Construction Waste Management

- A Literature Review -

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EXECUTIVE SUMMARY

Construction and demolition (C&D) waste consists of all materials that must be disposed during construction, demolition and renovation. Studies have shown that on sites where waste is comprehensively managed, it is possible to divert between 70 and 90% from landfills using source separation. This document is a summary of approximately 70 articles and reports regarding the management of construction waste.

The information applies primarily to new, residential construction. The approaches discussed can apply to renovation and demolition of all building types. However, demolition has other issues and materials that may not be a concern for new construction.

In order to achieve a high degree of waste diversion, careful consideration must be given to each individual site, as each one is different and has different constraints and opportunities. Space for storing materials, for example, is a major factor to consider when deciding whether to attempt separation of materials on site. Time and resource constraints also limit the amount of waste reduction that is possible.

The management of construction waste can be summarized by the 3Rs: Reduce waste at source, Reuse what would normally be landfilled, and Recycle materials for which there is no immediate use. Waste at sites of new construction is generally more likely to be both reused and recycled since it is easier to keep materials cleaner and isolated than at demolition sites. Another advantage to new construction for following the 3Rs is that construction generally occurs in phases, which increases the potential for separating, reusing and recycling materials. Of the 3Rs, reducing waste is the most efficient and the most effective because reduction means producing less waste to begin with.

A waste management plan is an approach to handling waste that will minimize waste, maximize material recovery, and reduce total waste management costs. A waste management plan is recommended for all construction sites. Before developing a waste management plan, it is important to know local regulations governing waste disposal, including disposal fees and restrictions on materials allowed in landfills.

The first step to a waste management plan is the generation of a waste audit, which is the process of determining how much waste is generated and when. Whether material is to be reused or recycled, it must be separated from other materials and from waste. Suggestions are provided for different techniques for material separation.

Before implementing a construction waste management plan, local regulations, the

availability of recycling centres and disposal costs must be obtained as these can vary substantially.

The following conclusions have been taken from various reports, and apply fittingly to the information presented in this literature summary.

1. Education in waste stream generation and waste handling has a positive effect on minimizing waste at building sites.
2. It appears that having a knowledgeable site superintendent and a builder committed to a waste management program are the keys to successful reduction in waste generated on a construction site.
3. It is estimated that a 50 percent reduction of dimensional lumber waste is possible by educating trades persons on careful cutting practices and by having effective on-site supervision.
4. Not all waste from construction is presently reusable or recyclable. Because of the difficulty in recycling of some products, emphasis should be placed on reducing the amount going into the waste stream, by paying more attention to efficient building design and efficient use of materials.
5. In order to realize maximum recycling possibilities, materials must be fully sorted and properly stored. Sufficient uncontaminated volumes are needed to make it economically feasible to recycle.
6. Over-supply of materials encourages theft.
7. There is a growing potential for reusing/recycling through local businesses and recycling plants and depots.
8. Separation of wastes is relatively easy if trades people collect and carry materials to secondary users or storage depots. However, in one study [150], almost half of the respondents, after two years of implementation, had difficulty separating and/or storing waste on the construction site. Involvement by those generating the waste encourages participants to devise better ways to reduce or dispose of waste.
9. In most cases, there may not be a clear economic argument for recycling waste. It may cost the builder as much to sort, store and dispose of waste in alternative ways as it does in dumping fees. From the study [150], after two years of implementing construction waste management plans, only 13 percent of participants reported increased costs, 38 percent reported little or no effect on the bottom line, and 17 percent saved money. Nevertheless, it is only through continued efforts in recycling that more economical possibilities will emerge. Economic considerations aside, there is a good will value in being known as environmentally responsible.
10. Builder interest in waste reduction and recycling is driven primarily by considerations of cost and convenience
11. The most immediate cost savings can be realized through reduction of material used. By reducing waste, less material needs to be ordered thereby lowering material costs to the builders as well as disposal costs.

A number of reports and organizations are listed as resources for further information.

RÉSUMÉ

Les déchets de la construction et de la démolition englobent tous les matériaux qui doivent être éliminés au cours des travaux de construction, de démolition et de rénovation des bâtiments. Des études ont démontré que, dans les emplacements où les déchets étaient l'objet d'une gestion totale, il était possible de détourner entre 70 et 90 p. 100 de ces matériaux des terrains d'enfouissement en ayant recours à la séparation à la source. Le présent document constitue un condensé de près de 70 articles et rapports concernant la gestion des déchets de la construction.

Les renseignements fournis s'adressent d'abord et avant tout aux constructions résidentielles neuves. Les méthodes examinées peuvent s'appliquer à la rénovation et à la démolition de tous les genres de bâtiment. Toutefois, la démolition offre d'autres problèmes et implique d'autres matériaux qui ne concernent pas les nouvelles constructions.

Pour obtenir un haut degré de réorientation des déchets, il faut prendre garde à bien examiner chacun des emplacements puisque ceux-ci présentent différentes contraintes et offrent diverses possibilités. Ainsi, l'espace pour entreposer les matériaux constitue un des principaux facteurs à envisager lorsqu'il faut décider si l'on va tenter de séparer ces mêmes matériaux sur place. Les contraintes de temps et de ressources limitent également la quantité de déchets que l'on peut éliminer.

La gestion des déchets de la construction peut se résumer aux trois grands R, c'est-à-dire Réduire les déchets à la source, Réutiliser ce qui normalement aboutirait dans les terrains d'enfouissement et Recycler les matériaux pour lesquels il n'existe aucune utilisation immédiate. Les déchets que l'on retrouve sur les emplacements des constructions neuves sont généralement plus aptes à la réutilisation et au recyclage puisqu'il est plus aisé de garder des matériaux propres et isolés dans ces lieux que sur des terrains de démolition. Un des autres avantages qu'il y a à se conformer à la règle des trois R dans le cas des bâtiments neufs est que les travaux de construction, qui ont généralement lieu en diverses étapes, augmentent les possibilités de séparer, de réutiliser et de recycler les matériaux. Parmi les activités réalisées dans le cadre des trois R, la diminution des déchets constitue la démarche la plus efficace et la plus rationnelle parce qu'elle signifie une production moindre de ce genre de déchets et un bon point de départ.

La disponibilité d'un plan de gestion des déchets demeure une façon adéquate d'en faciliter la manipulation, ce qui permet de réduire la quantité de ces produits, de favoriser au maximum la récupération des matériaux et d'abaisser le total des coûts s'y

rapportant. Un tel plan de gestion est recommandé pour tous les chantiers de construction. Avant d'élaborer un plan de gestion des déchets, il est important de connaître les règlements locaux qui régissent l'élimination des déchets, notamment les droits à payer et les restrictions quant aux matériaux permis dans les sites d'enfouissement.

La première étape d'un plan de gestion des déchets s'avère l'exécution d'une vérification relative à la quantité de déchets à traiter, ce qui se décrit comme étant le processus visant à déterminer l'importance des déchets produits et la période où cela se fait. Que les matériaux soient destinés à la réutilisation ou le recyclage, il faut les séparer des autres matériaux et des déchets eux-mêmes. On trouvera ci-joint quelques suggestions sur les diverses techniques de séparation des matériaux.

Avant de mettre en application le plan de gestion des déchets produits par la construction, il convient de vérifier l'existence de centres de recyclage et les coûts entourant l'élimination parce que ces divers éléments peuvent varier substantiellement.

Les conclusions qui sont données ci-après ont été tirées de différents rapports, et celles-ci s'appliquent parfaitement aux renseignements fournis dans le présent résumé de la documentation disponible.

1. La sensibilisation à la production des flux de déchets et au traitement de ceux-ci a un effet positif sur la réduction de ces produits dans les chantiers de construction.

2. Il apparaît que la présence d'un contremaître averti et d'un constructeur engagé dans un programme de gestion des déchets demeure l'élément clé d'une réduction fructueuse des déchets produits sur un chantier de construction.

3. On estime possible la réduction de moitié des déchets de bois de construction de dimensions courantes en sensibilisant les responsables de ce secteur d'activités aux méthodes rationnelles de coupe et en exerçant un contrôle effectif sur le terrain.

4. Ce ne sont pas tous les déchets de la construction qui sont recyclables ou réutilisables. En raison des difficultés qui caractérisent le recyclage de certains produits, il faut mettre l'accent sur la réduction du flux de déchets produits en se concentrant sur la conception de bâtiments à haut rendement énergétique et sur l'utilisation rationnelle des matériaux.

5. Afin de tirer le maximum des possibilités de recyclage, il faut trier soigneusement les divers matériaux et les entreposer de manière adéquate. Un volume suffisant

de matériaux non contaminés est indispensable pour assurer la rentabilité du recyclage.

6. Un approvisionnement abondant de matériaux encourage le vol.

7. Les possibilités de réutilisation et de recyclage sont de plus en plus élevées dans les entreprises locales, ainsi que dans les dépôts et les installations de recyclage.

8. La séparation des déchets est une opération relativement aisée si les responsables de ce secteur d'activités recueillent et transportent les matériaux vers les utilisateurs secondaires ou les dépôts de stockage. Toutefois, dans une des études (150), près de la moitié des répondants ont déclaré que, après deux années de mise en œuvre, ils éprouvaient de la difficulté à séparer ou à stocker les déchets sur les chantiers de construction. L'intervention de ceux qui produisent les déchets encourage les participants à concevoir de meilleurs moyens de réduire ou d'éliminer les déchets.

9. Dans la majorité des cas, il n'existe sans doute aucun argument économique clair en faveur du recyclage des déchets. Les frais de tri, de stockage et d'élimination des déchets par des moyens de rechange peuvent être aussi élevés pour un constructeur que ceux reliés au déversement. Selon l'étude (150), après deux ans d'application des plans de gestion des déchets sur les chantiers de construction, seulement 13 p. 100 des participants ont rapporté la hausse de leurs frais, 38 p. 100 ont indiqué peu ou prou d'effets sur les résultats nets, tandis que 17 p. 100 ont affirmé avoir économisé de l'argent. Malgré tout, seule la persistance dans les activités de recyclage permettra d'en arriver à des possibilités sur le plan économique. Si l'on fait abstraction des considérations économiques, c'est un atout d'être reconnu comme ayant la volonté d'agir de manière responsable en matière d'environnement.

10. L'intérêt manifesté par les constructeurs au chapitre de la réduction et du recyclage des matériaux réside principalement dans les avantages liés aux coûts et à l'aspect pratique.

11. Les économies les plus immédiates peuvent se réaliser par la réduction de la quantité de matériaux utilisés. En diminuant la quantité de déchets, il n'est pas nécessaire de commander autant de matériaux, ce qui permet aux constructeurs d'abaisser les coûts d'acquisition et d'élimination.

Pour de plus amples informations, le document contient une liste de plusieurs rapports et organisations qui sont donnés à titre de ressources.

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1.0 INTRODUCTION

This document is a summary of approximately 70 articles and reports regarding the management of construction waste. The management of waste is increasingly important as landfills are reaching capacity; there is particular concern regarding the use of natural resources; disposal costs are increasing; and knowledge regarding the effects of contaminants from landfills leaching into the soil and ground water is increasing.

This document applies primarily to new, residential construction. The approaches discussed can apply to renovation and demolition of all building types. However, demolition has other issues and materials that may not be a concern for new construction.

Most of the information relates to activities in Canada and the United States. There is limited discussion of activities in other countries.

Because of the volume of information and number of references reviewed, the references used in each section are listed at the end of that section, with the goal of making this document a more useful reference and tool. References are numbered sequentially, from one section to the next, and therefore some references appear more than once. Numbers in square brackets refer to the reference listed at the end of the section.

2.0 BACKGROUND

Construction and demolition (C&D) waste consists of all materials that must be disposed during construction, demolition and renovation. Typically, items such as beverage containers are treated as municipal solid waste (MSW). In construction, waste includes anything that is used in the construction of buildings, and in some cases, roads. Materials include such things as site clearing, packaging, and cut-offs / left-overs from framing lumber, sheathing, drywall, piping, wiring, insulation, carpeting and other finishing materials including paints. In demolition, waste includes all items that are not salvaged.

Studies have shown that on sites where waste is comprehensively managed, it is possible to divert between 70 and 90% from landfills using source separation. In order to achieve this degree of waste diversion, careful consideration must be given to each individual site, as each one is different and has different constraints and opportunities. Space for storing materials, for example, is a major factor to consider when deciding whether to attempt separation of materials on site. Time and resource constraints also limit the amount of waste reduction that is possible. Issues such as these are discussed in Section 5.0, Approaches to Construction Waste Management.

All too often the mechanisms to identify, and prioritize for action, the waste streams that will arise are not available at the planning stage of construction works. Resource and waste management decisions are therefore being taken by practitioners without sufficient knowledge of the quantity and composition of waste that will be generated on their sites. [8]

Many materials that are more difficult to separate and that are worth less per unit weight are still going to landfill, even when they are present in large quantities. [9]

Traditionally, limited C&D waste quantities have been recycled, generally on a source separated basis, to the extent that economic reward provided an incentive. Recently, environmental concerns have led to increased attention towards source reduction, source separation, and the processing of mixed C&D waste for subsequent reuse, recycling and recovery in North America and Europe in light of:

- increased disposal costs (Europe also has environmental taxes on disposal);
- the fact that C&D wastes are both heavy and bulky and therefore undesirable for disposal in landfills;
- bans on the disposal of C&D wastes at landfills;
- increased environmental protection requirements and costs for landfills designated only for C&D wastes;

- the need to meet increased legislative requirements for reduction, recycling and re-use (3Rs) targets from the total waste stream;
- the high potential for 3Rs and recovery for C&D wastes;
- the significant percentage of the total waste stream which C&D wastes represent (as high as 25 percent in North America);
- the fact that in Europe the quantity of C&D waste disposed is 50 percent higher than MSW disposal requirements; and
- the need to develop closer co-ordination between industry and municipal waste management. [4]

Existing landfill space is limited in most urban centres; and numerous environmental problems, including water contamination and gas emissions, are associated with landfills. When wastes are diverted from landfills, a number of environmental and economic advantages occur: [13]

- Raw materials and energy are conserved.
- Waste disposal costs are reduced, as is the cost of materials.
- An on-site inspector can be hired with cost savings.
- Materials can be used more efficiently.
- Revenue can be generated by selling used goods and materials.
- Wastes can be managed in an environmentally sound way.

2.1 Construction and Demolition Waste in the Western World

2.1.1 Canada

According to Tan G. Lee from the University of Calgary, construction and demolition waste in Canada represents between 25 and 30% of all waste sent to landfill, or approximately 9 million tonnes per year. We produce more solid waste than almost any other country. The demand for more waste disposal sites has increased landfill and incinerator tipping fees by up to 500% since the mid-1980s. As landfill sites across Canada reach capacity, municipalities become more selective about what goes into them. [1]

As much as 2 ½ tons of wastage of new products brought to the site are produced in the construction of an average house. The costs of disposing of this waste can represent up to 4% of total house construction costs in some Canadian municipalities [2]

2.1.2 European Union

Construction and demolition waste constitutes a highly significant proportion of all wastes. If one excludes earth and excavated road material the amount of construction and demolition waste generated is estimated to be roughly 180 million tonnes per year.

Those wastes also have very high recovery potential, as shown by the pilot projects carried out and the action taken in some Member States, which have achieved recycling levels of more than 80%. However, only a small proportion of this waste stream is actually recovered in the European Union as a whole. [20]

Within the European Union, 25% of the waste is recycled. However, the technical and economic feasibility of recycling has been proven, thus enabling certain Member States (and in particular Denmark, the Netherlands and Belgium) to achieve recycling rates of more than 80%. [20]

2.1.3 United States

According to the U.S. Environmental Protection Agency (EPA), some 60 percent of America's landfills have closed within the last 10 years. Those that remain are rapidly running out of space. [5]

Studies conducted by the Solid Waste Department of Portland, Oregon (Metro), estimated that approximately 4 lbs. of waste is generated for every square foot of floor area of new residential construction. [16]

The following facts about C&D debris are from Characterization of Building-Related Construction and Demolition Debris in the United States, EPA document 530-R-98-010. [17]

- An estimated 136 million tons of building-related C&D debris were generated in 1996. (This compares to 208 million tons of municipal solid waste in 1996.)
- An estimated 20-30 percent of building-related C&D debris was recovered for processing and recycling in 1996. The materials most frequently recovered and recycled were concrete, asphalt, metals, and wood.
- An estimated 35-45 percent of building-related C&D debris was sent to C&D landfills in 1996. An estimated 30-40 percent of C&D debris is managed on-site, at municipal solid waste landfills, or at unpermitted disposal sites.
- Forty-three percent of the waste (58 million tons per year) is generated from residential source.

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3.0 WASTE MATERIALS AT A CONSTRUCTION SITE

Various studies indicate that wood and drywall are the largest contributors to the C&D waste stream, constituting approximately 60% in new construction. Wood is the largest contributor, followed by drywall. A different study indicates that asphalt, concrete and wood represent about 70 percent of waste C&D materials generated in Canada, while significant quantities of rubble/aggregate, paper, gypsum, building materials, metal and other materials are found in the remaining 30 percent.

A study in Edmonton in the early '90s found that an average of 2,800 kg of waste per house was generated.

3.1 WOOD

Dimensional lumber represents the largest source of wood waste for structural support, framing, siding, trim etc., followed by plywood and particle/chipboard which is used for concrete forms, flooring, roofing, panelling, etc. Other smaller sources of wood waste such as furniture and cabinets are also found in building C&D waste. A second source of wood waste specifically identified in the literature by British Columbia and associated with C&D activity, is landclearing wood wastes. Wood waste generated by landclearing activities, consisting largely of stumps and logs, represent a significant portion (between 18 and 29 percent of total C&D waste generated) and over 50% of total C&D wood waste generated in B.C. in 1988 and 1992. [27]

3.2 DRYWALL

Drywall, another major component of the waste stream, is commonly discarded at the rate of one pound of waste for each square foot of finished floor area, or 12% of new construction drywall. [35] 64% of drywall waste is generated from new construction, followed by demolition (14 percent), manufacturing (12 percent), and renovation (10 percent). [35]

Hydrogen sulfide gas may be produced when landfilling gypsum, particularly in a wet climate. Several conditions are required, including a moist, anaerobic environment, and a low pH. Hydrogen sulfide gas is toxic at high concentrations (~1,000 parts per million) and has a foul, rotten egg odor. Several communities in Canada do not accept drywall at landfills for this reason. Incineration may produce toxic sulfur dioxide gas. Therefore, incineration of gypsum is prohibited by some jurisdictions. [35]

3.3 ASPHALT SHINGLES

Approximately 11 million tons of waste asphalt roofing shingles are generated in the U.S. per year. Reroofing jobs account for 10 million tons, with another 1 million from manufacturing scrap. Asphalt is banned from same landfills so alternative disposal methods are becoming increasingly important. [38]

3.4 CARPETS

Used carpet and rugs generated nationwide in 1993 amounted to around 2 million tons, according to the U.S. Environmental Protection Agency's *Characterization of Municipal Solid Waste: 1994 Update.* [34]

3.5 OTHER MATERIALS

As for the other materials found at sites of new construction [31]

- masonry is the heaviest component and includes rubble from concrete blocks, bricks and tile remnants can cost a lot to dump in landfill sites;
- on a volume basis, cardboard is a significant component of the waste stream,
- metal wastes can contribute significantly to the waste stream in demolition, but not so much in new construction.
- plastics represent a serious waste disposal problem because their volumes are increasing and they do not degrade in landfill sites.
- unless disposed of properly, paints, solvents and sealants can leak damaging chemicals into the soil, groundwater and the atmosphere for decades.

3.6 HAZARDOUS WASTES

Hazardous wastes include the following materials: asbestos, lead pipes, adhesives, wood treated with preservatives, and contaminated soil, in addition to paints, solvents and sealants. The volume of waste from these sources is relatively small compared with the total volume of the stream and is more significant in demolition rather than new construction. However, special precautions must be taken for their management since their presence may contaminate the entire waste stream.

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4.0 LEGISLATION AND REGULATIONS GOVERNING CONSTRUCTION WASTE MANAGEMENT IN CANADA

There does not appear to be a consensus regarding the need and effectiveness of introducing legislation to force the reduction of waste. It has been suggested that the most effective way to encourage waste minimization is to make it cost effective.

Local policies and regulations regarding disposal of solid waste vary widely from jurisdiction to jurisdiction. In some areas dumping of certain wastes, such as wood, gypsum wallboard and corrugated cardboard are restricted. Where these policies are enforced, the construction industry has made the necessary changes to comply. For example, the Saint John, New Brunswick, area is similar to many other areas of the country that do not specifically restrict the disposal of certain construction waste materials. In these areas, waste reduction can only be achieved by a decision of the client or of the contractor. Though the steady rise in the cost of waste disposal may have some effect on waste disposal practices, the use of cost alone as a stimulus to reduce waste will often be ineffective. In some cases the high cost of waste disposal may be accepted as the price of convenient removal of waste from a project site. [53]

In 1989, the federal government and the provinces, through the Canadian Council of Ministers of the Environment (CCME), established a national goal of 50% reduction in waste going for disposal by the year 2000, using 1988 as the baseline year. In that year (1988), Canada produced 15 million tonnes of construction waste. [48].

In 1989, the Canadian Council of Ministers of the Environment (CCME) established a multistakeholder National Packaging Task Force to develop national policies for reducing the environmental impact of packaging. Due to the amount of packaging resulting, indirectly, from construction (virtually everything delivered to a construction site is packaged, legislation concerning packaging is of significance to construction waste management. The Task Force comprises representatives from federal, provincial, territorial and municipal governments, industry, consumer and environmental groups. The Task Force developed the National Packaging Protocol (NaPP), which was endorsed by the CCME in March 1990. The Protocol is a voluntary covenant viewed by members of the Task Force as a ten-year commitment, and as a challenge to turn around Canada's packaging waste generation and disposal practices. Under the terms of the Protocol, stakeholders voluntarily agreed to reduce by 50 percent the amount of packaging sent for disposal by the year 2000. The Protocol sets out six packaging policies for Canada and establishes three milestone targets for the diversion of packaging waste from disposal compared to a base year of 1988. The Six Packaging Policies are:

1. All packaging shall have minimal effects on the environment.

2. Priority will be given to the management of packaging through source reduction, reuse and recycling.
3. A continuing campaign of information and education will be undertaken to make all Canadians aware of the function and environmental impacts of packaging.
4. These policies will apply to all packaging used in Canada, including imports.
5. Regulations will be implemented as necessary to achieve compliance with these policies.
6. All government policies and practices affecting packaging will be consistent with these national policies. [43]

This packaging protocol affects the construction industry given that packaging is used on virtually all products and materials brought to the site.

- adopt a waste management policy to be implemented on all projects;
- promote this policy to all employees and partners;
- select durable products in the purchase of construction materials;
- minimize the purchase of materials to meet the required amounts only;
- adopt techniques that will minimize construction wastes;
- reuse all possible waste products on site;
- implement source separation on site for recycling purposes;
- identify markets of recycled goods;
- identify potential users of waste materials;
- use landfill sites only where no other options are available.

Province-specific information and initiatives are provided, in brief, in "Construction and Demolition Waste in Canada: Quantification of Waste and Identification of Opportunities for Diversion From Disposal" [42], and are summarized below. British Columbia and Ontario are the only provinces where construction materials have been banned (as of August 1992) from some landfill sites (both federal and provincial).

4.1.1 Alberta

In March 1992, Alberta Environment completed the first step of a waste minimization program that included the C&D industry and identified it as the number one priority. Recommendations included the preparation of industry-specific waste minimization guidance documents and preparation of factsheets. Subsequently, a C&D Waste Minimization Manual was published by Alberta Environment which outlines design considerations, purchasing and inventory initiatives and site activities which can minimize waste on a construction site.

4.1.2 Manitoba

In March 1991, Manitoba Environment issued a strategy report for a new program, the Waste Reduction and Prevention (WRAP) program.

4.1.3 Ontario

The Province of Ontario has enacted the most comprehensive waste management legislation in Canada which will require C&D companies where greater than 50 people are employed to prepare and implement waste audits, waste reduction workplans and implementation programs for any project of 2000 square meters or greater.

In the early 1990s, the province of Ontario struck a Construction and Demolition (C&D) Waste Reduction Strategy Team to identify practical ways of achieving the provinces waste reduction target of reducing waste by at least 50 percent by the year 2000 compared to 1987 levels. In 1994, provincial regulations were introduced affecting waste management in several industries, including residential construction. In contrast to these developments, in the early 1990s de-regulation led to competition between landfill sites, and tipping fees plummeted. The sudden drop in landfill costs together with the rise of big disposal companies offering automated separation of mixed wastes meant that construction waste disposal has become cheaper and less complicated, and therefore less a concern for the home builder. This, despite the fact that landfills are nearing capacity and society continues to struggle with the costs of the waste burden. [40]

In January 1993, the Ontario construction industry adopted the Ontario Construction Industry 3Rs Code of Practice relating to waste management: REDUCE, REUSE, and RECYCLE. The Code is not intended to be a comprehensive document establishing a construction industry standard for the 3Rs of waste management. However, the Ontario construction industry will promote strategies to reduce the amount of waste being sent to landfill. [50]

4.1.4 Quebec

Construction and Demolition (C&D) waste in Quebec is not disposed of in the same location as sanitary waste. Special sites which undergo less stringent regulations are selected for C&D wastes. However, new legislation for the management of waste adopts a more integrated approach, with the goal of reducing by half, by the year 2000, the volume of waste to be delivered to landfills. The new version of the regulation will deal specifically with the recycling and recovery of C&D waste including the requirement for annual reports on data regarding the management of waste. It is anticipated that this will

lead to a better understanding of these wastes, the treatment of C&D disposal and to an evaluation of their reuse and recycling potential. [42]

4.1.5 Nova Scotia

In February 1996, the provincial government enacted the Nova Scotia Waste-Resource Management Regulations in order to achieve the Provinces 50% waste reduction requirement by the year 2000. The regulations include the issuance of Construction and Demolition Debris Disposal Site Guidelines. The guidelines clearly defined C&D debris materials, and established the Province's role in regulating disposal sites. [44]

4.1.6 British Columbia

The Greater Vancouver Regional District (GVRD) has developed a 3Rs (Reduce, Reuse, Recycle) Code of Practice for the Building Industry which is a voluntary Code that encourages builders to:

- assess waste types and volumes, and establish waste reduction plans at all project sites;
- separate asphalt, concrete, clean wood, scrap metal and cardboard for recycling at construction and/or demolition sites;
- reuse materials on construction and renovation sites, wherever possible;
- salvage reusable materials from buildings during demolition and renovation;
- relocate entire buildings which would otherwise be demolished;
- minimize damage to construction materials through proper on-site storage and handling; and
- ask suppliers to minimize product packaging and/or take back packaging for reuse or recycling. [46]

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5.0 APPROACHES TO CONSTRUCTION WASTE MANAGEMENT

5.1 INTRODUCTION

The management of construction waste can be summarized by the 3Rs: Reduce waste at source, Reuse what would normally be landfilled, and Recycle materials for which there is no immediate use. Waste at sites of new construction is generally more likely to be both reused and recycled since it is easier to keep materials cleaner and isolated than at demolition sites. Another advantage to new construction for following the 3Rs is that construction generally occurs in phases, which increases the potential for separating, reusing and recycling materials. Of the 3Rs, reducing waste is the most efficient and the most effective because reduction means producing less waste to begin with.

A waste management plan is an approach to handling waste that will minimize waste, maximize material recovery, and reduce total waste management costs. This section outlines the basics of a waste management plan to meet these objectives.

5.2 LOCAL REGULATIONS

Before developing a waste management plan, it is important to know local regulations governing waste disposal, including disposal fees and restrictions on materials allowed in landfills. Where available, it may be possible to be included on a mailing list with announcements regarding changes to fees and rules.

It is in the best interests of builders and renovators to work with haulers who understand and support good waste management practices. As the waste generator, you may be held legally responsible for the disposal of your waste materials, even if you have hired someone else to dump them. In fact, fines have been levied against builders and renovators because their haulers dumped illegally. [83]

5.3 ANALYZE PROJECT WASTE

The first step to a waste management plan is the generation of a waste audit, which is the process of determining how much waste is generated and when. The audit itemizes all the wastes generated in the construction process over time, and determines the volume as well as the cost of disposal. The following steps can be taken in the development of a waste audit:

- Determine waste management costs for conventional disposal.
- Determine the types and quantities of construction waste generated.
- Identify alternatives to the disposal of construction waste materials

- Determine the costs associated with handling the recovery of various construction waste materials.

The duration and the complexity of the audit will depend on the size of the operation. Small builders and renovators will probably have a clear picture of the types and amounts of waste they typically produce after monitoring the waste from only a few jobs. Larger builders may have to track their waste output for several months. [NOTE: Waste audit charts are included in "Construction and the Environment – How Home Builders and Renovators Can Help Build a Green Future" [83]]. The waste audit should identify how materials are wasted on site.

5.4 Implementing the Waste Management Plan

For a waste management plan to be effective, everyone involved at the construction site must participate. This means that all members of the team must be kept informed about decisions regarding, and successes of, the waste management plan. The following steps are suggested:

- Identify a person responsible for the waste management plan, such as a site supervisor.
- Discuss waste management at project meetings. Include all trades and subcontractors involved in the project and gather their input on proposed waste management activities.
- Review subcontract provisions to ensure clarity regarding responsibilities for waste management.
- Encourage workers to change their attitudes toward waste management. They must become aware of the environmental and economic implications of waste reduction and recycling.
- Charge back any trades who fail to comply with contract requirements to clean up or manage waste.
- Tell contractors that the company will deal only with those who manage their waste in environmentally friendly ways.

5.5 The 3Rs

This section describes, in general, an approach to the 3Rs and how it can be part of the waste management plan. Material-specific suggestions are given in subsequent sections.

5.5.1 Reduce

Product reduction is the most effective way to conserve energy and reduce contributions to the post-industry waste stream. When a product can be reduced with no significant

loss of effectiveness, two things happen: no additional energy must be expended to manufacture a new product, and the original product does not become waste. [85]

- Reducing waste must start even before construction begins. The following outlines, in general, steps that can be taken to reduce the amount of waste generated:Store materials so as to prevent damage from careless handling and weather.
- Store leftover supplies and materials for your next project.
- Order materials just before they are needed so that they are less likely to be damaged, misplaced or stolen.
- Favour designs that use standard sizes, such as eight-foot lengths.
- Use advanced framing techniques such as: moving studs from 16-in. to 24-in. on-center (if structurally viable), eliminating unnecessary cripples and nailers, and other methods for reducing framing materials.
- Keep an eye on the waste generated as this indicates how efficiently crews and subcontractors use materials. Using a dumpster with 6-ft-high sides can conceal a lot of unnecessary waste. A debris pile, or piles, that is fenced off with rolled wire or plastic mesh, will keep the waste visible.
- Prefabricate common elements at central locations.
- Make subcontractors responsible for ordering and buying their own materials. This will give them more incentive to use materials wisely. If subcontractors are required to include the cost of removing their waste in their bids, they will have more incentive to produce less waste.
- Use, when possible, materials that are both recycled and recyclable.
- Have suppliers take away as much of their packaging as is practicable or remove packaging before shipping materials to your site. Alternatively, materials can be wrapped in reusable blankets or padding.
- Buy materials such as fasteners, paint, caulking and drywall mud in bulk containers.
- Favour renovation over demolition whenever appropriate.
- Use alternative building systems, such as Structural Insulated Panels (SIPs), that combine the structural framing and the insulation of the building.

5.5.2 Reuse

Reusing materials is particularly beneficial when applied to demolition and renovation. Materials and structural elements can be removed carefully, so as to maintain their integrity. The following steps outline, in general, steps that can be taken to reuse materials on new construction sites rather than disposing of them:

- Scratched or dented cabinets, doors and other fixtures can be donated to non-profit groups, such as Habitat for Humanity, then taken as a tax-deductible charitable donation. Non-profit organizations can be given access to the construction site after hours for sorting through and taking materials, resulting in less waste being hauled to landfill and consequently less cost for the builder.

- Sheet flooring can be neatly rolled and stored for the homeowner.
- Off-cuts, whether wood, flooring, gypsum, etc., can be reused on-site when attention is given to reusing materials (Section 7.2 provides material-specific suggestions).

5.5.3 Recycle

The handling of waste will depend on the method chosen. It may be necessary to separate materials on-site. Some recycling companies will accept only certain types of waste, while others will accept mixed waste and sort it for recycling. Local construction waste resource directories, provincial environment departments, municipal engineering departments and local recycling groups are good sources for information on waste management firms, as well as legal responsibilities. Request bids and proposals from construction waste management firms when implementing a waste management plan.

As outlined in Construction Works NewsGram #6 [73], there are four methods for the collection and delivery of materials to recycling facilities.

- Commercial haulers: This option involves contracting with one or more garbage or recycling service providers to place collection containers on-site and haul the full containers to recycling facilities. This strategy works well on projects where large quantities of materials are generated.
- Self-hauling: For residential construction and remodeling, this is often the recycling method of choice.
- Cleanup services: A construction clean-up service that includes recycling offers garbage and recycling services all in one.
- Commingled recycling: Commingled recycling programs collect containers of mixed recyclables or mixed garbage and recyclables, and separate them at the waste handling facility. This option is convenient for cramped sites, but the cost savings are limited and recycling rates may be lower than other options. This is discussed further in Section 5.6, Material Separation.

Using worksheets and the waste audit, determine the costs and savings for recycling each material and method. Based on these results, decide which materials to recycle. It may not be cost-effective to recycle all the wastes generated.

Subcontractors can either be responsible for their own waste or can use the recycling bins on-site. If subcontractors are responsible for their own waste, it may be necessary to require written reports to ensure that material is actually being recycled. Similarly, it may be necessary to require haulers to report the volumes, weights and costs of each load of material that is sent to be recycled to ensure that the material is being taken to a licensed facility.

The cost of transport can be a major factor in the economics of recycling; it has been reported that beyond a 25 km limit, the economic return on recycling seems to be very difficult to achieve. [84]

Material-specific suggestions are given in Section 7.3.

5.5.4 Promotion and Education

Promotion and education are two critical factors in the successful implementation of a waste management plan. "Construction WorksNewsGram #8" [75] provides the following steps:

- Include waste handling requirements in all project documents. This makes it clear from the beginning that waste prevention and recycling is expected from all crew members and subcontractors.
- Treat waste management like a safety program. Integrate recycling training into the safety education, or design a separate recycling education program.
- Create a name or slogan for the program to be used in education and promotion. Inexpensive rewards such as hats, T-shirts, or decals can provide incentives to make the plan work.
- Share the success. Let subcontractors and crews know how effective they have been by regularly posting the volumes of materials reused or recycled.
- Be positive! When the crew and subcontractors are motivated and understand the goals, they will figure out creative ways to overcome obstacles and work efficiently.

5.6 Material Separation

5.6.1 Mechanical separation and processing

All recyclable material can be commingled, or collected in one container, and separated at a processing facility. Generally, this is a more costly approach since the cost advantage of selling recyclable material is lost. In addition, there is more contamination of the materials and therefore the recovery rate is less than would have been achieved with source separation.

The following description of mechanical separation and processing is from "Construction and Demolition Waste in Canada: Quantification of Waste and Identification of Opportunities for Diversion From Disposal" [60]:

- Material is dumped onto a concrete pad tipping area, where it is inspected and oversize items are removed by a grapple. The grapple is also used to load the material to be processed into the feed hopper.
- From the hopper, the material travels by conveyor up to a Bezner bucket conveyor. The bucket conveyor is a cross conveyor made of 225 x 225 mm x 100 mm

compartments. As the waste stream tumbles across the bucket conveyor, all items that will fit into the compartments are removed from the stream.

- This material is then screened to remove fines (or very small items).
- Metals are then removed by magnetic separator and the remaining material is transferred onto a slider belt conveyor and processed through a sorting enclosure area along with the stream of material which passes over the bucket conveyor.
- The sorting enclosure is elevated over roll off containers where material is picked from the conveyor and dropped through chutes into the containers. All items not removed are considered residue and landfilled.
- Bezner classifiers separate the waste stream by size, shape and weight.

There are not many established processing facilities, or Material Recovery Facilities (MRFs), in North America but more are being developed.

An advantage to using a central processing plant for the recycling of construction waste is simplicity. The builder only needs to deal with one waste management company and employees need spend no time or effort separating materials and putting them in the correct containers. These facilities have been able to achieve a recovery rate of up to 82 percent. It has been suggested that materials separated on the construction site are generally contaminated and almost always need separation off-site anyway.

In selecting a Waste Management Service and Recovery Facility, determine how much each firm can recover. It may not be cost-effective to hire the firm who can recover the most.

5.6.2 Source or Site Separation

Source separation, which is also called site separation, involves keeping waste materials apart right from the beginning.

Separate containers, or piles, can be established for each of the following materials on-site:

- scrap metals,
- wood,
- corrugated cardboard,
- drywall, and
- unrecoverable mixed construction waste.

Construction sites can/should also have a container for aluminum, plastic, and glass beverage containers.

Materials that are separated on-site for recycling must, generally, be kept clean and isolated. The degree of isolation required may vary between recycling centres. One approach is to keep the disposal containers away from the active job site, as well as away from the view of the public. It may be necessary to have small containers that are removed/emptied frequently in order to reduce the contamination. A central recycling depot is a possiblity for a development with several builders, but the cooperation of all must be maintained for this method to be successful. The developer can coordinate the waste management for a fee (this method was used at a trial site in Edmonton where the developer charged $200/house). On the other hand, one study in the US found that this system of centrally located containers did not work, and posed the risk of untidy and unsafe job sites.

A sample of a collection center layout can be found in "Residential Construction Waste: From Disposal to Management". [78]

The size and location of the site will significantly affect on–site waste management. In general, it can be advantageous to provide some piles for reusable scraps so that sub-trades can easily locate them. For instance, a segregated pile of lumber off-cuts could be used for bridging or backing, and a pile of scrap sheet metal could be reused for patches. Garbage cans and other small containers can be used to collect recyclable materials generated in smaller amounts.

Site separation can be made easier for the crews by following some of these suggestions [60]:

- Put labels on bins to show what kinds of waste are allowed in them, such as Wood Only! On a small job site, where there may be only one bin, place dividers in the bin to separate different types of waste and check periodically to make sure they have not been removed. New bins are being developed with permanent dividers for this very reason. Alternatively, partition off areas for piles of waste – when the waste is visible, more care is generally taken so as not to throw out unnecessary amounts.
- Have small, labeled containers for each recyclable material in front of each house. These bins can be made of plywood or isolate an area using plastic fencing. This means that workers do not have to transport their waste to central areas, and the bins can be emptied frequently thereby reducing the amount of contamination. The public is less likely to dump waste, and the cost of the rental of boxes is saved. Also, there is almost an automatic separation as the work proceeds in phases (e.g., wood from the framing stage).
- Require subtrades to clean up their waste and put it into proper bins by writing this requirement into tender documents and contracts. This step will reduce the clean-up time for your own crews and is just good building practice. An example of wording that could be put into a contract is "The subcontractor is responsible for daily clean-

up and removal of all waste materials created during construction activities. If wastes are to be cleaned up by other personnel, the subcontractor will be back-charged at the rate of __ dollars per hour." [83] Subcontractors not set up to haul waste may wish to negotiate with the general contractor to have waste removed.

- Remove waste frequently. For example, hauling away wood waste when framing is completed will lessen the likelihood that it will get mixed with other garbage.
- Centralize certain site operations, if possible. You might, for instance, cut all the wood for a group of houses in one place so that all the waste will be in one spot as well.
- Use central containers with locks to reduce the disposal of unwanted waste by the public in off-hours.

Advantages of source separation include reduced disposal costs and potential income through the sale of salvaged material. To maximize the disposal cost savings, labor requirements for material separation and disposal must be minimized. This can be achieved with an appropriate source separation strategy, and identifying suitable local processors.

5.6.3 Other Approaches to Material Separation

Some specialized waste haulers will clean up and sort wastes from around a site. This makes it unnecessary for on-site workers to sort the wastes. Contamination is also minimized because the waste hauler has direct control over what is loaded on the truck.

A materials management crew (e.g., of two to four people) can make rounds to clean up the job site. The size of the crew and frequency of pickups are determined by construction activity. The crew can use a truck or trailer, and some type of containers to pickup all unusable materials for recovery or disposal. The crew also sorts reusable materials into stockpiles suiting the needs of the construction crews. The rounds end back at the collection center where all materials are placed in designated containers. This waste hauler could either be a subcontractor or a company employee.

Clean-up services can time their pick-up of waste to relate to the various stages of construction, allowing wood, cardboard, drywall, or other materials to be substantially separated by the building process. Other advantages of this type of waste material handling are: predetermined waste disposal costs, the builder can specify the degree of clean-up, and it becomes someone elses responsibility to determine what can and cannot be recycled. These types of services have been most effective in areas that have relatively high disposal costs and established recycling markets for common construction waste materials.

Using a portable grinding machine, it is possible to grind up all wood waste and drywall and apply it to the site just before seeding or sodding the lot. If all wood waste and drywall could be handled this way, containment, transport, and landfilling costs would be eliminated for up to 65 percent of job-site waste. If cardboard were included, it would be even higher. The equipment can be rented, or for large production builders, bought. However, local regulations may not allow this type of disposal.

5.7 SITE SUPERVISION

An effective waste management plan, when using site-separation in particular, requires one person designated to be responsible for the waste management activities. Typically, this person is the site manager, or an employee whose job includes clean-up on one or several sites. She or he will need the authority and support of managers in order to be able to influence site workers and waste-hauling personnel. This person should also have the following responsibilities:

- Oversee the efficiency of the waste management system and coordinate the pickup of containers or the hauling of waste.
- Ensure that materials are separated for recovery.
- Distinguish reusable materials from materials suitable for recycling.
- Guarantee waste clean-up by the appropriate personnel.
- Coordinate the storage of on-site materials to safeguard against theft, damage and contamination.
- Work with staff carpenters and site superintendent on the best locations for stockpiling reusable materials.

5.8 CONCLUSION

Builders represent just one group that needs to be involved in construction waste management. Waste haulers, recyclers, local building product manufacturers, landfill operators/owners, and local solid waste officials all need to be involved in a successful waste reduction/waste management plan. Local building associations might be a good source for contacts for developing an industry-wide approach.

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6.0 EXPERIENCES IN CONSTRUCTION WASTE MANAGEMENT IN OTHER COUNTRIES

According to D. Elder, Canada and the U.S. are significantly ahead of the rest of all other markets in managing construction waste, except Europe: land pressures in some of the smaller countries are so great that they have been recycling building materials for centuries in ways that we don't even think about. [89]

This section summarizes some of the initiatives, statistics and experiences related to construction waste management in countries outside of North America.

Waste management is obviously a concern all over the world. By way of example is the Inter-Regional Workshop on Technologies of Sustainable Waste Management (SWM) that was held in Alexandria, Egypt, from 13 to 15 July 1999. Representatives from 14 nations participated in the workshop which was co-organised by the Centre for Environment and Development in the Arab Region and Europe (CEDARE), UNEP IETC, Osaka, Japan, and the Association of Enterprises for Environmental Conservation (AEEC) in Egypt. The workshop also received support from UNEPs Regional Offices in West Asia (ROWA) and Africa (ROA). Participants included those from Djibouti, Egypt, Jordan, Lebanon, Kenya, Kuwait, Malta, Morocco, Nigeria, Oman, Palestine, Qatar, UAE and Yemen. Other participants included representatives of international organisations, NGOs, and private sector companies in the field of waste management. Workshop participants came up with a set of recommendations for follow-up actions in the area of waste management, one of which is: UNIDO and UNEP IETC should begin documenting environmental and waste management best practices in the building and construction industry. [93]

6.1 EUROPEAN UNION

The hierarchical principle applying to waste management methods (prevention then recycling, energy extraction and finally disposal) is not applied in most of the Member States, thus leading to sub-optimum utilisation of natural resources. [90]

Waste that can be recovered in the EU include: aggregates obtained from concrete and brick waste, waste containing gypsum, wood, plastics, ferrous and non-ferrous metals, and glass. A recycled material that appears to be of particular concern is aggregate. The volume of recycled aggregate is sufficient that it becomes significant enough that assurances are necessary that there will be no discrimination on the basis of an aggregates origin. A specific initiative on the environmental issues of PVC is in preparation for the Commission. The Netherlands, Austria, Denmark and Germany have already begun initiatives to collect plastic waste, in particular PVC. [92]

Directorate E, the Directorate for General Environment of the European Commission, put forward a strategy, recommending a series of actions to improve the management of the C&D waste stream. Apparently, in some European countries, there is considerable illegal landfilling, particularly of C&D waste. Very few Member States have specific management legislation. A difficulty that arises in the implementation of a strategy for managing C&D waste is that C&D waste is produced very differently in each of the EU countries. Environmental protection also varies greatly. However, those countries (and in particular the Netherlands, Denmark and Belgium) which have introduced measures to improve its management, have achieved high levels of recycling. Directorate E of the European Commission suggests that the classification used in the European Waste Catalogue should be used as the basis for gathering and submitting data on the production and management of this waste stream. [90]

Other initiatives by the Directorate include:

- Directive 1999/3/EEC was developed with the aim, as far as possible, to prevent or diminish the adverse effects of landfilling waste on the environment and human health throughout the service life of a given landfill. It is deemed that landfill sites must be properly managed and illegal dumping must be made virtually impossible and subject to penalties. [90]
- The Directorate is encouraging Member States to eliminate discrimination against the use of recycled materials and to amend regulations if they are found to raise barriers to the use of recycled materials. [90]
- Under Article 7 of Directive 91/156/EEC on waste, Member States are to draw up waste management plans that cover, in particular, construction and demolition waste. Those plans may be national, regional or local, but must apply throughout the Member States. They should also be accompanied by codes of good practice in order to help manage that stream. [90]

Some examples of measures that have already been taken by members of the European Union (excluding the United Kingdom, which is discussed separately in the following section) are: [90]

- The Netherlands has drawn up a national building site waste plan for the period 1993-2000 comprising 50 measures aimed at banning the landfilling of recoverable waste. Most construction and demolition waste is already recovered and the recovery rate is expected to rise to 90% in the year 2000.
- In Denmark, the municipalities are the bodies responsible for collecting construction and demolition waste. More than half of the Danish municipalities (especially the major towns and cities) have introduced specific regulations on the sorting of this waste. A management plan set a recovery target of 82% for 1993. This target has since been exceeded in a great many places.

- In Germany, a voluntary agreement was concluded in 1996 between the Federal Ministry of the Environment and the federation to which most construction and demolition undertakings belong, with the aim of reducing the volume of waste disposed to landfill by 50% between 1995 and 2005.
- The waste management strategy in Dublin sets a recycling target of 82% for 2004.

The market for recycled materials is not highly developed in the south European countries (Italy, Spain, Portugal, Greece). They recycle very little of a sufficient quality and quantity to meet the demand for building materials at a moderate cost. [94]

A large number of control processing plants have been established in the last 5-10 years in many European countries including: The Netherlands (60), Denmark (17), The United Kingdom (>= 1) Ireland (0), Germany (BRD) (300), Belgium (>= 49), France (>= 10), Spain (1), Portugal (0), Italy (5). [86]

Examples of country-specific initiatives follow:

6.1.1 United Kingdom

A case study in the United Kingdom identified areas of bad practice in the handling of construction waste. These included poor storage, over ordering, poor segregation and poor handling of materials. The recommended approach taken to overcome these incorporated many of the suggestions found in section 5.0 and include:

1. Help sub-contractors to be responsible for material wastage.
2. Develop recovery of plasterboard with manufacturer.
3. Minimize packaging waste using crusher.
4. Segregate waste materials for reuse.
5. Order key housing units in pre-designed packages. [87]

The construction industry in the UK generates over 70 million tonnes of waste each year. Reducing the amount of waste generated by the construction industry is often, as in North America, constrained by the tight time and resource controls applied to project schedules. It appears that the approaches to construction waste management outlined in Section 5.0 can apply to the United Kingdom construction industry in the case of training and education, conducting waste audits, and implementing the 3Rs at the design stage. However, a study is being conducted by the Construction Industry Research & Information Association (CIRIA) to assess the feasibility of developing a tool to forecast and measure waste streams in construction. [88]

6.1.2 Germany

A workshop, the Global Pilot Workshop on Adopting ESTs, was held in Dresden, Germany in September, 1996: the pilot programme on adopting, applying and operating

Environmentally Sound Technologies (ESTs) has been developed by UNEP IETC in collaboration with the Centre for International Postgraduate Studies in Environmental Management at the Dresden University of Technology in Germany. Included in the discussion were proposals for the development of recycling sites for construction waste. [92]

6.2 AUSTRALIA

According to the Waste Management Association of Australia (WMAA), Construction and Demolition (C&D) waste is a significant component of the waste stream. It is estimated that over 1.5 million tonnes of C&D waste is landfilled in the greater Sydney region per year. Reducing C&D waste has therefore become a priority with the government. Efforts must be made to ensure that there are both facilities for recycling as well as markets for recycled goods. The C&D Division of the WMAA are currently addressing this challenge. [94]

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7.0 THE THREE 'R's OF CONSTRUCTION WASTE MANAGEMENT

7.1 METHODS TO REDUCE WASTE MATERIALS

The 3Rs are described previously in Section 5.5. The first of these Rs is Reduction. Reduction is the first step in a waste management plan because it is the most efficient and effective means of managing waste, both environmentally and financially. Using materials more efficiently means less use of virgin, or new, materials, which also saves money. Sending less waste for disposal further enhances savings. Sending less waste for disposal means cost savings in disposal fees as well as environmental benefits.

This section describes material specific-suggestions for reducing the amount of construction materials sent for disposal at a construction site.

7.1.1 Site

Methods to reduce the amount of waste from site preparation include:

- Minimize disruption to existing vegetation and soils by limiting the use of large machinery.
- As many trees as possible should be left standing. When they must be felled, chip the roots and branches on site.
- Limit the amount of excavation to limit soil disturbance.

7.1.2 Wood

Methods to reduce the amount of wood, or lumber, wasted on-site include:

- Review floor plans and elevations to ensure optimal use of sub-flooring and sheathing.
- Detail framing layouts to allow for more accurate lumber ordering. Where possible, have studs and joists pre-cut to reduce on-site waste.
- Use standard sizes when designing to reduce cutting waste.
- Favour designs with framing spaced at 24" o.c. rather than 16".
- Increase the spacing of floor joists, for example from 16" to 24" o.c., if structurally viable.
- Reduce the header sizes wherever possible.
- Amend framing details, where necessary, to minimize unnecessary corner studs, to avoid excessive amounts of lumber at window and door openings and to prevent overbuilt lintels wherever possible.
- Use pre-cut and pre-assembled roof and floor trusses which ensure that most of the waste is produced in a central location, where it can be recycled more easily.
- Use foam core panels or other factory assembled wall panels.

- Consider using resource-efficient materials, such as modular wall panels, wooden I-beams and flooring underlay made from recycled cardboard.
- Buy kiln-dried lumber to reduce waste from warping and shrinkage.
- Store lumber to prevent warping and twisting from exposure to the elements.

A study in Edmonton and one in the United States indicate that waste of dimensional lumber can be reduced by 50% if these techniques are employed.

7.1.3 Drywall

Methods to reduce the amount of drywall/gypsum wasted on-site include: [98, 99]

- Evaluate floor plans to see if room sizes can be standardized to minimize the off-cuts from board stocks.
- Construct standard sized walls and flat ceilings. Drywall sheets come in sizes from 4x8 to 4x16, and in thicknesses from ¼ to 1 inch. As 9-foot ceilings are becoming more popular, drywall is now available in 4-1/2-foot widths.
- Cut drywall waste into small pieces and place within the interior partition walls as thermal mass to smooth temperature fluctuations from one room to another, or in wall cavities in garages. Choose the locations for this reuse carefully to allow for future rewiring or replumbing.

7.1.4 Masonry

Methods to reduce the amount of masonry wasted on-site include:

- Improve take-offs and ordering procedures so that half skids of brick and block are not wasted.
- Store masonry products carefully to reduce damage from the elements and loss due to theft.
- Cut forms and order concrete carefully.

7.1.5 Cardboard

Methods to reduce the amount of cardboard wasted on-site include: [98]

- Most of the cardboard waste on a job site comes from packaging, therefore, where possible, specify reusable packaging, or
- Specify that suppliers are responsible for delivering goods with a bare minimum of packaging and for removing the packaging after delivery. A well-timed construction process will ensure that unprotected articles are not on the site long enough to become exposed to potential damage.
- Buy as many materials as possible in bulk containers.

7.1.6 Metal

Methods to reduce the amount of metal wasted on-site include:

- Require sub-trades to take away their own wastes. This encourages them to improve their efficiency and to reduce waste.

7.1.7 Paints, Solvents and Sealants

Methods to reduce the amount of paints, solvents and sealants wasted on-site include:

- Purchase only what is needed.
- Buy in bulk.
- Improve storage methods.

7.2 Methods to Reuse Waste Materials

The second of the 3Rs, as described in Section 5.5, is Reuse. Where possible, reuse waste that is generated in other stages of construction. When a material cannot be reused on-site, where possible, save it for reuse at another construction site. Also, clients are demanding that their architects find unique architectural pieces to incorporate into their new buildings, and across Canada salvaging components from buildings being demolished has become a very profitable business. [103]

Masonry, asphalt and chipped wood are used by landfills for daily cover and/or road base. Usually reduced tipping fees reflect that some value is attributed to these materials when put to one final use before being buried. [95]

Salvageable materials can be given to businesses (such as the Recycled Building Supply Center in Durham) that collect and resell used construction materials. [100]

This section describes material-specific suggestions for reusing waste construction materials that are typically sent for disposal at a construction site.

7.2.1 Site

Excavated soils and trees can be used for final site landscaping. Vegetation can be mulched on-site for landscape materials whenever possible.

7.2.2 Wood

Wood, or lumber, can be reused in the following applications:

- By making all cuts at a central location, smaller lengths of lumber can be made available for cripples, lintels, bridging, forming stakes and blocking without sawing up specially ordered 16-foot joists.

- Pallets can be torn apart and reused as forming stakes.
- Pallets can be returned to the vendors.
- Specific reusable forms, such as oiled shiplap, can be reused.
- With improved inventory and storage procedures, leftover lumber can be transported from one job site to another and used there.
- After all other avenues are exhausted, lumber residue can be reused as kindling or, if collected in large enough quantities, as fuel for central heating plants. [98]
- Plywood sheathing cut-off scraps that are rectangular and are 18 inches or more in width can be stockpiled for use as foundation forms.

7.2.3 Drywall

Drywall can be reused in the following applications:

- Reuse scraps for patches.
- Use cutoff pieces of new construction drywall as forms to support gunite (concrete sprayed on at high pressure) as it is being sprayed.
- Allow charities, such as Habitat for Humanity, to use off-cuts. They usually require half-size or larger. [110]

7.2.4 Masonry/Aggregates

Masonry and aggregates can be reused in the following applications:

- Brick and concrete waste can be used on-site under walkways or driveways.
- Excess concrete brought to the site can be used for such things as parking stops.
- Residue concrete can be resold for use in retaining walls.
- Blocks and bricks should be saved before they sink into the mud of a work site, and stored in a central location for use on another job. For example, excess brick from one or several projects can be used to build fireplaces or chimneys elsewhere.
- Masonry can be buried on the builders next construction site or left on site for the home buyers use.

7.2.5 Metalwork-HVAC and Electrical Wiring

Metalwork-HVAC and electrical wiring can be reused in the following applications:

- Use second-hand materials, such as circuit breaker boxes from used building materials supply stores.
- Store reusable cuttings in a central location in a separate pile to make it is easier to locate small pieces that might be needed for a repair.
- Small amounts of wiring can be / have been used by art students.

7.2.6 Paints

Paint can be reused in the following applications:

- Use leftover paint as a primer coat or undercoating on future paint jobs.

7.2.7 Carpet

Carpet can be reused in the following applications:

- Habitat for Humanity, which accepts like-new construction materials for affordable housing, is one organization that may find use for good reusable carpet, although it may require a minimum carpet quantity of about 800 square feet.
- Carpet can be cleansed, rejuvenated, restyled, and reinstalled as fresh carpet.
- Carpet can sometimes be leased, wherein carpet is taken back by the supplier after the end of the term of the lease. The carpet supplier will then recycle the worn carpet, ideally into a new carpet. [109]

7.2.8 Insulation

Leftover batt-type insulation can be reused in the following applications:

- added to attics,
- placed in interior walls to act as soundproofing,
- used as ventilation baffles in attics, and
- installed into house envelopes at joist header assemblies.

In commercial roofing systems, the extruded polystyrene insulation can generally be reused. Checks of previously installed extruded polystyrene insulation have shown the R-value to be in excess of 90 percent of the original R-value in many cases, even on roofs over 12 years old. All insulations can be reused if they are kept dry. Extruded polystyrene resists moisture penetration in all but the most extreme cases and, therefore, is often the most reusable. [96]

7.2.9 Glass

Glass can be reused in the following applications:

- Crushed glass can be used as aggregate material in french drains (subsurface drainage systems). [104]

7.2.10 Plumbing

Use fixtures from old buildings.

7.3 METHODS TO RECYCLE WASTE MATERIALS

It has been found that up to 80% of the waste from a construction site can be recycled when separated at source. This can result in cost savings for the builder as well as environmental benefits by reducing the waste being sent to the landfill.

Recycling facilities for cardboard, wood, gypsum/drywall and masonry are the most common. Technology for recycling other materials is developing, and in all cases, the availability of recycling centres must be determined before a recycling plan is initiated at a job site.

The acceptability and value of any load of recyclable material is increased if the material is kept clean, which may be easier if it is separated at source. It has been found that separate bins for different materials is the easiest way to accomplish this, or use scrap wood to build dividers in a bin. Dedicated containers can work well when they can be moved from the site at the end of the phase of work (for example, remove the bin for wood when the framing is complete; remove the bin for drywall once the interior finish is complete). See Section 5.6 for more information regarding material separation.

The following sections provide material-specific information for recycling construction waste.

7.3.1 Wood

Most wood waste generated at a construction site is recyclable. Wood can be recycled in the following products:

- manufactured building products/engineered wood products such as OSB,
- landscaping mulch,
- wood pulp,
- industrial fuel,
- compost bulking agent,
- animal bedding (use chipped wood), and
- landfill cover.

Wood should generally be untreated and unpainted. However, painted and/or treated wood might be acceptable in some products. There may be concern regarding the recycling of engineered wood products (plywood, OSB, wood I-beams) due to the adhesives they contain. Nails may not be a problem as they can be separated during the processing of the wood.

Cut-offs and scraps generated during the framing and trimming stages constitute a relatively clean and homogeneous waste stream that can make an excellent feedstock

for engineered wood production. This type of wood waste represents a highly desirable form of wood waste that processors are eager to obtain.

To minimize disposal costs and potentially generate income, contractors should contact local wood waste processors and inquire about setting up drop boxes on site for wood waste scraps. However, it may be more cost-effective to have a mobile chipper operator come to your site then to haul your waste to the grinder.

7.3.2 Drywall

Drywall, or gypsum, can be recycled into the following products:

- soil amendment (its use is controversial due to various additives, however this use has shown promise in preliminary research),
- gypsum board (up to 15% in new gypsum) (the gypsum can be sold as a powder, with or without paper, or molded into pellets),
- absorbent media (recycled gypsum can be sprinkled on floors of mechanics shops to absorb grease),
- animal bedding (recycled gypsum can be combined with wood shavings for animal bedding where it can be substituted for sawdust or sand to absorb moisture),
- flea powder (gypsum makes up over 90 percent of the inert material of some flea powders),
- athletic field marker (gypsum is used to mark lines on athletic fields), and
- paper (the paper can remain for some uses, such as soil amendment, though it may be removed for aesthetic reasons, otherwise most of the paper can be screened out, and recycled into paperboard, new wallboard paper, packaging, or compost).

Gypsum scraps should be kept dry, and uncontaminated by other wastes.

Technology is now available for the separation of paper from the gypsum in drywall. That, combined with the discovery in the 1980s that gypsum reacts in landfills to produce high levels of hydrogen sulphide, resulting in a ban at some landfills, has improved the development of the recycling market for gypsum products. However, recycling plants are not necessarily available in all centres.

Potential Markets for Drywall Waste

As research continues, new markets for recycled drywall are being developed (as reported in "Drywall Recycling" [110]). Some of the promising potential uses are listed below.

- **Cement Production:** Cement plants use large quantities of virgin gypsum. The gypsum is added to the clinker to control setting time. At one plant, test runs using recycled gypsum showed positive results except that the paper caused problems.

They stated they would be interested in recycled gypsum with 1 percent paper or less.

- **Stucco Additive:** A company in New Jersey is adding recycled gypsum to stucco.
- **Sludge Drying:** A company in New York is researching the mixing of recycled gypsum with sludge for bulking and drying. The State of New York is funding the study.
- **Water Treatment:** Recycled gypsum could be used to settle dirt and clay particles in turbid water. The State of New York is also funding this study.
- **Salty Soil Treatment:** Recycled gypsum could be used to facilitate the leaching out of sodium salt in soil along roads where salt is placed during winter.
- **Manure Treatment:** Recycled gypsum can be mixed with animal wastes to combine with ammonia and reduce odor. Several case studies in the state of Washington showed mixed results with this application.

Equipment

Grinding equipment can range from a large plant to a small mobile chipper. A hammermill is often used. The machinery grinds the drywall, producing about 93 percent gypsum powder and 7 percent shredded paper, by weight. Drywall recycling produces dust, which can be handled with a baghouse or air vacuum system. [110]

Most drywall from a construction site is recyclable. Drywall can be stacked on four by four wooden pallets for hauling to the recycling plant. Drywall can be easily scored with a utiility knife to fit on the pallett. Generally, the drywall must be clean, with no nails or screws, and, depending on the recycling centre, might not be acceptable if painted.

7.3.3 Masonry/Aggregate

Masonry and aggregate, including concrete, rock, asphalt and brick, are very expensive to dispose of since they are heavy and bulky. However, these materials can be recycled easily. Some recycling centres charge extra if rebar or other metals are included. Some recyclers accept mixed loads, but it is essential to check first.

Recycled aggregate can be used:

- in paved roads as aggregate base, aggregate subbase, and shoulders,
- in gravel roads as surfacing,
- as base for building foundations, and
- as fill for utility trenches.

More specifically:

- asphalt can be crushed and mixed with new asphalt (hot mix and cold mix);

- concrete can be crushed and screened as aggregate for road subbase, concrete, cement blocks, and fill; and
- brick can be reused or crushed for ornamental stone.

At this time, the primary market is aggregate base and subbase in road projects.

In recycling these materials, there are different waste management costs depending upon the level of recycling technology: [117]

- On-site crushing with mechanical sorting is the lowest cost option. This type of mobile crusher is being developed in the southern European States where the cost of disposal to landfill is very low and raw materials are cheap. This type of equipment is relatively common in Canada and the United States.
- More elaborate technologies are available that enable better-quality recycled aggregates to be produced by separating less desirable components. These technologies are becoming more common in France, the United Kingdom and certain Italian and Belgian regions. They are also available in Canada and the United States.
- Technologies are available that allow better sorting, resulting in high quality aggregate, at a price. In Europe, these technologies have only been developed in Denmark, the Netherlands, and Germany where there are laws banning these materials from landfills, or charges are very high for such disposal.

The availability of the technologies and recycling centres will dictate the costs for these different levels of recycling, which affect their economic viability. All recycling of aggregate is financially beneficial because of its bulk and the high cost to landfill it.

If on-site crushing is not chosen, asphalt, as well as other aggregates, can be taken to a processing plant where the following equipment will be used: [111]

- a hopper to receive the material,
- a jaw to break it into more manageable pieces,
- a cone or impact crusher to reduce size again,
- a vibrating screen to sort the aggregate, and
- a conveyor belt with a rotating magnet to remove metal contamination.

It is likely that local specifications would require that recycled aggregate meet the same grading and quality specifications as virgin aggregate.

7.3.4 Cardboard

Corrugated cardboard is the most commonly used packaging material for building products. Cardboard does not contribute greatly to the total weight of material in the waste stream, but may contribute as much as 30 percent of the total volume if it is not consolidated. Storing cardboard can be a challenge. One technique is to flatten it and

place it on a spike to prevent it from blowing away. Alternatively, cardboard can be kept separate at the job site in a separate dumpster. Because cardboard is so bulky, a compactor/baler is a useful tool, however, they are often too expensive unless volumes are great enough. However, if the volume of cardboard is great enough, they do become cost-effective. If dumping fees increase, compactors may become more attractive.

Corrugated cardboard is easily recyclable. Clean corrugated cardboard is recyclable seven to 10 times before the fibres become too short to recycle. There are an increasing number of depots willing to accept and pay for clean, dry corrugated cardboard. [120]

Corrugated cardboard can be recycled into the following products:

- other paperboard products (i.e., boxboard),
- cores for carpet rolls,
- drywall paper,
- fibreboard, and
- floor underlay.

Most recycling centres will not accept cardboard that contains plastic liners or wax-coated boxes. Styrofoam packing that is often used in packaging can render the cardboard almost impossible to recycle.

7.3.5 Metals

While metals can be recycled and the metal recycling industry is well established, the quantity of metals generated on residential construction sites is so low that many builders landfill it along with other waste. Some companies will pay for scrap and there are several depots where scrap can be deposited for free. [112]

Siding cut-off waste typically generated from a single home can be over 200 pounds, but this is generally not enough to be accepted at a recycling facility. This will depend on the facility. It may be possible, however, to return siding to a siding or building supply distributor where it can be collected until quantities are large enough to warrant recycling.

Galvanized metal framing is increasingly being used in housing construction and off-cuts can be recycled into new steel. Other metal waste that is generated at construction sites include aluminum, copper, steel, and brass, which can be sold to scrap metal yards

7.3.6 Vinyl/Plastics

Vinyl is recyclable and scrap vinyl has a reasonably high market value, but the amount of waste that is generated on a construction site is small, making recycling less attractive

and less cost-effective. Some builders make a point of separating these recyclables even if quantities are small. [95]

Plastics can be recycled in the following products:

- fuel, from plastic,
- plastic lumber, from ABB plastic,
- highway barriers, from PVC plastic,
- traffic cones, from polyethylene,
- insulation, from polystyrene,
- garbage bags,
- composters,
- drainage tiles, and
- sump liners.

Generally, plastic tarps and bags are not acceptable for recycling.

There is an organization called The National Polystyrene Recycling Company (NPRC). The organization was formed by Amoco Chemical Co., ARCO Chemical Co., Chevron Chemical Co., The Dow Chemical Co., Fina Oil and Chemical Co., Huntsman Chemical Corp., Mobil Chemical Co. and Polysar, Inc. The ultimate goal of NPRC is to recycle 25 percent of the single-service polystyrene foam used in the US by 1995. [96]

As with metal siding, vinyl siding cut-off waste typically generated from a single home can be over 200 pounds, but this is generally not enough to be accepted at a recycling facility. This will depend on the facility. It may be possible, however, to return siding to a siding or building supply distributor where it can be collected until quantities are large enough to warrant recycling.

Plastic waste, in order to be acceptable for recycling, should be kept clean, and should be in substantial volumes.

7.3.7 Asphalt Shingles

Asphalt shingles are often landfilled, although some are recycled, where facilities exist. There are, however, many products that can be made with recycled asphalt. More information on each of the following products is available from the California Integrated Waste Management Board:

- asphalt pavement (See "Asphalt Roofing Shingles in Asphalt Pavement", Pub #431-97-033),
- aggregate base and subbase (See "Asphalt Roofing Shingles in Aggregate Base", Pub #431-97-032), and

- cold patch for potholes, sidewalks, utility cuts, driveways, ramps, bridges, and parking lots. (See "Asphalt Roofing Shingles in Cold Patch", Pub #431-98-013).

Recycled asphalt shingles can also be used for:

- pothole patch,
- road and ground cover,
- new roofing, and
- fuel oil.

7.3.8 Paints, solvents and sealants

Paint recycling facilities are now in operation in most large communities, and more are being added all the time. Waste alkyd and latex paints can be recovered and converted into materials that meet or exceed the quality and performance of commercially available paint products and are safe to use. [98]

7.3.9 Carpet

Carpet is a major source of waste in the construction and demolition sector (primarily demolition). For example, approximately 2 million tons of carpet waste are produced annually in the United States. As such, companies or carpet manufacturers, are developing patented techniques or processes for recycling carpet. Some of these company-driven programs are outlined below [109]:

- BASF has developed a carpet-recycling initiative called the 6ix Again® Program. The nylon carpet fibre is first separated from the backing and utilized in one of two ways. It can go through a d-polymerization process to create raw material for the manufacture of virgin nylon. As well, it can be mixed with virgin nylon to produce a product that can be used for new carpeting or other nylon products, such as automotive parts, molded plastic and synthetic lumber. The nylon can be recycled over and over again, making it a closed-loop process. As for the leftover backing material, BASF makes every effort to find companies that may be able to use it, however, they do not guarantee that they will not dispose of it. Launched in February 1994, the program is available throughout the United States and Canada. The only limit to participation is the old carpeting must be replaced with a 6ix Again® product. For more information, see www.basf.com/commitment/ecology/econews/6ixAgain.html
- As part of DuPonts Partnership for Carpet Reclamation, the DuPont Flooring Systems stores will take any type of used carpet for reprocessing at DuPonts Chattanooga, Tennessee plant, as long as the replacement carpet is purchased from their stores. For more information, see www.dupont.com/Antron/PCR.html
- The Evergreen nylon recycling facility is a joint venture of Allied Signal and DSM Chemicals North America and can process 200 million pounds of nylon 6 carpet per

year. For more information on Allied Signals carpet recycling program and collection sites, contact Mr. Ed Hanger at (949) 727-0462 or visit the Web site at http://www.n6recycling.com/

- POWERBOND® ER3™, the worlds first carpet backing made from 100-percent recycled content materials. It is used on all of Collins & Aikmans modular carpet tiles and some of its six-foot roll carpeting. The company reclaims pre- and post-consumer carpeting, either its own or that manufactured by other carpet companies, or a similar composition, and with that as raw material for its backing system, manufactures new carpeting. Since Collins & Aikman does not mine virgin materials to make the carpet backings, it saves resources – and continues to save resources – because its life cycle is endless and is guaranteed not to be landfilled or incinerated. [121]
- wTe Corp. (Bedford, Massachusetts) investigated the viability of using old carpet as a fuel supplement to coal in large industrial and utility boilers (see www.wte.com).

Used carpets may also be recycled and used as a component of the following products:

- auto parts,
- plastic lumber, and
- parking stops.

For further information on carpet recycling, see also, Carpet & Padding: Reuse & Recycling Opportunities, an 8 panel pamphlet by the National Association of Home Builders Research Center (NAHBRC).

7.3.10 Glass

Glass can be recycled into fiberglass or used in place of sand in paving material.

7.3.11 Conclusions

Recycling plants may need to meet local environmental criteria for air and water and zoning. Recycling facilities are not always readily available.

To help expand markets for recyclable materials, it is important to buy building supplies that contain recycled materials. Some of these materials have been used for years by the construction industry, but they have not been advertised as recycled. There are also many new recycled-content building materials that you may not be aware of. [100]

The use of recycled building materials is going to gradually have a significant impact on the construction of buildings. More and more, indoor air quality is a critical issue, and the quality of the materials used in construction is critical. However, ensuring the quality

of recycled building materials can be challenging. Also, there is going to be a gradual impact on the economics of whether it is better to renovate or demolish buildings.

7.4 Materials That Are Not Recycled or Reused

Waste materials that cannot be recycled or reused are sent to a landfill, or alternatively, can be incinerated. Cases exist where recycling is not possible, generally when material is contaminated, such as with treated or painted wood, in which case energy recovery, by incineration, is a valuable, and viable, option.

Energy recovery through incineration of waste wood in primary forest products industries in Ontario is common place and is also frequently employed by other industries to supplement boiler fuel. Provided air quality regulations can be met by the operator, energy recovery of C&D wood can be achieved effectively in this manner.

Other less relevant forms of energy recovery such as fermentation and pyrolysis also represent an opportunity for C&D wood waste. However, the present limited capacity of these facilities precludes their use for energy recovery of C&D wood waste on a large scale. [102]

Only two provinces specifically reference incineration. In both cases, incineration was not a factor in handling C&D waste. Due to the inert nature of a large proportion of C&D wastes, it was not considered to be ideal for incinerator feedstock in a mixed state. [102]

7.5 References

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8.0 TYPICAL COSTS OF MATERIAL DISPOSAL

In the short term, many builders realize that anything wasted on the job costs them twice: once when its purchased, and again when its hauled off for disposal. Of course, disposal is a relatively tiny portion of the construction budget – about one-half of one percent of the cost of the typical home. But with the average builder earning a 5 percent profit margin, even small gains can make a difference. [133]

The builder must be careful to research the costs associated with waste disposal carefully, since these costs vary tremendously from region to region, and from year to year.

Care must be taken to consider all aspects of cost for waste disposal including labor, transportation and disposal fees. [131]

8.1 LANDFILLS

The cost of landfilling in Ontario, after increasing steadily for many years, dropped dramatically in the 1990s. Municipal landfills now compete with privately owned landfills here and across the United States and Quebec borders. Deregulation at the Canada/US border is blamed for huge decreases in the cost of waste disposal. [128]

As a rough indication, the following costs are reported for landfilling:

Hamilton, Ontario	$6 / tonne in 1975
	$180 / tonnne in 1990
	$70 / tonne in 1991
Toronto, Ontario	$150 / ton in 1991
	$150 / tonne in 1993
Ottawa, Ontario	$46 / ton in 1991
Quebec	$8.00 to $10.00 / tonne in 1993
Prince Edward Island	$20.00 / tonne in 1993
Newfoundland	$8.50 / tonne in 1993
Halifax, Nova Scotia	$78 / ton in 1991
Fredericton, New Brunswick	$43 / ton in 1991
Saint John, N.B.	$20 / ton in 1993
Regina, Saskatchewan	$12 / ton in 1991
Saskatchewan	$4.10 / tonne in 1993
Edmonton, Alberta	$15 / ton in 1991
Alberta	$8.00 to $10.00 / tonne in 1993
Vancouver, British Columbia	$70 / ton in 1991

In terms of costs of waste disposal per house, it has been estimated that it costs anywhere from less than $100 up to $1000. More specifically, the following costs are reported by the various home builders associations in 1990:

Toronto Home Builders Association	$300,
Regina Home Builders Association	$311,
In Edmonton	$300 to $450, and
In the United States	$511 US.

8.2 *Central Processing Facilities*

Capital costs, in the United States (in US dollars) were reported as follows in 1990, in Vermont.

low technology	$500,000-$1 million for 50-500 tons/day
medium technology	$1 million, 100 tons/day
	$3 million, 500 tons/day high technology
	$3 million 500 tons/day
	$5 million, 1,000 tons/day
Integrated Solid Waste Management	$5 million for 1,000 tons/day
	10 million for 2,500 tons/day

Processing costs, or tipping fees, range from $50 US/Ton to $25 US/Ton and $6 US/ cu. yd.

Available information on the net costs of processing mixed C&D waste is limited for North American conditions as costs are highly dependent on waste composition, operating conditions, C&D activity, the early stage of development of the systems and markets and variability in disposal cost which frequently determine whether or not a facility can turn a profit. [130]

8.3 *Waste Disposal Costs by Material Type*

gypsum board and old carpet waste	over $85 per tonne in Vancouver.
drywall / gypsum	$65 per tonne in the Toronto area
dimensional lumber	$85 per tonne

Note: disposal bans for drywall are in place in Peel, Metro, York, and Durham [127]

At recycling facilities used in a case study in Florida, in 1996, the following costs were determined (in US dollars):

metal:	Accepted load – None	Rejected load - $275 - $375
wood	Accepted load - $140	Rejected load - $275 - $375
cardboard	Accepted load – None	Rejected load - $375
drywall	Accepted load – None	Rejected load - $990

8.4 WASTE DISPOSAL COSTS PER HOUSE

According to the National Association of Home Builders, the average cost of waste removal is US $500 per residential construction site ($511 in a 2000 report). [126]

A case study in Florida in 1996 had average total costs for waste disposal or waste service of $750 US per house. There was little or no recycling or reusing of construction waste materials. [138]

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9.0 AVAILABILITY OF C&D RECYCLING FACILITIES

Directories, or databases, of local recyclers and waste haulers who offer construction waste recycling services have been compiled by several municipalities (e.g. Waterloo Region, Guelph, Region of Ottawa-Carleton), local home builders associations (e.g. London) and others (e.g. Recycling Council of Ontario, Clean Washington Center). There is a perception that recyclers are closing down as fast as they are opening up, and that such directories are immediately out of date. Those who have used them say that recyclers listed are often too far away, or may not accept materials due to over-supply. This supply-demand imbalance is not unique to the construction industry, but it certainly discourages at-source separation, and ensures recycling remains the least practical of the 3Rs. [139]

Other initiatives to encourage the recycling of construction waste include the development of a database on recycled-content/resource efficient building materials by the US Home Builders Association Research Center (NAHBRC). The database is called REDI™, and is continually updated. [139]

9.1 REFERENCES

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10.0 OTHER SOURCES

This section lists both organizations and publications that may be useful, in addition to references listed in previous sections, with respect to construction waste management.

10.1 ORGANIZATIONS

10.1.1 Canada

C&D Waste Web Site — collects and posts region and waste-specific information, case studies and contacts, links to and from other sites, etc. www.cdwaste.com "This resource has been developed as a repository of information for Canadian construction and demolition (C&D) waste management and 3Rs options. Information from other countries is also welcome. The following agencies have provided funding for the creation, promotion and maintenance of this site." Public Works and Government Services Canada, Environment Canada, Ontario Ministry of Environment, Department of National Defence, Ontario Reality Corporation, Innovative Management Solutions Inc."

Strategic Planning for Applied Research and Knowledge (SPARK) committee in BC -- The SPARK construction committee created a waste management sub-committee, to undertake research into the existing situation in BC.

Used Building Materials Association www.ubma.com "The Used Building Materials Association is a member non-profit, membership based organization that represent for-profit companies and non-profit organizations involved in the acquisition and redistribution of used building materials in Canada and the United States."

10.1.2 United States

Builders and Architects for a Sustainable Environment (BASE) in Portland, Maine

California Integrated Waste Management Board (CIWMB) – Their web site has numerous good fact sheets on C&D (www.ciwmb.ca.gov/ConDemo/) CIWMB is responsible for managing California's solid waste stream—helping California divert 50 percent of its waste from landfills by 2000 and protecting public health and the environment. The Waste Board is one of six agencies under the umbrella of the California Environmental Protection Agency. www.ciwmb.ca.gov/

California Recycling Business Assistance Team, or "R-Team," is a network that assists businesses that use recycled feedstock in manufacturing. Assistance is provided for financial, marketing, technical, business, and permitting needs. The R-Team is a cooperative effort of the CIWMB, California Trade and Commerce Agency, Business

Environmental Assistance Centers, and the U.S. EPA. Contact the R-Team by e-mail rteam@mrt.ciwmb.ca.gov or at (916) 341-6526.

CalMAX Program (California Materials Exchange) publishes free ads to help businesses find markets for materials traditionally discarded, including C&D materials. The CalMAX catalog is available on line at http://www.ciwmb.ca.gov/CalMAX/ and the database is updated daily. The hard-copy catalog is published quarterly. Contact: CalMAX, (877) 520-9703 (toll free).

Carpet and Rug Institute: "The Carpet and Rug Institute (CRI)...has formed a recycling committee which is actively working to resolve technical problems in carpet recycling, to study life cycle costs, to develop viable collection systems, and to monitor and encourage the use of alternate technologies to facilitate carpet recycling". For additional information, call CRI's headquarters at Dalton, Georgia, (706) 278-3178, or CRI-West at (818) 967-5208.

Clean Washington Center (CWC) – Another good source of fact sheets and publications on many aspects of C&D recycling. (www.cwc.org/)

King County Washington, Department of Natural Resources, Solid Waste Division – see http://dnr.metrokc.gov/swd/bizprog/sus_build/susbuild.htm for other links for the integration of recycling and green building design in construction plans.

New England Sustainable Energy Associations

The National Polystyrene Recycling Company (NPRC)

Smart Growth Network (www.smartgrowth.org/) is a subset of www.sustainable.org developed and maintained by the Sustainable Communities Network (SCN). Their website has links to other sites, organizations and publications related to Construction Waste Management.

The Reusable Building Materials Exchange on the internet is a good place to list reusable building materials. Sponsored by King County the service is free to contractors who want to make excess building materials available to the general public. The link to the site is http://dnr.metrokc.gov/swd/rbme/index.htm

Triangle K Council of Governments – This North Carolina organization produced "WasteSpec", a great tool particularly for large or commercial projects in terms of contract specification language for waste management. (www.tjcog.dst.nc.us/cdwaste.htm)

Used Building Materials Association (www.ubma.com) "The Used Building Materials Association is a member non-profit, membership based organization that represent for-profit companies and non-profit organizations involved in the acquisition and redistribution of used building materials in Canada and the United States."

Vermont's Builders for Social Responsibility – recently completed plans for a healthy, energy-efficient, affordable demonstration house.

Waste Reduction Institute of Minnesota (WRITAR)

West Coast Ecobuilding Network, promoted by Jeff Learned of Kent, Washington; published the Pacific Northwest Ecobuilding Directory listing 90 builders in the Northwest who claim to practice "green" construction.

Zone Loan Programme, low interest loans are available for businesses starting or expanding recycling operations. The business must be located in a designated Recycling Market Development Zone (RMDZ). Contact the R-Team by e-mail rteam@mrt.ciwmb.ca.gov or at (916) 341-6526.

10.1.3 Other

Construction Industry Research & Information Association (CIRIA) in the UK. "CIRIA is a UK-based research association concerned with improving the performance of all involved with construction and the environment. CIRIA works with industry to develop and implement best practice, leading to better performance. CIRIA produces best practice guidance in the form of technical reports, strategic guides, training packs, CD-ROMs and leaflets on issues of importance to the construction industry. These documents address key aspects of business practices such as legislation and regulation, training, management and economics. CIRIA also specialises in promoting and implementing best practice guidance to help industry practitioners improve their performance."

European Union of Developers and House Builders (UEPC) -- "UEPC is a European association created in 1958. The UEPC represents 30,000 developers or firms involved in house building and development that are members of federations from the 13 constituent countries. It represents the national federations of developers and house builders and is recognized by the European Authorities. It has, among others, observer status at EOTA (European Organisation for Technical Approvals). UEPC is a Non-governmental Organisation with consultative status (Roster) in the Economic and Social Council of the United Nations. It is also a member of the European Construction Forum, the Construction Contact Point and one of the founding members of the European Housing Forum. It is consulted by CEN (European Committee for Standardisation) and

by the SCC (Standing Committee for Construction). UEPC is a member of GAIPEC (Groupe des Associations InterProfessionnelles Europeennes de la Construction – Groupe of European InterProfessional and Trade Associations of the Building Industry), set up by the European Commission and it chaired the 'Liability'-group." www.uepc.org/english/content_stat_txt.htm] United Nations Environment Programme [see www.unep.or.jp/ietc/Action_Start.asp?Q1=!!&Q2=!]

United Nations Environment Programme; International Environmental Technology Centre (IETC) "IETC is co-sponsoring "WASTE 2001", the largest congress and exhibition on the sustainable management of waste to take place in the Middle East. IETC's achievements in municipal solid waste management will be on display in the form of technical publications, including "International Source Book on Environmentally Sound Technologies for Municipal Solid Waste Management" and "Guidelines for Integrated Solid Waste Management for Small Island Developing States." IETC will also demonstrate its electronically searchable directory of ESTs and "maESTro", an electronic tool for accessing and exchanging information on ESTs. "WASTE 2001" will be held in Cairo, Egypt, from 28 February to 2 March 2001."

There are other contacts, organizations and publications related to waste management at www.bae.ncsu.edu/bae/programs/extension/publicat/wqwm/ag473_19.html

10.2 PUBLICATIONS

"Beyond Waste – Salvaging & Resale of Used Building Material" This website contains links to companies in California that specialize in salvaging and resale of used building products: www.sonic.net/~precycle/BeyondWasteLinks.html

'C&D Debris Recycling", Intertech Publishing, 9800 Metcalf, Overland Park, Kansas, 66212, (800) 441-0294 This magazine is free.

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"Construction and Demolition Waste: Generation, Regulation, Practices, Processes, and Policies", Cosper, S.D., Hallenback, W.H., and Brenniman, G.R. (1993), Office of Solid Waste Management, University of Illinois – Chicago (312) 996-6927

"Construction Site Recycling; National Association of Home Builders' Handbook on Recycling Building Materials for Home Builders, Developers, and Contractors", NAHB,

1201 15th St., NW, Washington, D.C. 20005-2800, (800) 368-5242, (202) 822-0200 ext. 463

"Contractor's Guide to Preventing Waste and Recycling" is available in either hard copy or over the internet: http://dnr.metrokc.gov/swd/bizprog/sus_build/a_plan.htm

"Designing With The Environment", Environment Canada's Waste Reduction Office 1992 "Suggestions are provided for conscientious reduction of C&D waste along with issues related to material selection and building processes." [see www.cdwaste.com/english/docs_e.htm for a link to the site.]

"Environmental Building News" — provides new product reviews, case studies, in-depth and short articles, book reviews, events, etc. Contacts and telephone numbers are often included (www.ebuild.com)

"From Roof to Roads: Recycling Asphalt Roofing Shingles Into Paving Materials" (8-panel pamphlet) NAHBRC "Another large single-item waste stream (over 7 million tons annually) with good recycling opportunities . This pamphlet covers everything from dealing with asbestos content to DOT road specs for recycled-content paving."

"Guide to Resource-Efficient Building Elements", by Steve Loken, published by the Center for Resourceful Building Technology.

"How to Clean-Up in the Construction Waste Management Business: A Small Business Opportunity in Disposal & Recycling Services" (8-panel pamphlet) NAHBRC "The most convenient disposal and recycling service is one in which there are no or few containers, pick up timed to separate out recyclables (all wood after framing) and the builder chooses the level of service (waste pick-up, job-site pick-up, broom clean interior). This pamphlet uses three such businesses to show how this system works for builders and recyclers."

National Packaging Protocol", Environment Canada's Green Lane – www.ec.gc.ca/napp-pne

"National Wood Recycling Directory"", by The American Forest and Paper Association, is a listing of recycling sites that accept wood waste, including construction debris. It costs $5.00. To order a copy call AFPA at 202-462-2700 (see www.oikos.com/esb/46/sitewaste.html)

"On-Site Grinding of Residential Construction Debris: The Indiana Grinder Pilot", (40 pages) NAHBRC "A detailed report, including the technological, environmental, and economic feasibility of grinding wood, cardboard, and drywall on the job site for use as

erosion control material and soil amendment. Detailed appendices on the cost for both custom and production builders."

"REDI product database" and the "Guide to Resource Efficient Elements" both available from the Iris Catalog (see www.oikos.com/esb/46/sitewaste.html)

"Residential Construction Waste Management: A Builder's Field Guide", NAHBRC (www.nahbrc.org)

"Solid Waste Management Sourcebook", United Nations Environmental Programme, International Environmental Technology Centre [www.unep.or.jp/ietc/search/Query.asp]

"Sourcebook for Sustainable Design", published by Architects for Social Responsibility (a committee of the Boston Society of Architects)

"The Blue Book--Building & Construction", PO Box 500, Jefferson Valley, NY 10535-0500, (800) 431-2584 (916) 485-3832 (Sacramento rep), Web site: http://www.thebluebook.com/ This document is free.

"The Environmentally Responsible Construction and Renovation Handbook", Public Works and Government Services Canada. "The document was developed to provide project managers with an overview of the environmental issues associated with construction and renovation project, including waste diversion. [see www.cdwaste.com/english/docs_e.htm for more information.]

"The NMS Guide to Environmentally Responsible Specifications for New Construction and Renovations", National Master Specification Secretariat; "to assist specification writers in minimizing the environmental impacts associated with all aspects of construction, renovation and demolition projects." [see www.cdwaste.com/english/docs_e.htm for more information.]

"The reclaimed and recycled construction materials handbook", S Coventry, C Woolveridge, S Hillier 1999, CIRIA Publication Code: C513. Available through the CIRIA website. "This handbook addresses this problem by consolidating available knowledge into one user-friendly reference. The book includes guidance on current waste management legislation, assessment of risk, economic issues, specifications and standards, and the implications for designers."

"Waste Management and Recovery: A Field Guide for Remodelers", NAHB Research Center

"Waste minimisation and recycling in construction – a review", Guthrie, P & Mallett, H, 1995, CIRIA Publication Code: SP122. Available through the CIRIA website. "This book

describes the outcome of the first stage of CIRIA's major research project on waste minimisation and recycling in construction, taking the reader through a detailed review of resources, waste, and recycling issues and then explaining the roles and responsibilities of the parties involved."

"Waste minimisation and recycling in construction – design manual", Coventry, S & Guthrie, P, 1998, CIRIA Publication Code: SP134. Available through the CIRIA website. The publication describes "how you can minimise waste by reducing the resources needed for construction; reducing the quantity of waste generated from construction and demolition sites; and improving the reclamation of materials from the waste stream."

"Waste minimisation in construction – site guide", Guthrie, PM, Wolveridge, AC, Patel, VS 1997, CIRIA Publication Code: SP133.

wastenot – a quarterly publication on cost effective sustainable construction & demolition. "wastenot began in the winter of 1996, and is a quarterly publication on cost-effective sustainable construction and demolition (C&D). The newsletter relies on a variety of funding sources for support. wastenot is managed by by dEsign consultants, an environmental and waste management consulting firm in Ottawa, Ontario. The content of wastenot includes technical articles submitted by public and private sector industry professionals, interviews, editorials, reviews, and a calendar of events. The topics covered explore the environmental aspects of such things as construction, renovation and demolition projects, indoor environments, municipal works, government regulations, policy and training initiatives, and green products and building materials."

WasteSpec: Model Specifications for Construction Waste Reduction, Reuse, and Recycling – "The 114-page manual includes detailed specifications, information for bidders on estimated recyclable waste, worksheets and forms, and a list of further resources"; by Trinagle J Council of Governments (TJCOG) and two Raleigh, North Carolina, architects: Cheryl Walder with Design Harmony and Greg Flynn with Abacot Architecture; funded by the U.S. Environmental Protection Agency; published in 1995

10.3 .REFERENCES

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142. "Recycling of plastic foam roof insulation", by Dave Roodvoets published in RSI July 1992.

143. "Construction Site Waste: A New Profit Center?", Energy Source Builder, oikos (www.oikos.com/esb/46/sitewaste.html)

144. "Residential Construction Waste Disposal Demonstration: British Columbia Draft Final Report", Prepared by Sheltair Scientific Ltd with Habitat Design and Consulting and CHBA B.C. for CMHC

145. "Green Builders Sprouting All Over" by Kathleen O'Brien, published in Eight-Penny News, Volume 10, Number 8

146. "Construction and Demolition Recycling Program", Integrated Waste Management Board, Construction and Demolition Fact Sheet (http://www.ciwmb.ca.gov/ConDemo/factsheets/RecyProg.htm)

147. "Carpet", Integrated Waste Management Board, Construction and Demolition Fact Sheet (http://www.ciwmb.ca.gov/ConDemo/factsheets/Carpet.htm)

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11.0 TRAINING

This section lists some of the training programs that are available for construction waste management.

"The CRD Resource Management Training Course", developed by by dEsign consultants, with financial assistance from Industry Canada, Alberta Environmental Protection, the Northwest Territories Department of Resources, Wildlife, and Economic Development, Canada Mortgage and Housing Corporation, and PCL Constructors Canada Inc. The Environmental Management Institute will manage the program. It is designed to develop skills in waste audits, waste reduction workshops, on-site separation of materials, identifying local reuse and recycling opportunities, cost recovery, and general waste reduction procedures and principles. Contact Judy Morris at Alberta Environmental Protection by phone (780) 422-2144, fax (780) 422-5120.

"The Ottawa Construction Association and by dEsign consultants have collaborated to develop a construction waste reduction course. As of January 1996, the course will be part of the Ottawa Construction Association's training schedule. The curriculum will not only provide a solid theoretical background, it will also, through the use of group exercises, discussions and study of real-life examples, develop in-depth understanding and problem-solving skills."

"Training Materials – Construction and Demolition Waste Management Course - The course teaches participants how to incorporate waste C&D management initiatives into all stages of project delivery, including:

- Completion of a waste audit and waste reduction workplan;
- Inclusion of waste management specifications with the tender process;
- Implementation of the waste reduction plan during C&D projects;
- Measurement of the C&D waste diversion rate; and
- Documentation of the C&D waste diversion project successes."

For more information about the course contact: Brad Wallace, Innovative Management Solutions Inc., 350 Sparks Street, Suite 309, Ottawa, Ontario (see www.cdwaste.com/english/train/green.asp)

12.0 CONCLUSION

The conclusions listed here are taken from various reports, and apply fittingly to the information presented in this literature summary.

1. Education in waste stream generation and waste handling has a positive effect on minimizing waste at building sites.
2. It appears that having a knowledgeable site superintendent and a builder committed to a waste management program are the keys to successful reduction in waste generated on a construction site.
3. It is estimated that a 50 percent reduction of dimensional lumber waste is possible by educating trades persons on careful cutting practices and by having effective on-site supervision.
4. Not all waste from construction is presently reusable or recyclable. Because of the difficulty in recycling of some products, emphasis should be placed on reducing the amount going into the waste stream, by paying more attention to efficient building design and efficient use of materials.
5. In order to realize maximum recycling possibilities, materials must be fully sorted and properly stored. Sufficient uncontaminated volumes are needed to make it economically feasible to recycle.
6. Over-supply of materials encourages theft.
7. There is a growing potential for reusing/recycling through local businesses and recycling plants and depots.
8. Separation of wastes is relatively easy if trades people collect and carry materials to secondary users or storage depots. However, in one study [149], almost half of the respondents, after two years of implementation, had difficulty separating and/or storing waste on the construction site. Involvement by those generating the waste encourages participants to devise better ways to reduce or dispose of waste.
9. In most cases, there may not be a clear economic argument for recycling waste. It may cost the builder as much to sort, store and dispose of waste in alternative ways as it does in dumping fees. From the study [149], after two years of implementing construction waste management plans, only 13 percent of participants reported increased costs, 38 percent reported little or no effect on the bottom line, and 17 percent saved money. Nevertheless, it is only through continued efforts in recycling that more economical possibilities will emerge. Economic considerations aside, there is a good will value in being known as environmentally responsible.
10. Builder interest in waste reduction and recycling is driven primarily by considerations of cost and convenience.
11. The most immediate cost savings can be realized through reduction of material used. By reducing waste, less material needs to be ordered thereby lowering material costs to the builders as well as disposal costs.

12.1 REFERENCES

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