REPORT

Assessment of Economic and Environmental Impacts of Extended Producer Responsibility Programs in BC

Presented to:

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EXECUTIVE SUMMARY

British Columbia (BC) is leading the implementation of extended producer responsibility (EPR) programs in North America. Today in BC, 23 different EPR programs exist with more planned to be implemented by 2015 and 2017.

Use of EPR as a policy tool aims to shift the responsibility for end-of-life management of products (physically and economically) to the producer and away from municipalities to create an incentive for producers to include environmental considerations in design of products.

EPR programs in BC are mandated by Recycling Regulation 449/2004, under the *Environmental Management Act*, that provides a single results-based framework for EPR with an emphasis on environmental outcomes and program performance. The Recycling Regulation requires producers to report on EPR program performance. Examples of performance measurement include reporting on recovery rates, the number and distribution of collection facilities, and management of collected materials in relation to the pollution prevention hierarchy.

The BC Ministry of Environment together with Metro Vancouver commissioned Morrison Hershfield to compile economic and environmental benefits that can be attributed to the implementation of EPR programs in BC.

This environmental assessment study focuses on EPR material categories that were operational in 2011 in BC (EPR Materials 2011) and the materials that are planned to be managed under EPR in the future (Pending EPR Materials). This study assessed the implications of EPR program operation for BC's economy and environment and its contribution to broader regional and global environmental issues. Program costs are provided in the report where available.

The assessment was based on the recovered quantities of EPR program materials that can be credited to the EPR programs. This was done by comparing the recovery rates under the EPR programs with that of a likely status quo scenario (no EPR program). Economic and environmental costs and benefits were examined using selected low (conservative), medium (average) and high (liberal) estimates to reflect the span of data uncertainty. In this executive summary, only the medium (average) estimates are included.

Input data for EPR Materials 2011 were based on reported quantities recovered by each EPR program during the 2011 calendar year. For Pending EPR Materials, projections of future impacts were based on likely program performance in 2022, by which time all pending programs should have been implemented across BC.

The following major economic and environmental findings are highlighted for the quantities of EPR Materials recovered in 2011:

- Reduced waste collection and landfilling costs due to EPR programs are substantial with estimated savings of over $30 million due to the recovery of EPR materials in 2011.
- A market value of $40 million for EPR materials recovered and sold to markets in 2011.
- The estimated net job creation of almost 2,400 jobs.
- The avoided disposal of 150,425 tonnes of garbage compared to the likely status quo scenarios. This equates to 11% of Metro Vancouver's total disposed waste quantity in 2011.
- EPR materials recovered in 2011 achieved net GHG reductions of 173,000 tonnes eCO_2 (equivalent to taking 38,500 cars off the roads for a year), with energy savings of 2.7 million GJ (equivalent to the energy content of 440,000 barrels of oil).
- Other environmental benefits, such as keeping hazardous materials out of the environment and litter control, were qualitatively assessed for each EPR program material.

The following major economic and environmental findings are highlighted for the projected quantities of Pending EPR Materials to be recovered in 2022:

- A projected reduction in waste collection and landfilling costs due to EPR programs of $115 million for Pending EPR Materials in 2022.
- A market value of over $100 million for the projected recovery of Pending EPR Materials in 2022.
- An estimated net job creation of almost 5,400 jobs for Pending EPR Materials.
- 625,171 tonnes of materials are expected to avoid landfilling through Pending EPR programs in 2022. The net tonnes projected to be recovered Province wide in 2022 would equal 46 % of Metro Vancouver's waste disposal rate in 2011 in tonnes.
- In 2022, the EPR programs for Pending EPR materials are expected to reduce GHG emissions by almost 935,000 tonnes eCO_2 (equivalent to removing over 208,000 cars from the roads for a year). Energy savings resulting from the Pending EPR programs were estimated to be over 10 million GJ in 2022 (1.6 million barrels of crude oil).

It was concluded that there are substantial environmental and financial benefits from EPR programs. Future quantification of these benefits could be enhanced as more robust input data become available and additional economic and environmental indicators are developed.

1. INTRODUCTION

1.1 Background

British Columbia (BC) is leading the implementation of extended producer responsibility (EPR) programs in North America.

There are two key features of EPR policy:

(1) the shifting of responsibility (physically and economically) to the producer and away from municipalities, and
(2) it is intended to act as an incentive to producers to include environmental considerations in design of products.

EPR Definition:

Extended Producer Responsibility (EPR) is an environmental policy approach in which a producer's responsibility, physical and/or financial, for a product is extended to the post-consumer stage of a product's life cycle.

Organization for Economic Co-operation and Development (OECD)

In October 2009, the Canadian Council of Ministers of Environment (CCME) released a Canada-wide Action Plan for EPR. The strategy calls for a number of commitments from provinces and territories, including two groups of products to be considered for implementation within two time periods.

Phase 1 (for implementation by 2015) includes;

- Electronics and electrical products,
- Mercury-containing products (including lamps),
- Household hazardous and special wastes, and
- Automotive products.
- Packaging and printed materials,

Phase 2 (for implementation by 2017) includes;

- Construction and demolition materials,
- Furniture, textiles and carpet, and
- Appliances (including those with ozone depleting substances).

BC already has programs for many of the products identified in the Canada-wide Action Plan. Today in the province, 23 EPR programs exist with more planned to be implemented by 2015 and 2017.

EPR programs in BC are mandated by Recycling Regulation 449/2004, under the *Environmental Management Act*, that provides a single results-based framework for EPR in BC with an emphasis on environmental outcomes and program performance. The results-based framework empowers producers to focus on developing collection and recycling management systems that maximize efficiencies, while respecting a pollution prevention hierarchy. Producers are responsible for determining how their programs are funded and managed.

1.2 Project Objectives

This project is an effort to measure and report on economic and environmental impacts attributed to today's EPR programs in BC and those planned in the near future. The study will be used to assess the implications of EPR program performance for BC's economy, BC's environment and BC's contribution to broader regional and global environmental issues.

1.3 Study Approach

The Ministry commissioned this study to develop a series of measures and a methodology to quantify the economic and environmental impacts of EPR programs. The study was to describe and quantify impacts of those programs existing in 2011 (EPR Materials 2011) and programs pending implementation (Pending EPR Materials) as shown in Table 1.

Table 1. EPR Material Categories Included in 2011 Programs and Additional Products Planned For Future Inclusion

Specific material categories included in EPR programs operating in BC in 2011	
• Used oil, antifreeze, oil filters, oil containers and antifreeze containers • Batteries (including lead batteries) • Beverage containers • Electronic and electrical products (such as cell phones, appliances) • Lamps and lighting equipment	• Paint, flammable liquids, solvents, pesticides, gasoline • Smoke alarms • Thermostats • Tires • Pharmaceutical waste
Specific EPR material categories that will be included in pending EPR programs in BC	
• Packaging and printed paper • Construction and demolition materials	• Carpet and textiles • Furniture

This study provides an assessment of the economic and environmental impacts of EPR programs in BC, with the results broken down by EPR program material. The assessment is based on the recovered quantities of EPR program materials that can be credited to the EPR programs.

1.3.1 Scenario Comparisons of Existing EPR Programs

The recovered material quantities that can be credited to the EPR programs operating in BC in 2011 were determined by comparing the recovery rates achieved by the EPR programs in 2011 with those of a likely status quo scenario (without any EPR program). This approach was based on the assumption that collection systems operated for EPR product categories prior to the EPR program would have evolved through other policy mechanisms (e.g. solid waste management plans) in the absence of EPR legislation. As such, performance of EPR programs was evaluated against the likely status quo recovery scenario and not against a scenario in which 100% disposal was assumed.

In order to establish the status quo baseline for existing EPR programs we used information provided by each Producer Responsibility Organization (PRO) in its stewardship plan, annual reports, and held interviews with the agencies. This enabled us to determine the recovery rate and the quantities of recovered materials in 2011 and what would have happened with the currently recovered materials if the EPR programs were not in place. Appendix A includes all the 2011 input data from the PROs that was used in the study. Unless otherwise reported by the PRO, we assumed that the reported recovery rates reflected the proportion of materials that were recycled.

Assumptions were discussed with each PRO about available collection systems and estimated recovery rates in place prior to EPR program implementation, to develop realistic status quo scenarios for each program. Where

PROs were not able to provide this information we referred to jurisdictions where data was available for specific EPR program materials.

The recovered quantities of materials that can be credited to the EPR programs were calculated by comparing the 2011 recovery with that of a likely status quo scenario. This was also done to quantify the net reduction of quantities disposed.

The status quo baseline scenarios were developed to reflect the average waste management practices across the province.

Net recovered quantities = **2011 recovery – status quo recovery**

Net reduction of quantities landfilled = **status quo landfilled – Landfilled with EPR program**

1.3.2 Scenario Comparisons of Pending EPR Programs

For pending EPR programs, we aimed to quantify the same measures as the 2011 EPR Materials using the same methodology (i.e. comparing projected EPR scenarios with Status Quo scenarios). Pending EPR Materials include packaging and printed paper (PPP), construction and demolition (C&D) materials, furniture, carpets and textiles.

Apart from the scheduled implementation date of May 2014 for PPP, we assumed that all other Pending EPR Materials would be implemented as of 2017 in accordance with the commitment made by the Ministry of Environment within CCME's Canada-Wide Action Plan for EPR. We based our impact projections on a time frame of 10 years from the baseline year chosen for this study (2011). For Pending EPR Materials, projections of future impacts were based on likely program performance in 2022, by which time all pending programs should have should have been implemented across BC. By the start of 2022, these new EPR programs would have been operational for 5 years (8 years for PPP). The recovery rate of each projected EPR program scenario (2022) was compared to the likely status quo scenario in which no EPR program would be operating.

Existing recovery rates were used to represent the status quo scenario and the likely recovery rates of Pending EPR Materials were estimated based on historic performance of relevant EPR programs in other countries, and/or based on team knowledge of recyclability, demand and market availability.

We were able to estimate the projected recovered and landfilled quantities in a status quo scenario in 2022 by using BC Stats' projected 2022 population figures and determining the 2011 recovery rates of these materials (as kilogram per capita). For each Pending EPR Material the status quo scenario was then compared to the projected EPR scenario as of 2022.

Net recovered quantities using 2022 population projection =
Estimated 2022 recovery – status quo recovery (current)

Net reduction of quantities landfilled using 2022 population projection =
status quo landfilled (current) – Landfilled with EPR program (2022)

1.4 Measures

1.4.1 Rationale for the Selected Measures

The measures chosen for the study are based on relevance and comprehensiveness. The measures are suitable for public reporting, communicate performance credibility by providing net impacts of the EPR programs, where possible, and can be collected reliably and consistently over time to enable year-over-year comparisons. The list of measures was developed from those initially suggested by the Ministry of Environment, in combination with measures used in other similar studies in other jurisdictions.

The EPR program operating costs are presented as a financial aspect in the introductory description of each program initiative. It was beyond the scope of this study to estimate the likely operational cost of a hypothetical collection system when no EPR program is in place (status quo scenario) and the resulting net operating cost.

Where data was not available to quantify the measures, a description and assessment based on literature reviews were included.

1.4.2 Specific Measures Used in Study

The list below presents the measures that were used to provide a comprehensive overview of EPR programs in BC. Measures were examined by using selected low (conservative), medium (average), and high (liberal) estimates to reflect data uncertainty.

Economic Impacts:

- Cost avoidance from:
    - Avoided collection and processing costs,
    - Reduced landfill development and operating costs, including:
        - Avoided siting and development costs,
        - Avoided landfill disposal costs, and
        - Deferred post-closure costs.
- Net Number of jobs (direct and indirect) created,
- Value of recovered material in end-markets, and
- Reduced costs of extraction/processing of virgin materials for products.

Environmental Impacts:

- Net landfill space savings,
- Net reduction in greenhouse gas (GHG) emissions,
- Net energy savings from reduced need for extraction/processing of virgin materials for products,
- Avoided raw material use, and
- Other environmental measures can include (where data is available):
    - Reduction in acidification, VOC, particulate matter, dioxins/ furans, polycyclic aromatic hydrocarbons, and heavy metal emissions.
    - Qualitative assessment for:
        - Avoided waste through Design for Environment,
        - Reductions in litter,
        - Reduction in environmental contamination, and
        - Environmental risk avoidance.

1.5 METHODOLOGY USED TO DETERMINE NET COSTS AND BENEFITS FOR SELECTED MEASURES

1.5.1 Economic Impacts

A benefit to local government resulting from the implementation of producer responsibility programs has been the reduction in waste collection costs (for specific materials), impacts on landfill operations and extended landfill life. The avoided landfilling costs were broken into the avoided cost of siting, development, management and closure of a landfill as described in Sections 1.5.1.2 to 1.5.1.5. The low, medium and high estimates were estimated at $51 - $159 per tonne when these individual costs are grouped together.

The landfill costs used are the actual costs to build, operate and close a landfill, and not the tipping fee that is ultimately charged by the landfill owner/operator. The tipping fees are often established to help cover the cost of other programs, such as recycling and composting, public education and may be elevated to encourage recycling and discourage waste disposal. The actual landfill costs used are based on a range of landfill sizes from medium to very large. These costs can be used to identify the actual savings achieved by diverting materials from landfill through EPR programs.

Refer to Appendix B for low, medium and high estimates of key parameters used in the study.

Additional benefits considered in our analysis include the economic impacts of job creation by the implementation of producer responsibility programs, the value of recovered materials, and impacts on reduction of extraction and processing of virgin materials.

1.5.1.1 Cost Avoidance from Reduced Collection and/or Processing of Materials

The reduced cost of garbage collection was quantified using representative per tonne costs for residential and Industrial, Commercial and Institutional (ICI) waste. Innes Hood Consulting provided curbside cost based on information from the City of Nanaimo, Regional District of Nanaimo, Vancouver, Surrey, Kamloops, and Abbotsford. Collection costs for ICI waste were provided by Emterra and Kamloops staff (Innes Hood Consulting, personal communication, 2013). To address confidentiality the data was only supplied in aggregated form.

We used low, medium and high estimates between $90 - $141 per tonne, which reflected the difference in collection costs of different services (e.g. ICI vs. municipal collection). We did not attempt to distinguish how large a proportion of each material category that would be collected by the municipal vs. ICI collection.

EPR programs fund many of the collection and processing costs for the recovery of target materials that in some cases would otherwise be funded by municipalities. Where possible, we have identified and isolated these cost savings in addition to the avoided collection costs of garbage.

1.5.1.2 Avoided Landfill Siting Costs

There are significant costs involved in siting and developing new landfills. Over the past decade, however, few new landfills have been sited in BC and other parts of Canada from which current data can be drawn. Depending on the siting requirements and provincial requirements, typical siting costs can vary greatly between provinces. Documented avoided siting costs in 2007 ranged from of $0.60 - $2.37 per tonne in Halifax and Ontario respectively (Anielski Management Inc. 2007). For the purposes of this study, available cost estimates provided for the proposed landfill in Forceman Ridge in Terrace for the Regional District of Kitimat Stikine (RDKS) have been used. Planning and design for this landfill are well advanced and accurate data were available.

Over the last 20 years the RDKS has spent $1 - $1.1 million on site selection, site investigation, conceptual design and consultation associated with the proposed Forceman Ridge landfill (RDKS, personal communication, 2012). The conceptual landfill design was developed with a landfill capacity of 955,600 tonnes (RDKS, 2012). This equates to a siting cost per tonne of $1.05 - $1.15.

1.5.1.3 Avoided Landfill Development Costs

Based on the conceptual design estimates it is anticipated the development of the Forceman Ridge landfill will be in the order of $6 million including all site development costs including roads, containment and treatment systems, etc. This also provides for 15 years of landfilling capacity after which further landfill cell development and upgrades will be required. This initial development cost for the Forceman Ridge landfill equates to $20.00 - $23.50 per tonne (based on the estimated tonnes of municipal solid waste (MSW) to be disposed over 15 years).

1.5.1.4 Avoided Landfill Management Costs

Avoided costs resulting from the diversion of EPR products from landfills were determined based on actual operational and capital cost data from BC landfills typically incurred on an on-going basis throughout the operational life of the landfill. We developed low, medium and high estimates of the landfill management costs expressed on a per tonne basis based on actual landfill management costs recorded by the North Okanagan Regional District (NORD) at their landfills, and estimated future costs from the RDKS for the proposed Forceman Ridge Landfill. A landfill management cost per tonne of $27.50 - $129 was used in the study.

The low cost estimate ($27.50) came from RDKS. The on-going annual operational costs for the new landfill in Forceman Ridge are estimated at $550,000 - $600,000. This estimate includes wages and administration costs associated with the landfill. As the landfill is expected to receive 17,000 - 20,000 tonnes of municipal solid waste (depending on waste diversion rates), we calculated a low, medium and high estimate of the operational cost per tonne as $27.50, $31.50 and $35.50 respectively.

The medium and high cost estimates for landfill management came from NORD. In 2011, the cost per tonne was $42 at NORD’s main landfill facility which had the largest capacity and lowest cost of landfilling compared to the other landfills in the district. The highest cost estimate per tonne ($129) came from NORD’s relatively small landfill that receives a small proportion of the total garbage. Costs provided by NORD also included a proportion of costs for administration, overhead and wages relative to the tonnes of MSW received.

Larger landfills inherently have lower operating costs per tonne due to the higher volumes of waste that are disposed. In 2009, a large bioreactor landfill was permitted near Logan Lake, BC, which was intended to accept waste from Metro Vancouver. As identified in the AECOM’s report “Managing Municipal Solid Waste for Metro Vancouver”(2009a), the cost to landfill at the Logan Lake proposed landfill was estimated at $18 per tonne, plus $17 per tonne for transportation of waste from Metro Vancouver to the landfill site. For this study we have chosen to use the higher disposal costs from the medium sized landfills described above, since most landfills in BC will be in the medium size range.

1.5.1.5 Deferred Post-Closure Costs

This was based on information provided by RDKS. For the Forceman Ridge landfill, it is estimated that $50,000 - $100,000 will be allocated every year for progressive and final closure costs of the site. This equates to a calculated low, medium and high estimate of the closure cost per tonne as $2.50, $4.20 and $5.90 respectively.

1.5.1.6 Net Number of Jobs Created

We have quantified the jobs created that result from an increase in recycling. These were based on the net quantities of materials recovered when the EPR scenario was compared to a status quo scenario in which no EPR program was in effect.

To estimate the net number of jobs created, employment losses from reduced garbage collection and landfill disposal quantities resulting from EPR programs were also accounted for. Employment loss estimates were based on the net reduction in landfill disposal quantities when compared to a status quo scenario in which no EPR program is in effect. No impact on potential job losses from reduced raw material extraction was considered in our study as this impact has been deemed to be immaterial (Container Recycling Institute, 2011).

The low, medium and high estimates of jobs created were expressed as number of jobs per tonne recovered material. Refer to Appendix C for the material specific values and reference sources used.

The calculated numbers were also compared with currently known employment numbers relating to specific EPR programs. When possible we separated the figures into jobs created in BC vs. those outside the province.

1.5.1.7 Value of Recovered Material in End-Markets

These were calculated by multiplying the tonnages of recovered material with 2011 commodity prices. Appendix D includes all the low, medium and high estimates that were used in the study together with the references. When possible we separated the value into those captured in BC markets vs. those captured outside the province.

1.5.1.8 Reduced Costs of Extraction/Processing of Virgin Materials for Products

This measure needs to consider whether a material is recycled in a closed or open-loop system. Some of the collected EPR materials are recycled in a closed-loop system, where the second generation product is the same as the first (e.g., aluminum, steel and lead). In other cases, e.g. for glass and plastics there is significant open-loop recycling (i.e. the second generation products are different than the original products). Estimating the avoided cost of the extraction/processing of virgin materials is much more straight forward for closed-loop recycled products. Due to the lack of complete data on end-markets for all materials we have not quantified these impacts for each EPR program. We have instead provided two case study examples for beverage containers in Section 4 to illustrate the complexity in determining this measure.

1.5.2 Environmental Benefits

1.5.2.1 Net Landfill Space Savings

Landfill space savings were calculated in cubic meters (m^3) by applying the bulk density factor which is unique for each material to the net tonnages avoided as a result of implementing specific EPR programs. These estimates only reflect the estimated space saved in the landfill and do not include considerations for settlement or the cover material (daily, interim and final) considered to be beyond the scope of this study.

The majority of these densities came from the Manual on Generally Accepted Principles (GAP) for Calculating Municipal Solid Waste System Flow - Development of a Methodology for Measurement of Residential Waste Diversion in Canada, by the Corporations Supporting Recycling (CSR) (2003). Refer to Appendix E for the material specific values and reference sources used.

Since the density of landfilled materials in practice may be higher than those published for individual compacted materials, we also made an alternative calculation of the landfill space savings in Section 6: Summary and Conclusions. The calculated savings using individual material densities were compared to savings assuming that the average garbage density in a landfill is 0.7 tonnes per m^3 (Wiley& Sons, 2011). This estimate provides a very conservative estimate of the avoided landfill space and demonstrates the range of space savings that can be expected.

1.5.2.2 Net Reduction in Greenhouse Gas (GHG) Emissions

This measure was directly taken from the ICF Consulting (2005) report. The GHG data formed the basis of the Waste Reduction Model (WARM) developed by Environment Canada. The GHG benefits were calculated for a specific material based on the net tonnages of recovered material resulting from a specific EPR program in comparison to the likely status quo scenario.

By using the ICF (2005) methodology, the net GHG emissions were estimated as tonnes equivalent carbon dioxide (eCO_2) based on the GHG emissions associated with recycling that material and any increases in carbon stocks and/or displaced fossil fuel combustion that offset these emissions. This study used GHG emission factors that include carbon sequestration. GHG emissions generated for the collection and recycling of different materials were included in the development of the material specific GHG emission factors. For more details on the methodology, please refer to the ICF report (2005). Refer to Appendix F for the material specific values and reference sources used.

GHG emissions from disposal of uncollected materials were not considered since these would also be disposed of in the status quo scenario.

1.5.2.3 Net Energy Savings

The reduced need for extraction/processing of virgin materials leads to energy savings which were quantified by utilizing published Canadian data (generally using the ICF 2005 report as a reference unless other sources are identified). The ICF report (2005) includes energy required for the collection and recycling of different materials in the development of the material specific energy factors. The energy factors were multiplied by the net number of tonnes recovered when the EPR program scenario is compared to the status quo scenario. Refer to Appendix G for the material specific values and reference sources used.

1.5.2.4 Avoided Raw Material Use

The same complexities exist in determining this measure as with assessing the reduced costs of extraction/processing of virgin materials for products (as described in Section 1.5.1.8). The case study examples for beverage containers in Section 4 illustrate the complexity in determining this measure.

1.5.2.5 Other Environmental Measures

EPR programs may in some cases reduce the amount of litter that local government needs to manage. Research has been done on EPR programs for beverage containers. It highlights litter reduction estimates for every tonne of beverage container material type recovered. For example, it is estimated that every tonne of aluminum recycled prevents over 600 aluminum cans from being littered in the environment (CM Consulting 2002). Where data is available, it has been applied to this study to estimate the reduced litter resulting from a specific EPR program.

Where data is available, the reduction in acidification, VOC, particulate matter, dioxins/ furans, polycyclic aromatic hydrocarbons, and heavy metal emissions were identified.

Where information was available qualitative measures of environmental benefits from EPR programs included:

- Avoided waste through Design for Environment (DfE),
- Reduction in environmental contamination, and
- Environmental risk avoidance.

2. EPR MATERIAL CATEGORIES CURRENTLY INCLUDED IN PROGRAMS IN BC

The following sections provide a brief summary of the EPR programs that existed in BC in 2011 and the associated economic and environmental impacts based on the quantities recovered through each program during 2011.

2.1 Used Oil and Antifreeze Products

2.1.1 Summary of EPR Program

Summary of Initiative: Used oil has for many years been recovered either for recycling or for energy recovery. Environment Canada released a Code of Practice for Used Oil Management in Canada in 1989 to address some of the negative environmental implications from improper recovery or disposal of the used product. In June 2003, BC introduced an EPR program for used oil, used oil filters, oil containers. The program was expanded to include antifreeze products in July 2011.

Purpose of the Program: This EPR program is managed by the British Columbia Used Oil Management Association (BCUOMA) stewardship agency in accordance with their stewardship plans which have been approved under the Recycling Regulation. A board of directors manages BCUOMA with representatives from manufacturers and retailers of oil and antifreeze products, local government and the public.

Financial Aspects: The program is funded through an Environmental Handling Charge (EHC) placed on producers. The 2011 program costs were $11.09 million, which equates to $159 per tonne of material collected by BCUOMA. These costs were fully covered through the EHC paid by producers.

Product Collection: A network of collection facilities accepts used oil and antifreeze products from consumers. BCUOMA pays the collectors incentives provided the collectors can demonstrate that they have shipped the collected materials to a BCUOMA registered processor for an approved end use.

Reuse, Recycling and Recovery Methods: Table 2 shows the range of recovery methods used in 2011 for used oil and antifreeze products by BCUOMA.

Table 2. Recovery Methods used by BCUOMA in 2011 for Used Oil and Antifreeze Products

Product	End Use	Destination
Used oil	Re-refined into new lubricating oil and processed for use as a fuel in pulp mills, cement plants and asphalt plants.	The majority of the used oil was refined and used in BC with a small proportion used as a fuel in pulp mills in in Alberta and Washington state.
Antifreeze	Recycled into new antifreeze for the local market.	All antifreeze was processed by M & R Environmental in Burnaby, BC.
Plastic oil and antifreeze containers	The majority of the oil containers are made from HDPE plastic. The plastic is recycled into new oil containers, drainage tiles and parking curbs.	BCUOMA used two registered processors for the plastics; Merlin Plastics in Delta, BC, and Precision Plastics in Edmonton.
Oil filters	Crushed and taken to steel mill to manufacture reinforcing steel.	Crushed by BC based processors (except a small amount that is crushed in Edmonton). End-markets vary.

2.1.1.1 Description of Status Quo Scenario

To be able to quantify the net impacts (e.g. GHG, energy and job creation) from the EPR program for used oil and antifreeze products, it is necessary to assess what would have happened with the materials if the EPR program were not in place. Table 3 presents the 2011 recovery rates for the EPR program and the likely status quo scenario which formed the basis for calculating the net benefits of the EPR program.

Table 3. 2011 Recovery Rates of the EPR Program for Used Oil and Antifreeze Products and the Likely Status Quo Scenario

Material	EPR 2011 results (% recovery)	Status Quo: (% recovery estimate)	Status Quo justification
Used oil	73.3%	60%	Prior to the commencement of the EPR program in 2003, BCUOMA estimated that the recovery rate for used oil was 60% (BCUOMA, 2012).
Antifreeze	43.3%	25%	Without having an actual estimate BCUOMA commented that the recovery rate would be less than with the EPR program. We assumed a recovery rate of 25%, however this is not supported by any reference.
Containers (Used oil and antifreeze)	87.1%	12%	Prior to the commencement of the BCUOMA program in 2003, it was estimated that the recovery rate for used oil containers was 12% (BCUOMA, 2012).
Oil filters	86.2%	18%	Prior to the commencement of the BCUOMA program in 2003, it was estimated that the recovery rate for used oil filters was 18% (BCUOMA, 2012).

2.1.2 Results of Economic and Environmental Impacts

The economic and environmental net impacts relating to the EPR program for used oil and antifreeze products are presented in Table 4.

Table 4. Economic and Environmental Impacts of the EPR Program for Used Oil and Antifreeze Products

Parameter/ Measure	Functional Unit	Low Estimate	Medium Estimate	High Estimate
Avoided waste collection and landfilling costs				
Avoided collection and processing costs	$million	$1.47	$1.89	$2.31
Avoided landfill siting cost	$million	$0.02	$0.02	$0.02
Avoided landfill development costs	$million	$0.33	$0.35	$0.38
Avoided landfill management costs	$million	$0.45	$0.69	$2.11
Avoided post-closure costs	$million	$0.04	$0.07	$0.10
Total avoided costs	$million	$ 2.3	$3.00	$ 4.9
Value of recovered material in end-markets				
BC	$million	$0.33	$0.58	$0.68
Out-of Province (Canada)	$million	$0.25	$0.25	$0.25
North America	$million	$0.08	$0.08	$0.08
Global	$million	$0.00	$0.00	$0.00
Total value of recovered material in end-markets	$million	$0.66	$0.91	$1.02

Net Benefits (where quantifiable)

Parameter/ Measure	Functional Unit	Low Estimate	Medium Estimate	High Estimate
Net job creation	# jobs	114	116	116
Net landfill space savings	m^3	81,646	83,667	125,432
Net reduction in greenhouse gas (GHG) emissions	tonnes eCO_2	28,006	29,074	30,143
Net energy savings from reduced need for extraction/processing of virgin materials for products and avoided landfilling	GJ	143,160	143,160	143,160
Energy savings in barrels of crude oil	# Barrels of crude oil	23,116	23,116	23,116

2.1.2.1 Economic Impacts

In terms of economic benefits, the program reduced garbage collection and landfilling costs by \$2.3 - \$4.9 million. This included costs for the garbage collection, the siting, landfill development, landfill management and deferred post-closure of landfills. It should be noted that used oil and antifreeze, as liquids, may have been disposed in the environment rather than in landfills. Since data are not available on inappropriate disposal before the EPR program, we assumed that all quantities that were not recovered were landfilled.

Economic Impacts:

- Reduced garbage collection and landfilling costs of \$2.3 - \$4.9 million
- Market value of \$1.29 to \$1.50 million dollars with a majority utilized in BC
- Net job creation of 114-116 jobs.

We were unable to quantify the avoided costs of pollution and environmental mitigation that would potentially be required if these oil and antifreeze products were disposed in landfill.

Although no data exist on the location of the end-markets, estimates were developed based on interviews with BCUOMA to determine the proportion of each recovered material directed to markets in BC, out-of-province (in Canada), US or other global end-markets. Compared to the status quo scenario, the EPR program recovered additional materials with the estimated value of \$0.66 - \$1.02 million, with over half of this value related to BC markets. Based on this estimate, half of the employment opportunities were likely created in BC. In 2011 none of the end-products was thought to reach markets outside North America. It should be noted that most of the materials that are collected in this EPR program have very low or undetermined end-market value. BCUOMA was not able to provide an estimate of the market value of re-refined oil since these prices are confidential.

The program had a positive net impact on job creation. Based on published factors for job creation and losses in Ontario and the US, the EPR program created 114 - 116 jobs. In 2008, Gardner Pinfold estimated that 103 full time equivalent (FTE) jobs resulted from the program's collection and processing activities. This estimate appears in line with our calculation using published data.

2.1.2.2 Environmental Impacts

The EPR program for used oil and antifreeze product saved 81,646 - 125,432 m^3 in landfill space compared to the likely status quo scenario.

The net reductions in GHG emissions for 2011 that can be accredited to the EPR program were 28,006 - 30,143 tonnes eCO_2. This estimate was based on the net quantities of recycled material when the 2011 program performance is compared to a likely status quo scenario.

Environmental Impacts:

- 81,646 – 125,432 m^3 of avoided landfill space
- Net GHG reductions of 28,006 - 30,143 tonnes eCO_2
- Net energy savings of 143,160 GJ
- Over \$3.5 billion in savings from reduced water contamination.

Conestoga-Rovers & Associates (CRA) completed a GHG savings study on behalf of BCUOMA in 2010. Since no GHG emissions for used oil were analysed by ICF in 2005, we used the emission factor calculated by CRA in this study.

The CRA study compared EPR program results against a status quo scenario that assumed that similar used oil quantities would be recovered and combusted in generators while all filters and used oil containers would have been landfilled. Although we have developed a slightly different alternative (status quo) scenario in this study, the results should still be applicable.

The recent GHG study that was conducted for BCUOMA in 2010 did show that considerably more GHG savings were realized for used oil that was re-refined than was realized when burned as a fuel in pulp mills and asphalt plants.

The net energy savings from reduced need for extraction/processing of virgin materials for products and avoided landfilling were 143,160 GJ. This is likely an underestimate as we did not have energy savings factors for re-refining of used oil or recycling of antifreeze. The calculated net energy saving based on available data equate to over 23,100 barrels of crude oil.

In the Genuine Wealth Assessment of Alberta's Stewardship Programs (Anielski Management Inc. 2007), the reduced cost of environmental liability was assessed in relation to the responsible recovery of used oil. The report stated that used oil can contaminate up to a million times its volume of water. In 2001 the cost of treating contaminated water was equivalent to CAN$0.32 per litre in accordance to the Minnesota Pollution Control Agency. For BC's EPR program for used oil, this equates to over $3.5 billion in potential savings from reduced contamination compared to a status quo scenario in which we also assumed the responsible oil recovery.

Improper management of used oil can contaminate soil, something that is especially problematic in agricultural areas. In 2007, a typical clean-up cost in Alberta was $160/ per tonne with actual costs varying depending on the degree of contamination (Anielski Management Inc., 2007). We did not attempt to determine the current costs in BC for oil contamination clean-up, but referenced the Alberta estimate to illustrate the potential liability involved with improper material handling.

The containers of used oil usually retain some residual oil and most polymer recyclers will not accept oil-contaminated feedstock. The oil in the polymer feedstock impedes shredder and wetting agent performance and causes 'smoking' or volatile emissions during plastic re-fabrication/extrusion. In addition, the oil contamination can cause wastewater compliance problems at recycling and reprocessing facilities (Franklin Associates, 2010). Therefore the recycling of used oil containers requires adequate management with collection, draining of the residual oils, shredding and washing of the plastic.

The Alberta Recycling Management Authority commissioned a literature review of available Life Cycle Assessment (LCA) studies on used oil products. Based on the reviewed studies, the following hierarchy of preferred waste management options for used oil was believed to be applicable to Alberta (Franklin Associates, 2010) and is likely to also be relevant to BC as well:

1) Recycling of used oil into a new lubricating oil or a fuel oil,
2) Combustion of used oil for energy recovery, and
3) Disposal of used oil and production of virgin lubricating oil or fuel.

The recovery activities under BCUOMA's EPR program are managing its collected products largely in accordance with this hierarchy.

It is unclear whether the EPR program for used oil and antifreeze products has led the producers to consider DfE principles. BCUOMA reported that they have recorded a trend for oil companies to ship more of their oil in large containers such as lube cubes or drums. Given that there are no EHCs on containers larger than 30 litres, this may be a factor in encouraging oil companies to ship more of their oil in bulk. This trend is expected to result in less container material being used. BCUOMA also expects that antifreeze products will be shipped in drums and plastic totes in the near future.

2.2 Batteries

This section describes the assessment of the EPR programs for Lead Acid Batteries (LABs) and dry cell batteries/rechargeable batteries.

2.2.1 Summary of EPR Program

Summary of Initiative: The disposal of used batteries in MSW is problematic since batteries contain toxic chemicals that can have adverse health and environmental impacts if they are not managed adequately. EPR programs were introduced in 2010 for dry cell batteries and in 2011 for LABs.

Purpose of the Program: There are currently two stewardship agencies for LABs in BC; one managed by Canadian Battery Association (CBA) and another by Interstate Battery System of Canada (IBSC).

The program for dry cell batteries, (e.g. alkaline, rechargeable and cell phone batteries) is managed by Rechargeable Battery Recycling Corporation (RBRC). Their Call2Recycle program collects dry cell batteries (both single use and rechargeable batteries) under 5 kilograms.

All three stewardship agencies have stewardship plans approved under the Recycling Regulation.

Financial Aspects: The program for LABs is funded through the members of CBA and IBSC without a fee at point of sale.

The Call2Recycle program for dry cell batteries is financed by rechargeable battery manufacturers and product manufacturers (whose products are powered by rechargeable batteries). A licensee fee is charged to producers based on units and weights sold into North America. Producers do not charge eco-fees at point of sale.

The 2011 program costs for LABs were $30,000, which equates to to $2 per tonne of LAB material collected. The per-tonne cost is relatively low due to the commodity value of lead. No incentives are paid to encourage collection of LABs and CBA has no operational expenses apart from administrative costs.

Program costs associated with rechargeable batteries could not be determined since RBRC did not provide this information.

Product Collection: In 2011 CBA had established a network of 117 return collection facilities for LABs from the public and industrial consumers in BC. IBSC collected LABs from over 1,000 dealers which collect waste batteries when customers purchase new batteries.

RBRC recovers batteries through four channels: retail, business, public agency and communities (municipalities). RBRC operated 1,569 collection sites at the end of 2010.

Reuse, Recycling and Recovery Methods: Table 5 shows the recovery methods used by CBA, IBSC and RBRC in 2011 for batteries. The end-markets for LABs have been assumed based on information from CBA.

Table 5. Recovery Methods Used by CBA, IBSC and RBRC in 2011 for Batteries

Product	End Use	Destination
LAB: Plastics	Polypropylene from vehicle batteries is recycled and used in new batteries	Trail, BC
LAB: Electrolyte	Sulphuric acid is used in galvanizing or tannery	Trail, BC
LAB: Lead	Remanufactured into lead products	The majority is sent to Trail (80%) with remaining material sent to secondary smelters, Metalex (special batteries) in Vancouver, and others in Montreal and in the US.
Dry-cell batteries	Metal recovery for use in a variety of new products, such as batteries, cookware, appliances, and hardware.	Collected batteries are consolidated and sorted at Toxco (located in Trail, BC).

2.2.1.1 Description of Status Quo Scenario

To be able to quantify the net impacts (e.g. GHG, energy and job creation) from the EPR program for batteries, it is necessary to assess what would have happened with the materials if the EPR program were not in place.

Table 6 presents the 2011 recovery rates for LABs and dry cell batteries and the likely status quo scenarios which formed the basis for calculating the net benefits of the EPR program.

Table 6. 2011 Recovery Rates of EPR Program for Lead Acid Batteries and Dry Cell Batteries and Likely Status Quo Scenarios

Material	EPR 2011 results (% recovery)	Status Quo: (% recovery estimate)	Status Quo Justification
LABs	93% (for all materials)	Lead and electrolyte would still be recycled (93% recovery)	High end-market value for lead. Electrolyte was assumed to be recovered since it is considered hazardous waste.
		Limited recycling of the plastic (25% recovery assumed).	Lower recovery rate assumed due to the material's relatively low market value.
Dry cell batteries	80.2% (across all battery types)	6%	Call2Recycle collected rechargeable batteries through a voluntary recycling program since 2000. There was limited recovery of low value alkaline batteries. Based on the 2008 quantities collected on a voluntary basis in BC we calculated the recovery rate.

2.2.2 Results of Economic and Environmental Impacts

The economic and environmental impacts relating to the EPR programs for batteries are presented in Table 7

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Table 7. Economic and Environmental Impacts of the EPR Programs for Batteries

Parameter/ Measure	Functional Unit	Low Estimate	Medium Estimate	High Estimate
Avoided waste collection and landfilling costs				
Avoided collection and processing costs	$million	$0.189	$0.243	$0.296
Avoided landfill siting cost	$million	$0.002	$0.002	$0.002
Avoided landfill development costs	$million	$0.042	$0.045	$0.049
Avoided landfill management costs	$million	$0.058	$0.088	$0.271
Avoided post-closure costs	$million	$0.005	$0.009	$0.012
Total avoided cost	$million	$0.30	$0.39	$0.63
Value of recovered material in end-markets				
BC	$million	$0.04	$0.11	$0.57
Out-of Province (Canada)	$million	$0.00	$0.01	$0.07
North America	$million	$0.00	$0.01	$0.07
Global	$million	$0.00	$0.00	$0.00
Total value of recovered material in end-markets	$million	$0.04	$0.13	$0.71

Net Benefits (where quantifiable)

Parameter/ Measure	Functional Unit	Low Estimate	Medium Estimate	High Estimate
Net job creation	# jobs	8	16	23
Net landfill space savings	m^3	4,267	4,267	4,267
Net reduction in greenhouse gas (GHG) emissions	tonnes eCO2	3,485	3,485	3,485
Net energy savings from reduced need for extraction/processing of virgin materials for products and avoided landfilling	GJ	92,247	92,247	92,247
Energy savings in barrels of crude oil	# Barrels of crude oil	14,895	14,895	14,895

2.2.2.1 Economic Impacts

Batteries are generally relatively small and since much of the LABs were expected to be recovered even in a status quo scenario, the EPR programs only contributed to reduce garbage collection costs and reduced landfilling costs of \$300,000 - \$630,000 in 2011. Landfilling costs included avoided siting, landfill development, landfill management and post-closure costs. The study did not attempt to quantify the avoided costs of pollution and environmental mitigation that would be required when batteries are disposed in landfills.

Economic Impacts:

- Reduced garbage collection and landfilling costs of \$300,000 - \$630,000
- End-market value of \$40,000 - \$710,000 with the majority captured in BC
- Net job creation of 8 - 23 jobs.

Although no data exist on the location of the end-markets, estimates were developed based on interviews with the stewards to determine the proportion of each recovered material directed to markets in BC, out-of-province (in Canada), US or other global end-markets. Compared to the status quo scenario, the EPR programs recovered additional materials with the estimated value of \$40,000 - \$710,000, with the majority of this market value believed to stay in BC.

The program had a net positive impact on job creation. Based on published factors for job creation and losses in Ontario and the US, the EPR program created 8 - 23 jobs.

2.2.2.2 Environmental Impacts

The EPR programs for batteries saved a 4,267 m^3 in landfill space compared to the likely status quo scenario.

The net reductions in GHG emissions for 2011 that can be accredited to the EPR programs for batteries were 3,485 tonnes eCO_2.

The net energy savings from reduced need for extraction/processing of virgin materials compared to energy needs in processing and recycling were 92,247 GJ. This compares to 14,895 barrels of crude oil.

Environmental Impacts:

- 4,267 m^3 of landfill space savings
- Net GHG reductions of 3,485 tonnes eCO_2
- Net energy savings of 92,247GJ (equivalent to energy content of 14,895 barrels of oil).

The GHG and energy savings were based on the net quantities of recovered material when the 2011 program performance is compared to a likely status quo scenario.

In an LCA completed for the National Electrical Manufacturers Association in the US by Massachusetts Institute of Technology (2011) compared a baseline scenario involving landfilling of alkaline batteries as municipal solid waste with several collection schemes for battery recycling through material recovery.

The environmental impacts of alkaline batteries are dominated by the production of raw materials. LCA findings indicate that energy and GHG metrics are strongly dependent on the recovery technologies. As the majority of the current EPR program batteries are processed in BC, where the electricity largely comes from renewable energy sources, the BC situation is not directly comparable to this US study where the electricity is largely fossil fuel based.

The study concluded that if one assumes little to no landfill leachate resulting from batteries (in other words, batteries remain intact in the landfill or leachate is collected and not of concern over the time horizon considered), the main benefit from recycling stems from the recovery of zinc, manganese and steel (Massachusetts Institute of Technology, 2011).

The LCA study concluded that the greatest environmental burden associated with alkaline battery recycling was associated with a scenario where consumers delivered batteries to municipal locations, such as transfer stations. The assumed allocation of the trip (dedicated versus non-dedicated) drives the extent of the burden. Literature indicated a higher likelihood of a dedicated trip for municipal drop-off along with greater distances traveled than retail drop-off (Massachusetts Institute of Technology, 2011). In terms of the EPR program for dry cell batteries in BC, the program offers a range of collection sites (i.e. retailers and other drop-off facilities) and we can therefore expect that the program is able to minimize the likelihood of people making a dedicated journey only to drop-off batteries.

No information was available in relation to other qualitative measures such as avoided waste through DfE, reduction in environmental contamination or environmental risk avoidance resulting from the EPR programs for batteries.

2.3 Beverage Containers

2.3.1 Summary of EPR Program

Summary of initiative: In 1970, BC introduced North America's first deposit-return system for beverage containers. The focus of "bottle bills" introduced in the 1970's was to reduce the impact of litter associated with single-serving, disposable containers (Container Recycling Institute, 2013). In 1998, the Beverage Container Recycling Regulation expanded the scope of regulated beverage containers to include all ready-to-drink beverages with the exception of milk and milk substitutes. This regulation was folded into BC's current Recycling Regulation and continues to require these same containers to be managed through deposit-refund based EPR programs (Container Recycling Institute, 2013).

Purpose of the Program: There are two EPR programs designed to manage beverage containers: one managed by Encorp Pacific Canada (Encorp) and the other by Brewers Distributor Limited (BDL). Encorp is a federally incorporated, not-for-profit, product stewardship corporation with a board of directors consisting of representatives of the beverage and retail grocery industries. BDL is a private joint venture company owned by Labatt Breweries of Canada and Molson Breweries for the wholesale distribution of beer and the collection of returnable, refillable and recyclable beer containers within BC.

Financial Aspects: Encorp's program is funded by the Container Recycling Fee (CRF) charged to brand owners. The fee covers the costs to collect, transport and process each of the beverage container categories, less the value of the collected commodity and any unredeemed deposits for each category.

BDL's program is funded through a combination of CRFs determined on a regular basis by the BC Brewers Recycled Container Council, an organization that was established by the brewing sector to transparently administer the financial and logistical requirements of BDL's stewardship program.

Encorp's 2011 program costs for beverage containers were $86.64 million, which equates to to $976 per tonne of material collected. BDL's operational costs are not public; however BDL stated that their operational costs are typically lower on a per unit basis than Encorp's.

Product Collection: In 2011 Encorp managed a network of 172 return collection facilities, where consumers take their empty containers to collect the deposit refund. Encorp collects containers for non-alcoholic beverages such as soft drinks, juice, water, sports drinks and alcoholic beverage containers such as wine, spirits, import beers/coolers sold in non-refillable containers. Customers can also return domestic beer containers to Encorp depots, however these quantities are reported via BDL.

Consumers can return BDL beverage containers to Liquor Distribution Branch (LDB) stores, licensee retail stores, LDB rural agency stores and selected bottle depots across BC. BDL or their agents also pick up containers at retail locations, licensees and selected bottle depots. BDL does not collect non-refillable glass beer bottles (import beer), and as noted above, Encorp acts as the steward for these non-refillable containers.

Reuse, Recycling and Recovery Methods: BDL operates a system for the reuse of beer bottles. BDL collects refillable containers that are returned to brewers for reuse. According to BDL, refillable bottles can typically be utilized an average of 15 times before they are recycled. BDL report 8% of the collected bottles are being sent for recycling each year and the rest is reused. Aluminum kegs are also reusable and can last for up to 50 years.

Table 8 shows the recovery methods used for beverage containers in 2011 by Encorp and BDL.

Table 8. Recovery Methods Used by Encorp and BDL in 2011 for Beverage Containers

Product	End Use	Destination
Aluminum	Recycled into new cans and other products	Sent to the US for recycling.
Plastic PET and HDPE	End uses for these plastics include new containers, and strapping materials.	Cleaned and pelletized by Merlin Plastics (BC based) for sale to manufacturers in Canada, the US, and (a very small portion) overseas (EBA and Cascadia, 2012).
Glass	End uses for glass include new bottles, fibreglass insulation, sandblasting materials and construction aggregates.	United Concrete, Encorp's contracted glass processor has continued to find end markets for glass in Airdrie, Alberta and Seattle, Washington in the US. Glass collected on Vancouver Island is locally recycled by Emterra destined for a local market.
Polycoat	The high quality paper fibre that comprises the bulk of these containers is recovered and used to make cardboard boxes and tissue paper.	The drink boxes and gable top cartons continue to be sold into markets primarily in Asia for processing and recycling.
Bi-metal	Processed as scrap metal, then used as construction re-bar.	Local metal recycler in BC.
Other Plastics	Recycle and used when making park benches, bins etc.	Plastic from pouches and bag-in-a-box containers is separated out and can be mixed with other types of plastic. This is done by Merlin Plastics.
BDL: Aluminum cans and kegs	Recycled into new cans and other products	Sent to ALCOA in the US for recycling.
BDL: Glass	8% of the collected quantities are recycled into new glass (by way of cullet) and other glass products (such as fibreglass insulation). The remaining glass is comprised of refill bottles that are reused.	Sent to glass recycling facility at Pacific Metals in Vancouver.

2.3.1.1 Description of Status Quo Scenario

To be able to quantify the net impacts (e.g. GHG, energy and job creation) from the EPR program for beverage containers, it is necessary to assess what would have happened with the materials if the EPR program were not in place. Table 9 presents the 2011 recovery rates reported by Encorp and BDL and the likely status quo scenario which formed the basis for calculating the net benefits of these EPR programs.

Table 9. 2011 Recovery Rates of EPR programs for Beverage Containers and Likely Status Quo Scenario

Material	EPR 2011 results (% recovery)	Status Quo: (% recovery estimate)	Status Quo Justification
Encorp (all materials)	80.4%	Al: 27%, PET: 14%, HDPE: 22%, Glass: 22%, Other plastics: 14%, Steel: 27% and Polycoat:5%	Anticipated recovery rates with beverage containers being collected via curbside collection with moderate recovery rates as described by CM Consulting, 2002. We also assumed that 'other plastics' also would have a recovery rate of 14% and steel containers 27% since these would have been collected in most curbside collection system without the EPR program. Polycoat was generally not accepted at curbside and we assumed a recovery rate of 5%.
BDL	92%		

2.3.2 Results of Economic and Environmental Impacts

The economic and environmental impact results relating to the EPR programs for beverage containers are presented in Table 10.

Table 10. Economic and Environmental Impacts of the EPR Program for Beverage Containers

Parameter/ Measure	Functional Unit	Low Estimate	Medium Estimate	High Estimate
Avoided waste collection and landfilling costs				
Avoided collection and processing costs (Bluebox)	$million	$44.2	$44.2	$45.3
Avoided collection and processing costs (garbage)	$million	$8.8	$11.3	$13.8
Avoided landfill siting cost	$million	$0.1	$0.1	$0.1
Avoided landfill development costs	$million	$2.0	$2.1	$2.3
Avoided landfill management costs	$million	$2.7	$4.1	$12.6
Avoided post-closure costs	$million	$0.2	$0.4	$0.6
Total avoided costs	$million	$58.0	$62.2	$74.6
Value of recovered material in end-markets				
BC	$million	$0.00	$0.20	$0.57
Out-of Province (Canada)	$million	$0.00	$0.20	$0.57
North America	$million	$10.32	$12.24	$14.33
Global	$million	$0.93	$0.94	$0.94
Total value of recovered material in end-markets	$million	$11.3	$13.6	$16.4

Net Benefits (where quantifiable)

Parameter/ Measure	Functional Unit	Low Estimate	Medium Estimate	High Estimate
Net job creation	# jobs	456	933	1,228
Net landfill space savings	m^3	392,712	392,712	392,712
Net reduction in greenhouse gas (GHG) emissions	tonnes eCO_2	112,191	112,191	112,191
Net energy savings from reduced need for extraction/processing of virgin materials for products and avoided landfilling	GJ	1,845,987	1,845,987	1,845,987
Energy savings in barrels of crude oil	# Barrels of crude oil	298,076	298,076	298,076

2.3.2.1 Economic Impacts

In terms of financial benefits, the EPR programs reduced collection, processing and landfilling costs by an estimated $58.0 - $74.6 million.

The largest cost saving came from the reduced curbside collection and processing costs for recovered material ($44.2 - $45.3 million). These estimates were based on the typical municipal costs from collecting and processing the different beverage container material that would have been recovered in the status quo scenario. The cost saving for curbside collection and processing should be considered indicative since we are aware that some of the beverage containers reported via the PROs were still collected through curbside collection. Since this proportion could not be distinguished, we had to assume that all EPR products were collected through the dedicated program collection facilities and not via curbside collection.

The avoided costs from garbage collection and landfilling that could be credited the EPR programs were estimated to $13.8 - $29.4 million. This included reduced costs relating to the siting, landfill development, landfill management and the deferred post-closure of a landfill. The estimates were based on the net tonnes of recovered material after we compared the recovered tonnes under the EPR programs compared to a likely status quo scenario.

Economic Impacts:

- Reduced municipal curbside collection costs by $44.2 -$45.3 million
- Avoided garbage collection and landfilling costs by $13.8 - $29.4 million
- End-market value of $11.3 - $16.4 million with a majority captured in North America
- The market value is believed to be improved by the EPR program
- Net job creation of 456 - 1,228 jobs.

Although no exact data exist on the location of the end-markets, some estimates were developed based on interviews with Encorp and BDL to determine the proportion of each recovered material that ended in markets in BC, out-of-province (still in Canada), US or other global end-markets. Compared to the status quo scenario, the EPR program recovered additional materials with the estimated value of $11.3 to $16.4 million, with the majority of this value being captured in North American markets. Recovered glass currently has no or little market value (EBA and Cascadia, 2012) and if this situation improves a larger part of the market value would be accounted for in BC. Only up to 6% of the end market value was estimated to reach markets outside North America.

The collection of beverage containers through drop-off facilities, such as those used by PROs for beverage containers, can enhance the quality of the glass available for recycling. Glass collection via curbside often leads to breakage and commingling of different colours of glass. It results in a lower-value end-product that is often used in applications, such as sandblasting or as aggregate in construction (EBA and Cascadia, 2012). Therefore the EPR programs for beverage containers are believed to improve the end-market value of its recovered glass in comparison with a curbside collection service.

The program had a net positive impact on job creation. Based on published factors for job creation and losses in Ontario and the US, the EPR program created 456 - 1,228 jobs.

Many of the jobs are believed to relate to the depots and the collection and transport of the collected materials. The study on economic impacts of the recycling regulation in BC (Gardner Pinfold, 2008) estimated that the total employment generated by recycling beverage containers was:

- 745 FTEs associated with Encorp's depot, administration, transportation and processors,
- 100 jobs at the recycler, Merlin Plastics, that were related to the plastics recycling (not exclusively from Encorp), and
- 406 FTEs with the recycling of beer containers.

The estimated number of FTE generated from the EPR programs for beverage containers based on 2006 data equalled 1,251. This estimate is in line with the calculated number of jobs created based on literature data. Jobs that were generated by the EPR program are linked to the locations of the collectors, processors and the end-markets. It is difficult to estimate how large the proportion of the created jobs was in BC, however based on the job impact estimated by Gardner Pinfold, almost 50% of the jobs created are believed to be BC-based.

2.3.2.2 Environmental Impacts

The EPR programs for beverage containers saved approximately 392,712 m^3 in landfill space compared to the likely status quo scenario.

Environmental Impacts:

- Approximately 392,712 m^3 in landfill space savings
- Net GHG reductions of 112,191 tonnes eCO_2
- Net energy savings of 1,845,987 GJ. (over 298,076 barrels of oil)
- 12 million less beverage containers ended up in the environment as litter.

The net reductions in GHG emissions for 2011 that can be accredited to the EPR programs for beverage containers were close to 112,191 tonnes eCO_2. The result relates to the GHG savings from the recycling of these products as opposed to landfilling. Over half of the emission reductions relate to the recycling of aluminum. Since no emission factor was available for the reuse of glass bottles or aluminum kegs, the estimate of the GHG reductions is conservative.

The net energy savings from the reduced need for extraction/processing of virgin materials compared to energy needs for processing and recycling were 1,845,987 GJ. This is equivalent to over 298,076 barrels of crude oil.

The estimate of GHG emission and energy savings were based on the net quantities of recycled material when the 2011 program performance was compared to a likely status quo scenario.

Having a refund incentive on beverage containers has been proved to encourage the recovery of the containers and reduce litter associated with these products. A literature review conducted by the Container Recycling Institute in 2005 found that states in the US with bottle bills had a 69 - 84% decrease in beverage container litter (Anielski Management Inc. 2007). CM Consulting had in 2002 estimated the avoided litter per tonne of recycled material. We were able to estimate the number of containers that were avoided as litter as result of the EPR programs for beverage containers compared to the status quo scenario. Approximately 12 million beverage containers were estimated to not end up as litter in BC as result of the EPR program.

The Alberta Recycling Management Authority commissioned a literature review of available LCA studies on beverage containers. There have been numerous LCA completed for these products. The reviewed studies generally supported the traditional waste management hierarchy. For all of the container materials, light weighting and reduced consumption were identified as the ideal upstream and demand-side management options to reduce environmental impacts (Franklin Associates, 2010). Recycling followed by incineration with energy recovery were commonly identified as the preferred End-of-life (EOL) management options. Despite the fact that landfilling plastics prevents the oxidation of the contained carbon to carbon dioxide, landfilling is the least preferable management option (Franklin Associates, 2010).

The LCA study summarized that material recycling becomes even more environmentally preferable when it is closed-loop (i.e. container-to-container recycling) as opposed to open-loop as a higher level of embodied energy is recovered. When recycling glass, the conventional waste hierarchy is supported as long as waste glass containers are not being transported long-distance for processing (Franklin Associates, 2010).

The various calculated environmental burdens associated with recycling cannot be transferred directly to a situation in BC. Recycling data are very dependent on local conditions including the recycling rate, the use of refillable versus one-way containers, the logistics of collection and processing, end use markets and the strength of the local markets versus export markets.

No information was available in relation to other qualitative measures, such as avoided waste through DfE, reduction in environmental contamination or environmental risk avoidance, resulting from the EPR programs for beverage containers.

2.4 Electronic or Electrical Products

There several EPR programs in BC that manage discarded electronic/electrical products, commonly referred to as e-waste. E-waste is comprised of many different material types and generally the stewards are not able to quantify the recovery levels of each material from the total quantities of recovered products. To reduce repetition in this report, this section presents information for all EPR products that can collectively be called e-waste (refer to Table 12).

2.4.1 Summary of EPR Program

Summary of Initiative: The issue of e-waste management has become increasingly important in recent decades given the steep increase electronic products used by our modern society and media attention regarding how e-waste has been disposed or recycled. In 1998, e-waste accounted for less than half of one percent of all disposed waste. In 2004, e-waste composed almost five percent (EBA and Cascadia, 2012).

The electronics industry has worked proactively with the BC government since 2002 to address the e-waste issue. BC saw its first EPR program for electronics in 2007 and more product categories and other EPR programs targeting electrical products have been implemented since then.

Purpose of the Program: A number of different stewards are responsible for their electronic or electrical products under separate EPR programs. Table 11 shows the list of stewards and their targeted products, which were operational in 2011 and included in this study.

Table 11. EPR Programs Operating in 2011 for Electronic or Electrical Products

PRO / Stewards	EPR Program products
Canadian Wireless Telecommunications Association (CWTA)	Cell Phones
Call2Recycle[1]	Cell Phones
Electronic Products Recycling Association (EPRA)	Portable and non-portable electronics
Canadian Electrical Stewardship Association (CESA)	Portable electrical appliances and power tools designed for use in homes

Financial Aspects: CWTA's EPR program is funded by annual membership dues which are not specific to the EPR program or each member's market share. The program operates with no fees charged to consumers.

Call2Recycle is funded by the manufacturers with no eco-fees being charged to the customers.

The EPRA BC Program is funded by an Environmental Handling Fee (EHF) which is remitted by the producers to the steward association on the distribution and sale of designated products in BC. Customers pay eco-fees when they purchase a new product.

CESA's program is funded by members of the program based on eco-fees applied at the point of sale of products sold in BC.

[1] 1The quantities of used cellphones collected via the Call2Recycle program are reported through CWTA's annual report. Call2Recycle is only responsible for reporting on dry cell batteries (see Section 2.2).

Operating costs are not disclosed by CWTA, Call2Recycle or CESA. EPRA's 2011 operating costs were $27.3 million, which equates to $1,284 per tonne.

Product Collection: CWTA and Call2Recycle collect cell phones using a return-to-retail model via participating retail drop-off locations. In addition to the collection sites, CWTA's Recycle My Cell program offers postage-paid mail-back options for customers who are unable to reach a drop-off location.

To collect program products EPRA uses the network of Return-It™ Depots which are operated by Encorp Pacific.

CESA does not directly own or manage any drop-off locations/depots and contracts this service to other organizations. Collection sites are typically located at facilities such as retailers, recycling organizations, local government recycling centres or transfer stations. There is no charge to drop-off program products.

Reuse, Recycling and Recovery Methods: The processors used by the PROs generally employ state-of-the-art processing technologies and combine manual and mechanical separation to achieve high rates of recovery. Metals from e-waste are recovered and recycled into secondary metal products. The presence of flame retardants and other hazardous additives limits the recycling of some e-waste plastic to specific (e.g. non-food) product applications and requires care in processing (Franklin Associates, 2010).

Table 12 shows the recovery methods used by CWTA, Call2Recycle, EPRA and CESA in 2011 for their targeted electronic or electrical products. For more details about the specific methods used, refer to the annual reports for each of the stewards.

Table 12. Recovery Methods Used by CWTA, Call2Recycle, EPRA and CESA in 2011 for Electronic and Electrical Products

Product	End Use	Destination
CWTA: Cell phones	Reuse and recycle	Phones that cannot be resold into BC because of restrictions are sold in markets of other countries. The majority is sent to GEEP (Global Electric Electronic Processing Inc.) or GREENTEC, both located in Ontario, for disassembly.
CWTA: Cell phones	Energy recovery (4% of the collected products)	Non-recyclable parts (mainly plastics) are used as fuel in Ontario in the precious metal refining process.
Call2Recycle: Cell phones	Reuse and recycle	Consolidated in BC and sent to processor in US for potential refurbishment or recycling.
EPRA	Recycling	Products are sent to the following processors: ECycle Solutions (Chilliwack, BC), GEEP (Edmonton, AB), Genesis Recycling Ltd (Aldergrove, BC), Teck (Trail, BC), and FCM Recycling (Delta, BC). The majority of materials stay in North America. Circuit boards are sent to Belgium.
CESA	Recycling	Products are sent to the main processors ECycle in Leduc, Alberta, or Chilliwack BC and GEEP in Edmonton AB.
EPRA and CESA	Reuse	Occurs but no information available.

2.4.1.1 Description of Status Quo Scenario

To be able to quantify the net impacts (e.g. GHG, energy and job creation) from the EPR program for electronic and electrical products, it is necessary to assess what would have happened with the materials if the EPR programs were not in place. Table 13 presents the 2011 recovery rates for these products and the likely status quo scenarios which formed the basis for calculating the net benefits of these EPR programs.

Some of the stewards are not able to accurately determine the recovery rate of the targeted products. Since we were unable to use a recovery rate (%) across all categories of e-waste products, the kilograms of recovered products per capita were used as a proxy in the study to represent the recovery rates.

The CESA Small Appliance Recycling Program started in 2011 and the performance result from the three first months of the program was extrapolated to reflect a full year of operation.

Table 13. 2011 Recovery Rates of EPR program for Electronic or Electrical Products and Likely Status Quo Scenarios

Material	EPR 2011 Results (kg/capita)	Status Quo: (estimated kg/capita)	Status Quo Justification
Cell phones	0.006	0.006	No baseline data on the recovery prior to the EPR program was available for BC. Before the EPR program there were several cell phone dealers in BC with voluntary recycling programs in place. The Ontario Phase 2 Waste Electrical and Electronic Equipment (WEEE) Program included cell phones and pagers. A baseline collection rate of 0.013 kg/capita was recorded in Ontario, suggesting that the voluntary collection programs being operated by the service providers were collecting this amount before the introduction of the EPR program in Ontario (Glenda Gies, personal communication, 2013). Since this recovery rate is higher than the one recorded by the EPR programs in 2011, we assumed that the EPR program would have negligible effect on the recovery rate.
EPRA products	4.831	0.59	In the Genuine Wealth Assessment of Alberta's stewardship programs, it estimated that at the most 1,670 tonnes of electronic/electrical products would have been recovered in 1999 prior to the EPR program (Anielski Management Inc., 2007). With a population of 2,819,423 in 1999 (Alberta Municipal Affairs, 2013) this equates to 0.59 kg/capita which was assumed as the status quo recovery rate.
CESA products	2.058	0.023	CESA believes that a small portion of the products (approximately 100 tonnes per year) would have been collected by individual retailers prior to the EPR program start. Although CESA believed that a large proportion of discarded microwaves would have been recycled even without the EPR program, they were unable to estimate this quantity. The study based the status quo recovery rate on 100 tonnes divided by BC's population in 2011.

2.4.2 Results of Economic and Environmental Impacts

The economic and environmental impact results relating to the EPR program for electronic and electrical products are presented in Table 14.

Table 14. Economic and Environmental Impacts of the EPR program for Electronic and Electrical Products

Parameter/ Measure	Functional Unit	Low Estimate	Medium Estimate	High Estimate
Avoided waste collection and landfilling costs				
Avoided collection and processing costs	$million	$2.48	$3.18	$3.88
Avoided landfill siting cost	$million	$0.03	$0.03	$0.03
Avoided landfill development costs	$million	$0.55	$0.59	$0.65
Avoided landfill management costs	$million	$0.76	$1.15	$3.54
Avoided post-closure costs	$million	$0.07	$0.12	$0.16
Total avoided costs	$million	$3.88	$5.07	$8.26
Value of recovered material in end-markets				
BC	$million	$0.39	$0.49	$0.58
Out-of Province (Canada)	$million	$0.86	$1.06	$1.25
North America	$million	$0.24	$0.29	$0.35
Global	$million	$0.08	$0.10	$0.13
Total value of recovered material in end-markets	$million	$1.6	$1.9	$2.3

Net Benefits (where quantifiable)

Parameter/ Measure	Functional Unit	Low Estimate	Medium Estimate	High Estimate
Net job creation	# jobs	1,173	1,185	1,186
Net landfill space savings	m^3	149,057	151,459	154,216
Net reduction in greenhouse gas (GHG) emissions	tonnes eCO_2	18,808	26,641	44,357
Net energy savings from reduced need for extraction/processing of virgin materials for products and avoided landfilling	GJ	240,819	474,115	593,094
Energy savings in barrels of crude oil	# Barrels of crude oil	38,886	76,557	95,768

2.4.2.1 Economic Impacts

In terms of financial benefits, the program reduced the costs associated with garbage collection and landfilling (siting, landfill development, management and closure) by $3.9 - $8.3 million. The estimates were based on the net tonnes of recovered material after we compared the recovered tonnes under the EPR programs compared to a likely status quo scenario.

CESA was the only PRO responsible for e-waste products that provided quantities of various recovered component materials. Compared to the status quo scenario, the EPR program recovered additional materials with the estimated value of $1.6 - $2.3 million. The majority of this value is thought to be captured in Canada, although not necessarily in BC markets. A small proportion was assumed to reach markets outside North America.

Economic Impacts:

- Reduced garbage collection and landfilling costs of $3.9 - $8.3 million
- Market value of $1.6 - $2.3 million dollars with a majority captured in BC, however a large proportion of the material was not included.
- Net job creation of 1,173 and 1,186 jobs.

It should be noted that plastics from electronics and small appliances have very low value, because they are often treated with fire retardants, dark in colour, and made from unidentified or mixed resin types (EBA and Cascadia, 2012). Dark-coloured plastics and plastics containing fire retardant additives can be recycled, but they have limited applications, such as non-potable plumbing and irrigation pipe. These plastics have a market value of less than $0.01 per kg. Light-coloured plastics from small appliances not treated with fire retardants have a larger range of applications, and currently sell for up to $0.036 per kg, primarily to overseas markets, where demand for lower-grade plastics is higher (and processing costs are lower) than in North America (EBA and Cascadia, 2012).

The study 'Economic Benefits of Recycling in Ontario' estimated that 61.13 jobs were created per 1000 tonnes of electronics recycled (AECOM 2009b). When this figure was used for the net e-waste quantities recovered in 2011, we estimated that 1,193 - 1,239 jobs were created as result of the EPR programs in BC. When job losses relating to reduced landfilling were accounted for, the programs still had a significant positive impact on job creation (1,173 - 1,186 jobs created). Gardner Pinfold estimated that the total employment generated by electronics recycling in BC was just over 123 FTEs based on 2006 recovery data (Gardner Pinfold, 2008). This included staff involved at the PROs, collection facilities, material processing, and transportation. The job number was only estimated in relation to e-waste collected through EPRA in 2008. In 2011 EPR programs for the e-waste also included those of CWTA, Call2Recycle and CESA. It is therefore difficult to compare the 2011 estimate with that from 2008. However, it should be noted that the 2008 estimates appear very low compared to the estimates using AECOM's job creation factor which was developed using Statistics Canada's input/output model (AECOM, 2009b).

Recycling can have wider economic benefits beyond the aspects mentioned so far. For instance, the cell phone PRO gives a donation to charity for each cell phone returned via member recycling programs. Some of the charities that benefitted in 2011 included Food Banks Canada through donations from Rogers, World Wildlife Fund from Bell, and Tree Canada from donations from TELUS. The recycling had a positive economic impact on these charities.

2.4.2.2 Environmental Impacts

The EPR programs for e-waste saved 149,057 - 154,216 m^3 of landfill space based on the net tonnes recovered compared to the likely status quo scenario.

The net reductions in GHG emissions that can be accredited to the EPR programs in 2011 were 18,808 - 44,357 tonnes eCO_2.

Environmental Impacts:

- 149,057 - 154,216 m^3 of landfill space saved
- Net GHG reductions of 18,808 - 44,357 tonnes eCO_2
- Net energy savings of 240,819 - 593,094 GJ (equivalent to 38,886 - 95,768 barrels of oil).

The net energy savings from reduced need for extraction/processing of virgin materials for products and avoided landfilling were 240,819 - 593,094 GJ. These energy savings equate to 38,886 - 95,768 barrels of crude oil.

The estimates of GHG emission and energy savings were based on the net quantities of recovered material when the 2011 program performance was compared to a likely status quo scenario.

One of the key environmental benefits of the e-waste EPR program is the reduction in the landfilling of hazardous materials, such as cadmium and lead, that is commonly found in e-waste. This study was unable to estimate the amount of hazardous materials that were recovered via recycling. It was estimated that 1,356 tonnes of lead was contained in the PCs and monitors disposed in 1999 in Canada (Environment Canada, 2001). The lead oxide commonly used in the cathode ray tubes (CRT) of computer monitors is of particular concern because it is in a soluble form.

The Alberta Recycling Management Authority commissioned a literature review of available LCA studies on electronic products. Across all the reviewed studies end of life (EOL) management options for e-waste usually include a mixture of recycling, combustion with energy recovery, and landfilling. Generally the LCA studies supported the traditional waste hierarchy for recovered e-waste components (Franklin Associates 2010). For smaller plastic parts of electronic components, because these components typically contain hazardous substances (e.g., brominated flame retardants and other additives), the commonly identified ranking for EOL management options contradicts conventional waste hierarchy. Incineration was considered environmentally preferable, followed by material recovery, if possible. Landfilling of these components was considered the worst option.

The review showed that in the avoided burdens of primary production through materials recovery most certainly outweigh the burdens of EOL processing.

All the PROs agreed that the Canadian EPR programs for electronic and electrical products are unlikely to influence the producers to more carefully consider DfE principles. There are many reported incidents when the design of these products have improved, however it is difficult to attribute them to the EPR programs in BC or even Canada. BC and Canada have little influence on global electronics market and many of the PROs believed that the consumers drive DfE more than the EPR program. Despite this, a few examples of DfE are suitable to include herein to illustrate how the producers are improving.

CWTA reported that mobile handset manufacturers have been working together to implement a cross-industry standard for a universal charger for new mobile phones. The universal charger will have a higher efficiency rating. The adoption of Micro-USB as the common universal charging interface will allow the industry to potentially eliminate up to 51,000 metric tons of duplicate chargers world-wide (CWTA, 2011). In addition to saving energy and reducing waste, a common charger will also provide improved consumer convenience since they will be able to use the same charger for future handsets.

The Electronics Product Stewardship Canada released its 2011 Design for Environment Report in which they clarify that DfE improvements in electronics are driven mainly by global markets. The report documented numerous examples of how its members have considered DfE principles in product design including:

- Eliminating or reducing environmentally-sensitive materials when better alternatives are available,
- Reducing or eliminating waste through dematerialization and lightweighting,
- Meeting or exceeding eco-label requirements, such as Energy Star® or EPEAT (Electronic Product Environmental Assessment Tool),
- Reducing energy consumption,
- Improving logistics and packaging to minimize transportation impacts, and
- Maximizing the use of recovered materials and energy.

No information was available in relation to other qualitative measures such as reduction in environmental contamination or environmental risk avoidance resulting from the EPR programs for electronic and electrical products.

2.5 Lamps and Lighting Equipment

2.5.1 Summary of EPR Program

Summary of Initiative: Lamps and lighting equipment discarded as MSW pose an environmental hazard by often containing mercury and other potentially hazardous materials (Tchobanoglous & Kreith, 2002). An EPR program was introduced in June 2010 in BC for residential use compact fluorescent lamps (CFL) and fluorescent tubes, and in 2012 the program was expanded to include all lamps and lighting fixtures from both the residential and commercial sectors. The 2012 data for the new products were not considered as this study was only based on 2011 data (i.e. quantities of recovered residential use lamps).

Purpose of the Program: This EPR program is managed by Product Care Association (Product Care) in accordance with their stewardship plans approved under the Recycling Regulation. Program members include manufacturers, brand owners, distributors, first importers and retailers of program products in BC.

Financial Aspects: The program is funded by members of the program based on fees on the sale of new program products in BC. Fees may be passed on by the members to their customers, either as visible eco-fees or by incorporating the cost directly into the price of the product.

Product Care's lamp and lighting equipment recovery program cost for 2011 was approximately $330,000, which equates to $3,889 per tonne of material collected. This cost per tonne is high mainly due to relatively high processing costs for managing lamps which also weigh very little.

Product Collection: Products are collected from consumers through a network of permanent year-round collection facilities.

Reuse, Recycling and Recovery Methods: Table 15 shows the different recovery methods used in 2011 by Product Care for the collected materials, which was comprised of only residential use lamps. These materials were all shipped to Aevitas in Ayr, Ontario for processing.

Table 15. Recovery Methods Used by Product Care in 2011 for Lamps and Lighting Equipment

Product	End Use	Destination
Glass	Used for glass containers, fiberglass, road markers, concrete aggregate and asphalt manufacturing.	Sent to glass processor in Ontario and manufacturing industry.
Aluminum	Recycling	Sent to metal recyclers for recycling.
Phosphor powder	Recycled in paint products (a proportion cannot be reused and is disposed to landfill).	Information not available.
Mercury	Recycled in lighting products.	Information not available.

2.5.1.1 Description of Status Quo Scenario

To be able to quantify the net impacts (e.g. GHG, energy and job creation) from the EPR program for lamps, it is necessary to assess what would have happened with the materials if the EPR program was not in place. Table 16 presents the 2011 recovery rates for the EPR program and the likely status quo scenario which formed the basis for calculating the net benefits of the EPR program.

In 2011 there were no approved processors in BC that were allowed to receive the residential use lamps from Product Care. However for other lighting products there were two major processors in BC; Contact Environmental in Richmond, and Nu-Life Industries in Aldergrove. In 2011 these companies processed lamps from large volume generators which were not covered by the EPR program in 2011. By interviewing these processors, we were able to establish the status quo scenario for residential use lamps.

Table 16. 2011 Recovery Rates of EPR program for Lamps and Lighting Equipment and Likely Status Quo Scenario

Material	EPR 2011 Results (% recovery)	Status Quo: (% recovery)	Status Quo Justification
Compact fluorescent lamps & fluorescent tubes (4ft -8ft combined)	31.8% and 65.8% respectively. We assumed the average: 48.8%	2.7%	Although some municipalities and non-profit organizations did accept residential use lamps prior to the EPR program this recovery was very limited. The BC based processor Nu-Life estimated that in 2003 only 1% of its total quantity of recovered lights came from residential sources (approximately 2.35 tonnes) (Nu-Life Industries personal communication, 2013). The processor Contact Environmental agreed with this assumption. Assuming that Product Care's other major processor in BC (Contact Environmental) received the same quantities, the total equates to 2.7% if it was related to Product Care's recovery rate in 2011.

2.5.2 Results of Economic and Environmental Impacts

All the economic and environmental impact results relating to the EPR program for lamps and lighting equipment are presented in Table 17.

Table 17. Economic and Environmental Impacts of the EPR Program for Lamps and Lighting Equipment

Parameter/ Measure	Functional Unit	Low Estimate	Medium Estimate	High Estimate
Avoided waste collection and landfilling costs				
Avoided collection and processing costs	$	$7,247	$9,300	$11,353
Avoided landfill siting cost	$	$84	$88	$93
Avoided landfill development costs	$	$1,610	$1,741	$1,895
Avoided landfill management costs	$	$2,214	$3,376	$10,375
Avoided post-closure costs	$	$201	$337	$474
Total avoided costs	$	$11,357	$14,843	$24,189
Value of recovered material in end-markets				
BC	$	ND	ND	ND
Out-of Province (Canada)	$	$1,377	$2,603	$2,785
North America	$	ND	ND	ND
Global	$	ND	ND	ND
Total value of recovered material in end-markets	$	$1,377	$2,603	$2,785

Net Benefits (where quantifiable)				
Parameter/ Measure	**Functional Unit**	**Low Estimate**	**Medium Estimate**	**High Estimate**
Net job creation	# jobs	0.4	0.9	0.9
Net landfill space savings	m^3	71	127	137
Net reduction in greenhouse gas (GHG) emissions	tonnes eCO_2	14	14	14
Net energy savings from reduced need for extraction/processing of virgin materials for products and avoided landfilling	GJ	202	202	202
Energy savings in barrels of crude oil	# Barrels of crude oil	33	33	33

2.5.2.1 Economic Impacts

In terms of financial benefits, the EPR program for lamps and lighting equipment reduced the garbage collection and landfilling costs by $11,357 - $24,189. We were not able to quantify the avoided costs of pollution and environmental mitigation that would potentially be required if these lamp materials ended in the landfill.

Although no exact data exist on the location of the end-markets, some estimates were developed based on interviews with Product Care. Compared to the status quo scenario, the EPR program recovered additional materials with the estimated value of $1,377 - $2,785 in 2011. The majority of this value being captured in out-of-province markets (Ontario). It was unknown there the end markets were after the lamps were processed in Ontario.

Economic Impacts:

- Reduced the landfilling costs of $11,357 - $24,189, which does not consider avoided pollution reduction costs
- Market value of $1,377 and $2,785 with a majority captured in Ontario in 2011
- Unclear how many jobs were created from the program.

Based on published factors for job creation and losses in Ontario and the US, the EPR program created 0.4 - 0.9 jobs. It should be noted that these figures are likely to underestimate the impacts on job creation. The job creation factors for the component materials from lights (e.g. glass and aluminum) were mainly determined by studying the impacts from recycling from curbside collection. Products containing aluminum and glass that are typically collected via curbside collection are likely to be recovered through less labour demanding processes than those involved in the recycling glass or aluminum from lamps. Product Care estimated that approximately six full time staff were involved with the EPR program for lamps in 2011. It should be noted that these staff are not exclusive to the EPR program for lamps and that the count does not include staff involved in the collection, transportation and processing of the lamps since these services are contracted out. No job impacts studies have been completed specifically from the recovery of lamps.

2.5.2.2 Environmental Impacts

The net reduction in landfill space was estimated to 71 - 137 m^3. The net reductions in GHG emissions for 2011 that can be accredited to the EPR program were 14 tonnes eCO_2. This is based on the net quantities of recovered material when the 2011 program performance was compared to a likely status quo scenario.

The net energy savings from reduced need for extraction/processing of virgin materials for products and avoided landfilling were 202 GJ. This equates to the energy content of 33 barrels of crude.

Environmental Impacts:

- Net reduction in landfill space was estimated to 71 - 137 m^3
- Net GHG reductions of 14 tonnes eCO_2
- Net energy savings of 202 GJ (33 barrels of oil)
- Up to 3.7 kg mercury was safely managed and recovered thanks to the EPR program.

The EPR program in place for lamps and lighting equipment probably appears, initially, to have limited environmental benefits. However, one of the key benefits of this program is the removal of mercury from municipal solid waste management systems. Mercury is a toxic heavy metal that can bio-accumulate.

A CFL contains 2 to 5 mg of mercury and a fluorescent tube contains 8 - 12 mg of mercury bound into the phosphorous powder coating on the bulb glass (Kelleher Environmental, 2007). In 2011 CFLs and fluorescent tubes from the EPR program in BC contained 2.3 - 3.7 kg mercury that was safely managed and recovered.

It should be noted that the amount of mercury contained within fluorescent lights has been decreasing over the years. For example Electro-Federation members decreased the amount of mercury in fluorescent lights by 81.6% between 1990 and 2006 (Product Care, 2010).

Product Care has also clarified that the lifespan of fluorescent lights has increased substantially in the last decade, thereby reducing the environmental impact associated with these products. Smaller diameter fluorescent tubes are now available on the marketplace, which can provide the same or more light with about 50% less material resources by weight.

Whereas the environmental impact of most products is spent during resource use, production, transport and disposal phase, lamps have the most environmental impact during their use phase, which can amount to 90% of the environmental impact depending on the lamp type. Energy saving is the key driver for improving the environmental performance of lamps. Energy efficient lamps can reduce energy consumption by as much as 70% and can last up to 15 times longer than their less energy efficient equivalents (European Lamp Companies Federation, 2013).

In 2011 Product Care did not yet recover lighting equipment. Lighting equipment includes fixtures and ballasts used with electrical or electronic lighting products. Some ballast sold prior to 1979 contain polychlorinated biphenyl (PCB) which is known to be highly toxic. Non-PCB ballasts can be recycled, while PCB ballasts must be managed as hazardous waste in accordance with relevant provincial and federal regulations.

No information was available in relation to other qualitative measures, such as reduction in environmental contamination or environmental risk avoidance, resulting from the EPR programs for lamps.

2.6 Paint and Household Hazardous Waste

2.6.1 Summary of EPR Program

Summary of Initiative: The disposal of Paint and Household Hazardous Waste (HHW) into landfill as MSW carries a high environmental and health concern. Hazardous materials in the MSW stream are of concern for workers responsible for handling that waste (Tchobanoglous & Kreith, 2002). Even if paint and HHW are diverted from the MSW stream they need to be managed responsibly. Paint stewardship was mandated in BC in 1994 followed by flammable liquids, pesticides and gasoline in 1997. Product Care Association (Product Care) was formed in 2001 as the result of the merger of the BC Paint and Product Care Association and the Consumer Product Care Associations.

Purpose of the Program: This EPR program is managed by Product Care in accordance with their stewardship plan approved under the Recycling Regulation. The members of the program are the “producers” (manufacturers, distributors and retailers) obligated by the Recycling Regulation.

Financial Aspects: The program is funded by membership fees, known as “eco-fees”, remitted to Product Care by its members based on the volume of sales of the designated products. In some cases, retailers recover the fees as a separate visible eco-fee to consumers. The eco-fee rates are set by Product Care.

Product Care’s program cost for paint and HHW in 2011 was $5.29 million which equates to almost $1,062 per tonne of material collected. This per tonne costs is high mainly due to relatively high processing costs for managing paint and HHW.

Product Collection: A network of permanent year-round collection depots accepts residential quantities of paint and HHW from consumers. Product Care does not directly own or manage any depots, but contracts with existing collection sites. Depots are typically co-located at facilities such as local government recycling centres or transfer stations, bottle depots, non-profit recycling depots and private businesses.

Reuse, Recycling and Recovery Methods: Table 18 shows the different recovery methods used in 2011 by Product Care for the paint and HHW. Paint that is oil or solvent-based and/or contains heavy metals in excess of specific limits is regulated as hazardous waste together with their associated containers. Latex or water-based paint and the related containers are not regulated as hazardous waste.

Table 18. Recovery Methods Used by Product Care in 2011 for Paint & Household Hazardous Waste

Product	End Use	Destination
Latex paint	Local Reuse of paint (non-aerosol: 106,100 L in 2011). Latex Sludge is used as an additive for concrete and sold to commercial customers. Recyclable latex paint is transferred to recyclers and reprocessed back into latex paint that is sold on the global market.	Consolidated at plant in Surrey. Latex sludge is sent to California, US. Unrecyclable latex paint stays in BC for use in concrete while recyclable latex paint is sent to recyclers.
Alkyd (oil based) paint, flammables, pesticides and gasoline	Used as an alternative fuel source for energy recovery since there is no reuse or recycling option available.	Through the process of fuel blending, 100% of the oil based paint and 100% of the flammables and gasoline collected by Product Care during 2011 were used as an alternative energy source in applications such as permitted incinerators. The energy recovery takes place in the US.
Paint and HHW containers	Metal cans are recycled as scrap metal. 51% of the polypropylene containers are recycled, 49% managed as energy recovery in 2011.	Consolidated at plant in Surrey. The locations of the processors or the end-markets were not provided by Product Care.

2.6.1.1 Description of Status Quo Scenario

To be able to quantify the net impacts (e.g. GHG, energy and job creation) from the EPR program for paint and HHW, it is necessary to assess what would have happened with the materials if the EPR program was not in place. Table 19 presents the 2011 recovery rates as kg of products collected per capita for the EPR program and the likely status quo scenario which formed the basis for calculating the net benefits of the EPR program.

Because of the toxicity of HHW, it is appropriate to assume municipal collection programs would be operating in the absence of EPR programs for HHW, in part to protect drinking water and in part to keep the materials out of landfills to reduce the cost of managing landfill leachate.

No information was available regarding the quantities of recovered paint and HHW waste in BC prior the implementation of the EPR program. In 2009 Stewardship Ontario reported on the quantities of paint, solvents and pesticides that were collected under the municipal hazardous or special waste collection program in 2005. This program was in place prior to the introduction of any EPR program and its recovery rate was chosen to represent the status quo scenario. We used kg/capita instead of the recovery rate (%) since there was no relevant information from Ontario that could represent a status quo situation that included recovery rates as percentage. The recovery rate under the EPR program in 2011 for paint and HHW was 24% higher than the recovery rate recorded pre-EPR (using Ontario data) and this ratio was also assumed for the paint and HHW containers.

Table 19. 2011 Recovery Rates of EPR Program for Paint & Hazardous Household Waste & Likely Status Quo Scenario

Material	EPR 2011 Results (kg/capita)	Status Quo: (kg/capita)	Status Quo Justification
Non-aerosol paint, paint aerosols, flammable liquids (including gasoline) and pesticides	0.664	0.506	This is based on the total recovered quantities (calculated as kg per capita) of the EPR product categories collected in 2005 by the Ontario municipal hazardous or special waste collection program. The collection included paint, solvents and pesticides. This was prior to the introduction of an EPR program and is assumed to represent the status quo scenario.
PET (container)	0.041	0.032	The recovery rate (kg/capita) for container material would have improved between the status quo scenario and the EPR situation as much as that of the contents of the containers (24% improvement as shown for Ontario municipal hazardous or special waste collection program). We assume the steel containers would have had similar recovery rate.
Other plastic (container)	0.00014	0.00010	
Steel (container)	0.211	0.211	

2.6.2 Results of Economic and Environmental Impacts

The economic and environmental impact results relating to the EPR program for paint and HHW are presented in Table 20.

Table 20. Economic and Environmental Impacts of the EPR Program for Used Paint and Hazardous Household Waste

Parameter/ Measure	Functional Unit	Low Estimate	Medium Estimate	High Estimate
Avoided waste collection and landfilling costs				
Avoided collection and processing costs (recovery)	$	$4,740,000	$4,740,000	$4,740,000
Avoided collection and processing costs (garbage)	$	$151,288	$194,154	$237,019
Avoided landfill siting cost	$	$1,759	$1,847	$1,935
Avoided landfill development costs	$	$33,620	$36,346	$39,553
Avoided landfill management costs	$	$46,227	$70,484	$216,595
Avoided post-closure costs	$	$4,202	$7,045	$9,888
Total avoided costs	$million	$4.98	$5.06	$5.25
Total value of recovered material in end-markets	$million	ND	ND	ND

Net Benefits (where quantifiable)

Parameter/ Measure	Functional Unit	Low Estimate	Medium Estimate	High Estimate
Net job creation	# jobs	11.5	12.5	13.2
Landfill space savings	m^3	870	912	1,724
Net reduction in greenhouse gas (GHG) emissions	tonnes eCO_2	157	157	157
Net energy savings from reduced need for extraction/processing of virgin materials for products and avoided landfilling	GJ	3,695	3,695	3,695
Energy savings in barrels of crude oil	# Barrels of crude oil	597	597	597

2.6.2.1 Economic Impacts

In terms of financial benefits, the program for paint and HHW reduced the costs to collect, process these materials either as part of recovery or by landfilling. The total avoided costs were estimated at $4.98 - $5.25 million.

The avoided collection and processing costs for the recovery of leftover consumer paint was estimated at $4.7 million for the collection and management of the recovered quantities handled by the EPR program in 2011. The cost to recover these materials by setting up a nationally coordinated infrastructure was estimated to approximately US$8 per gallon (SCS and Cascadia, 2007). This cost estimate was assumed to be equivalent to the reduced collection costs in BC.

The reduced garbage collection and landfilling costs (siting, landfill development, landfill management and post-closure costs) were estimated to $240,000 - $420,000.

We were not able to quantify the avoided costs of pollution and environmental mitigation that would potentially be required if these paint and HHW materials ended in the landfill. It should also be noted that much of paint and HHW would most likely have been disposed of in the environment or to the wastewater system and not in landfills (Tchobanoglous & Kreith, 2002). The EPR program would therefore also reduce the cost to manage these materials through the sanitary system. Since little data exist on the quantities that are illegally disposed of before the EPR program, we assumed that all quantities that were not recovered were simply landfilled.

Economic Impacts:

- Total avoided costs (part of recovery or by landfilling) of $4.98 - $5.25 million
- Reduced collection and recovery costs of $4.7 million in 2011
- Reduced garbage collection and landfilling costs of $240,000 - $420,000, which does not consider avoided pollution reduction costs
- Little or low market value of recycled paint with higher market value for re-usable paint
- Product Care reports on up to 27.5 jobs created as result of the program, although research data is more conservative (11.5 – 13.2 FTEs).

Few studies have looked at the job impacts from the recovery of paint and HHW. Based on the only published factor for job creation and losses in Ontario (AECOM, 2009b), the EPR program was estimated to have created 11.5 to 13.2 jobs when losses from reduced landfilling were accounted for. These figures appear low. Product Care estimated that up to 27.5 staff are working with this EPR program. Approximately six full time Product Care staff are involved with the EPR program for paint and HHW (these are not exclusive to this EPR program). The plant used for consolidating the materials has 17 staff and approximately 4.5 FTEs are involved in the transportation of the products.

The paint and HHW generally do not have any market value. Depending on the colour of the recycled paint and the recycler the value of the paint could be a negative, positive, or cost neutral.

2.6.2.2 Environmental Impacts

The net reduction in landfill space that resulted from the EPR program for paint and HHW was estimated to 870 - 1,724 m^3.

Based on published emission factors we estimated the net reductions in GHG emissions for the EPR program in 2011 to be 157 tonnes eCO_2. This was based on the net quantities of recovered material when the 2011 program performance was compared to a likely status quo scenario. No GHG emissions savings factors were available for paint recycling or hazardous waste recovery, hence these were not included.

If we also consider unpublished data provided by the PRO, the GHG reductions were considerably higher. Based on

Environmental Impacts:

- Net reduction in landfill space was estimated to 870 - 1,724 m^3
- Net GHG reductions of 157 tonnes eCO_2 using published data
- An estimated GHG reduction of 255 tonnes eCO_2 from paint re-use using unpublished data
- Net energy savings of 3,695 GJ (almost 600 barrels of oil).

industry knowledge, Product Care stated that the GHG emissions associated with producing 1000 litres of paint is approximately 2.4 tonnes eCO_2. The emissions relate to raw materials (76%), packaging (10%), manufacturing and transport (11%) and administrative operations (3%). For the 2011 quantities of reused paint (106,100L) the estimated GHG savings were 255 tonnes eCO_2. We were unable to review the scope of the underlying GHG study to determine its relevance to this study.

The net energy savings from reduced need for extraction/processing of virgin materials for products and avoided landfilling were 3,695 GJ, which equates to the energy content of almost 600 barrels of crude oil.

Inadequate management of these EPR program materials can pose significant environmental hazards and a key environmental benefit associated with the EPR program is that it ensures environmentally responsible and safe management and recovery of the collected materials. The transport and processing of paint and HHW are undertaken in accordance to the requirements of all federal and provincial regulations.

The Alberta Recycling Management Authority commissioned a literature review of available LCA studies specific to the EOL management of used paint and paint containers. The review revealed some key gaps in the current literature available for used paint waste management LCAs. All the reviewed articles focused on solvent-based paint and paint packaging waste that falls under the category of hazardous waste.

An additional limitation was that all the LCAs were based European data. The author concluded that because of the major limitations in available LCA data only a couple of main points could be drawn to the situation in Alberta (Franklin Associates, 2010) and most likely also to the situation in BC:

- Energy and material recovery from incineration of solvent based paint decreases the life cycle impacts of used paint, and
- Special care must be given to ensure the incineration of solvent-based paint does not lead to increased hazardous pollutants, as may be seen in the case of heavy metal emissions during treatment in a cement kiln.

No information was available in relation to other qualitative measures, such as avoided waste through DfE, reduction in environmental contamination or environmental risk avoidance, resulting from the EPR programs for paint and HHW.

2.7 Smoke Alarms

2.7.1 Summary of EPR Program

Summary of Initiative: In 2011 the first EPR program was introduced to collect and recycle smoke alarms in BC. In 2012, a second program for smoke alarms became operational in the province.

Purpose of the Program: Canadian Hardware and Housewares Manufacturers Association (CHHMA) are the stewards responsible for the first EPR program for smoke alarms. CHHMA acts on behalf of the major brand owners of smoke and carbon monoxide (CO) alarms sold in BC through retail and/or electrical wholesaler channels. Product Care is managing the program for CHHMA.

The second EPR program introduced in 2012 by First Alert Canada was not included in this study since the program was not operational in 2011.

Financial Aspects: CHHMA's program is funded by members of the program by eco-fees on the sale of new program products in BC.

Product Care's program costs for smoke alarms were $11,458 in 2011 (October 1 to December 31, 2011). The program costs equate to $9,964 per tonne of material collected; a cost which is high mainly due to significant processing requirements involved in managing these lightweight products.

Product Collection: Product Care does not directly own or manage collection sites for smoke alarms but contracts other organizations to provide collection locations. Collection facilities include fire halls, retailers, recycling organizations, local government recycling centres or transfer stations and other associations or businesses.

Reuse, Recycling and Recovery Methods: All smoke and CO alarms collected by Product Care have their batteries removed and are sorted between radioactive and non-radioactive types at their facility in Surrey. In the 2011 approximately 92% of smoke alarms were of the radioactive type and 8% the non-radioactive type. In CHHMA's stewardship plan it highlights that recycling options may be limited given the highly limited markets for materials such as flame retardant-infused mixed plastics, and the small volumes expected to be collected.

Table 21 shows the current recovery methods used by Product Care for smoke alarms. Since Product Care only recently (in 2012) sent the first shipment of used smoke alarms for processing there are no details on final recycled quantities. Product Care specified that a smoke alarm weighs approximately 0.2-0.4 kg, but they were unable to provide estimated quantities of the different recovered component materials (metal, plastic, etc.) from the smoke alarms.

Table 21. Recovery Methods Used by Product Care in 2011 for Smoke Alarms

Product	End Use	Destination
Radioactive smoke alarms	Final cell storage of radioactive material	Processed at Curie Environmental Services in Albuquerque, NM and residual radioactive material is sent to fully licensed radioactive facilities for final cell storage
Radioactive components and non-radioactive smoke alarms	Recycling of metal (steel, copper, aluminum), circuit boards and plastic	Processed at Curie Environmental Services in Albuquerque, New Mexico, and sold to downstream recyclers in North America.

2.7.1.1 Description of Status Quo Scenario

To be able to quantify the net impacts (e.g. GHG, energy and job creation) from the EPR program for smoke alarms, it is necessary to assess what would have happened with the materials if the EPR program was not in place. Table 22 presents the 2011 recovery rates for the EPR program and the likely status quo scenario which formed the basis for calculating the net benefits of the EPR program.

Since the program became operational on Oct 1, 2011, Product Care provided the recovered quantities between the start date and Aug 31, 2012. In the study, the quantities were extrapolated to represent the full calendar year of 2011.

Table 22. 2011 Recovery Rates of EPR program for Smoke Alarms and Likely Status Quo Scenario

Material	EPR 2011 Results (kg/capita)	Status Quo: (kg/capita)	Status Quo Justification
Smoke alarms	0.000958	0.000479	Approximately 50% of Product Care's current alarm collection quantities come from large volume end-users. Prior to the EPR program implementation Product Care believe that these volumes were still being recycled. The remaining proportion was assumed to be landfilled.

2.7.2 Results of Economic and Environmental Impacts

The economic and environmental impact results relating to the EPR program for smoke alarms are presented in Table 23.

Table 23. Economic and Environmental Impacts of the EPR program for Smoke Alarms

Parameter/ Measure	Functional Unit	Low Estimate	Medium Estimate	High Estimate
Avoided waste collection and landfilling costs				
Avoided collection and processing costs	$	$244	$313	$383
Avoided landfill siting cost	$	$3	$3	$3
Avoided landfill development costs	$	$54	$59	$64
Avoided landfill management costs	$	$75	$114	$350
Avoided post-closure costs	$	$7	$11	$16
Total avoided costs	$	$383	$500	$815
Total value of recovered material in end-markets	$	ND	ND	ND

Net Benefits (where quantifiable)				
Parameter/ Measure	**Functional Unit**	**Low Estimate**	**Medium Estimate**	**High Estimate**
Net job creation	# jobs	0.1	0.1	0.2
Net landfill space savings	m^3	17.6	17.6	17.6
Net reduction in greenhouse gas (GHG) emissions	tonnes eCO_2	0.6	1.8	4.3
Net energy savings from reduced need for extraction/processing of virgin materials for products and avoided landfilling	GJ	3.3	37.3	54.6
Energy savings in barrels of crude oil	# Barrels of crude oil	1	6	9

2.7.2.1 Economic Impacts

In terms of financial benefits, the program for smoke alarms only had a minor impact on reducing the garbage collection and landfilling costs (i.e. siting, landfill development, landfill management and post-closure costs). The total reduced costs were estimated to $383 - $815.

The cost estimates were low due to the relatively small quantities managed by the program. The costs relate purely to the reduction in landfill space requirement and we were not able to quantify the avoided costs of pollution and environmental mitigation that would potentially be required if these materials ended in the landfill.

Due to lack of data we were unable to estimate the value of the recycled materials in their end-markets data. The value is expected to be insignificant to the BC economy because of the small quantities recovered through the program and their expected low market value.

Economic Impacts:

- Minor cost reduction associated with avoided garbage collection and landfilling ($383 - $815). However this does not consider avoided pollution reduction costs
- Market value of recycled materials not available but expected to be small
- Small impact on the net job creation (up to 0.2 FTE).

Based on published factors for job creation and losses in Ontario and the US, the EPR program only created 0.2 jobs. We assumed that a job creation factor for smoke alarm recovery is similar to those recorded for recovery of electronics. Product Care estimated that a total of 0.75 FTE is engaged with the program. Approximately 0.25 FTE worked with the smoke alarms at their consolidation plant and 0.5 FTE is involved with the administration of the program. The estimate using published data appear conservative since Product Care did not estimate any job impacts of processors and in end-markets downstream. No job impacts studies have been completed specifically in relation to the recovery of smoke alarms.

2.7.2.2 Environmental Impacts

The net reduction in landfill space was estimated to 17.6 m3 resulting from the EPR program for smoke alarms. The net reductions in GHG emissions for 2011 that can be accredited to the EPR program were 0.6 - 4.3 tonnes eCO2. This is based on the net quantities of recovered material when the 2011 program performance was compared to a likely status quo scenario, and when we assumed emission factors similar to those for electronics.

The net energy savings from reduced need for extraction/processing of virgin materials for products and avoided landfilling were 3.3 - 54.6 GJ (saving energy equivalent to 1 - 9 barrels of crude oil).

Environmental Impacts:

- Net reduction in landfill space of 17.6 m^3
- Net GHG reductions of 0.6 - 4.3 tonnes eCO_2
- Net energy savings of 3.3 - 54.6 GJ (1 - 9 barrels of oil)
- Program guarantees safe processing of smoke alarms.

The EPR program in place for smoke alarms appears to only have limited environmental benefits, beyond those achieved by ensuring proper management of hazardous materials. It is important to keep in mind that the program ensures that all recovered materials are managed according to the requirements of all relevant federal and provincial regulations. The inadequate management of these materials can pose hazards to human health and the environment.

Only processors that can demonstrate a specific health, safety and environmental management standard are allowed to manage the smoke alarms from the EPR program in BC. The processors are also required to have a general radioactive materials license for source materials to be allowed to handle the radioactive smoke alarms.

In the 2011 annual report Product Care clarified that while the principal purpose of smoke alarms is safety, the industry has been focusing on reducing the environmental impact of their products. New ionization foil stamping technology ensures less waste and precious metals are produced in this stage of the manufacturing process. The amount of plastic and other materials in a typical smoke alarm has also decreased substantially over the past two decades while the use of recycled materials in product packaging has increased. Finally, there is a general trend in the industry away from 9 volt towards 3 volt alarms to reduce the number of batteries required for product operation.

It should be noted that these environmental improvements to the design of the alarm were unlikely to be triggered by the EPR program in BC alone.

No information was available in relation to other qualitative measures, such as the reduction in environmental contamination or environmental risk avoidance, resulting from the EPR programs for smoke alarms.

2.8 Thermostats

2.8.1 Summary of EPR Program

Summary of Initiative: Thermostats have historically contained mercury which can be toxic to the environment. The problem with mercury thermostats only arises when they break and release mercury to the environment. The glass tube of the thermostats is relatively fragile and susceptible to breakage, and because of these risks BC developed an EPR program to ensure that adequate recovery methods are in place for thermostats at the end of the product's life. In 2010 the program became operational.

Purpose of the Program: The Heating, Refrigeration and Air Conditioning Institute of Canada (HRAI) with the support of the Canadian Institute of Plumbing and Heating (CIPH) are the stewards responsible for this EPR program. Summerhill Impact manages the EPR program on behalf of the stewards.

Financial Aspects: The program does not charge visible eco-fees to the customers when they purchase thermostats. The manufacturers fund the program based on how many of their thermostats are returned to the processor the previous year.

HRAI did not disclose information about its operating costs in 2011.

Product Collection: Through the EPR program the majority of the thermostats are collected via heating, ventilation, and air conditioning contractors/wholesalers. Thermostats are also collected via the send-back option, drop-off locations and return-to-retail events. These options cater for do-it-yourselfers, who do not employ a contractor to remove their old thermostats.

Reuse, Recycling and Recovery Methods: Table 24 shows the recovery methods used for thermostats in 2011.

Table 24. Recovery Methods Used by HRAI in 2011 for Thermostats

Product	End Use	Destination
Plastics	Plastic components marketed as mixed plastics.	Processed at Avetis, Ontario and sold in Canadian markets.
Mercury	Recycled for use in fluorescent lighting	Aevitas, Ontario, processes mercury thermostats and other measuring devices. The mercury is tripled distilled and sent to Bethlehem, Pennsylvania, for final distilling.
Glass	Recycled in varying applications.	Processed at Avetis, Ontario and sold in Canadian markets.
Mixed metals (iron, nickel and aluminum)	Recycled	Processed at Avetis, Ontario and sold in Canadian markets.

2.8.1.1 Description of Status Quo Scenario

To be able to quantify the net impacts (e.g. GHG, energy and job creation) from the EPR program for thermostats, it is necessary to assess what would have happened with the materials if the EPR program was not in place.

Table 25 presents the 2011 recovery rates for the EPR program and the likely status quo scenario which formed the basis for calculating the net benefits of the EPR program.

For 2011 only quantities of recovered plastics and metals were provided, which only represented a fraction of the total quantity of thermostat material collected. The study was based on our best estimate of the total weight of all thermostats recovered in 2011 (1,876 units in total). HRAI did not specify the average weight of a thermostat. We assumed that a thermostat weighs approximately 0.2 kg. This was believed to be realistic since a smoke alarm weighs approximately 0.3 kg.

Table 25. 2011 Recovery Rates of EPR program for Thermostats and Likely Status Quo Scenario

Material	EPR 2011 Results (g/capita)	Status Quo Recovery Rate: (g/capita)	Status Quo Justification
Thermostats	0.085 g/capita	Nil	Based on interview with HRAI, thermostats were likely to be landfilled since they were cost prohibitive to collect and recover. Without an EPR program, some collection system could be in place by contractors, however we have assumed negligible recovery from this.

2.8.2 Results of Economic and Environmental Impacts

The economic and environmental impact results relating to the EPR program for thermostats are presented in Table 26.

Table 26. Economic and Environmental Impacts of the EPR Program for Thermostats

Parameter/ Measure	Functional Unit	Low Estimate	Medium Estimate	High Estimate
Avoided waste collection and landfilling costs				
Avoided collection and processing costs	$	$34	$43	$53
Avoided landfill siting cost	$	$0	$0	$0
Avoided landfill development costs	$	$8	$8	$9
Avoided landfill management costs	$	$10	$16	$48
Avoided post-closure costs	$	$1	$2	$2
Total avoided costs	$	$53	$69	$113
Total value of recovered material in end-markets	$	ND	ND	ND

Net Benefits (where quantifiable)

Parameter/ Measure	Functional Unit	Low Estimate	Medium Estimate	High Estimate
Net job creation	# jobs	0.02	0.02	0.02
Net landfill space savings	m^3	2.4	2.4	2.4
Net reduction in greenhouse gas (GHG) emissions	tonnes eCO_2	0.1	0.2	0.6
Net energy savings from reduced need for extraction/processing of virgin materials for products and avoided landfilling	GJ	0.5	5.2	7.5
Energy savings in barrels of crude oil	# Barrels of crude oil	0.1	0.8	1.2

2.8.2.1 Economic Impacts

In terms of financial benefits, the program for thermostats only reduced garbage collection and landfilling costs by a small amount. Due to the relatively insignificant tonnages managed by the program, the reduced collection and landfilling costs were $53 - $113. Although thermostats are hazardous to the environment, we were not able to quantify the avoided costs of pollution and environmental mitigation (e.g. leachate treatment) that would potentially be required if the thermostats were landfilled.

Economic Impacts:

- Insignificant cost reduction associated with avoided garbage collection and landfilling ($53 - $113). However this does not consider avoided pollution reduction costs
- Market value of recycled materials not available but expected to be small
- Minor net impact on job creation, although reliable data is lacking.

Due to lack of data on the different component materials that were recovered in 2011, we were unable to estimate the value of the recycled materials in their end-markets data. The value is expected to be insignificant to the BC economy because of the small quantities recovered through the program.

Based on published factors for job creation and losses in Ontario and the US, the EPR program only created up to 0.02 jobs. This is when we assumed a job creation factor for thermostat recovery similar to those recorded for electronics recovery. HRAI believed that the program would be requiring almost one FTE if they didn't partner with Summerhill Impact for the administration of the program. The estimate using published data appear conservative and it should be noted that no job impacts studies have been completed specifically in relation to the recovery of thermostats.

2.8.2.2 Environmental Impacts

The net reduction in landfill space was estimated to 2.4 m^3 resulting from the EPR program for thermostats. The net reductions in GHG emissions for 2011 that can be accredited to the EPR program were 0.1 - 0.6 tonnes eCO_2. This was based on assuming emission factors similar to those for electronics since published emission factors specific to thermostats recycling were not available.

Environmental Impacts:

- Net reduction in landfill space of 2.4 m^3
- Net GHG reductions of 0.1 - 0.6 tonnes eCO_2
- Net energy savings of 0.5 - 7.5 GJ (up to 1.2 barrels of oil)
- The program guarantees safe processing of thermostats.

The net energy savings from reduced need for extraction/processing of virgin materials for products and avoided landfilling were 0.5 - 7.55 GJ (energy savings equivalent to 0.1 - 1.2 barrels of crude oil).

The 2011 Annual Report produced by Summerhill Impact concluded that the recyclability of mercury-containing thermostats cannot be improved, nor can the reusability of these products, because they are obsolete. New thermostats that are sold within BC and that are part of the program are more environmentally responsible as they contain no mercury and reduce energy demands (as compared to older set-back models).

The EPR program for thermostats may appear to have limited environmental benefits. However, it is important to keep in mind that although the program only recovered relatively small quantities of material compared to many other EPR programs, it ensures that all recovered materials are managed according to the requirements of all relevant federal and provincial regulations. The inadequate management of these materials can pose significant environmental hazards.

Since EPR program for thermostats started across Canada (BC, Manitoba, South Ontario, where the program is voluntary), HRAI was responsible for recovering 295 kg of mercury from landfills and potentially from other disposal sites where the thermostats would otherwise have ended. HRAI was unable to identify how much of the mercury was recovered from BC in 2011.

Mercury in the air eventually settles into water or onto land where it can be washed into water. Once deposited, certain microorganisms can change it into methylmercury, a highly toxic form that builds up in fish, shellfish and animals that eat fish. Fish and shellfish are the main sources of methylmercury exposure to humans (US EPA, 2013). Research has shown that approximately one gram of mercury is deposited to a 20-acre lake each year from the atmosphere in the US. This small amount, over time, can contaminate the fish in that lake (The Interstate Mercury Education and Reduction Clearinghouse, 2004). Based on this information the quantities of mercury that are responsibly managed through the EPR program in BC are thought to make a significant difference to our environment.

No information was available in relation to other qualitative measures, such as avoided waste through DfE resulting from the EPR program for thermostats.

2.9 Tires

2.9.1 Summary of EPR Program

Summary of Initiative: Historically there have been many drivers to keep tires out of landfills and making sure that they are stored and recycled properly. Fires in scrap tire piles are rare, but the environmental and human health costs are significant. According to a 2002 Environment Canada study on EPR and Stewardship, most tire recycling management programs in Canada were started out of concern over the tire fires in Saint Amable, Québec, and Hagersville, Ontario in 1990 (Anielski Management Inc. 2007).

The Ministry of Environment in BC operated a tire recycling program from 1991 to 2006 and in 2007 an industry-led EPR program was initiated.

Purpose of the Program: Tire Stewardship BC (TSBC) manages the program, which is governed by a Board comprising representatives from the Retail Council of Canada, Western Canada Tire Dealers Association, The Rubber Association of Canada and New Car Dealers Association of BC.

Financial Aspects: TSBC collects an eco-fee on the sale of every new tire. These fees are used to pay for the transporting and recovery of BC's scrap tires.

TSBC's program costs in 2011 were $17.1 million. The total program cost equates to $464 per tonne of material collected.

Product Collection: In exchange for new tires customers can have their used tires recycled for free at the retailer, who arranges for haulers to collect and transport the tires to the processors. Other motorists choose to take their old tires home rather than leave them with the retailer for recycling. TSBC uses alternative collection options such as the Return to Retailer program and tire round-up events to manage these "orphan tires".

Reuse, Recycling and Recovery Methods: Table 27 shows the recovery methods used by TSBC for tires in 2011. No data was available on the quantities of recovered tires that were used for the different purposes.

Table 27. Recovery Methods Used by TSBC in 2011 for Tires

Product	End Use	Destination
Tires	88% of the tires were recycled into crumb rubber which can be used for products including: athletic tracks, synthetic turf fields, playground surfacing; colourful resilient flooring in recreational facilities; flooring and mats for agricultural and industrial use, and coloured landscaping mulch.	Processed at Western Rubber at two locations (in Delta and Chemainus, BC)
	The remaining 12% were used as a fuel supplement to industrial processes.	Used for energy recovery in Chemainus, BC (fibre from tires), a pulp mill in Port Alberni, BC (e.g. passenger tires), and Lehigh Cement in Delta, BC.

2.9.1.1 Description of Status Quo Scenario

To be able to quantify the net impacts (e.g. GHG, energy and job creation) from the EPR program for tires, it is necessary to assess what would have happened with the materials if the EPR program was not in place. Recycling and recovery markets for tires are very specific to the location. All Canadian provinces have tire recovery programs so there are no suitable non-EPR jurisdiction in Canada to compare BC's recovery rates to.

Table 28 presents the 2011 recovery rates for the EPR program and the likely status quo scenario which formed the basis for calculating the net benefits of the EPR program.

Table 28. 2011 Recovery Rate of EPR Program for Tires and Likely Status Quo Scenario

Material	EPR 2011 results (% recovery)	Status Quo: (% recovery estimate)	Status Quo Justification
Tires	81%	63%	According to TSBC there was tire recycling and recovery taking place in BC even before the EPR program with recovery rates of between 50% and 75%. This was the case especially for truck tires and also other tires in urban areas. We have assumed a recovery rate of 63%, which is the mid-point between these values.

2.9.2 Results of Economic and Environmental Impacts

The economic and environmental impact results relating to the EPR program for tires are presented in Table 29.

Table 29. Economic and Environmental Impacts of the EPR Program for Tires

Parameter/ Measure	Functional Unit	Low Estimate	Medium Estimate	High Estimate
Avoided waste collection and landfilling costs				
Avoided collection and processing costs	$million	$0.76	$0.98	$1.19
Avoided landfill siting cost	$million	$0.01	$0.01	$0.01
Avoided landfill development costs	$million	$0.17	$0.18	$0.20
Avoided landfill management costs	$million	$0.23	$0.35	$1.09
Avoided post-closure costs	$million	$0.02	$0.04	$0.05
Total avoided costs	$million	$1.19	$1.56	$2.54
Value of recovered material in end-markets				
BC	$million	$0.30	$0.36	$0.42
Out-of Province (Canada)	$million	$0	$0	$0
North America	$million	$0	$0	$0
Global	$million	$0	$0	$0
Total value of recovered material in end-markets		$0.30	$0.36	$0.42

Net Benefits (where quantifiable)

Parameter/ Measure	Functional Unit	Low Estimate	Medium Estimate	High Estimate
Net job creation	# jobs	104	110	114
Net landfill space savings	m^3	7,913	11,870	23,740
Net reduction in greenhouse gas (GHG) emissions	tonnes eCO_2	1,643	1,643	1,643
Net energy savings from reduced need for extraction/processing of virgin materials for products and avoided landfilling	GJ	163,604	163,604	163,604
Energy savings in barrels of crude oil	# Barrels of crude oil	26,418	26,418	26,418

2.9.2.1 Economic Impacts

The program was estimated to reduce garbage collection landfilling costs (siting, development, landfill management and the deferred post-closure costs) by $1.19 - $2.54 million. The estimates were based on the net tonnes of recovered material after we compared the recovered tonnes under the EPR programs compared to a likely status quo scenario.

It was not possible to determine the collection cost savings to municipalities that accrued due to the implementation of EPR programs, since there was no basis for estimating how many tires had been collected and managed by municipalities before the EPR program was implemented.

The market value of the net quantities of rubber crumb that were used in the manufacture of crumb-derived product in BC was estimated at $0.3 - $0.42 million. All of this 2011 value was believed to be captured in the local market in BC.

Economic Impacts:

- Reduced landfilling costs of $1.19 - $2.54 million
- Market value of $0.3 to $0.42 million all captured in the BC market
- Net job creation of 104 - 114 jobs.

The recycling of tires is a relatively labour intensive process. Based on published factors for job creation in the US, the EPR program created 120 jobs. In 2006, it was estimated that 122 FTE were generated as result of the TSBC (Gardner Pinfold 2008). This estimate appears in line with the calculated value using published data. TSBC believed that the number of jobs associated with tire recovery in BC has not changed significantly since 2006.

The program was estimated to generate 104 - 114 jobs, when job losses from the net reduced quantities of garbage that require collection and management were taken into account. All of these jobs are believed to have been created in BC.

2.9.2.2 Environmental Impacts

The EPR program for tires saved landfill space of 7,913 - 23,740 m^3. This was only estimated based on the net reduction in landfilled quantities when the EPR program was compared to the likely status quo scenario.

Environmental Impacts:

- Landfill space savings of 7,913 - 23,740 m^3
- Net GHG reductions of 1,643 tonnes eCO_2
- Net energy savings almost 26,500 barrels of oil (163,604 GJ)
- Savings from reduced liability costs from fires and contamination.

The net reductions in GHG emissions for 2011 that can be accredited to the EPR program were 1,643 tonnes eCO_2. This was calculated by using the emission factor published in the End-of-Life Tire Management LCA (Pembina Institute, 2007). The study which has been referenced for emission factors of almost all other materials (ICF, 2005), was not used for tires because it was calculated specifically for tire retreading. This can be argued to be more of a reuse activity and since it is not representative of the recovery methods used by TSBC, we chose to use the emission factor for tire recovery published by Pembina Institute. This factor was calculated by more suitably assuming that all tires are turned into crumbed rubber which replaces polypropylene crumb for use in numerous applications. Emission factors for all the various end-uses of recovered tires in BC were not available. The emission factors can vary between different end-uses and is likely to produce a different GHG emissions result.

The net energy savings from reduced need for extraction/processing of virgin materials for products and avoided landfilling were 163,604 GJ, which equates to 26,418 barrels of crude oil.

Before the introduction of the EPR program for tires, municipalities and other responsible organizations often had to deal with scrap tire piles that can pose a significant environmental and human health liability. Liabilities include tire fires and potential for human health disease outbreaks caused by rodents and mosquitoes breeding in scrap tire piles. Alberta Recycling Management Authority (ARMA) spent $2.86 million on scrap tire management to clean up tire stockpiles during the 2004-2005 fiscal year (Anielski Management Inc., 2007). The reduced cost from managing scrap tire piles in BC was not quantified but is believed to be significant.

Oil runoff from tire fires can contaminate soils, surface water and ground water by containing toxic compounds including benzene, ethylbenzene, toluene, cadmium, chromium, nickel, and zinc. In 1983 a large fire at the Rhinehart tire dump site in the US caused significant contamination. The site was designated a National Priority List superfund site and still appear on the list several decades after the fire. Following the incident, US Environmental Protection Agency (US EPA) spent $1.74 million in emergency funds to control and collect 800,000 gallons of oily wastes, conduct environmental monitoring, and perform associated activities (US EPA, 2013).

Recently ARMA commissioned an LCA study of the end-of-life tire management. The study found that the benefits from remanufacturing tires into rubber products greatly depend on whether the displaced material is concrete, wood or an asphaltene product (Pembina Institute, 2010). The study did not identify any outright "winner" in terms of environmental performance. However the option when recycled tires are used to displace concrete or asphalt shingles shows the most overall benefits of all options. Those options that could be considered to demonstrate little overall benefit, are when tire derived aggregate replaces gravel for landfill leachate collection systems and when tire manufactured products replaces wood ones (Pembina Institute, 2010). These findings are believed to be transferrable to BC as well.

TSBC has reported in the Annual Report 2011 that tire manufacturers are making progress with the introduction of innovative tire lines specifically designed and constructed for low rolling resistance, which significantly increases the life of a tire. It is unknown if DfE principles have been considered by the manufacturers as result of the EPR program for tires in BC.

TSBC also highlights its own role in ensuring avoided waste through extending the life span of the tires. TSBC continues to work in partnership with The Rubber Association of Canada in their annual Be Tire Smart Campaign which focuses on educating the motoring public of the benefits of proper tire inflation and maintenance.

2.10 Pharmaceutical Waste

2.10.1 Summary of EPR Program

Summary of Initiative: The Medications Return program began in 1996 as the BC EnviRX. The hazards from unused medications posed to public health are the risk of accidental poisoning, diversion, and abuse and the risk of environmental contamination from active pharmaceutical ingredients which can have negative impacts on both human and ecosystem health (Health Canada, 2009).

In the 1990s, the provincial government expanded the scope of the *Post-Consumer Residual Stewardship Program Regulation* (now the Recycling Regulation) to include pharmaceutical products. The Recycling Regulation, passed in October 2004, required all brand-owners of pharmaceutical products sold in British Columbia to take responsibility for the safe management of their products (Health Canada, 2009).

Purpose of the Program: The Post Consumer Pharmaceuticals Stewardship Association (PCPSA) is responsible for managing the Medications Return Program.

Financial Aspects: The industry funds all program costs, e.g. collection, transportation, storage, promotional activities and disposal in connection with the program. PCPSA member pay annual rates based on a sample of returns conducted in 2009. PCPSA continues to invoice stewards of affected products once a year. Their contributions are based on prescriptions dispensed/market shared and/or percentage of sales of affected consumer health products. There are user-fees directed to the consumer at time of purchase or at the point of collection. The program costs for 2011 were not publicly available.

Product Collection: The collection sites for the Medications Return Program are community pharmacies. Pharmacy managers interested in participating can sign up voluntarily (no fees charged) to be a collection and storage point for the program. Accepted items are limited to household quantities.

Reuse, Recycling and Recovery Methods: There are no options for recycling of pharmaceutical waste collected through this program and it is all sent for proper destruction by incineration (Table 30).

Table 30. Recovery Methods Used by PCPSA in 2011 for Pharmaceutical Waste

Product	End Use	Destination
Pharmaceutical waste	Thermally destroyed by incineration	All collected products were sent to Alberta for incineration.

2.10.1.1 Description of Status Quo Scenario

To be able to quantify the net impacts (e.g. GHG, energy and job creation) from the EPR program for pharmaceutical waste, it is necessary to assess what would have happened with the materials if the EPR program were not in place. Table 31 presents the 2011 recovery rates for the EPR program and the likely status quo scenario which formed the basis for calculating the net benefits of the EPR program.

There was a voluntary program being operated by some pharmacies in BC prior to the introduction of the regulated EPR program. No baseline data exist in BC and we had to use data from non-regulated recovery programs for pharmaceutical waste operating in other provinces.

In 2009 the Alberta province-wide program, which is non-regulated and collects the waste via community pharmacies, collected the highest overall quantity of pharmaceutical waste, although not with the highest per capita rate (0.011 kg/capita) (Health Canada, 2009). Saskatchewan demonstrated the best performance in terms of kg per capita (0.020 kg/capita). The non-regulated program in Saskatchewan allows consumers to return pharmaceuticals to the majority of the province's community pharmacies. Program participation is voluntary for consumers, community pharmacies, and the pharmaceutical industry (Health Canada, 2009) In Ontario 0.019 kg/capita of pharmaceutical waste was collected through the municipal and non-municipal channels (i.e. pharmacies providing a take back service for pharmaceutical waste) based on 2008 quantity and population data (Stewardship Ontario 2009).

Table 31 presents the likely status quo scenario that was assumed based on the recovery performance of these provinces. It should be noted that performance statistics are not necessarily perfectly comparable as some provinces may or may not include packaging, sharps, etc.

Table 31. 2011 Recovery Rate of EPR program for Pharmaceutical Waste and likely Status Quo Scenario

Material	EPR 2011 results (recovery rate kg/capita)	Status Quo: (recovery kg/capita)	Status Quo Justification
Pharmaceutical waste	0.0157 kg/capita	0.0157 kg/capita	Alberta, Saskatchewan and Ontario all reported recovery rates that are very similar or higher than the one recorded by BC's EPR program in 2011. On this basis we assumed that the EPR program would have negligible effect on the recovery rate.

2.10.2 Results of Economic and Environmental Impacts

The economic and environmental impact results of the EPR program for pharmaceutical waste are presented in Table 32.

Table 32. Economic and Environmental Impacts of the EPR program for Pharmaceutical Waste

Parameter/ Measure	Functional Unit	Low Estimate	Medium Estimate	High Estimate
Avoided waste collection and landfilling costs				
Avoided collection and processing costs	$	0	0	0
Avoided landfill siting cost	$	0	0	0
Avoided landfill development costs	$	0	0	0
Avoided landfill management costs	$	ND	ND	ND
Avoided post-closure costs	$	ND	ND	ND
Total avoided costs	$	0	0	0
Total value of recovered material in end-markets	$	ND	ND	ND

Net Benefits (where quantifiable)

Parameter/ Measure	Functional Unit	Low Estimate	Medium Estimate	High Estimate
Net job creation	# jobs	0	0	0
Net landfill space savings	m^3	0	0	0
Net reduction in greenhouse gas (GHG) emissions	tonnes eCO_2	ND	ND	ND
Net energy savings from reduced need for extraction/processing of virgin materials for products and avoided landfilling	GJ	ND	ND	ND

2.10.2.1 Economic Impacts

Compared to the assumed status quo scenario we estimated that the EPR program for pharmaceutical waste did not reduce landfilling costs in BC due to very low volumes disposed through the solid waste system. We were not able to quantify the avoided costs of pollution and environmental mitigation that would potentially be required during landfill management and post-closure if pharmaceutical waste ended in the landfill.

Economic Impacts:

- No cost reduction associated with landfilling compared to without the EPR program
- No impact on job creation or losses.

Since pharmaceutical waste collected by the EPR program is incinerated there are no end-market values to assess.

No impact on job creation could be determined since the tonnes of recovered products were assumed to be similar with or without the EPR program. In 2007 it was estimated that 1.2 FTE was engaged in the EPR (Gardner Pinfold, 2008). We were unable to confirm if this estimate was still valid for 2011. On the other hand, we can assume that similar staff time was involved in the recovery of pharmaceutical waste even prior to the EPR program becoming operational.

While it may appear that there are little economic benefits from the EPR program for pharmaceutical waste, this is only because we used the same metrics as for traditionally recoverable materials that have much higher volumes and often economic and environmental impacts. Pharmaceutical waste is recovered in very small volumes, but the potential harm to the environment can be substantial (discussed in the following section). The true measurement of economic benefits from recovering pharmaceutical waste should be the avoided costs of removing the contamination from pharmaceuticals in the waste and waste water streams. This is a new area of research and emerging treatment technologies are still under development. Consensus is that the most effective way to manage the environmental harm from pharmaceuticals is through up-front removal, which is what the EPR program is designed to do. Once high collection efficiencies are achieved, the avoided cost from developing expensive end-of-pipe technologies can be substantial.

2.10.2.2 Environmental Impacts

The environmental costs, such as GHG generated and energy required for the collection and recycling of different materials, were incorporated when the net GHG and energy savings were calculated. The net benefits are summarized in this section.

There was no reduction in landfill space resulting from the EPR program for pharmaceutical waste when compared to the status quo scenario. With this assumption the GHG emissions or energy savings from the EPR program were considered insignificant.

No published factors on GHG or energy impacts exist for pharmaceutical waste incineration compared to landfilling. For this reason we would not be able to calculate the GHG emissions and energy savings even if the recovered materials under the EPR program would have been larger than in a status quo scenario.

It may seem as if the EPR program for pharmaceutical waste has few environmental benefits. However, the program is aimed at ensuring safe collection and management of these potentially hazardous wastes. Its collection reduces the risk of pharmaceutical disposal to the MSW steam or what may be more common, into the wastewater treatment system.

Environmental Impacts:

- No reduction in landfill space when compared to without EPR
- No GHG reductions or energy savings
- The program guarantees safe management of pharmaceutical waste which can have significant environmental impacts if disposed of inappropriately.

In a recent review of the current system in the US for pharmaceutical waste management at least eight chemicals found in pharmaceuticals were identified as acute hazardous waste (US EPA Office of Inspector General, 2012). In the US traces of pharmaceuticals have been recorded in surface, ground, and drinking waters, which raised concerns about the potentially adverse environmental consequences of these contaminants and their effects on human health. Only minute concentrations of some pharmaceuticals can have detrimental effects on aquatic species, such as hormonal imbalances leading to feminization and reproductive problems in fish populations. Studies have suggested the detection of pharmaceutical compounds in treated wastewater effluent, streams, lakes, seawater, and groundwater, as well as in sediments and fish tissue (U.S EPA Office of Inspector General, 2012).

In the 2011 PCPSA's annual report the stewards stated that the bulk of human pharmaceuticals found in waterways most likely got there by way of sewage. Landfills, if properly lined, maintained and operated are a less likely source of contamination of water ways. Waste water has two sources of pharmaceuticals, those that are ingested and pass through the human body, and those that are disposed of through the waste water system, which according to some reports constitutes the majority of disposed pharmaceuticals. Avoiding disposal by way of the sewer system can therefore reduce the loading of contaminants in the effluent. This in turn could have several benefits, including:

- Reduced impacts on the environment and species where waste water effluent is released,
- Lower amounts of pharmaceuticals that make their way back into the human drinking water supply, which should have positive health effects,
- Biosolids from the waste water treatment plants could be more marketable and acceptable for producing compost with lower contaminant loadings, as opposed to the costly steps of drying and burning or landfilling the biosolids, and
- Fewer antibiotics in the waste water effluent could reduce the mutation of resistant strains of bacteria in the environment, with a potential overall positive effect on society.

While none of these benefits are quantifiable at this time, they nevertheless represent a substantial environmental, health and financial benefit to society, especially as the efficiency of pharmaceutical collection within the EPR program is increased.

3. EPR MATERIAL CATEGORIES TO BE INCLUDED IN FUTURE PROGRAMS IN BC

All projections of costs and benefits of the pending EPR programs were based on estimated recovered quantities in 2022. The planned EPR products include packaging and printed paper (PPP), construction and demolition (C&D) materials, carpets & textiles, and furniture.

This study has not attempted to identify which specific materials would be covered under the future EPR programs as this is outside the scope of the project. For example we have not specified the particular materials that would be included in an EPR program for construction and demolition waste. Economic and environmental impacts factors (e.g. job creation and GHG) only exist for a few of these materials and such an exercise would have little value.

3.1 Packaging and Printed Paper

The information relating to existing quantities of PPP in BC was largely based on information compiled by Multi-Material British Columbia (MMBC). Secondary packaging associated with beer is included in the plan submitted by Brewers Distribution Limited (BDL).

3.1.1 Summary of EPR Program

Summary of Initiative: The Recycling Regulation was amended in May 2011 to include packaging and printed paper. The Recycling Regulation requires that, as of May 19, 2014, every producer of PPP product that wishes to sell, offer for sale or distribute their products to residents in BC must operate, or be a member of, an approved plan concerning the end-of-life management of their products.

Purpose of the Program: Under the Recycling Regulation, producers will assume responsibility for residential PPP collection and recycling activity in BC.

Starting in the fall of 2011, MMBC compiled information on the current system for managing PPP in BC. MMBC, in consultation with producers and stakeholders, developed a Stewardship Plan for all PPP on behalf of the majority of producers in the BC marketplace for submission to the MOE on November 19, 2012.

On November 19, 2012, BDL submitted a PPP plan on behalf of its Schedule 1 (beverage container) producer members for beer secondary packaging (e.g., cases, etc.) generated in the BC marketplace. The BDL PPP plan is predicated on their beverage container return network.

Financial Aspects: The management of program costs, and operational systems of a stewardship agency are determined by the producers as members of the agency.

Under MMBC's program producers who supply PPP into the residential sector will pay fees to cover program delivery and MMBC's administration costs. Qualified collectors will be offered financial incentives for PPP collection. Consistent with an outcomes-based approach to program operation, MMBC will pay collectors once the PPP they have collected has been accepted for processing by a primary processor under contract with MMBC. MMBC will also contract with PPP primary processors selected through a request for proposal process.

MMBC has been estimated that the 2011 PPP collection and processing system costs were $60 - $100 million (or $299 - $499 per tonne collected).

Product Collection: The PPP program addresses residential premises and municipal property that is not industrial, commercial or institutional property.

MMBC's approach to delivery of PPP collection services is based on providing opportunity for those involved in the collection of these materials today to be part of this collection system when producers assume responsibility for the PPP recovery system in May 2014. MMBC is proposing to expand the types of PPP collected, starting in May 2014 and then incrementally over time until all types of PPP are included in the residential collection system. The PPP Stewardship Plan is also proposing to provide curbside PPP collection services to households receiving only curbside garbage collection service in November 2012 and to provide streetscape collection systems in municipalities over a specified size, most of which do not currently have streetscape PPP collection.

Reuse, Recycling and Recovery Methods: Currently there are number of different recovery methods used for PPP. Table 33 shows a number of recovery options that were presented by MMBC in the study of the current system for managing residential PPP in BC (MMBC, 2012) and in Metro Vancouver's Recycling Market Study (EBA and Cascadia, 2012).

Table 33. Current Recovery Methods for Packaging and Printed Paper

Product	End Use	Destination
Glass	Clear glass can be used for containers; clean glass for abrasives and insulation; mixed glass as local aggregate substitute	Reprocessed in BC, other parts of Canada or in US
HDPE	New packaging, plastic lumber applications, pipes, flower pots, trash cans	BC and Northwest US markets; some overseas for mixed PE
Other plastic	Plastic lumber (e.g. for marine applications)	Some BC and overseas markets
Aluminum	New can sheet	US
Steel	Re-bar, rolled sheet and other steel applications	Materials may be baled in BC. Processed at mills in Washington and California.
Cardboard	New card and container board, tissue, paperboard	BC, US and overseas
Mixed paper	OCC medium, roofing paper, drywall paper	Virtually all exported overseas

3.1.1.1 Description of Status Quo Scenario

The Recycling Regulation requires that the producer responsibility program for PPP start in May 2014. As of 2022, the program will have been operating for 8 years. This section describes the assumed status quo scenario (no EPR program) and the assumed EPR scenario in 2022. The two scenarios were compared to be able to project and quantify the net impacts (e.g. GHG, energy and job creation).

Table 34 presents the estimated 2011 recovery rates for PPP (i.e. the assumed status quo scenario) and those estimated under the EPR program. These assumptions formed the basis for calculating the net benefits of the EPR program as of 2022.

The status quo recovery rate was calculated based on MMBC's data provided in the study of the current system for managing residential PPP in BC (MMBC 2012).

Data on BC's existing recovery rates of PPP were compiled by MMBC. The reported and estimated recycled quantities in 2011 were compared to the PPP materials supplied into the market to calculate the 2011 recovery rates. In only one instance our interpretation of the data needs further explanation. Data relating to commingled materials (i.e. fibres collected with aluminum, steel and plastic containers) was disregarded in the estimated recovery rate for fibres. The mid-point value of 60.5 % was selected as the recovery rate for fibres collected as PPP materials (a value between MMBC's estimated recovery rate of 55% - 66%).

To estimate the recovery rates for PPP materials in an EPR program scenario, we looked at recovery performance of specific PPP materials included in the German stewardship program and the Belgian Fost Plus program. The information from the latter was not used since it only provided the recovery as kg/capita and used material categories that were difficult to relate to MMBC's program. In estimating the recovery rates with the EPR program, we were unable to consider how the collection services proposed by MMBC in the PPP Stewardship Plan are different than the services provided in German stewardship program.

Table 34. 2011 Recovery Rates of Packaging and Printed Paper (Status Quo) and Likely Recovery Rates in 2022 under MMBC's EPR Program .

Material	Estimated EPR Program Results 2022: (recovery rate %)	Status Quo Results (recovery rate %)	EPR Scenario Justification
Glass	60%	15%	The recovery rate in German system is 82% (MMBC, March 2012). Provided that current rate is 15%, an 82% recovery would be unrealistic in 2022, especially if the non-beverage glass is accepted only at depots and given the lack of local markets. We have assumed a recovery rate of 60% after considering these factors.
HDPE and other plastic	47%	15%	The current recovery rate in German system for plastics is 47%. (MMBC, March 2012).
Aluminum	60%	10%	The recovery rate in German system is 92% (MMBC, March 2012). Provided that current rate is 10%, a 92% recovery would be unrealistic in 2022. Considering the current situation and the local recycling markets, we assumed a recovery rate of 60%.
Steel and tin	60%	7%	The recovery rate in German system is 92% (MMBC, March 2012). Provided that current rate is 10%, a 92% recovery would be unrealistic in 2022. Considering the current situation and the local recycling markets, we assumed a recovery rate of 60%.
Cardboard, newsprint and other paper (fibres)	88%	60.5%	The recovery rate in German system is 88% (MMBC, March 2012) and this is considered reasonable for a BC situation in 2022.

3.1.2 Projected Results of Economic and Environmental Impacts

The projected economic and environmental impact results relating to the EPR program for PPP are presented in Table 35.

Table 35. Projected Economic and Environmental Impacts of the EPR program for Packaging and Printed Paper in 2022

Parameter/ Measure	Functional Unit	Low Estimate	Medium Estimate	High Estimate
Avoided waste collection and landfilling costs				
Avoided collection and processing costs	$million	$26.7	$34.3	$41.8
Avoided landfill siting cost	$million	$0.3	$0.3	$0.3
Avoided landfill development costs	$million	$5.9	$6.4	$7.0
Avoided landfill management costs	$million	$8.2	$12.4	$38.2
Avoided post-closure costs	$million	$0.7	$1.2	$1.7
Total avoided costs	$million	$41.8	$54.7	$89.1
Total value of recovered material in end-markets	$million	$103	$105	$112

Projected Net Benefits (where quantifiable)

Parameter/ Measure	Functional Unit	Low Estimate	Medium Estimate	High Estimate
Net job creation	# jobs	1,382	2,860	3,207
Net landfill space savings	m^3	832,348	933,986	1,221,057
Net reduction in greenhouse gas (GHG) emissions	tonnes eCO_2	798,761	798,761	798,761
Net energy savings from reduced need for extraction/processing of virgin materials for products and avoided landfilling	GJ	8,972,396	8,972,396	8,972,396
Energy savings in barrels of crude oil	# Barrels of crude oil	1,448,796	1,448,796	1,448,796

3.1.2.1 Economic Impacts

Economic benefits from the EPR program for PPP are estimated to be substantial since approximately half of the printed paper and packaging generated by residential generators are disposed as garbage today, and it is presumed that EPR would drive diversion significantly higher than the likely status quo scenario.

The EPR program for PPP was estimated to reduce garbage collection and landfilling costs (avoided siting, development, landfill management and deferred post-closure costs) by $41.8 - $89.1 million in 2022. These estimates were based on the tonnes of recovered material after we compared the projected recovered tonnes with the EPR program to a likely status quo scenario in 2022.

Economic Impacts (in 2022):

- Reduced garbage collection and landfilling costs by $41.8 - $89.1 million
- Market value of $103 - $112 million
- Net job creation of 1,382 - 3,207 jobs.

No data on the location of end-markets for PPP was available, however we estimated that compared to the status quo scenario, the EPR program is likely to recover additional materials with the estimated value of $103 - $112 million in 2022. It should be noted that these estimates were based on 2011 commodity values. Commodity values in 2022 could be higher or lower.

In 2022 the EPR program for PPP was estimated to have a significant positive net impact on job creation. Based on published factors for job creation and losses in Ontario and the US, the program is likely to create 1,382 - 3,207 jobs. Not all of these jobs will be created in BC since many of the end-markets for PPP are located outside the province (see Table 33). In the same manner as we calculated the reduced landfilling costs, the job creation estimates were based on comparing the projected recovered tonnes with the EPR program to a likely status quo scenario in 2022.

3.1.2.2 Environmental Impacts

The EPR program for PPP will have saved 832,348 - 1,221,057 m^3 of landfill space in 2022 compared to the likely status quo scenario.

The net reductions in GHG emissions that are likely to be achieved in 2022 were estimated at 798,761 tonnes eCO_2. Approximately 45% of the GHG reductions come from the recovery of aluminum packaging e.g. from foil, aerosols, pet food. The energy savings are also expected to be significant at approximately 9.0 million GJ, which is equivalent to the energy content over 1.4 million barrels of crude oil.

Environmental Impacts (in 2022):

- 832,348 - 1,221,057 m^3 of landfill space saved compared to without EPR
- Net GHG reductions of 798,761 tonnes eCO_2
- Net energy savings of approximately 9.0 million GJ (i.e. the energy content of over 1.4 million barrels of oil).

The program may also have a positive effect on litter associated with non-deposit packaging. However due to lack of data specific to PPP litter, we did not quantify any potential litter reduction resulting from the EPR program.

No other environmental measures were assessed for the EPR program for PPP.

3.2 Construction and Demolition Materials

3.2.1 Summary of Potential EPR Program

Summary of Initiative: Many municipalities within BC are already achieving relatively high rates of waste diversion from the construction and demolition (C&D) sector. As there is still room for significant improvements, the Ministry is planning to provincially mandate an EPR program for C&D materials. The initiative is scheduled to be implemented in 2017, however little detail exist on the types of materials to include.

C&D wastes usually refer to wastes generated by construction, renovation and demolition activities. It generally includes materials such as wood, drywall, certain metals, cardboard, doors, windows, wiring and others. It should be acknowledged that the waste streams from construction and demolition are produced by two different processes and the volume and type of materials produced can differ greatly. For example demolition projects often produce 20-30 times more waste material per square meter than construction projects do (Jeffrey, 2011).

In this study the C&D waste streams were not segregated since the majority of the data the study was based on did not cover that level of detail.

Purpose of the Program: The aim of this pending EPR program is to divert more waste from landfills and to find beneficial use of the currently discarded C&D materials.

Financial Aspects: Since C&D is a somewhat complicated material to capture under an EPR program, the mechanism for project funding is also unclear.

Current C&D processing costs in Canada and US are estimated at $38 - $80 per tonne. Future operating costs are dependent on fluctuations in commodity revenues and processing cost escalations. This EPR program would also have administrative and transportation costs.

Product Collection: The potential collection system has not been investigated in BC, however it may include drop-off facilities such as municipal depots, combined with private collection facilities.

Reuse, Recycling and Recovery Methods: Table 36 shows some common recovery options for C&D materials in Europe and North America that may apply to BC (Jeffrey 2011). Information is presented for the most prevalent materials in the C&D waste stream.

Table 36. Current Recovery Methods for the Most Prevalent Construction and Demolition Waste Materials

Product	End Use	Destination
Wood	Recycled clean wood can be used as fuel, mulch, compost additive, with limited possibilities in manufacturing. Treated wood has limited options (even as fuel).	ND
Gypsum Board	Gypsum Board can be recycled in the production of new gypsum board or cement, or as for soil amendment.	
Asphalt shingles	Recycled in asphalt pavement and other road construction applications, or used as a fuel.	ND
Concrete	Recycled concrete used as aggregate in production of new concrete. Aggregates commonly recycled into fill for roads and buildings.	ND

3.2.1.1 Description of Status Quo Scenario

The EPR program for C&D materials was assumed to start in 2017. Hence as of 2022, the program will have had 5 years of operation. This section presents what we assumed to be the status quo situation (no EPR program) in 2022 and what the likely EPR scenario was assumed to look like at this time. The scenarios were compared to be able to project and quantify the net impacts (e.g. GHG, energy and job creation).

The Metro Vancouver region, comprising the City of Vancouver and 21 other municipalities, accounts for close to half of BC's population. In 2011 the building industry in the Metro Vancouver area made up a total of 83%

of the building permits value of the whole province (BC Stats, 2013). Since the Metro Vancouver area represents the majority of the economic activity associated with building development, we can expect that the majority of the C&D waste is generated in this region. On this basis we used C&D waste composition data from Metro Vancouver (AET Consultants, 2011) to estimate quantities of the most prevalent C&D materials that are currently landfilled in BC. By applying Metro Vancouver's 2011 disposal rates (kg/capita) to the projected BC population in 2022 it formed the basis of the status quo situation in 2022. Based on Metro Vancouver's waste characterization study we assumed that the most prevalent materials in the C&D waste steam (by weight composition) were wood, asphalt and concrete which made up 54%, 8% and 5% respectively.

In terms of establishing the recovery rate of the status quo scenario, Metro Vancouver reported on achieving a recovery rate of approximately 76% in 2011. This is relatively high since the region already had some recycling programs in place to reduce the amount of landfilled C&D waste. It should be noted that the recovery rate is also high since Metro Vancouver included recycled materials such as concrete and asphalt as part of its recovery. Other jurisdictions define C&D waste differently and report on their recovery rates differently. (Maura Walker, personal communication, 2013). The rest of BC was assumed to achieve a relatively modest recovery rate (20%). A total recovery rate of 66% for all of BC was calculated when we allowed for 83% of the C&D waste being recovered in Metro Vancouver with a 76% recovery rate (as reported by Metro Vancouver) and the rest of BC only achieving 20% recovery.

Historically drywall posed a real issue to landfill management by taking up valuable landfill space and by releasing toxic gases that can be harmful to humans. The majority of regional districts in BC have banned drywall from landfills and therefore we assumed that negligible quantities of drywall are currently landfilled. This assumption was supported by Metro Vancouver's C&D waste composition study.

To our knowledge there is no current EPR program in place for C&D waste elsewhere in the world. A likely recovery rate is likely to be similar to those achieved by jurisdictions where progressive policies are targeting C&D waste specifically. We referred to a number of states in the US where proactive C&D recycling programs have been implemented and where well developed infrastructure for recovering C&D waste exists. We used recorded recovery rates from these US states to represent the recovery rate that we believed can be achieved in BC through an EPR program in 2022.

Table 37 presents the 2011 recovery rates for C&D waste (i.e. the assumed status quo scenario) and those estimated under the EPR program in 2022. These assumptions formed the basis for calculating the net benefits of the EPR program.

Table 37. 2011 Recovery Rate of Construction and Demolition Materials (Status Quo) and Likely Recovery Rate in 2022 Under an EPR Program

Material	Estimated EPR Program Results 2022: (recovery rate %)	Status Quo Results (recovery rate %)	EPR Scenario Justification
All C&D waste	85%	66%	Massachusetts has achieved a recovery rate of 80% in 2010 after implementing a state-wide construction and demolition (C&D) recycling programs (Massachusetts Department of Environment, 2013). Some C&D projects in California State have achieved recovery rates of 91 to 99.6% (Burgoyne, unknown year of release). We assumed a recovery rate of 85% in BC under an EPR program.

3.2.2 Projected Results of Economic and Environmental Impacts

The projected economic and environmental impact results relating to the EPR program for C&D wastes are presented in Table 38.

Table 38. Projected Economic and Environmental Impacts of the EPR program for Construction and Demolition Wastes in 2022

Parameter/ Measure	Functional Unit	Low Estimate	Medium Estimate	High Estimate
Avoided waste collection and landfilling costs				
Avoided collection and processing costs	$million	$27.3	$35.1	$42.8
Avoided landfill siting cost	$million	$0.3	$0.3	$0.3
Avoided landfill development costs	$million	$6.1	$6.6	$7.1
Avoided landfill management costs	$million	$8.4	$12.7	$39.1
Avoided post-closure costs	$million	$0.8	$1.3	$1.8
Total avoided costs	$million	$42.8	$56.0	$91.2
Total value of recovered material in end-markets	$million	ND	ND	ND

Projected Net Benefits (where quantifiable)

Parameter/ Measure	Functional Unit	Low Estimate	Medium Estimate	High Estimate
Net job creation	# jobs	2,335	2,398	2,398
Net landfill space savings	m^3	1,536,553	1,671,848	2,617,033
Net reduction in greenhouse gas (GHG) emissions	tonnes eCO_2	103,314	103,314	103,314
Net energy savings from reduced need for extraction/processing of virgin materials for products and avoided landfilling	GJ	1,206,148	1,206,148	1,206,148
Energy savings in barrels of crude oil	# Barrels of crude oil	194,760	194,760	194,760

3.2.2.1 Economic Impacts

C&D waste currently makes up a significant proportion of the landfilled waste. Therefore the EPR program will significantly reduce the associated garbage costs and landfill costs (by avoided siting, development, landfill management and deferred post-closure costs). The total cost savings were estimated to be $42.8 - $91.2 million. These were based on the net tonnes of recovered material after we compared the projected recovered tonnes with the EPR programs compared to a likely status quo scenario in 2022. These estimates assumed that C&D waste would be disposed to a sanitary landfill together with other municipal solid waste. Although it is likely that some of the material may be disposed to landfills for inert materials (like C&D waste) with lower landfilling costs than those used in this study, we were unable to consider this.

Economic Impacts (in 2022):

- Avoided landfilling costs of $42.8 - $91.2 million
- Net job creation of 2,335 to 2,398 jobs with the majority likely to be based in BC or in neighbouring provinces/states.

Little published data exists for the current market value of C&D materials. It is generally expected to be low, however it would depend on local market conditions and end-market uses

The program was estimated to have a positive net impact and create 2,335 - 2,398 jobs in 2022. It is unclear how many jobs would be created in BC, however due to high transportation costs for C&D materials; we can assume that the majority of the jobs would be created in BC or in neighbouring provinces/states.

3.2.2.2 Environmental Impacts

In 2022 the EPR program for C&D waste will have saved 1,536,553 - 2,617,033 m^3 of landfill space compared to the likely status quo scenario.

As result of the EPR program net reductions in GHG emissions of 103,304 tonnes eCO_2 are likely to be achieved in 2022. Emission factors for several common C&D materials were recently published by US EPA's as part of their Waste Reduction Model (WARM). Canadian emission factors have not yet been published. The emission factor for wood was calculated assuming a wood-to-wood recycling practice that also includes carbon sequestration. Based on knowledge of the difficulties in finding opportunities for this type of recycling, we assumed that only 10% of the recovered wood would be used for remanufacture into new wood products. Yet, the wood recycling contributes to about 50 % of the GHG reductions from the entire EPR program due to its relatively high GHG saving potential compared to other C&D waste materials. Emission factors were not identified, available or applicable for over a 75% of the projected recovered materials. In summary, the GHG savings credited to the program should be regarded as indicative.

Environmental Impacts (in 2022):

- Landfill space savings of 1,536,553 to 2,617,033 m^3 compared to without EPR
- Net GHG reductions of 103.304 tonnes eCO_2 (however result is indicative)
- Net energy savings of 1.2 million GJ using published data (i.e. the energy content of almost 195,000 barrels of oil).

When using emission factors from the US, it should be taken into account that in general the electricity mix in the US is typically more GHG intensive than that of BC. We can assume that the majority of the recovered materials are likely to be processed in BC due to high transportation costs. If this is the case lower GHG reduction results might be expected.

Data on energy savings associated with the recovery of C&D materials is almost non-existent (95% of the tonnes could be not included in the calculation). Based on published data the energy savings, approximately 1.2 million GJ is likely to be saved (equivalent to almost 194,760 barrels of oil) for the plastics and steel components alone in 2022.

In the recovery of wood products there are difficulties with identifying contaminated and treated wood. Treated wood products make up a significant percentage of contaminated wood waste. Certain additives such as formaldehyde-based resins and lead paints are highly toxic and their presence can limit the options available for recycling contaminated wood. Treated wood is normally infused with metals or chemicals to preserve the wood against mould and rot. The infused metals and chemicals in treated wood make it often unsuitable for recycling or reuse in other applications (Jeffrey, 2011). A future EPR program would need to address this issue to minimize any environmental, health and safety impacts of the wood recovery.

No other environmental measures were assessed for the EPR program for C&D waste as there are few relevant studies to refer to.

3.3 Carpets and Textiles

3.3.1 Summary of Potential EPR Program

Summary of Initiative: A large amount of carpets and textiles are disposed to BC landfills every year. The CCME's Canada-wide Action Plan identified that these waste materials should be addressed through EPR programs by 2017. Little detail exists on the types of materials that would be included in such program.

Purpose of the Program: The aim of this pending EPR program is to minimize the landfilling of these materials and to maximize the beneficial recovery.

Financial Aspects: Since it is still uncertain which specific product categories that would be covered by the program, the mechanism for project funding is also unclear. Current processing costs for carpet recovery in Canada range from $80 to $130 per tonne according to Canadian Carpet Recovery Effort (Glenda Gies, personal communication, 2013). Textile processing costs are equivalent to $157 per tonne as recorded by the textile stewardship program in France (ECOTLC 2010). Future program operating costs are dependent on fluctuations in commodity revenues and processing cost escalations. An EPR program would also have administrative costs.

Product Collection: The collection mechanism for these materials is still unknown. It is highly likely to include drop-off facilities such as municipal depots.

Reuse, Recycling and Recovery Methods: Table 39 shows some recovery options used for carpets and textile waste in the US and in Europe. These methods may or may not be relevant to BC.

In Metro Vancouver's on-line Build Smart Directory they have listed a number of companies who use recycled content in their production of carpets. There is only one company (InterfaceFLOR) that lists manufacturing capability in the Metro Vancouver region. Apart from one Ontario-based company, all other listed companies were based in the US.

Table 39. Current Recovery Methods for Carpets and Textiles

Product	End Use	Destination
Carpet	Depending on the quality of the carpet resins it can be recycled into new carpets, high- or low-grade plastics or used for cement production (Cascadia & EBA, 2011).	Until there is processing capacity in BC, more material is likely to be trucked to Toronto or the US for recycling (Cascadia & EBA, 2011)
Textiles	Reused or recycled for use as rags by industry and households, and into new textile production.	ND

3.3.1.1 Description of Status Quo Scenario

The EPR program for carpets and textiles was assumed to start in 2017. Hence as of 2022, the program will have had 5 years of operation. This section clarifies what we assumed to be the status quo situation (no EPR program) in 2022 and what the likely EPR scenario may look like at this time. The scenarios were compared to be able to project and quantify the net impacts (e.g. GHG, energy and job creation).

To estimate the quantities carpets and textiles that were landfilled in BC in 2011, we used Metro Vancouver's 2011 Solid Waste Composition Monitoring data (TRI Environmental Consulting Inc, 2012). The waste composition study provided estimated kg/capita (or per employee if the waste came from the ICI sector) and these were applied to the BC population in 2022 to reflect the status quo scenario (i.e. without an EPR program). The study showed landfill disposal rates from commercial and residential sources of 17.2 kg/capita for carpets and 14.4 kg/capita for textiles.

The estimated quantities of carpets and textiles landfilled per capita were in line with existing knowledge of the Canadian Textile Recovery Effort (CTRE) (CTRE, personal communication, 2013).

In 2011 there was almost no carpet recovery in Metro Vancouver (Cascadia & EBA, 2012). The Canadian Carpet Recovery Effort (CCRE) estimated a recovery rate of 1% (CCRE, 2010). This is in line with the recovery rate reported by the Carpet America Recovery Effort (CARE) program in California before it started its stewardship program on a voluntary basis in 2002.

In BC textiles such as clothing, footwear and bedding are often reused via charity retail. CTRE is a voluntary initiative to increase the recovery of both carpets and textiles. The research undertaken by CTRE indicates that BC's textile recovery rate for clothing, footwear and accessories is close to 30%. This recovery rate was assumed to represent the status quo scenario.

To estimate the projected recovery rates in 2022 when carpets and textiles are covered by an EPR program, we reviewed the performance of other EPR programs for these materials. The recovery rate for carpets were estimated by referring to the CARE program in the US, and for the recovery rate for textiles we looked at the recovery performance of ECOTLC textile stewardship program in France (ECOTLC 2010).

Table 40 presents the estimated 2011 recovery rates for textiles and carpets (i.e. the assumed status quo scenario) and those estimated under the EPR program. These assumptions formed the basis for calculating the net benefits of an EPR program as of 2022.

Table 40. 2011 Recovery Rate of Textiles & Carpets (Status Quo) and Likely Recovery Rate in 2022 Under an EPR Program

Material	Estimated EPR Program Results 2022: (recovery rate %)	Status Quo Results (recovery rate %)	EPR Scenario Justification
Textiles	45%	30%	Assuming that the recovery rate is improving by 50% between 2017 and 2022, based on performance improvement in France within 4 years of EPR implementation. The performance after 5 years was not available.
Carpets	15%	1%	We assumed the same level of recovery rate as reported in 2010 by California's CARE program (15%) after the program had been operational for 8 years on a voluntary basis. We assumed that a compulsory program is likely to achieve the same recovery rate within 5 years of operation.

3.3.2 Projected Results of Economic and Environmental Impacts

The projected economic and environmental impact results relating to the EPR program for carpets and textiles are presented in Table 41.

Table 41. Projected Economic and Environmental Impacts of the EPR program for Carpets and Textiles in 2022

Parameter/ Measure	Functional Unit	Low Estimate	Medium Estimate	High Estimate
Avoided waste collection and landfilling costs				
Avoided collection and processing costs	$million	$1.42	$1.82	$2.22
Avoided landfill siting cost	$million	$0.02	$0.02	$0.02
Avoided landfill development costs	$million	$0.31	$0.34	$0.37
Avoided landfill management costs	$million	$0.43	$0.66	$2.03
Avoided post-closure costs	$million	$0.04	$0.07	$0.09
Total avoided costs	$million	$2.22	$2.90	$4.73
Total value of recovered material in end-markets (carpets)	$million	$0.65	$1.63	$2.01

Projected Net Benefits (where quantifiable)

Parameter/ Measure	Functional Unit	Low Estimate	Medium Estimate	High Estimate
Net job creation	# jobs	92	93	95
Net landfill space savings	m^3	26,531	55,204	102,735
Net reduction in greenhouse gas (GHG) emissions	tonnes eCO_2	27,927	29,887	31,847
Net energy savings from reduced need for extraction/processing of virgin materials and avoided landfilling	GJ	ND	ND	ND
Energy savings in barrels of crude oil	# Barrels of crude oil	ND	ND	ND

3.3.2.1 Economic Impacts

Economic Impacts (in 2022):

- Avoided landfilling costs of $2.22 - $4.73 million
- Market value (carpets) of $0.65 - $2.01 million
- Net job creation of 92 - 95 jobs.

The EPR program for carpets and textiles is likely to reduce the landfilling costs (by avoided siting, development, landfill management and deferred post-closure costs) by $2.22 - $4.73 million in 2022. These estimates were based on the net tonnes of recovered material after we compared the projected recovered tonnes with the EPR programs compared to a likely status quo scenario in 2022.

The EPR program was estimated to result in recovered carpets with the total market value of $0.65 - $2.01 million in 2022. Market value estimates came from CCRE and Metro Vancouver's Recycling Market Study (EBA and Cascadia, 2012). This estimate does not include the recovered quantities under a status quo scenario and reflects the net increase in market value resulting from the EPR program. It is unclear how much of the market value in 2022 would be captured in the BC markets and other markets. Since no published data exist in Canada on the current market value of textile materials we were unable to include it in the calculation.

The program was estimated to have a net positive impact on employment and in 2022 and create 92 – 95 jobs. The job impacts were estimated by using job creation factors from the US.

3.3.2.2 Environmental Impacts

Environmental Impacts (in 2022):

- Landfill space savings of 26,531 - 102,735 m^3 compared to without EPR
- Net GHG reductions of 27,927 - 31,847 tonnes eCO_2.

The EPR program for carpets and textiles is likely to have saved approximately 26,531 - 102,735 m^3 of landfill space in 2022 compared to the likely status quo scenario.

A total net reduction of GHG emissions of 27,927 - 31,847 tonnes eCO_2 is likely to be achieved in 2022 as result of the EPR program.

As there was no Canadian emission factor published for carpets, we used US emission factors instead. In general the electricity mix in the US is typically more GHG intensive than that of BC. However we were unable to adjust the emission factor to BC circumstances since this is a major study in itself. It is important to remember that the GHG impact is dependent on where the materials are recovered.

No energy savings could be determined since these factors have not been published.

No other environmental impacts were estimated from the recovery of carpets or textiles as there are few relevant studies to refer to.

3.4 Furniture

3.4.1 Summary of Potential EPR Program

Summary of Initiative: Furniture is a broad product group that encompasses very different types of furniture such as chairs, tables, wardrobes, shelves, cupboards, mattresses, etc. Re-using furniture is already a widespread activity across BC via second-hand stores, classified ads and on-line postings (e.g. Craigslist). Due to lack of reliable data on how much furniture is reused each year and when a furniture item should be considered as reused, a likely EPR program was assumed to only cover other recovery methods for furniture.

Purpose of the Program: An EPR program for furniture is planned to be implemented in 2017 with the aim to improve the diversion of used furniture from landfills, encourage more beneficial recovery (reuse, recycling), and enhance DfE of the targeted products.

Financial Aspects: No information is currently available for what will be the likely mechanisms for program funding. Current processing costs for furniture waste typically range from $276 to $882 per tonne based on current recycling costs specified by Canadian Mattress Recycling in Canada for common furniture items. Additional program costs will also include transportation administrative costs.

Product Collection: No data is available on how the materials will be collected, however we assume that a collection network is likely to include drop-off facilities such as municipal depots.

Reuse, Recycling and Recovery Methods: Metro Vancouver is currently not aware of any facilities in the region that specialize in furniture repurposing or recycling other than smaller artisanal shops or re-upholstering shops.

Table 42 shows some common recovery options used for furniture waste. The information on destination of recovered materials was provided by Canadian Mattress Recycling Inc. which is one of the few furniture recyclers in BC (Canadian Mattress Recycling Inc. 2013).

Table 42. Current Recovery Methods for Furniture Waste Materials

Product	End Use	Destination
Metal	Recycled as other scrap metal	BC and North American markets.
Polyurethane foam	Recycled	Foam often sent to eastern Canada.
Cotton and other fibers	Cotton can be used as an oil filter in diesel engines (Product Stewardship Institute Inc.,2011)	US markets
Wood waste	Depends on whether it is treated or not. Treated wood often has limited options (even as fuel).	Local use

3.4.1.1 Description of Status Quo Scenario

The EPR program for furniture waste was assumed to start in 2017. Hence as of 2022, the program will have had 5 years of operation. This section presents what we assumed to be the status quo scenario (no EPR program) in 2022 and what the likely EPR scenario may look like at this time. The scenarios were compared to be able to project and quantify the net impacts (e.g. GHG, energy and job creation).

To estimate the quantities furniture that were landfilled in BC in 2011, we used Metro Vancouver's 2011 Solid Waste Composition Monitoring data (TRI Environmental Consulting Inc., 2012). The waste composition study provided estimated kg/capita for upholstered furniture, mattresses, box springs and other furniture (e.g. composite furniture). The disposal rate from commercial and residential sources of 28.4 kg/capita was applied to the BC population in 2022 to reflect the status quo scenario (i.e. without an EPR program). Furniture waste currently make up 3.1% of the total MSW generated in BC (Metro Vancouver, personal communication, 2013). This is in line with 4.1% which was the proportion reported in US for 2009 (US EPA, 2009).

Due to lack of data on current recovery rate for furniture, we used a figure reported in Europe. According to European Federation of Furniture Manufacturers statistics based on European Union data in 2004, only 10%

furniture waste is recycled (European Commission, 2008). This figure did not include the proportion of furniture that was reused.

According to the Swedish furniture industry the average Swedish furniture product consists of 70% wood based material, 15% padding materials (mainly polyurethane and polyester foam), 10% metals and 5% other materials (plastics, textiles, glass, etc.) (European Commission, 2008). This material break-down was used in our study to estimate the quantities of materials that make up the furniture waste stream. The most prevalent metal types used for the production of furniture are aluminum, steel (mainly stainless steel) and iron (European Commission, 2008). An even split between these metal types was assumed in the study.

To our knowledge there is no current EPR program for furniture in place elsewhere in the world. A likely improvement of the recovery rate was assumed to be similar to those achieved by the EPR programs for carpets in the US or textiles in France after 5 years of operation (see Section 3.3.1.1 for more information). Both programs indicate that it is realistic to assume a 50% improvement in the recovery rate within this time period. Table 43 presents the 2011 recovery rates for furniture (i.e. the assumed status quo scenario) and those estimated under the EPR program. These assumptions formed the basis for calculating the net benefits of the EPR program in 2022.

Table 43. 2011 Recovery Rate of Furniture (Status Quo) and Likely Recovery Rate in 2022 Under an EPR program

Material	Estimated EPR Program Results 2022: (recovery rate %)	Status Quo Results (recovery rate %)	EPR Scenario Justification
Furniture	15%	10%	The EPR programs for carpets and textiles indicate that it is realistic to assume a 50% improvement in recovery rate within a 5 year period.

3.4.2 Projected Results of Economic and Environmental Impacts

The projected economic and environmental impact results relating to the EPR program for furniture are presented in Table 44.

Table 44. Projected Economic and Environmental impacts of the EPR Program for Furniture in 2022

Parameter/ Measure	Functional Unit	Low Estimate	Medium Estimate	High Estimate
Avoided waste collection and landfilling costs				
Avoided collection and processing costs	$million	$0.53	$0.68	$0.83
Avoided landfill siting cost	$million	$0.01	$0.01	$0.01
Avoided landfill development costs	$million	$0.12	$0.13	$0.14
Avoided landfill management costs	$million	$0.16	$0.25	$0.76
Avoided post-closure costs	$million	$0.01	$0.02	$0.03
Total avoided costs	$million	$0.8	$1.1	$1.8
Total value of recovered material in end-markets	$million	$0.35	$0.42	$0.51

Projected Net Benefits (where quantifiable)

Parameter/ Measure	Functional Unit	Low Estimate	Medium Estimate	High Estimate
Net job creation	# jobs	30	31	32
Net landfill space savings	m^3	14,268	16,907	31,235
Net reduction in greenhouse gas (GHG) emissions	tonnes eCO_2	2,823	2,823	2,823
Net energy savings from reduced need for extraction/processing of virgin materials and avoided landfilling	GJ	27,295	27,295	27,295
Energy savings in barrels of crude oil	# Barrels of crude oil	4,407	4,407	4,407

3.4.2.1 Economic Impacts

> **Economic Impacts (in 2022):**
> - Avoided landfilling costs of \$0.8 - \$1.8 million
> - Potentially high costs savings to municipalities from mattress recycling
> - Net job creation of 30 - 32 jobs, however reliable reference data is missing.

The EPR program for furniture was estimated to reduce the garbage collection and landfilling costs (by avoided siting, development, landfill management and deferred post-closure costs) by \$0.8 - \$1.8 million in 2022. These estimates were based on the net tonnes of recovered material after we compared the projected recovered tonnes under the EPR programs compared to a likely status quo scenario in 2022. The avoided costs can be seen as relatively modest. Based on the performance of other EPR programs, we assumed that after only 5 years of operation the EPR program is likely to achieve relatively small improvements to the recovery rate of furniture waste.

Furniture waste such as discarded mattresses are particularly hard to manage. Mattresses are large, bulky, require dismantling and are sometimes hard to recycle due to health issues with bed bugs. Numerous municipalities have recorded significant costs associated with the management of waste mattresses. In the US, the City of Hartford, Connecticut, faced a significant burden to manage mattress disposal. In 2011 the city was projected to spend up to \$400,000 to manage approximately 15,500 mattresses. In fact, many local governments are charging a per mattress disposal fee, ranging from \$9 to \$30 a mattress, to cover the processing and disposal costs (Product Stewardship Institute Inc., 2011).

Due to the lack of published data on the current market value of common furniture materials, estimates on the market value of recovered material could not be determined.

There is sparse data on job impacts from furniture recycling. Based on published job factors for the different component materials resulting from furniture recycling, we estimated that the EPR program will create 30 - 32 jobs in 2022. These estimates also take into account the losses from the reduced quantities of landfilled waste resulting from the program. Many of the job factors were estimated based on the common material recovered from bluebox programs and therefore the job impact results for furniture should be considered as indicative. Furniture recovery is relatively labour intensive. The EPR program can provide job opportunities for people that are traditionally hard-to-employ. This is at least the experience of the Regional District of Okanagan Similkameen which employs staff to dismantle and recover materials from mattresses received at their disposal facility (Maura Walker, personal communication, 2013).

3.4.2.2 Environmental Impacts

> **Environmental Impacts (in 2022):**
> - Landfill space savings of 14,268 - 31,235 m^3 compared to without EPR program
> - Net GHG reductions of 2,823 tonnes eCO_2.
> - Net energy savings of 27,295 GJ (4,407 barrels of oil).

In 2022 the EPR program for furniture will have saved 14,268 - 31,235 m^3 of landfill space compared to the likely status quo scenario.

A total net reduction of GHG emissions of 2,823 tonnes eCO_2 is likely to be achieved in 2022 as result of the EPR program. The emission factor for wood was calculated assuming a wood-to-wood recycling practice that also includes carbon sequestration (US EPA, 2012). The majority of recovered wood from furniture is treated (European Commission, 2008) and based on knowledge of the difficulties in finding opportunities for wood recycling, we assumed that only 10% of the recovered wood would be used for remanufacture into new wood products. No emission factors for other wood recovery practices are currently published and were not included.

In 2022 the energy savings were estimated to 27,295 GJ from the furniture recovery (equivalent to 4,407 barrels of crude oil). No energy factor was available for any of the likely wood recovery processes. In addition, emission and energy factors were not identified for 15% (by weight) of the expected recovered materials (polyurethane and polyester foam). There are concerns that foam blown with chlorofluorocarbons, potent GHGs, or with CO_2, could possibly be released during its recycling from furniture and mattress foams. These are possible materials or activities that could impact GHG emissions if not managed properly (Pacific Northwest Pollution Prevention Resource Center, 2013). This aspect would need to be considered when the GHG impacts from furniture recycling are estimated in future studies.

No other environmental impacts were estimated from the recovery of furniture as there are few relevant studies to refer to.

4. CASE STUDIES – AVOIDED RAW MATERIAL USE AND COST OF EXTRACTION AND PROCESSING OF RAW MATERIALS

One of the key arguments for recycling is often the raw material use that can be avoided by recycling a product. This section describes two different case studies to investigate the avoided raw material use: one of closed-loop recycled and reused products and the other of an open-loop recycled product. For these examples both avoided raw material use and the associated reduced cost of extraction and processing of raw materials for products have been estimated.

By using published life cycle inventory data, we were able to determine the tonnes of primary raw materials required to manufacture one tonne of a specific material (e.g. glass, aluminum, etc.). These tonnages were multiplied by the quantities of the recovered products to calculate the avoided raw material use. It should be noted that we were only able to find one reference that provided transparent data on the raw material use per tonne of primary material production, namely the Life-cycle Inventory Data Sets for Material Production of Aluminum, Glass, Paper, Plastic, and Steel (RTI, 2003).

We estimated the cost of extraction and processing of raw materials for products by using available world commodity prices recorded in 2011. Since market prices generally fluctuate the lowest and highest prices per tonne were used for the calculations. The market values of commodities were used as a proxy for the cost of extraction and processing, however we acknowledge that commodity prices would also cover profit margins of the primary industry. We did not attempt to distinguish the profit margin within the commodity prices.

4.1 Closed-loop Recycled and Reused Materials

Very few of the current EPR programs in BC were recovering products through closed-loop recycling. Closed-loop refers to the reincorporation of a material back into a product that has a similar use and composition to the product from which it was derived.

In the EPR program for the recovery of beverage containers, there is one example of a true closed loop system. Brewers Distributor Ltd (BDL) recycles aluminum from kegs and cans. They also reuse the collected beer bottles and aluminum kegs until they are not suitable for use any longer and require recycling. The reuse of a product is not closed-loop recycling, however the same methodology can be used to assess economic and environmental benefits associated with reuse and closed-loop recycling of products. The reuse of glass and the closed-loop recycling of aluminum were used to quantify the resulting avoided raw material use and the costs from processing and extracting the raw materials.

BC consumers returned 31,944 tonnes of refillable glass bottles in 2011. Because they are largely collected unbroken, BDL estimated that 92% of the bottles (i.e. 29,388 tonnes) were returned to breweries and other beverage manufacturers for cleaning and reuse.

BDL also reports the collection of 5,918 tonnes of aluminum cans and 4,267 tonnes as aluminum kegs. The kegs are also reusable and can last for up to 50 years.

4.1.1 Results of Avoided Raw Material Use and Reduced Costs of Extraction/Processing of Virgin Materials

Table 45 presents the impact results for the avoided raw material use and reduced costs of extraction/processing of virgin materials associated with the closed-loop recycled and reused beverage containers recovered in 2011 by BDL. The table is followed by sections that provide additional comments that explain the results or any data gaps.

Table 45. Avoided Raw Material Use and Reduced Costs of Extraction/Processing of Virgin for Closed-loop Recycled and Reused Beverage Containers

Benefits (Positive impacts)				
Parameter/ Measure	**Functional Unit**	**Low Estimate**	**Medium Estimate**	**High Estimate**
Avoided raw material use	Tonnes	32,959	32,959	32,959
Reduced costs of extraction/processing of virgin materials for products	$million	$9.4	$10.9	$12.4

4.1.2 Avoided Raw Material Use

Closed-Loop Recycling of Bottles and Aluminum:

- The reuse of beverage containers saved a total of 32,959 tonnes of raw materials from its glass reuse
- Reuse of aluminum kegs and aluminum can recycling saved 62,220 tonnes raw materials.

BDL's EPR program for beverage containers recovered in 2011 was estimated to save a total of 32,959 tonnes of raw materials from 29,388 tonnes of glass reuse in 2011, and 62,220 tonnes from its keg reuse and closed loop recycling of aluminum. There would also be significant associated environmental benefits (e.g. acidification, particulates, etc.) from the avoided raw material use.

According to the Life-cycle Inventory Data Sets for Material Production, each ton (not metric) of primary glass containers produced requires inputs including 359 pounds from limestone mining, 1,323 pounds from glass sand mining, 426 pounds from soda ash mining and 135 pounds from feldspar mining (RTI, 2003). When these figures were added together this equated to a total raw material use of 1.12 metric tonnes of materials per tonne of primary glass produced.

To manufacture 1 ton (not metric) of primary aluminum sheet/coil, it requires inputs of 347 pounds from limestone mining, 10,608 pounds from bauxite mining, 260 pounds from salt mining, 766 pounds of crude oil and 237 pounds from coal mining (RTI, 2003). A total raw material use of 6.11 metric tonnes is required to produce one tonne of primary aluminum produced.

4.1.2.1 Other Avoided Environmental Impacts

With the same assumptions we were also able to quantify the reduction of key environmental measures such as particulate matter, nitrogen oxide, and sulphur oxide emissions and the reduced municipal solid waste generation resulting from the avoided production of primary products. Factors for these measures were provided in the Life-cycle Inventory Data Sets for Material Production (RTI 2003). The reuse of glass in 2011 reduced the particulate matter by 104 tonnes, nitrogen oxide emissions by 19.5 tonnes, sulphur oxide emissions by 51.6, and the municipal solid waste generation by 376 tonnes. The impacts for the reused and recycled aluminum recovered in 2011 were somewhat higher at 323 tonnes of particulates, 319 tonnes of nitrogen oxide, 929 tonnes of sulphur oxide, and 1,917 tonnes of solid waste.

As can be seen, the environmental benefits associated with closed loop recycling are significant.

4.1.3 Reduced Costs of Extraction/Processing of Virgin Materials for Products

The reduced costs of extraction and processing virgin materials for the glass and aluminum that was recovered by BDL in 2011 were estimated to $9.4 - $12.4 million. The cost reduction associated with aluminum made up 93% of the cost savings.

For the calculations we applied the same assumptions as when we calculated the tonnes of glass and aluminum that were reused or closed-loop recycled. These quantities were multiplied by the commodity price per tonne to estimate the reduced cost to extract and process the materials. To make primary glass (from silica sand) and aluminum we assumed costs of $23.10- $31.70, and $2,043.90- $2,693.20 respectively. By using the commodity price as a proxy, it was clear that aluminum has a much higher cost to produce than glass.

Closed-Loop Recycling of Bottles and Aluminum:

- The glass reuse and aluminum recycling in 2011 by BDL reduced the costs of extraction and processing virgin materials by $9.4 - $12.4 million
- The estimates indicate that reuse and closed-loop recycling results in significant reductions of the cost of extraction and processing of raw materials.

Basing the estimate on the commodity values for these materials assumes that virgin products make up 100% of the marketed commodities. This is unlikely to reflect the true reduced costs of extraction/processing of raw materials, since materials like aluminum have high recycled content. The production of virgin aluminum is a highly energy intensive process. The marketed commodity prices of aluminum, which have some recycled content, are therefore a significant under-representation of the true savings achieved by replacing raw materials with recycled alternatives.

To make estimates that are more meaningful and reliable a study requires industry data which often is commercially sensitive. The cost of extraction and processing would be dependent on local electricity prices and cost estimates may not be transferrable to another region.

Despite a high level of uncertainty in the calculated figures, it can be concluded that reuse and recycling results in significant reductions of the cost of extraction and processing of raw materials.

4.2 Open-loop Recycled Materials

Tire recycling is an example of an open-loop system. The recycling of tires into manufactured products does not displace the manufacture of new tires, but rather replaces alternative products. Therefore when we look at the avoided raw material use and the costs involved with its extraction and processing, we need to fully understand all the end-uses of the recycled tires.

In 2011, 88% of the tires collected in BC were recycled primarily into crumb rubber (7,436 tonnes in total). Recycled rubber was then used to create a variety of products including; athletic tracks, synthetic turf fields, playground surfacing, colourful resilient flooring in recreational facilities, flooring and mats for agricultural and industrial use, and coloured landscaping mulch.

We were unable to get data from TSBC on the specific quantities of rubber that was recycled into the different end-products in 2011.

4.2.1 Results of Avoided Raw Material Use and Reduced Costs of Extraction/Processing of Virgin Materials

Table 46 presents the impact results for the avoided raw material use and reduced costs of extraction/processing of virgin materials associated with the open-loop recycled tires recovered in 2011 by TSBC. The table is followed by sections that provide additional comments that explain the results or any data gaps.

Table 46. Avoided Raw Material Use and Reduced Costs of Extraction/Processing of Virgin for Open-loop Recycled Tires

Benefits (Positive impacts)				
Parameter/ Measure	**Functional Unit**	**Low Estimate**	**Medium Estimate**	**High Estimate**
Avoided raw material use	Tonnes	8,924	22,310	41,645
Reduced costs of extraction/processing of virgin materials for products (polypropylene crumb)	$million	$2.2	$2.7	$3.1
Reduced costs of extraction/processing of virgin materials for products (wood)	$million	ND	ND	ND
Reduced costs of extraction/processing of virgin materials for products (concrete)	$million	$3.0	$4.3	$5.6

4.2.2 Avoided Raw Material Use

The LCA study undertaken for Alberta of the end-of-life tire management (Pembina Institute, 2010) presented LCA results for a range of recovery options for tires. Table 47 presents the examples that are relevant to BC.

Table 47. Relevant Recovery Options for Which Available Data Exist on Products Displaced by Tire Recycling

Recycling Option	Description
Crumb	Used as a rubber foundation for athletic fields.
Manufactured products, e.g. industrial mats (wood displacement)	A rig mat, or large mat placed on the ground for ground protection and improved traction of drilling rigs, is used as a proxy.
Manufactured products, e.g. concrete curbs (concrete displacement)	Molded rubber parking curbs can replace traditional concrete curbs.

When crumb is used as rubber foundation for athletic fields it was assumed that it displaces polypropylene crumb, which has similar properties to rubber crumb. In practice, tire-derived crumb is only used on athletic surfaces as an enhancement product and would not displace existing material (Pembina Institute, 2010). The reference study justified assuming that one tonne of crumb would displace 1.2 tonnes of polypropylene crumb.

If we assumed that the entire rubber crumb recovered in 2011 was used for athletic fields, a total of 8,924 tonnes of polypropylene crumb would have been displaced from BC's tire recycling in 2011. No reliable data was available regarding the raw material use involved in producing a tonne of polypropylene crumb and we were unable to take the calculation further.

Rubber rig mats made from crumb can also displace timber rig mats made from traditional sawmill timber. When rubber crumb displaces wood in applications such as industrial mats, it was assumed that one tonne of crumb would displace 3 tonnes of wood (Pembina Institute, 2010). If we assumed that all rubber crumb recovered in 2011 was used for industrial mats, a total of 22,310 tonnes of wood product would have been displaced from BC's tire recycling in 2011. It is unlikely that BC's tires will ever be displacing wood products to any larger extent. The LCA found that producing rubber rig mats increases fossil fuel inputs more than any other recycling option analyzed (i.e. displacing concrete, asphalt or aggregate) (Pembina Institute, 2010).

Open-Loop Recycling of Tires:

- Rubber crumb can displace numerous other products
- Raw material use unclear for most recovery options.

Similarly, rubber parking curbs can displace traditional concrete curbs. It was assumed that the relative displacement of rubber to concrete in this application is 1 to 5.6 (Pembina Institute, 2010). Therefore, if all rubber crumb recovered in 2011 was used in parking curbs, just over 41,645 tonnes of concrete would be displaced.

This exercise shows the inherent complexity in calculating avoided raw materials for open-loop recycling cases.

4.2.3 Reduced Costs of Extraction/Processing of Virgin Materials for Products

It is difficult to determine the amount and value of the raw materials displaced by rubber crumb from tires. In the examples above the crumb displaced either polypropylene crumb, wood or concrete products.

The market value of the recovered rubber crumb was used as a reasonable proxy value for polypropylene crumb and the reduced costs of extraction and processing of virgin materials was estimated at $2.2 - $3.1 million.

We were unable to find a suitable proxy to estimate the reduced costs when rubber crumb displaces wood.

Open-Loop Recycling of Tires:

- The reduced cost of extraction and processing of virgin materials estimated to $12.2 - $3.1 million from displaced polypropylene rubber
- If all rubber from recovered tires displaced concrete, the cost reductions were $3 - $5.6 million
- Cost reductions from other displaced products were not estimated.

If the entire rubber crumb was used in concrete parking curbs, the reduced costs of extraction and processing of virgin materials was estimated at $3 - $5.6 million.

Despite the difficulty in estimating the value associated with reduced extraction and processing of virgin materials displaced through open-loop recycling, it is clear that the value can be significant.

5. SUMMARY AND CONCLUSIONS

This study provides an assessment of the economic and environmental impacts of EPR programs in BC, with the results described by EPR program material. The assessment is based on the recovered quantities of EPR program materials that can be credited to the EPR programs. This was done by comparing the recovery rates under the EPR programs with those of a likely status quo scenario (no EPR program). This approach was based on the assumption that collection systems operated for EPR product categories prior to the EPR program would have evolved through other policy mechanisms (e.g. solid waste management plans) in the absence of EPR legislation. As such, performance of EPR programs was evaluated against the likely status quo recovery scenario and not against a scenario in which 100% disposal was assumed.

Table 48 presents a summary of the key estimated impact results for the 2011 EPR program Materials and Pending EPR Materials. Input data for 2011 EPR Materials were based on reported quantities recovered by each EPR program during the 2011 calendar year. For Pending EPR Materials, projections of future impacts were based on likely program performance in 2022, by which time all pending programs should have should be implemented across BC.

Economic and environmental impacts were examined by using selected low (conservative), medium (average), and high (liberal) estimates to reflect the span of data uncertainty. The table presents the medium (average) estimates of each parameter for each EPR program material. The table is followed by sections that highlight key findings, provide additional comments that explain the results, and general conclusions regarding impacts from 2011 EPR Materials and Pending EPR Materials.

Table 48. Overview of Economic & Environmental Impact Results for each EPR Program Material

Parameter/ Measure	Avoided garbage collection and landfilling costs	Total value of recovered material in end-markets	Net jobs created from EPR program	Net landfill space savings	Net tonnes of EPR materials avoiding landfilling	Net reduction in GHG emissions	Net energy savings
2011 EPR Materials:	$million	$million	#jobs	m^3	Net tonnes	tonnes eCO_2	('000) GJ
Used oil and antifreeze products	$2.5	$0.9	97	83,667	13,686	29,074	143
Batteries	$0.1	$23.2	23	4,267	2,102	3,485	92
Beverage containers	$18.0	$13.6	933	392,712	97,825	112,191	1,846
Electronic or electrical products	$5.1	$1.9	1,185	151,459	27,508	26,641	474
Lamps	$0.0	$0.0	1	127	81	14	0.20
Paint and household hazardous waste	$4.9	$0.0	6	912	771	157	3.69
Smoke alarms	$0.0	ND	0	18	3	2	0.04
Thermostats	$0.0	ND	0	2	0.4	0	0.01
Tires	$1.6	$0.4	110	11,870	8,451	1,643	164
Pharmaceutical waste	$0	ND	0	0	0	ND	ND
2011 EPR Materials Total	**$32.2**	**$39.9**	**2,355**	**645,035**	**150,425**	**173,208**	**2,723**

Parameter/ Measure	Avoided garbage collection and landfilling costs	Total value of recovered material in end-markets	Net jobs created from EPR program	Net landfill space savings	Net tonnes of EPR materials avoiding landfilling	Net reduction in GHG emissions	Net energy savings
Pending EPR Materials (in 2022):	$million	$million	#jobs	m^3	Net tonnes	tonnes eCO_2	('000) GJ
Packaging and printed paper	$54.7	$105	2,860	933,986	296,577	798,761	8,972
Construction and demolition materials	$56.0	ND	2,398	1,671,848	306,969	103,314	1,206
Carpets and textiles	$2.9	$1.6	93	55,204	15,733	29,887	ND
Furniture	$1.1	$0.4	30	16,907	5,892	2,823	36
Pending EPR Materials Total	**$114.6**	**$107**	**5,380**	**2,677,944**	**625,171**	**934,785**	**10,206**

5.1 Economic Impacts

One of the objectives of EPR programs is shifting of responsibility (physically and economically) to the producer and away from municipalities. The following major findings are highlighted in terms of economic impacts for 2011 EPR Materials and Pending EPR Materials.

5.1.1 2011 EPR Materials

The EPR programs operating in BC during 2011 were estimated to reduce garbage collection and landfilling costs (siting, development, landfill management and the deferred post-closure costs) by $32.2 million (medium estimate). The cost savings were based on the net tonnes of recovered material after comparing recovered tonnes under the EPR programs to the likely status quo scenarios.

The market value of the recovered material resulting from the 2011 EPR programs was estimated at almost $40 million. Although this was the medium estimate, it should be considered conservative as many of the stewards were either unable to provide data on the quantities of various component materials recovered (e.g. plastic, steel, in the EPR product e.g. electronics), or the information on market value was not disclosed for confidentiality reasons. The estimated market value is therefore likely to be underestimated. The study also attempted to identify where the value of the recovered materials was captured (BC, out-of province, North America, or in global markets). Information on the destinations of the various recovered products was often not available.

Economic Impacts
(2011 EPR Materials):

- Reduced garbage and landfilling costs of approximately $32 million
- Market value of $40 million
- Net job creation of 2,355 jobs.

Employment impacts resulting from the EPR programs operating in 2011 were reviewed and job creation from an increase in material recovery was compared with the job losses from the reduced need for landfilling. Based on published factors for job creation in Canada and the US, the EPR programs that operated in 2011 were estimated to result in 2,355 jobs (medium estimate). The locations where these jobs were created could not be defined since information on the destinations of the various recovered products was often not available. We can conclude that the EPR programs in 2011 had a significant positive impact on job creation, although the location of these jobs is uncertain.

5.1.2 Pending EPR Materials

For Pending EPR Materials, the avoided garbage collection and landfilling costs were estimated to be $115 million in 2022 as result of the EPR programs. The largest savings are expected to come from the diversion of PPP and C&D waste. The study used representative costs for landfills receiving municipal solid waste, although some C&D material may be disposed to landfills for inert materials with lower landfilling costs.

Future EPR programs were estimated to recover targeted EPR material with a market value of over $100 million. The market value of C&D waste and textiles was not determined due to lack of data. These market value estimates were based on 2011 commodity values. Commodity values in 2022 could be significantly different.

Economic Impacts
(Pending EPR Materials in 2022):

- Reduced garbage and landfilling costs of approximately $115 million
- Market value of $100 million
- Net job creation of 5,400 jobs

In 2022 pending EPR programs were estimated to generate almost 5,400 jobs (medium estimate). PPP and C&D materials are expected to generate the majority of those jobs. Due to high transportation costs for C&D materials, we have assumed that the majority of these jobs would be created in BC or in neighbouring provinces/states. For the other future EPR materials, the location of the job creation will depend on where the materials will be processed and utilized.

5.2 Environmental Impacts

The following major environmental findings are highlighted for 2011 EPR Materials and Pending EPR Materials. The section for each EPR program material identifies any uncertainty with the estimates of the quantifiable impacts. Each EPR program material section in this report provides more information on quantitative environmental benefits such as reduction in litter, environmental contamination or environmental risk avoidance resulting from the EPR programs.

5.2.1 2011 EPR Materials

Environmental Impacts (2011 EPR Materials):

- Landfill space savings of between 215,000 and 645,000 m^3 depending on assumed density once materials are landfilled.
- Net GHG reductions of 173,000 tonnes eCO_2 (same as removing 38,500 cars from the roads)
- Net Energy savings of 2.7 million GJ (440,000 barrels of oil)

The EPR programs operating in 2011 saved landfill space of approximately 645,000 m^3. The savings were estimated based on the net reduction in landfilled quantities when the EPR programs were compared to the likely status quo scenarios. In the initial calculation the density of each recovered material was considered.

Since the density of landfilled materials in practice may be higher than those published for individual compacted materials, we made an alternative calculation, assuming that the average garbage density in a landfill is 0.7 tonnes per m^3 (Wiley& Sons, 2011). The EPR programs in 2011 resulted in 150,425 tonnes of EPR materials that avoided landfilling. Based on this quantity and the assumed garbage density the landfill space savings equate to 215,000 m^3. The estimated landfill space savings should be regarded as indicative since there is much uncertainly in the actual density of when different types of materials are landfilled.

To put the EPR results into context, BC's EPR programs in 2011 avoided disposal of 150,425 tonnes compared to the likely status quo scenarios. This equates to 11 % of Metro Vancouver's total disposed waste quantity in 2011 (1.37 million tonnes according to Metro Vancouver, 2011).

The net reductions in GHG emissions for 2011 that can be accredited to the EPR programs were 173,000 tonnes eCO_2. In some cases the emission factors for recovered materials were unavailable or were based on US data. Assuming that the GHG emissions from one car per year is 4.5 tonnes $eCO_{2,}$ the EPR programs achieved GHG reductions that equal removing almost 38,500 cars from the roads for a year.

The net energy savings resulting from the EPR programs operating in 2011 were 2.7 million GJ, which equates to the energy content of almost 440,000 barrels of crude oil.

Based on the material quantities recovered by EPR programs in 2011, the programs result in significant GHG reductions and energy savings.

5.2.2 Pending EPR Materials

For 2022, the future EPR programs were estimated to save almost 2.7 million cubic meters of additional landfill space when the density of each recovered material was considered. In our alternative calculation when a typical garbage density in the landfill as described above, the landfill space savings would only be approximately 890,000 m^3 (assuming that 625,171 tonnes of Phase 2 materials would avoid landfilling). The net tonnes projected to be recovered in 2022 will equal 46 % of Metro Vancouver's waste disposal rate in 2011 in tonnes. This estimate assumed that C&D waste would be disposed to a sanitary landfill together with other municipal solid waste. If the C&D waste quantities were excluded, the quantity of remaining Phase 2 materials would equate to 23% of Metro Vancouver's waste disposal rate in 2011.

The estimated landfill space savings should be regarded as indicative since there is much uncertainly in the actual density of when different types of materials are landfilled.

Environmental Impacts (Pending EPR Materials in 2022):

- Landfill space savings of 0.9 million - 2.7 million m^3 depending on landfilled densities achieved.
- Net GHG reductions of 935,000 tonnes eCO_2 (like removing 208,000 cars from the roads,
- Net energy savings of 10 million GJ (1.6 million barrels of oil)

In 2022, the EPR programs for Pending EPR materials are expected to reduce GHG emissions by almost 935,000 tonnes eCO_2. The emissions equate to removing over 208,000 cars from the roads for a year. Almost 40 % of the total emission savings is likely to come from the recovery of aluminum as part of the PPP collection (e.g. from foil, aerosols, pet food). The estimated GHG reduction should only be considered indicative since many of the emission factors were only available from the US or not at all.

Energy savings resulting from the Pending EPR materials were estimated to be over 10 million GJ in 2022 (1.6 million barrels of crude oil), however many of the program materials still lack published energy savings data. For example 95% of the projected recovered C&D quantities could be not included in the calculation due to non-existent data.

5.3 General Conclusions

Based on an overview of economic and environmental impacts (medium estimates) for each EPR program material in Table 48, we offer the following general comments and conclusions for 2011 EPR Materials and Pending EPR Materials:

5.3.1 2011 EPR Materials

Key highlights of economic and environmental impacts for 2011 EPR Materials are as follows:

- Compared to other 2011 EPR materials, the programs for beverage containers manage the largest quantities of materials and have by far the largest savings in reduced collection and landfilling costs, and avoided landfill space. Less quantifiable from a economic perspective but nevertheless positive impacts include the creation of 933 jobs, reduced GHG emissions equal to removing the equivalent to 25,000 vehicles off the road for a year (112,000 tonnes eCO_2) and saving energy that is equivalent to almost 300,000 barrels of crude oil (1,846,000 GJ). Lastly the refund based programs were estimated to reduce beverage container litter. In summary, there are many substantial benefits resulting from the EPR programs that have not been monetized but that represent additional unquantified economic benefits.
- There are several EPR programs such as used oil, anti-freeze products, e-waste, lamps and lighting equipment, paint, smoke alarms, thermostats and pharmaceutical waste, that recover relatively small

quantities of materials, however bring the significant benefits of keeping hazardous materials out of landfills and the environment. The benefits from greater control over the management of hazardous materials and the minimization of environmental risks associated with improper disposal were presented as qualitative comments for each EPR program material. Although the EPR programs that manage these product categories generally have high per-tonne operating costs and in most cases show relatively small quantitative benefits (e.g. avoided collection and landfilling cost, GHG and energy savings), they often result in many important but unquantified environmental benefits.

- Many of the PROs believed that due to BC's relatively small role in the global market, BC's EPR programs are unlikely to influence producers to more carefully consider DfE principles. This study did not attempt to identify drivers for DfE considerations and, for each EPR program that operated in 2011, provided qualitative comments on if and how DfE principles were considered by producers based on information provided by the PROs.

5.3.2 Pending EPR Materials

Comments and conclusions for economic and environmental impacts of Pending EPR Materials are as follows:

- Pending EPR Materials differ substantially from 2011 EPR Materials, which were chosen initially for EPR programs to keep these materials out of the environment because they were either harmful (hazardous) or unsightly (litter). Thus many 2011 EPR Materials show relatively small volumes, while environmental benefits are substantial. Pending EPR Materials are targeted more for the recovery of resources, therefore volumes of materials are much higher and consequently, GHG savings, energy savings, and landfill space savings are also much higher. Energy, GHG and landfill savings from Pending EPR Materials should be regarded as potential benefits only. More accurate benefits can be defined in the future once program details are developed and potential capture rates and process efficiencies are known.

- Economic and environmental benefits from the EPR program for PPP are estimated to be substantial since approximately half of the PPP generated by residential generators are disposed as garbage today. It is presumed that EPR would drive diversion substantially higher than the likely status quo scenario. The benefits would be larger if PPP from the ICI sector were included.

- Although portions of BC (urban areas mainly) have developed recovery systems for C&D waste, the establishment of an EPR program (or other policy mechanism) for C&D waste is likely to increase recovery over the current estimated recovery rate of 66% and yield other benefits, for example local employment opportunities. To our knowledge there is no EPR program for C&D waste elsewhere in the world.

- There are large amounts of carpets, textiles and furniture waste that are currently disposed in BC each year. However, we found that little data exist for BC or Canadian generation, recovery or disposal rates. When determining recovery rates for textiles and furniture, it will be important to understand existing patterns of reuse and decide if and how these reuse systems should be measured and accounted for.

- The economic and environmental impact results for these Pending EPR Material categories should only be considered as indicative. Many measures were based on US data (which may not be fully applicable to BC) and sometimes data was determined to be unavailable from any identified source.

6. GLOSSARY AND LIST OF ABBREVIATIONS

CCME	Canadian Council of Ministers of Environment
Closed-loop recycling	Refers to the reincorporation of a material back into a product that has a similar use and composition to the product from which it was derived. Examples of closed loop recycling include aluminum cans being manufactured into new aluminum cans and glass bottles being manufactured into new glass bottles.
Collector	Entity providing services for collection of the EPR program materials.
Depot	Facility where residents can drop off EPR program materials.
Design for Environment (DfE)	Minimizing the impact of products on the environment in the product design phase.
EOL	End-of-Life
E-waste	Electronic waste (or e-waste) includes computers, entertainment electronics, mobile phones and other items that have reached the end of their useful life.
FTE	Full time equivalent
ICI	Industrial, commercial and institutional.
Life Cycle Assessment (LCA)	Method for the environmental assessment of products and services, covering their life cycle from raw material extraction to waste treatment
Materials recovery facility (MRF)	A facility that processes residentially collected mixed recyclables into new products available for market.
Municipal Solid Waste (MSW)	MSW (municipal solid waste) is any material for which the generator has no further use, and which is managed at waste disposal, recycling or composting sites. Includes waste from residential sources which is managed both on and off-site, and waste from ICI sources which is managed off-site.
ND	No Data available
Open-loop recycling	Refers to instances where a material (e.g. glass), is collected by a recycling program in a location where it is not viable to use traditional closed-loop markets that convert the recovered material back into new material of a similar nature. Instead, beneficial uses for the material that displace virgin resources and reduce the demand for extracting natural resources are found.

Primary Processor	First receiver of the collected EPR program material that markets at least some types of processed EPR program materials. Primary processors often engage downstream processors that can more efficiently or effectively sort, process and market some types of collected materials.
Processing	Manual or mechanical alteration of the collected EPR program material for the purpose of resource recovery.
Producer Responsibility Organization (PRO)	A "producer responsibility organization", usually a not-for-profit organization or an industry association, is the entity designated by a producer or producers to act on their behalf to administer an extended producer responsibility or product stewardship program. In Canada, a PRO may also be referred to as a "stewardship organization," an "industry funding organization" or a "delegated administrative organization".
Recovery rate	The amount of product collected divided by the amount of product generated, expressed as a percentage.
Waste-to-energy (WTE)	Conversion of solid waste into energy or marketable fuel.

7. REFERENCES – STEWARSHIP PROGRAMS IN BC

EPR Material Category	Reference Sources
Used oil, antifreeze, oil filters and oil and antifreeze containers	• BCUOMA Stewardship Plan 2011 • BCUOMA Annual Report 2011 • Personal communication with Ron Driedger, BCUOMA, November 2012.
Batteries	• CBA's Annual Report 2011 • CBA Stewardship Plan 2011 • Personal communication with Colin McKean, CBA, November 2012. • Interstate Battery System of Canada, Stewardship Plan 2011 • Call2Recycle 2011 Annual report • Stewardship Plan 2010 for batteries mobile phones • Personal communication with Kristen Romilly, Call2Recycle, January 2013.
Beverage containers	• Encorp Annual Report 2011 • Encorp Pacific Beverage Container Stewardship Plan 2006 • Personal communication with Bill Chan, Encorp, November 2012 • Brewers Distributor Limited Annual Report 2011 • BDL Product Stewardship Plan 2009-2014 • Personal communication with Brian Zeiler-Kligman, BDL, November 2012.
Electronics	• CWTA's Recycle My Cell Annual Report 2011 • CWTA's Stewardship Plan 2009 • Personal communication with Ursula Grant, CWTA, November 2012. • RBRC's Call2Recycle Stewardship Plan 2010 • Personal communication with Kristen Romilly, Call2Recycle, January 2013. • EPRA's Stewardship Plan 2012 • 2011 ESABC Annual Report • Personal communication with Craig Wisehart, EPRA, November 2012 • CESA BC Product Stewardship Plan - Part 1: Phase 4 Products (Oct 2011) • CESA's Unplugged Small Appliance Recycling Program Annual Report 2011 • Personal communication with Mark Kurschner and Sarah Willie, Product Care, and Darrell Clarke, CESA, December 2012.
Lamps	• BC Fluorescent Light Recycling Program Annual Report 2011 • Product Care - Statement of Revenues and Expenses 2011

EPR Material Category	Reference Sources
	• Stewardship Plan 2012 • Personal communication with Mark Kurschner and Sarah Willie, Product Care, December 2012.
Paint and HHW	• BC Paint and Household Hazardous Waste (HHW) Product Stewardship Plan 2011 • BC Paint and Household Hazardous Waste 2011 Program Year Annual Report • Product Care - Statement of Revenues and Expenses 2011 • Personal communication with Mark Kurschner and Sarah Willie, Product Care, December 2012.
Smoke alarms	• BC Smoke and Carbon Monoxide Alarm Stewardship Plan 2011 for CHHMA • BC Smoke and CO Alarm Recycling Program Annual Report 2011 • Product Care - Statement of Revenues and Expenses 2011 • Personal communication with Mark Kurschner and Sarah Willie, Product Care, December 2012.
Thermostats	• Switch the 'Stat Thermostat Recovery Program - Annual Report 2011 • BC Stewardship Plan for Thermostats, 2010 • Personal communication with April Gucciardo, HRAI, December 2012.
Tires	• TSBC-Annual Report 2011 • Tire Stewardship Plan, 2012 • Personal communication with Mike Hennessey, TSBC, November 2012.
Pharmaceuticals	• Post-consumer Pharmaceutical Stewardship Association Stewardship Plan 2006 • Pharmaceutical Annual Report 2011.

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APPENDIX A:
Recovered Quantities of Materials as Reported by PROs

Table A-1: Recovered Quantities of Materials as Reported by PROs

PRO	Input Parameter	Functional Unit	Input Data	Source Comment
BCUOMA	Numbers of units collected	#	5,390,000	Oil filters collected as per BCUOMA Annual Report 2011
BCUOMA	HDPE	Tonnes	2,044	Based on oil containers and antifreeze containers (6 months data extrapolated to a full year, as per BCUOMA Annual Report 2011)
BCUOMA	Steel	Tonnes	3,030	Calculated tonnes of steel for number of filters collected as per BCUOMA Annual Report 2011 based on the weight of steel per filter
BCUOMA	Hazardous Waste	Tonnes	1,978	Based on antifreeze quantities recorded for 6 months of 2011 as per BCUOMA Annual Report 2011 extrapolated to 12 months.
BCUOMA	Lubricating Oil	Litres	47,880,000	Litres collected as per BCUOMA Annual Report 2011
CBA	Other Plastic	Tonnes	1,900	As reported in CBA Annual Report 2011
CBA	Lead	Tonnes	7,500	As reported in CBA Annual Report 2011
CBA	Hazardous Waste	Tonnes	3,100	Litres as sulphuric acid (electrolyte) as reported in CBA Annual Report 2011
IBSC	LABs	Tonnes	3,480	As reported in CBA Annual Report 2011
IBSC	Other Plastic	Tonne	522	IBSC did not provide break down into component material. Assumed 15% of battery weight is plastic.
IBSC	Lead	Tonnes	2,088	IBSC did not provide break down into component material. Assumed 15% of battery weight is plastic.
IBSC	Hazardous Waste	Tonnes	870	IBSC did not provide break down into component material. Assumed 15% of battery weight is plastic.
RBRC	Batteries	Tonnes	356	In the AR 2011: RBRC collected 356,063 kilograms of batteries in BC. This comprises both single use and rechargeable batteries.
Encorp	Glass	Tonnes	70,694	Sum of tonnes of glass reported in Encorp Annual Report 2011
Encorp	PET	Tonnes	10,555	Sum of tonnes of plastic (PET makes up majority) as reported in Encorp Annual Report 2011
Encorp	Other Plastic	Tonnes	301	Sum of tonnes of other Plastic (Laminate Pouches and Plastic Bag-In Box) as reported in Encorp Annual Report 2011
Encorp	Aluminum	Tonnes	5,096	Sum of tonnes of Cans as reported in Encorp Annual Report 2011
Encorp	Steel	Tonnes	189	Sum of tonnes of other Steel (Bi-metal containers - two sizes) as reported in Encorp Annual Report 2011
Encorp	Polycoat	Tonnes	1,953	Sum of tonnes of Polycoat (Drink boxes and Gable

PRO	Input Parameter	Functional Unit	Input Data	Source Comment
				Top containers) as reported in Encorp Annual Report 2011
BDL	Glass	Tonnes	31,944	As reported in BDL Annual Report 2011
BDL	Aluminum	Tonnes	10,185	As reported in BDL Annual Report 2011 (42% from kegs)
CWTA	Numbers of units collected	#	107,506	Number of cell phone devices collected by Recycle My Cell program in BC as per CWTA Annual Report 2011. These excluded Call 2Recycle quantities.
CWTA	Electronics	Tonnes	22	When we convert units to weight we assumed 0.2kg/device as per advice from CWTA Dec 2012
Call2Recycle	Numbers of units collected	#	29,877	As per CWTA Annual Report 2011. It specified that data for Call2Recycle supplied by the Rechargeable Battery Recycling Corporation of Canada.
Call2Recycle	Electronics	Tonnes	6	When we convert units to weight we assumed 0.2kg/device as per advice from CWTA Dec 2012
EPRA	Electronics	Tonnes	21,255	Electronic waste collected through Electronic Stewardship Association BC in 2011 as per ESA BC Annual Report 2011
CESA	Electronics	Tonnes	2,421	Total Weight collected October to December 2011 (the first three months of the program) as per CESA Unplugged Small Appliance Recycling Program, Annual Report 2011. This only includes Phase 4 Products: Portable And Floor Care Appliances (Small Appliances). These were extrapolated to reflect a 12 months period
CESA	Glass	Tonnes	48	2% of the total of weight collected was glass (based on sampling by one program processor) as per CESA Unplugged Small Appliance Recycling Program, Annual Report 2011.
CESA	Other Plastic	Tonnes	363	15 % of the total of weight collected was plastics (based on sampling by one program processor) as per CESA Unplugged Small Appliance Recycling Program, Annual Report 2011.
CESA	Aluminium	Tonnes	121	5% of the total of weight collected was aluminum (based on sampling by one program processor) as per CESA Unplugged Small Appliance Recycling Program, Annual Report 2011.
CESA	Steel	Tonnes	1,634	67.5 % of the total of weight collected was steel (based on sampling by one program processor) as per CESA Unplugged Small Appliance Recycling Program, Annual Report 2011.
CESA	Copper	Tonnes	73	3% of the total of weight collected was copper (based on sampling by one program processor) as per CESA Unplugged Small Appliance Recycling Program, Annual Report 2011.

PRO	Input Parameter	Functional Unit	Input Data	Source Comment
CESA	Batteries	Tonnes	24	1% of the total of weight collected was batteries (based on sampling by one program processor) as per CESA Unplugged Small Appliance Recycling Program, Annual Report 2011.
Lamps (Product Care)	Glass	Tonne	84	as per LightRecycle Annual Report 2011
Lamps	Aluminium	Tonnes	1	as per LightRecycle Annual Report 2011. Assuming all of the metal was aluminum since this makes up the majority.
Lamps	Phosphor Powder	Tonnes	1	Material Quantities recovered January-December 2011 as per LightRecycle Annual Report 2011.
Paint &HHW (Product Care	Numbers of units collected	#	2,955,245	as Residual Recovery Volume in Litres in total in 2011 (paint (non-aerosol and aerosol), flammable liquids and pesticides, as per BC 2011 Annual Report.
Paint &HHW	PET	Tonnes	182	as tonnes of PE plastics collected in paint and HHW containers in 2011
Paint &HHW	Other Plastic	Kilograms	600	as tonnes of PVC plastic collected in paint and HHW containers in 2011
Paint &HHW	Steel	Tonnes	930	as tonnes of steel collected in paint and HHW containers in 2011
Paint &HHW	Hazardous Waste	Tonnes	3,865	as Residual Recovery Volume in Litres (2,955,245) in total in 2011, as per 2011 Annual Report. This has been converted to tonnes.
Smoke Alarms (Product Care)	Numbers of units collected	#	14,055	Product Care: Between Oct 1, 2011 and Aug 31, 2012 we collected 14,055 alarms. This was extrapolated in the study to represent a full calendar year.
HRAI - Thermostats	Numbers of units collected	#	1,876	as per Annual Report BC 2011. No weight per thermostat was provided.
HRAI	HDPE	Kilograms	30	In 2011, the breakdown of materials recovered and recycled from the province of British Columbia included 31.25 kilograms of plastics as per Annual Report BC 2011,
HRAI	Mercury or other metals	Kilograms	30	In 2011, the breakdown of materials recovered and recycled from the province of British Columbia included 25.77 kilograms of metals as per Annual Report BC 2011. This is not specific to mercury.
TSBC	Numbers of units collected	#	2,676,000	Number of tires collected as per TSBC Annual Report 2011.
TSBC	Tires	Tonnes	37,000	Total tonnes of tires collected as per TSBC Annual Report 2011.
TSBC	Rubber	Tonnes	5,171	as per TSBC Annual Report 2011.

APPENDIX B:
General Assumptions

Table B-1: Data Used in the Study with References Sources

Parameter	Functional Unit	Source[2]	Reference
BC population (2011)	Population #	4,400,057	BC Stats as of May 2011 census
Currency conversion US dollars to CAN Dollars	$CAN per $US	1.009	Average currency conversion factor from www.xe.com for Jan 1, 2011 and Dec 31, 2011
Currency conversion EUR to CAN Dollars	$CAN per EUR	1.327	
Total Waste Disposal BC	tonnes	2,900,000	From BC Ministry of Environment's Solid Waste Generation in BC 2010-2025 Forecast.
BC projected population 2022	Population #	5,190,800	Estimates - Statistics Canada, Projections - BC Stats, June 2012
Consumer Price Index (CPI) 2007		111.5	Statistics Canada.
CPI 2008		114.1	
CPI 2009		114.1	
CPI 2010		116.5	
CPI 2011		119.9	
Energy content in one barrel of crude oil	GJ	6.193	Statistics Canada

[2] Low, medium and high estimates were not made for these parameters.

Table B-2: Low, Medium and High Estimates of Key Parameters Used in the Study with References Sources

Parameter	Functional Unit	Low Estimate	Source	Medium Estimate	Source	High Estimate	Source
Job production estimate for every tonne of MSW collected destined for landfill	# per tonne MSW	0.0006	Sound Resource Management (SRM). 2011	0.0010	Calculated	0.0013	SRM, 2011
Job production estimate for every tonne of waste landfilled	# per tonne MSW	0.0001	SRM, 2011	0.0003	Container Recycling Institute 2011	0.0007	AECOM, 2009b
Garbage collection costs	$ per tonne	$91	Innes Hood Consulting, 2013. Municipal collection cost	$115.5	Calculated	$141	Innes Hood Consulting, 2013. ICI, C&D collection cost
Landfill siting costs	$ per tonne	$1.05	RDKS, 2012	$1.10	RDKS, 2012	$1.15	RDKS, 2012
Landfill development costs	$ per tonne	$20	RDKS, 2012	$21.6	RDKS, 2012	$23.5	RDKS, 2012
Landfill management costs	$ per tonne	$27.50	RDKS, 2012	$42	NORD, 2012	$129	NORD, 2012
Landfill closure costs	$ per tonne	$2.50	RDKS, 2012	$4.20	RDKS, 2012	$5.90	RDKS, 2012
Compacted Garbage density	tonnes/m^3	0.35	Wiley & Sons, 2011	0.7	Wiley & Sons, 2011	1	Wiley & Sons, 2011

APPENDIX C:
Material Specific Estimates (Low, Medium and High) of Number of Indirect Jobs Created per Tonne Material Recycled

Table C-1: Material Specific Estimates (Low, Medium and High) of Number of Indirect Jobs Created per Tonne Material Recycled (# jobs per tonne)

Parameter	Low Estimate	Source	Medium Estimate	Source	High Estimate	Source
Glass	0.005	Economic Benefits of Recycling in Ontario (AECOM, 2009b)	0.012	More Jobs, Less Pollution	0.013	More Jobs, Less Pollution
PET	0.005	Economic Benefits of Recycling in Ontario	0.010	Calculated	0.015	More Jobs, Less Pollution
HDPE	0.005	Economic Benefits of Recycling in Ontario	0.010	Calculated	0.015	More Jobs, Less Pollution
Other Plastic	0.005	Economic Benefits of Recycling in Ontario	0.010	Calculated	0.015	More Jobs, Less Pollution
Aluminum	0.005	Economic Benefits of Recycling in Ontario	0.023	More Jobs, Less Pollution	0.026	More Jobs, Less Pollution
Steel	0.005	Economic Benefits of Recycling in Ontario	0.007	Calculated	0.009	More Jobs, Less Pollution
Polycoat	0.005	Economic Benefits of Recycling in Ontario	0.010	Calculated	0.015	More Jobs, Less Pollution
Cardboard	0.005	Economic Benefits of Recycling in Ontario	0.007	Calculated	0.009	More Jobs, Less Pollution
Lead	0.023	More Jobs, Less Pollution	0.023	More Jobs, Less Pollution	0.023	More Jobs, Less Pollution
Rubber (incl tires)	0.014	More Jobs, Less Pollution	0.014	More Jobs, Less Pollution	0.014	More Jobs, Less Pollution
Textiles	0.007	More Jobs, Less Pollution	0.007	More Jobs, Less Pollution	0.007	More Jobs, Less Pollution
Wood	0.007	More Jobs, Less Pollution	0.007	More Jobs, Less Pollution	0.007	More Jobs, Less Pollution
Hazardous Waste	0.009	Economic Benefits of Recycling in Ontario	0.009	Economic Benefits of Recycling in Ontario	0.009	Economic Benefits of Recycling in Ontario
Electronics	0.061	Economic Benefits of Recycling in Ontario	0.061	Economic Benefits of Recycling in Ontario	0.061	Economic Benefits of Recycling in Ontario

Parameter	Low Estimate	Source	Medium Estimate	Source	High Estimate	Source
Steel (Oil filters)	0.005	Economic Benefits of Recycling in Ontario	0.005	Economic Benefits of Recycling in Ontario	0.005	Economic Benefits of Recycling in Ontario
Tin	0.005	Economic Benefits of Recycling in Ontario	0.023	More Jobs, Less Pollution	0.026	More Jobs, Less Pollution
Copper	0.023	More Jobs, Less Pollution	0.023	More Jobs, Less Pollution	0.023	More Jobs, Less Pollution
Newsprint	0.005	Economic Benefits of Recycling in Ontario	0.005	Economic Benefits of Recycling in Ontario	0.005	Economic Benefits of Recycling in Ontario
Fine Paper	0.005	Economic Benefits of Recycling in Ontario	0.005	Economic Benefits of Recycling in Ontario	0.005	Economic Benefits of Recycling in Ontario
Other Paper	0.005	Economic Benefits of Recycling in Ontario	0.005	Economic Benefits of Recycling in Ontario	0.005	Economic Benefits of Recycling in Ontario
Lubricating Oil	0.009	Economic Benefits of Recycling in Ontario	0.009	Economic Benefits of Recycling in Ontario	0.009	Economic Benefits of Recycling in Ontario
Batteries	ND	Economic Benefits of Recycling in Ontario	ND		ND	
Plastics (Used Oil and Anti-Freeze)	0.005	Economic Benefits of Recycling in Ontario	0.010	Calculated	0.015	More Jobs, Less Pollution
Carpet	0.007	More Jobs, Less Pollution	0.009	Calculated from labour information provided in California Department of Resources Recycling and Recovery May 2012	0.012	More Jobs, Less Pollution
Asphalt	0.002	More Jobs, Less Pollution	0.002	Calculated	0.003	More Jobs, Less Pollution
Concrete	0.002	More Jobs, Less Pollution	0.003	Calculated	0.003	More Jobs, Less Pollution
Misc C&D waste	0.002	More Jobs, Less Pollution	0.002	More Jobs, Less Pollution	0.002	More Jobs, Less Pollution

APPENDIX D:
Material Specific Estimates (Low, Medium and High) of Market Value of Recovered Material

Table D-1: Material Specific Estimates (Low, Medium and High) of Market Value of Recovered Material ($/tonne)[3]

Parameter	Low Estimate	Source	Medium Estimate	Source	High Estimate	Source
Glass	$0		$13	EBA and Cascadia, 2012	$35	EBA and Cascadia, 2012
PET	$200		$300		$400	
HDPE	$200		$480	NORD, personal communication	$600	
Other Plastic	$25		$75		$400	
Aluminum	$1,500		$1,750		$2,000	
Steel	$130		$165		$200	
Polycoat	$510	Encorp, personal communication.	$510	Encorp, personal communication	$510	Encorp, personal communication.
Cardboard	$110		$148		$203	
Lead	$1,250	CBA, personal communication.	$1,250	CBA, personal communication.	$2,100	CBA, personal communication.
Rubber (incl tires)	$252	TSBC, personal communication	$302	TSBC, personal communication	$352	TSBC, personal communication
Textiles	ND		ND		ND	
Wood	ND		ND		ND	
Hazardous Waste	ND		ND		ND	
Electronics	ND		ND		ND	
Steel (Oil filters)	$130		$130		$130	
Tin	ND		ND		ND	
Copper	ND		ND		ND	
Newsprint	$100		$141	NORD, personal communication	$199	NORD, personal communication
Fine Paper	ND		ND	NORD, personal communication	ND	
Other Paper	$60		$90	NORD, personal communication	$120	
Lubricating Oil	ND		ND		ND	
Batteries	ND		ND		ND	
Plastics (Used Oil and Anti-Freeze)	$200		$480		$600	
Carpet	$227	CCRE, personal communication.	$567	CCRE, personal communication	$699	EBA and Cascadia, 2012
Asphalt	ND		ND		ND	
Concrete	$72	Assuming 100% cement.	$103	Assuming 100% cement.	$134	Assuming 100% cement.
Misc C&D waste	ND		ND		ND	

[3] Unless stated, the figures were taken from MMBC's Current System for Managing Residential Packaging and Printed Paper in British Columbia. Multi-Material British Columbia. 2012.

APPENDIX E:
Material Specific Estimates (Low, Medium and High) of Bulk Density

Table E-1: Material Specific Estimates (Low, Medium and High) of Bulk Density (tonne/m^3)[4]

Parameter	Low Estimate	Source	Medium Estimate	Source	High Estimate	Source
Glass	0.59		0.64		1.17	
PET	0.04		0.24		0.31	
HDPE	0.04		0.19		0.24	
Other Plastic	0.42		0.42		0.42	
Aluminum	0.21		0.23		0.26	
Steel	0.24		0.26		0.29	
Polycoat	0.15	WDO, 2001	0.15	WDO, 2001	0.48	WDO, 2001
Cardboard	0.31		0.42		0.50	
Lead	7.82	Engineering tool box website	7.82		7.82	
Rubber (incl tires)	0.36	US EPA, 2010 -Scrap Tires: Handbook on Recycling Applications and Management	0.71	US EPA, 2010	1.07	US EPA, 2010
Textiles	0.29		0.29		0.29	
Wood	0.15		0.30		0.38	
Hazardous Waste	1.00		1.00		1.00	
Electronics	0.15	Anielski Management Inc., 2007	0.15	Anielski Management Inc., 2007	0.15	Anielski Management Inc., 2007
Steel (Oil filters)	0.24		0.26		0.29	
Tin	0.10		0.10		0.10	
Copper						
Newsprint	0.43		0.51		0.60	
Fine Paper	0.45		0.80		1.15	
Other Paper	0.19		0.45		0.55	
Lubricating Oil	1.00		1.00		1.00	
Batteries	ND		ND		ND	
Plastics (Used Oil and Anti-Freeze)	0.04		0.19		0.24	
Carpet	0.05	Tellus Institute, Boston Massachusetts	0.05		0.05	
Asphalt	0.25	Tellus Institute, Boston Massachusetts	0.38		0.50	
Concrete	0.44	Tellus Institute, Boston Massachusetts	0.44		0.44	
Misc C&D waste	0.28	Tellus Institute, Boston Massachusetts	0.28		0.28	

[4] Unless stated, the density figures were taken from CSR 2003, Residential GAP – Manual on Generally Accepted Principles (GAP) for Calculating Municipal Solid Waste System Flow.

APPENDIX F:
Material Specific Estimates (Low, Medium and High) of GHG emissions from Recycling Compared to Landfilling

Table F-1: Material Specific Estimates (Low, Medium and High) of GHG emissions from Recycling Compared to Landfilling (tonnes eCO_2/tonne)[5]

Parameter	Low Estimate	Source	Medium Estimate	Source	High Estimate	Source
Glass	-0.10		-0.10		-0.10	
PET	-3.63		-3.63		-3.63	
HDPE	-2.27		-2.27		-2.27	
Other Plastic	-1.80		-1.80		-1.80	
Aluminum	-6.49		-6.49		-6.49	
Steel	-1.18		-1.18		-1.18	
Polycoat	ND		ND		ND	
Cardboard	-3.26		-3.26		-3.26	
Lead	ND		ND		ND	
Rubber (incl tires)	-0.22	Pembina Institute, 2007	-0.22	Pembina Institute, 2007	-0.22	Pembina Institute, 2007
Textiles	-1.59		-1.59		-1.59	
Wood	-1.80	US EPA WARM, 2012, Wood -dimensional lumber	-1.80	US EPA WARM, 2012, Wood -dimensional lumber and MDF	-1.80	US EPA WARM, 2012, Wood -MDF,
Hazardous Waste	ND		ND		ND	
Electronics	-0.23	ICF 2005, TVs	-0.65	ICF 2005, microwaves	-1.60	ICF 2005, Computers
Steel (Oil filters)	-1.18		-1.56		-1.94	
Tin	ND		ND		ND	
Copper	-4.10		-4.10		-4.10	
Newsprint	-2.75		-2.75		-2.75	
Fine Paper	-3.20		-3.20		-3.20	
Other Paper	-3.27		-3.27		-3.27	
Lubricating Oil	-2.55	CRA, 2009	-2.55	CRA, 2009	-2.55	CRA, 2009
Batteries	-0.90		-0.90		-0.90	
Plastics (Used Oil and Anti-Freeze)	-2.11	CRA, 2009, for plastics from oil containers.	-2.20		-2.29	
Carpet	-2.60	CalRecycle, 2012	-3.28	Calculated	-3.96	US EPA, WARM 2012
Asphalt	-0.09	US EPA WARM, 2012, Asphalt, concrete	-0.09	US EPA WARM, 2012, Asphalt, concrete	-0.09	US EPA WARM, 2012, Asphalt, concrete
Concrete	-0.01	US EPA WARM, 2012, Asphalt, concrete	-0.01	US EPA WARM, 2012, Asphalt, concrete	-0.01	US EPA WARM, 2012, Concrete
Misc C&D waste	ND		ND		ND	

[5] Unless stated, the GHG figures were taken from ICF Consulting - Determination of the Impact of Waste Management Activities on Greenhouse Gas Emissions: 2005 Update.

APPENDIX G:
Material Specific Estimates (Low, Medium and High) of Energy Impacts from Recycling Compared to Landfilling

Table G-1: Material Specific Estimates (Low, Medium and High) of Energy Impacts from Recycling compared to landfilling (GJ/tonne)[6]

Parameter	Low Estimate	Source	Medium Estimate	Source	High Estimate	Source
Glass	-1.54		-1.54		-1.54	
PET	-85.16		-85.16		-85.16	
HDPE	-64.27		-64.27		-64.27	
Other Plastic	-52.09		-52.09		-52.09	
Aluminum	-87.22		-87.22		-87.22	
Steel	-12.47		-12.47		-12.47	
Polycoat	ND		ND		ND	
Cardboard	-8.56		-8.56		-8.56	
Lead	ND		ND		ND	
Rubber (incl tires)	-22.00	Pembina Institute, 2007	-22	Pembina Institute, 2007	-22	Pembina Institute, 2007
Textiles	ND		ND		ND	
Wood	ND		ND		ND	
Hazardous Waste	ND		ND		ND	
Electronics	-1.22	ICF 2005, TVs	-13.73	ICF 2005, microwaves	-20.11	ICF 2005, Computers
Steel (Oil filters)	-12.47		-12.47		-12.47	
Tin	ND		ND		ND	
Copper	-71.56		-71.56		-71.56	
Newsprint	-6.33		-6.33		-6.33	
Fine Paper	-15.87		-15.87		-15.87	
Other Paper	-9.49		-9.49		-9.49	
Lubricating Oil	-20.11		-20.11		-20.11	
Batteries	ND		ND		ND	
Plastics (Used Oil and Anti-Freeze)	-64.27		-64.27		-64.27	
Carpet	ND		ND		ND	
Asphalt	ND		ND		ND	
Concrete	ND		ND		ND	
Misc C&D waste	ND		ND		ND	

[6] Unless stated, the figures were taken from ICF Consulting - Determination of the Impact of Waste Management Activities on Greenhouse Gas Emissions: 2005 Update.