td>Increasing C&amp;D waste recycling rates requires a commitment from Dalhousie</td>
</tr>
<tr>
<td>1</td>
<td>Careful collaboration is needed between everyone involved with C&amp;D waste production and its management at Dalhousie</td>
</tr>
</tbody>
</table>

**4.5 Discussion and Recommendations**

A key recommendation for increasing the recycling of construction and renovation waste at Dalhousie is the instalment of separate bins for individual materials. If Dalhousie’s C&D waste continues to be collected as mixed waste, recycling rates for these materials will not increase. This is due to the fact that recycling centres within HRM do not normally have the capacity to thoroughly sort the mixed waste that they receive (see section 2 of this report). C&D materials that remain unsorted become landfill cover, a low value form of diversion that does not encourage further development of a recycling industry in Nova Scotia. This report strongly recommends that space is made available on campus for five permanent C&D waste bins to hold recyclable wood, gypsum board, metal, plastic, and mixed C&D waste. While there is not currently an opportunity for recycling C&D plastic waste other than polyethylene packaging wrap, the Halifax C&D Recycling Centre has begun construction of a facility that is designed to recycle C&D plastic waste (D. Chassie, personal communication, February 2, 2012). Therefore, the separation of plastic materials should be planned for.

Since space is very limited on campus, it is suggested that small bins are used and emptied more frequently. Some waste materials such as metal are not as common as others, and the separate bins can be sized according to the volume of material produced. The largest C&D waste bin could continue to be placed at the CSB building, with the other bins placed together where space permits. If multiple
C&D waste bins are used, the risks associated with allowing public access to the bins must be considered. Perhaps most important is the risk that Dalhousie University could be liable if someone climbs into a bin and is injured. Other considerations are that members of the public may dump unwanted waste into accessible bins and that valuable waste materials such as metals may be removed. To prevent these occurrences, it is recommended that Dalhousie University constructs a fence around the C&D waste bins or uses lockable bins. Combination locks could be used to ensure that the locked bins are easily accessible to all staff members.

4.5.1 Workshops

In order to increase the recycling of construction waste produced at Dalhousie’s workshops, waste materials should be placed in separate containers within each workshop before being taken to separate recycling bins. Since none of the workshops produce gypsum board waste, this would result in the use of up to four containers within each workshop. Recycling containers could replace the multiple garbage cans that are used today. The use of wood shavings and sawdust produced at Dalhousie in campus landscaping and composting applications should receive further evaluation and be adopted if practical. Metal and plastic shavings should also be recycled if markets exist.

Separated waste could be picked up weekly by Dalhousie staff and be taken to the permanent C&D waste bins. The system could work in a very similar way to cardboard recycling on campus. Cardboard is currently collected in all campus buildings and deposited at pick-up locations. Facilities Management staff then pick up the cardboard daily using a three-ton truck. Wheeled plastic waste bins have been successfully used at other universities for collecting separated construction waste. If this strategy is adopted, a truck with a tailgate hydraulic lift would be very useful for facilitating the dumping of each wheeled bin. The truck could contain plywood dividing walls to keep each waste material separate from the others.

The waste audits conducted at Dalhousie’s workshops indicate that C&D waste is currently contaminated by small amounts of municipal waste such as plastic food and beverage containers. A greater effort should be made at each workshop to ensure that such waste is not disposed of in construction waste containers since the contamination of separated waste increases the cost and difficulty of recycling each material.

Finally, several of Dalhousie’s workshops could significantly reduce their volume of construction waste if more storage space was made available for cut-offs. The Architecture Department woodworking shop and the Engineering Department concrete laboratory appear to have the greatest need for increased storage space. Since these workshops are close together a shared storage area could possibly be used. The Oceanography and Arts Centre workshops also indicated that finding increased storage space for cut-offs would reduce their waste volumes.
4.5.2 Construction and Demolition Projects

Through its commitment to LEED Gold certification for all new major construction projects Dalhousie University is increasing its commitment to recycling C&D waste. However, due to the flexibility of the LEED Canada rating system and the possibility that demolition aggregate recycling can discourage the recycling of other materials, it is recommended that Dalhousie University take further steps to guarantee high recycling rates for both construction and demolition materials during its construction projects. Two possible procedures for accomplishing this are outlined below.

- Stipulate on site separation and high recycling rates of 75-90% for both aggregate and non-aggregate materials in each request for proposals (RFP) or contract.

- Stipulate through the request for proposals (RFP) or contract that 75-90% of each material for which recycling opportunities exist will be separated on-site and recycled

Since Dalhousie University is located in a dense urban area, there is very limited space for waste bins at its building sites. Therefore, it is often difficult to have several waste bins for separated materials on a project site simultaneously. In these cases, a rotational system could be set up where bins for specific waste materials are placed on-site according to the waste currently being produced. Bin sizes should be chosen carefully and the potential to use bins with segregated compartments should be evaluated. Other options are that permanent bins are provided for the two highest volume materials while additional materials are hauled to a recycling centre once a significant volume has accumulated and that small volumes of material are taken to Dalhousie’s general segregated C&D waste bins.

It is recommended that Dalhousie University modifies its Sustainable Building Policy to include a commitment to recycle high percentages of both aggregate and non-aggregate C&D waste materials. Since the reuse of existing materials saves more energy and resources than recycling, opportunities to salvage and reuse or donate materials arising from campus renovation and demolition activities should be actively pursued.

4.5.3 Renovation Projects

In order to increase the recycling of waste materials produced from renovation projects, more materials will need to be separated on the job site. It is proposed that waste from small renovation projects is sorted on-site and trucked to new permanent C&D waste bins for separated materials. In this case, recyclable wood, metal, gypsum board and possibly plastics would be separated from other C&D waste produced during each project. Renovation projects often combine demolition and construction processes which results in a large variety of waste materials. For example, old painted shingles may be replaced on one of the campus houses. In this case, the first phase of the project would produce demolition waste, while the application of new shingles would create clean wood
construction waste. When materials such as gypsum board or asphalt shingles are removed separately during a renovation project, the additional time or effort required to deliver these materials separately to a C&D recycling centre would be minimal. In other cases, however, materials may be removed from a building in such a way that sorting them is a difficult and time consuming process. If so, three options present themselves.

- Additional time is taken to separate individual materials in order to increase recycling rates
- Additional labour is hired to separate renovation materials
- Materials which are difficult to separate are deposited in a mixed C&D waste bin

The final option is obviously less desirable from an environmental standpoint, but may be necessary due to time and monetary constraints. In this case, careful education of the workforce will be needed to ensure that only those materials that are difficult to separate are deposited in a mixed waste bin. Cut-offs produced during the construction phase of a renovation project should be relatively easy to sort during all projects.

When roll-off bins are used for large renovation projects, steps should be taken to ensure that recyclable C&D waste materials continue to be sorted on-site. In the event that space is too limited to allow multiple bins to be placed on-site, the options presented in section 4.5.2 should be explored.

Dalhousie University has committed through its Sustainable Building Policy to setting standards for “green building design and operations in all renovation projects of all sizes from retrofits of interior building spaces and houses to major buildings” (Dalhousie University, 2011, p. 2). It is recommended that Dalhousie incorporates a specific commitment to sorting and recycling high percentages of all easily separable and recyclable renovation waste materials into the new renovation standards. Easily separable waste should include all materials that are not attached together in such a way that considerable extra time is needed to separate them.

4.6 Conclusion

Due to the absence of mechanical sorting devices at recycling centres in HRM, the separation of C&D waste materials on campus is currently the best method for increasing the recycling of this waste stream at Dalhousie University. To accomplish this, multiple waste bins for separated materials are needed. Since space for waste bins on the Dalhousie campus is very limited, bins should be kept as small as possible. Public access to the bins should also be prevented if at all possible. Each workshop on campus should sort their construction waste as it is produced to avoid the additional cost of sorting these materials later on. Possibilities for increasing the available storage space at workshops that
produce large amounts of cut-offs should also be explored, as this could reduce the volumes of waste produced. During demolition and construction projects at Dalhousie, requests for proposals and contracts should require that high percentages of both aggregate and non-aggregate materials are diverted from a landfill for uses other than landfill cover. This could ensure that the weight of demolition aggregates does not discourage the recycling of other materials. Finally, Dalhousie’s Sustainable Building Policy should be modified to include a commitment to recycling high percentages of all wastes produced from demolition, construction and renovation activities.

5.0 Increasing the Recycling of C&D waste Within HRM

5.1 Methods – Literature Review, Expert Interviews, Findings from LeMarchant Street demolition

Research for this section of the report began with a comprehensive review of recent literature on C&D waste recycling in Europe and North America. Literature reviewed included academic journal articles, dissertations and grey literature. The literature review collected qualitative data on laws and policies that have encouraged C&D waste recycling as well as information on recycling processes for all common C&D waste materials. Information for the literature review was also gathered from personal communication with professionals knowledgeable of C&D waste management in North America. Further qualitative data was gathered through interviews with ten experts who work within HRM and are knowledgeable of current constraints and opportunities for reducing, reusing, and recycling C&D waste in the municipality. Analysis of the data from the LeMarchant Street demolition and deconstruction project also revealed opportunities for HRM and the province.

5.2 Findings:

The information from all expert interviews is summarized in Appendix D. The “main themes” outlined below refers to ideas or processes that were suggested by three or more of the experts interviewed during this research project.

5.3. Minimizing Waste by Design

This research project identified several procedures that can be used by designers and architects to reduce the demolition and construction waste produced by renovation and new construction projects. The first of these is the full or partial reuse of an existing building. Adapting existing structures to new uses provides substantial environmental benefits including the conservation of resources and energy related to materials manufacturing and transportation (Winkler, 2010). C&D waste production and energy use related to waste transport and recycling can also be greatly reduced in this way. The incorporation by architects and designers of specifications in the design guidelines that minimize C&D
waste was found to be a very effective process. Common specifications are that existing structures or demolition materials are reused in the new construction, C&D waste is sorted on-site and recycled, and that materials with recycled content are used.

The use of pre-built building components can also be an effective means of reducing construction waste and assisting deconstruction activities when a building is renovated or taken down. Experts stated that the use of pre-built components reduces the number of cut-offs produced during construction activities significantly. Pre-built components reduce construction waste by using fewer individual materials. Their construction in a factory environment also facilitates the collection of construction wastes and their reincorporation into the manufacturing process. It was also stated that prebuilt components can be designed to be easily dismounted and reused. While the use of dismountable components would probably be more expensive than traditional construction techniques, deconstruction and reuse at the end of a building’s life could be greatly facilitated. Finally, cut-offs from certain construction materials can be reduced if a structure is designed to incorporate standard sizes of these materials or divisions of standard sizes. Precise calculations of the materials needed, careful handling and storage of construction materials, and the incorporation of cut-offs during construction can also reduce the wastage of construction materials.

5.4 Recycling C&D Waste in HRM: Constraints and Opportunities

There are several circumstances that make the recycling of construction and demolition waste more challenging in HRM than many other North American municipalities. One of these is the relatively small population of HRM and the smaller quantities of waste materials that are produced as a consequence. Another challenging circumstance is the limited manufacturing of construction materials within Nova Scotia and the relative abundance of such natural resources as timber, gypsum and stone. However, despite these challenges there is much that can be done to develop new C&D recycling markets and increase the recycling of this waste stream in the municipality.

In order to recycle C&D waste it is necessary to sort the materials to some extent. While waste concrete, brick and masonry can be mixed together for use as fill in construction projects, most other reuse and recycling procedures require that each material is separated before it can be put to a new use. In those jurisdictions of North America with larger C&D waste streams it is becoming common to invest in machinery capable of extensively sorting mixed C&D waste. These machines can eliminate the need to sort C&D waste at the project site, but are expensive to purchase, require large amounts of energy and are dependent on large waste streams for their economical operation. While further research is needed to fully evaluate options for increasing the mechanization of C&D waste sorting at recycling centres in HRM, it appears that this practice is not currently economically viable.
Two companies operate recycling centres in HRM: Halifax C&D Recycling has a recycling centre and Royal Environmental Inc. operates RDM Recycling. Most C&D waste received at the recycling centres arrives mixed and these companies have different strategies for separating such waste for recycling. Halifax C&D Recycling has begun encouraging customers to sort their mixed waste at the recycling facility, undertakes minimal hand sorting with its own staff and reports an average recycling rate of 45% excluding diversion as landfill cover (D. Chassie, personal communication, February 15, 2012). RDM Recycling uses staff to hand sort the mixed waste and reports a recycling rate of 20-50% depending on the materials received, their condition, and the time available to sort by hand (K. Carter, personal communication, January 30, 2012). The ability of recycling centres in HRM to sort high percentages of mixed C&D waste is clearly constrained by an absence of mechanized processes, the inefficiency and high cost of hand sorting large waste volumes, and low market prices for recyclable materials. Since recycling centres in HRM do not currently have the economic incentive to thoroughly sort the C&D waste they receive, building owners, contractors and the provincial government will currently have to take the initiative if recycling rates are to be increased. Many of the experts interviewed for this research project stated that due to limited sorting at recycling centres, on-site separation of C&D waste materials is necessary to improve recycling rates in HRM. When waste materials are mixed together, they often become contaminated and are difficult to separate. Plasterboard for example breaks easily and small pieces can contaminate loads of clean wood and asphalt shingles. Therefore, careful on-site separation reduces the risk that materials will become contaminated and is the best opportunity to achieve high recycling rates in the absence of extensive mechanical sorting at recycling centres.

5.4.1 Construction waste

Since construction waste consists of new materials which are not bound together and has a lower volume than demolition waste, this waste is easier to separate on-site and may have a higher value than demolition materials. On the other hand, demolition materials represent a much larger source of waste. Research for this report indicated that the on-site sorting of recyclable construction waste should receive greater encouragement in HRM. Currently, there is only a small difference in price among tipping fees for most sorted and mixed waste at recycling centres within the municipality. A common message gathered from this research project is that similar tipping fees for sorted and mixed waste are currently a key constraint to C&D waste recycling as they provide little economic incentive for waste sorting. A few contractors in HRM are sorting their construction waste to some extent in order to sell materials such as metals for a profit. A large difference between tipping fees for sorted and mixed waste could provide strong economic encouragement for owners and contractors to invest in sorting their waste. It is recommended that the price difference in tipping fees for sorted and mixed waste at recycling centres and landfills in Nova Scotia is widened by applying a tax on mixed waste loads or using construction material deposit funds to restructure tipping fees. The development of new higher-value uses for construction waste could also raise the value of recycled materials and allow
recycling centres to lower their tipping fees for sorted waste. In addition, an expanded recycling industry could provide opportunities for contractors to pay lower fees or avoid them altogether by bringing sorted waste directly to a recycler. An example of this is Simlas Inc. which accepts construction plastic for recycling free of charge in Ontario. Higher fees for mixed C&D waste and lower fees for sorted materials could reduce or eliminate the current cost difference between maintaining recycling rates below 50% by mixing waste materials and achieving higher recycling rates by sorting waste into clean streams. It is acknowledged that space constraints on urban development sites can make it difficult or impossible to provide multiple waste bins for on-site sorting of construction waste. In these cases it may be necessary for contractors to sort their C&D waste on their own property or if possible at a recycling centre.

5.4.2 Constraints - Construction Waste

The constraints to on-site sorting of C&D waste in HRM identified during this research project are summarized below:

- Similar tipping fees at recycling centres for most sorted and mixed waste
- Owners often unwilling to pay significantly more for the sorting of construction waste on the project site
- Many urban development sites do not have enough space to allow several waste bins for separated materials
- The potential to reduce the cost of on-site sorting in HRM through staff training, efficient practices and the use of lower cost labour has not been fully developed
- A lack of economic value in most construction waste reduces incentive to reclaim these materials

5.4.3 Recommendations – Construction Waste

- Increase price difference in tipping fees for sorted and mixed waste at recycling centres and landfills to provide incentive for contractors to separate construction waste
- Increase opportunities for contractors to separate their C&D materials at recycling centres and landfills
- Encourage the development of local recycling processes for construction waste to increase diversion opportunities and increase the value of these materials
5.4.4 Demolition Waste

Demolition waste is more difficult to recycle than construction waste due to the age of the materials and contamination by chemicals, hydrocarbons and hazardous materials. Demolition materials are often difficult to separate from each other as well. Research conducted for this project indicates that a broad range of actions are needed in order for a greater percentage of demolition waste to be reused or recycled in HRM. The adaptation of existing buildings to new uses and the reuse of salvaged materials remain the most environmentally friendly options due to their ability to achieve high reductions in energy and virgin material use (Winkler, 2010). The sale of salvaged materials also currently provides more income to companies that deconstruct in HRM than recycling opportunities, increasing the economic case for deconstruction (R. Rhyno, personal communication, August, 22, 2012). This is due to a higher resale value for reusable materials and a lack of opportunities for demolition companies to sell or donate recyclable materials directly to companies that use them. The provincial government, architects and the construction industry should work together to reduce C&D waste by facilitating the incorporation of used building materials in new buildings and encouraging greater reuse of existing buildings. There is also an opportunity to develop markets for deconstructed materials. For example, deconstructed clean wood could be used in the manufacture of flooring, furniture and decorative trim work. Such development has the potential to increase jobs in the areas of deconstruction and manufacturing. Social programs can be combined with deconstruction and manufacturing activities to reduce labour costs, create jobs and develop skills. This is a common approach in other jurisdictions where youth-at-risk and shelter programs play a role in deconstruction projects.

The provincial government can raise the value of demolition materials by encouraging their use in manufacturing. In the UK, the Netherlands and Finland, used concrete and brick often replace up to 20% of the aggregate in new concrete mixes (Bio Intelligence Service, 2011). In New York State, clean waste wood is being converted into wood pellets for heating purposes (S. Buck, personal communication, January 27, 2012) while in many jurisdictions in North America used asphalt pavement is reincorporated into new hot-mix asphalt. It is recognized that the cost of materials with recycled content is often higher than materials with virgin content. However, such actions as raising tipping fees for mixed waste or a creating a tax reduction for products with recycled content could tip the economic balance in favour of reuse and recycling.

The higher cost of deconstruction versus demolition was identified as a significant constraint. While less expensive than deconstruction, mechanized demolition practices eliminate the possibility of reuse and create a mixed waste stream that is difficult to separate and recycle. Some sorting of demolition materials or selective dismantling usually takes place on-site when brick or concrete structures are torn down. This is done in order to use the brick or concrete as clean fill and thereby avoid the expense of sending aggregates to a recycling centre. Metal waste is also sorted out for recycling due to its value.
The potential to raise the value of other C&D waste materials in HRM through the creation of value-added recycling opportunities needs to be carefully considered as an option for encouraging deconstruction or selective dismantling. The ability for demolition contractors to bring their separated waste directly to a recycler and pay lower tipping fees could provide an economic incentive to selectively dismantle or deconstruct and could reduce the cost of deconstruction for the land owner. As with construction waste, small differences in tipping fees for sorted and mixed waste provide little economic incentive for contractors to spend extra time and money separating demolition materials.

Currently it may be cheaper to demolish hazardous waste and non-hazardous waste into one load and dispose of all the material at a hazardous waste landfill. Using statistics from the LeMarchant Street project would suggest that 70% of the material that could be reused or recycled would be landfilled in this scenario. This is approximately 30-40 tonnes of divertible material per average house demolition that could be used to create value-added products and jobs. In addition, >30% of material in older homes and buildings may be classified as hazardous waste.

Nova Scotia has older stock of homes and buildings. Hazardous such as lead paint and asbestos are commonly found in structures pre-dating the 1960s. Avenues for further study include identifying how older buildings and homes (pre 1960) are being demolished, how much of NS demolition projects include hazardous waste of what type, how is hazardous waste being managed, and what are the overall C&D diversion rate per material. A provincial-wide survey through organizations like CANS and the home builders association may enable provincial-wide response rate. In addition a case study of a demolition project with a structure that has no hazardous in it versus one that does would be useful to understand if this factor change demolition practises. It is our hypothesis that due to factors of time and tipping fees, that most jobs would knock down structures quickly into a mix load. This would be less complicated and cheaper. This will result in lower value recycling and reuse of C&D material and less jobs created. Economic policy and incentives and/or bans would likely need to be introduced to change practices.

As well, research could be undertaken to understand how hazardous material can be treated to reduce hazardous levels to non-hazard levels through recycling and composting activities. For example, in other jurisdictions efforts have been made to remove the outside edges of treated wood to utilize the 95% underneath that is clean wood for other applications. Clear regulation is needed to ensure that significant volumes of non-hazardous waste are not deposited in hazardous waste landfills. Such regulation would increase demolition material diversion rates and help protect workers.

Therefore, it is recommended that tipping fees at recycling centres are modified to encourage selective dismantling and deconstruction. A larger price difference in tipping fees for sorted and mixed waste could encourage greater reuse of existing buildings as well as salvaged materials and reduce or
eliminate the economic advantage of demolition practices. Finally, insufficient time to practice deconstruction or selective dismantling (particularly with wooden structures) was identified as a significant constraint during this research project. The lengthy process of removing hazardous materials from a structure before demolition frequently puts pressure on contractors to tear a building down quickly once they are free to do so. It is recommended that the municipal government of HRM modifies demolition permits so that a minimum time period for deconstruction is required after hazardous materials have been removed. This time period could vary depending on the size of the building in question and the materials it is constructed with.

**5.4.5 Constraints - Demolition waste**

- Little time is allowed for selective dismantling or deconstruction
- Recycling centre tipping fees do not encourage the separation of demolition materials for recycling
- Demolition waste materials often have little value
- The mixing of hazardous and non-hazardous waste and their mutual deposit in a hazardous waste landfill reduces diversion rates.

**5.4.6 Recommendations – Demolition Waste**

- Increase the development of value-added uses for recycled demolition materials
- Work with architects and the construction industry to increase the reuse of whole and partial buildings as well as individual construction materials
- Explore social and community programs that can combine deconstruction and value-added product creation to reduce the labour costs of demolition, create jobs as well as local products, and develop skills
- Conduct further study and research on how to change hazardous waste to non-hazardous waste through processes such as composting and mechanical trimming.
- Consider clear provincial legislation on C&D waste that will encourage more high-value C&D use. Examples of policy drivers include:
  - bans at all provincial landfills on materials for which recycling opportunities can currently be developed such as asphalt shingles, clean wood, and gypsum board;
mandate separation of material into clean streams
• require hazardous waste reports before demolition to ensure proper handling and to encourage the separation of hazardous waste from clean material
• Create a structure for tipping fees that eliminates the economic advantage of traditional demolition practices

5.5 Government Encouragement of C&D Waste Recycling

While the provincial government of Nova Scotia has encouraged C&D waste recycling through a variety of initiatives including municipal waste diversion credits, it can play a larger role in order to increase C&D waste recycling in HRM. This research project concludes that the provincial government, in collaboration with the Resource and Recovery Fund Board of Nova Scotia (RRFB) has the ability to help remove the largest constraints to increasing the recycling of C&D waste in HRM. As mentioned earlier, limited differences in recycling centre drop-off fees for sorted and mixed waste are a key constraint to encouraging contractors and building owners to separate C&D materials. The thorough separation of materials in turn is essential for most recycling processes. It is recommended that the provincial government addresses this constraint by considering the application of a tax on depositing mixed C&D waste material at recycling centres across the province. Such a tax would provide the economic incentive to sort and recycle C&D waste that is currently lacking in Nova Scotia. A tax would be a fair and transparent method for raising provincial recycling centre and landfill tipping fees for mixed waste and could help limit unequal support for C&D waste recycling at provincial recycling centres and landfills. Furthermore, a tax could provide funds for the monitoring and enforcement of proper C&D waste disposal to reduce the likelihood of illegal dumping. It is also recommended that fines for illegal dumping are increased and the practice of offering an initial warning is reviewed.

Landfill bans could be used to reduce the sending of C&D waste to landfill. In HRM the majority of C&D waste that is not recycled is used as landfill cover. While using C&D waste as landfill cover replaces virgin materials, this low-value diversion practice should not discourage recycling opportunities. A possible solution may be to encourage or require the sorting of C&D waste and only use materials for which no recycling opportunity currently exists as landfill cover. This scenario could be supported by landfill bans on all materials for which a recycling opportunity is possible to ensure that the percentage of HRM’s C&D waste sent to landfill is minimized. A main theme from the expert interviews is that a greater variety of opportunities for recycling C&D waste must be established in HRM. However, manufacturers will not invest in recycling processes unless they are assured a steady supply of uncontaminated waste materials. Landfill bans on wood and gypsum board for example would encourage the development of new uses for these materials such as the manufacturing of wood pellets and the use of gypsum board as a soil or compost amendment. Together, landfill bans and a large
price difference in tipping fees for sorted and unsorted waste could help produce high volumes of sorted waste materials and provide strong support for the development of new recycling industries in HRM.

Research conducted for this report suggests that the provincial government of Nova Scotia should take steps to support an increased use of recycled C&D materials in construction applications in Nova Scotia. For example, the use of recycled asphalt shingles (RAS) in asphalt pavement could probably be increased, especially for those pavements used in parking lots and other light-use applications. In HRM, Ocean Contractors Ltd. currently uses less than 2.5% recycled asphalt pavement (RAS) in its hot-mix asphalt (E. Henneberry, personal communication, June 16, 2011). However, there is evidence that the incorporation of up to 5% RAS (including the paper backing) in road grade hot-mix asphalt does not degrade the performance of the asphalt (Hanson, Foo & Lynn, 1997). It is quite possible therefore that the percentage of recycled asphalt shingles used in paving applications in Nova Scotia could be increased to 5% across the province. The use of recycled concrete and brick as structural fill in road construction is common in many jurisdictions in the United States and Europe, as is the incorporation of recycled asphalt pavement into new pavement. As mentioned earlier, the use of recycled concrete and brick in new concrete mixes is already widespread in countries such as England and the Netherlands (Bio Intelligence Service, 2011). The government of Nova Scotia should collaborate with the provincial construction industry to develop new construction specifications which allow for a greater use of recycled material as demonstrated by best practices elsewhere. Finally, several businesses in Nova Scotia are developing innovative recycling processes such as the plastic construction waste recycling facility planned by Halifax C&D Recycling and Casey Concrete’s production of concrete products with recycled glass content. The provincial government should consider encouraging the incorporation of recycled C&D waste in local manufacturing processes further through a tax reduction or subsidy for products with recycled content. Such a procedure would help offset the higher cost of products with recycled content and assist with the development of local recycling industries.

5.5.1 Recommendations

- Consider provincial landfill bans on materials for which recycling opportunities can currently be developed such as gypsum board, asphalt shingles, clean wood and metal

- Widen the price difference between tipping fees for mixed and sorted C&D waste considerably through the application of taxes on mixed waste, deposit funds to reduce sorted waste fees, or a combination of economic incentives

- Work with the provincial construction industry to develop specifications that allow an increased use of recycled materials in road construction, paving, and other applications
• Consider encouraging the local manufacture of products with recycled content through the application of a tax reduction or subsidy

5.6 Conclusion

Recycling waste from construction and demolition projects is not an easy task. The cost of separating C&D materials and preventing contamination is significant and clear incentives to recycle are needed in order to increase current recycling rates in HRM. Industry also needs to be assured that recycling is profitable and material supplies are steady in order to invest in new recycling technology. Research for this report found that the creation of C&D waste can be minimized by adapting existing buildings to new uses, reusing salvageable construction materials, using pre-built components for new construction, and designing structures to accommodate standard sizes of construction materials.

The provincial government could play a pivotal role in increasing the recycling of construction and demolition waste in HRM. The application of a tax on mixed C&D waste and/ or the development of deposit funds to subsidize C&D waste recycling could create the economic incentive for recycling this waste stream that is currently lacking in Nova Scotia. Larger volumes of sorted C&D waste materials would in turn encourage the further development of recycling industries in Nova Scotia. The application of landfill bans on recyclable C&D materials could also be an important tool for ensuring volumes of sorted C&D waste are large enough to encourage the development of new recycling industries. In order for high percentages of demolition waste (by volume) to be recycled, standard demolition practices need to be replaced by selective dismantling and deconstruction activities. Since dismantling structures is more time consuming and costly than demolishing them, these practices need to be encouraged through mandatory time allowances for deconstruction and economic incentives to reuse and recycle the resulting materials. The development of new recycling industries that will accept sorted demolition waste and allow demolition contractors to avoid recycling centre fees could create significant economic incentive for deconstruction in HRM. Together, an increase in deconstruction and recycling activities would provide new jobs and economic activity in the municipality. The government of Nova Scotia should increase local demand for recycled C&D materials by collaborating with the province’s construction industry to develop new construction specifications that allow for a greater incorporation of recycled content. The provincial government should also consider supporting the local manufacture of products with recycled content through a tax reduction or subsidy.
6.0 References


7.0 Appendices

Appendix A. Workshop Audit Interview Questions

1. Is this audit typical of the C&D waste found at this location? Yes/ No. If no, what other waste materials are produced?

2. How is the C&D waste stored before disposal?

3. Who removes the C&D waste produced? How often? (once a day/ week/ month/ year)

4. Do you have suggestions for improving the collection and storage of C&D waste at this location in order to increase the percentage of this waste that is reused or recycled?

5. Do you have other suggestions for improving the reduction, reuse and recycling of this material?

6. Do you have other comments or suggestions?
Appendix D. Expert Interview Data

The number of experts that gave a particular answer is indicated to the left of each answer. Experts usually did not provide an answer to all of the questions that were asked. However, most experts provided more than one answer for several questions as well. These circumstances explain the wide variety in total numbers of answers provided for each question.

Question 1. What opportunities are you aware of for minimizing construction and demolition waste during the architectural design process?

Main Themes:

- (4) Use pre-built components to facilitate deconstruction activities and minimize waste from off-cuts. Off-cuts are also easier to recycle in a manufacturing facility than on the project site
- (3) Architects and designers can specify that C&D waste from project is sorted on-site and recycled, and that used materials and materials with recycled content are chosen during construction
- (3) Construction waste can be reduced if a building is designed to accommodate standard sizes of construction materials

Minor Themes:

- (2) The reduction of packaging waste can and should be specified by the architect or designer
- (2) Construction materials that are easily recyclable in the local area should be used whenever possible
- (1) New concrete construction methods reduce the diversity of materials used and the volume of construction waste produced
- (1) Using high-quality materials and constructing buildings that last will reduce waste over time
- (1) Reuse existing materials when renovating

Question 2. To what extent could the separation of C&D waste materials at the construction or demolition site improve recycling rates within the Halifax Regional Municipality?

Main Themes:
- (3) This is the ideal situation for maximizing the recycling of C&D materials without contaminating them

- (3) Separating materials on-site will increase C&D recycling rates

**Minor Themes:**

- (1) The importance of this practice depends on current recycling opportunities in HRM and the amount of waste separation taking place at recycling centres.

- (1) The contamination of recyclable materials is a serious constraint to recycling them.

- (1) Have to be careful that government and municipal policies regarding the source separation of C&D waste are not too strict as this can be a constraint.

**Question 3.** What constraints and opportunities exist within the HRM for separating construction waste materials on and off the construction site?

**Main Themes:**

- (4) A lack of space for multiple waste bins is often a constraint.

- (3) The cost of separating construction waste is a constraint. Owners and Trades are not always willing to pay for the extra cost.

**Minor Themes:**

- (1) A market or use for separated C&D waste must exist.

- (1) HRM needs to develop more value-added markets for recycled C&D materials.

- (1) The more mixed your waste is, and the smaller the pieces, the harder it is to sort on-site or at a recycling centre.

- (1) Having unionized labourers sort construction waste on-site can still be cheaper than having Trades persons sort their waste.

- (1) Some Trades are using non-unionized labourers to sort their construction waste off the project site. This is done to reduce the cost of sorting, reduce drop-off fees at recycling centres and sell materials directly to a recycler.
Question 4. What constraints and opportunities exist within the HRM for separating demolition waste materials on and off the demolition site?

Main Themes:

- (5) The higher cost of deconstructing a building compared to demolishing it mechanically is currently a serious constraint
- (4) If hazardous materials must be removed, the time taken to do so puts pressure on owners to demolish the building as quickly as possible

Minor Themes:

- (2) Older buildings can be difficult to selectively dismantle due to the presence of hazardous materials, mould, decay, and materials which are difficult to separate.
- (1) Similar drop-off fees for sorted and mixed waste favour mechanical demolition processes
- (1) Selective dismantling is the only way to facilitate the reuse of construction materials
- (1) Markets for separated materials must be present for selective dismantling and deconstruction to make sense

Question 5. Do you know of any methods for reusing or recycling C&D waste which are not currently being used within the HRM, but could be successful here?

Main Themes:

(none)

Minor Themes:

- (2) A system for using waste concrete and brick in value-added products such as new cement should be set up
- (1) Increase recycling processes currently in place
- (1) Develop further opportunities for recycling clean gypsum board and clean wood while creating new opportunities for recycling synthetic carpets and other plastic construction materials
- (1) Should focus on recycling ecologically harmful materials rather than inert ones
Question 6. Do you think that Nova Scotia’s legislation and policies or HRM’s by-laws should be altered in any way to increase the percentage of C&D waste (other than landfill cover) that is reused or diverted?

Main Themes:

(none)

Minor Themes:

- (2) Increase fines for illegal dumping of C&D waste and increase surveillance of common dumping locations

- (1) Provincial government could require that all recyclable waste materials created from the construction and demolition of government buildings are recycled

- (1) HRM demolition permits should be modified to include a requirement that adequate time is allowed for deconstruction and that recyclable waste materials are sorted before drop-off at a recycling centre

- (1) HRM should create a municipal bylaw requiring that all wooden structures are deconstructed rather than demolished

- (1) A hazardous materials survey should be required for residential as well as ICI buildings before a demolition permit can be issued

- (1) Provincial and municipal governments should be more transparent about the ecological costs and benefits of recycling

- (1) Provincial government should do more to promote a strong recycling industry

- (1) Provincial government could subsidize local products made with certain percentages of recycled materials to off-set increased cost of producing these materials and encourage the development of a recycling industry

- (1) Provincial regulations governing the construction of C&D landfills are too weak

- (1) Policies need to be developed in other regions of Nova Scotia which require high C&D waste diversion rates
Question 7. Do you think that drop-off fees at landfills and recycling centres within the HRM encourage C&D waste reuse and recycling (excluding use as a landfill cover) to a sufficient extent?

Main Themes:

- (4) The difference in fees for sorted and mixed C&D waste is not large enough to encourage on-site separation of materials
- (1) Drop-off fees have to be high enough for recycler to make a profit despite the high cost of recycling machinery, transport costs and fluctuating prices for recycled materials
- (1) Low waste volumes require higher drop-off fees
- (1) High drop-off fees can encourage illegal dumping
- (1) Reductions in the fees for sorted materials combined with higher fees for unsorted materials can encourage sorting and discourage illegal dumping

Question 8. Do you know of any options for creating a “closed-loop” (cradle to cradle) recycling process for a specific C&D waste material which could be viable within the HRM?

Main Themes:

(none)

Minor Themes:

- (1) Unless the end market is close by, closed loop recycling may not be the most sustainable option due to transport emissions
- (1) Closed-loop recycling is more difficult in Atlantic Canada than some regions because of the small population, limited manufacturing and small waste streams
- (1) Closed-loop recycling of asphalt pavement should be developed in Nova Scotia
- (1) Closed-loop recycling of concrete could be developed here
- (1) Dalhousie University should sell its waste metal directly to recyclers
Question 9. What are the current challenges and restrictions for construction and demolition companies who wish to reuse and recycle C&D waste materials within HRM?

Main themes:
- (3) A lack of markets, especially value-added markets in Nova Scotia for recycled C&D materials is a constraint

Minor Themes:
- (2) Labour costs and other associated costs are a constraint
- (2) A lack of knowledge of opportunities for recycling waste materials and little knowledge of the importance of source-separating waste materials are challenges
- (1) Slightly lower drop-off fees for sorted materials do not encourage waste sorting
- (1) Owners are often unwilling to pay for the higher cost of source separation
- (1) A lack of space to source separate waste materials is a common constraint

Question 10. What are the challenges to sorting and storing sorted C&D waste materials at Dalhousie University?

Main Themes:
- (5) Limited space on campus for multiple waste bins is a significant challenge
- (3) The cost of sorting waste from construction and demolition projects
- (3) A university policy that encourages or requires C&D waste sorting is needed

Minor Themes:
- (1) Little knowledge of the importance of sorting the waste and of recycling markets are challenges
- (1) Restrictions on using less expensive labourers rather than Facilities Management staff to sort waste may be a constraint
- (1) Waste stored in publicly accessible waste bins can be a public hazard that Dalhousie is liable for
Question 11. What other challenges or restrictions currently limit the reduction, reuse and recycling of C&D waste at Dalhousie University?

Main Themes:

(none)

Minor Themes:

- (1) Increasing C&D recycling rates requires a commitment to this goal by Dalhousie University
- (1) It is currently not known if other opportunities for recycling this waste (besides drop-off at recycling centres) exist
- (1) Improving waste management at Dalhousie requires good collaboration between all parties involved and an in-depth understanding of how the university is managed

Question 12. Do you have any other suggestions for how a greater percentage of C&D waste could be reused or recycled at Dalhousie University or within the HRM?

Main Themes:

(none)

Minor Themes:

- (1) A goal must be to create the most sustainable recycling option which results in the fewest environmental impacts
- (1) More research and development is needed to create new opportunities for recycling C&D waste
- (1) Specifying a diversion percentage for each waste material based on recycling opportunities instead of using an overall target can be more sensible
- (1) Dalhousie should explore the possibility of partnering with salvage companies to ensure that recyclable waste materials are recovered during renovation projects
- (1) The provincial government should consider creating and subsidizing an employment program that hires unemployed people to separate and sort demolition materials