Evaluation of Recycling Pilot Projects

Final Report

March 2, 2010

Evaluation of Recycling Pilot Projects

Department of Environment, Government of Nunavut

10-2973

Gary Strong - Project Manager

Submitted by

Dillon Consulting Limited

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(In reply, please refer to)
Our File: 10-2973

March 2, 2010

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Attention: Jamessee Moulton, Solid Waste Management Specialist

Re: Evaluation of Recycling Pilot Projects in Nunavut

Dear Mr. Moulton:

Please find enclosed with this letter the Final report discussing the findings of Dillon Consulting Limited's (Dillon) evaluation of the pilot recycling projects initiated in Iqaluit, Rankin Inlet and Kugluktuk. As part of the report, Dillon has also included a general overview of recycling in Nunavut.

We have revised the final report to reflect your comments and questions you had on the previously submitted draft and final reports. Please feel free to contact us by phone at 920-4555 or by email at gstrong@dillon.ca should you have any further questions.

Yours truly,

Dillon Consulting Limited

Gary Strong, P.Eng.
Project Manager

Encl.

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Dillon Consulting Limited

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EXECUTIVE SUMMARY

Dillon Consulting Limited was retained by the Government of Nunavut (GN), Department of the Environment (DoE) to review a pilot beverage container recycling program implemented by the GN for the past two years. The purpose of the review is to determine the environmental and cost benefits for Nunavut if such a program is implemented on a larger scale.

Review of the program began with collection of information on the study including interviews of involved personnel as well as feasibility and framework reports related to the pilot study. Further reports relating to production of aluminum and plastic beverage containers (referred to as beverage containers throughout) and greenhouse gas emissions from transportation of recyclables were reviewed. Finally, studies of two other waste management projects that have been implemented in other Nunavut communities were examined. Estimated costs for each program were also completed.

In conclusion, our review determined the following items:

- Based on calculations and information obtained from the US EPA (2006), Franklin Associates (2004) and David Allaway, Oregon Department of Environmental Quality (personal communication February 9, 2010), carbon emissions created from transportation and recycling of beverage containers are much less than emissions created when primary materials are used to produce new beverage containers. Therefore globally, it is more environmentally sound to recycle the beverage containers.
- Due to the inert nature of the beverage containers, there are negligible environmental impacts created from landfilling the containers. As well, removing these containers from the landfill results in negligible cost and operational benefits for maintenance of the landfill.
- Beverage containers account for approximately 1% of the total volume of landfill waste in Nunavut. Based on a 20 year life cycle period for a community landfill, removal of beverage containers would increase the life span of the landfills by 2 to 3 months.
- The cost to establish and implement a Nunavut-wide beverage container recycling program is estimated to have a capital cost of $18.2 million to construct the depots and obtain the necessary equipment for each community, and an annual operating cost of $773,000/year.
- In order for the program to generate revenue equal to the annual operating costs, a deposit of $0.18/beverage container is required.
- The cost benefit ratio is very sensitive to the uptake of the population to recycling. (eg. The more cans that are recycled, the less revenue that the program will generate.)
- Based on the pilot study results, public support has been very encouraging. Therefore it is reasonable to assume that the implementation of a Nunavut-wide recycling program would be supported at the community level.
- The most applicable model for a beverage recycling program in Nunavut is to incorporate the program into the municipal waste management program already established in each community. The estimated revenues generated from a beverage recycling program in Nunavut are not enough to entice private contractors to become involved.
- There are two other waste management programs that have shown some success on a community level; removal of hazardous wastes from community landfills and removal of scrap metal from community landfills. These programs have a greater local environmental benefit than the proposed beverage recycling program.

1 INTRODUCTION

In 2006, the Government of Nunavut requested that the Department of Environment (DoE) investigate the feasibility of developing a Nunavut-wide recycling program. In response to this request DoE launched Pilot Recycling Projects in three different communities including Iqaluit, Rankin Inlet, and Kugluktuk.

Prior to launching the pilot programs, DoE considered the possibility of establishing the Nunavut recycling program based on the Northwest Territories recycling model which includes establishing a deposit-refund system and identifying private contractors to operate the recycling depots. However, DoE is concerned that the high cost of transporting recycled materials from Nunavut to southern locations and the limited revenue generated from recycled beverage containers would deter private contractors from taking on such a program in Nunavut. An alternative approach could include incorporating the local recycling program into the existing solid waste management infrastructure within each community. Transportation costs for the program would remain high, however the community would have access to staff to run the program and revenue generated from recycled beverage containers would be retained by the community.

The pilot projects were undertaken to determine the feasibility of operating a beverage recycling program in Nunavut. The pilot projects attempted to determine all aspects that would be involved in such a program including public support, program difficulties, costs and equipment needs. Since 1993, a beverage recycling program for alcoholic beverage containers has been in place in Iqaluit. The program is being operated locally by a private contractor who has established this program under the Liquor Control Commission deposit-refund program. For the pilot project, DoE retained the services of this contractor to operate the pilot program in Iqaluit.

The pilot projects in both Rankin Inlet and Kugluktuk are being operated by the municipalities. Unfortunately, the pilot project had to be suspended in Kugluktuk during the winter months as there was no available heated space for them to operate the program.

2 BACKGROUND

In the endeavor to determine the feasibility of a Nunavut-wide beverage container recycling program, the consultant reviewed previously conducted studies including the Feasibility Study - Nunavut Beverage Recovery Program that was completed by Nunami Jacques Whitford Limited in 2008; the Program Framework - Nunavut Beverage Container Recovery Program completed by Emery Paquin in 2008; and the Depot Standards – Operations and Service: Nunavut Beverage Container Recovery Program completed by Emery Paquin for the Department of Environment in 2009.

In addition to examining these background documents, the consultant examined the 2007-2009 data describing beverage container return rates from the three Pilot Beverage Container Recycling Project locations including Iqaluit, Kugluktuk, and Rankin Inlet. General cost and revenue estimates for a Nunavut-wide recycling program provided by the Department of Environment (DoE), Government of Nunavut, were also evaluated.

Gathering data for the purpose of this study required conducting interviews with DoE staff and Senior Administrative Officers from the communities spearheading the Pilot Beverage Container Recycling Projects. A representative of Dillon Consulting traveled to Iqaluit to meet with key staff, including;

- **Jamessee Moulton**, *Solid Waste Management Specialist, Department of Environment, GN; and*
- **Brian Hellwig**, *Supervisor of the Pilot Beverage Container Recycling Program in Iqaluit, Nunavut.*

A phone interview was conducted with Paul Waye, Senior Adminsitrative Officer for the Hamlet of Rankin Inlet. Further, a phone interview was solicited from the Senior Administrative Officer of Kugluktuk; however, after repeated requests the consultant did not receive a response from the parties concerned.

The consultant engaged in personal communication with various service providers including Nunavut Eastern Arctic Shipping Incorporated, Northern Transportation Company Limited, and Nunavut Sealink and Supply Incorporated. Furthermore, the consultant also utilized several professional and academic data sources, which are included in the Appendix and References section of the report.

3 ENVIRONMENTAL BENEFITS OF BEVERAGE CONTAINER RECYCLING IN NUNAVUT

There is some debate as to whether recycling beverage containers from Nunavut has environmental benefits or if these benefits are cancelled out due to emissions produced from shipping these containers such long distances (maximum distance for shipping from Grise Fiord to Montreal is approximately 6500km (Estimated using Google Earth Professional, 2010)). In order to determine if any benefits exist, the life-cycle of the product must be examined. The following sections describe the various life-cycle components for both aluminum cans and plastic beverage containers (PET).

3.1 Aluminum

3.1.1 Production from Virgin vs. Recycled Materials

The figure below shows the production process of using primary materials and recycled materials in the production of aluminum.

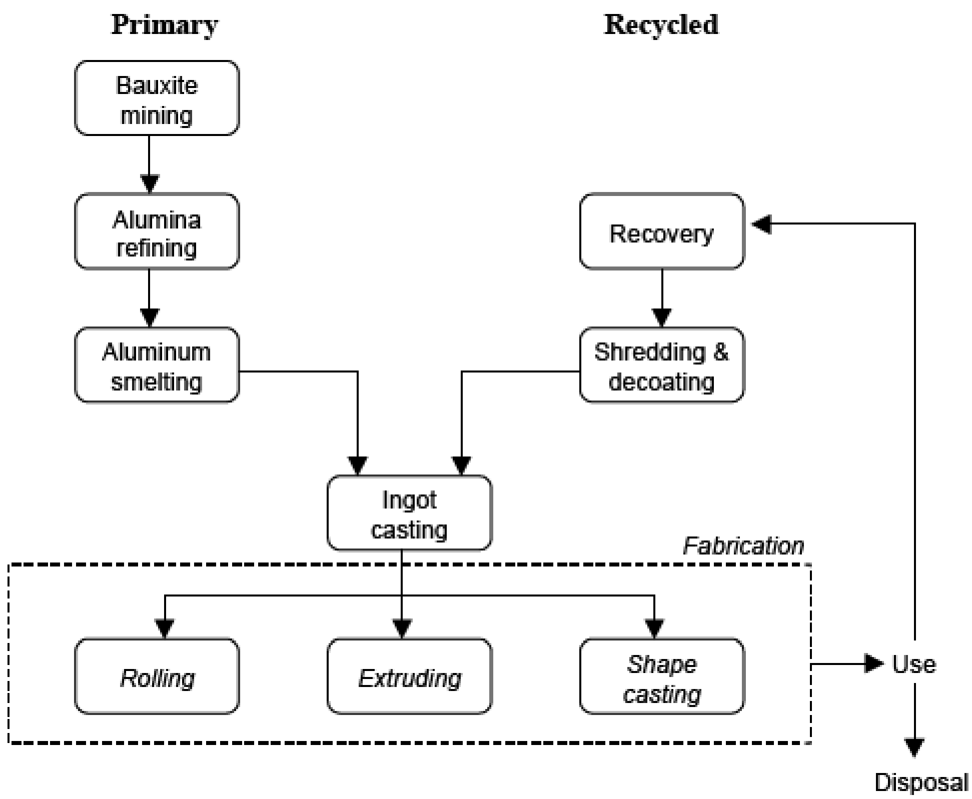

Figure 3-1 - Process Diagram for Production of Aluminum from Primary and Recycled Materials

Source: ICF Consulting (2005). *Determination of the Impact of Waste Management Activities on Greenhouse Gas Emissions: 2005 Update, Final Report*. Contract No. K2216-04-0006. Report can be found at http://www.nrcan-rncan.gc.ca/mms-smm/busi-indu/rad-rad/pdf/icf-finr-eng.pdf.

Bauxite ore is the primary (virgin) material that aluminum is made from. The ore is mined in many countries, however most bauxite ore and its refined product alumina, used in Canadian alumina and aluminum factories is imported (ICF Consulting, 2005). Alumina is converted to aluminum by a process called aluminum smelting. Aluminum smelting uses carbon anodes which can cause the generation of perfluorocarbon (PFC) emissions. These emissions contribute to the overall greenhouse gas emissions produced during production of aluminum from primary materials (ICF Consulting, 2005). Based on calculations completed by the US EPA (2006), the total greenhouse gas emissions produced during production of aluminum from virgin inputs is 4.11 MTCE (metric tons of carbon equivalent)/ton of aluminum. According to the US EPA (2006), this number includes emissions produced from:

- Use of fuel in mining operations, furnaces, etc.;
- Fuel used to create electricity during production of materials;
- Emissions from activities such as oil exploration, coal mining, and natural gas production;
- Conversion of limestone to lime, which is used in the production of aluminum; and
- PFCs emitted from the aluminum smelting process.

The emission number calculated does not include transportation of these materials. The US EPA (2006) has identified a separate emission factor number for the transportation of raw, intermediate and finished materials from the extraction site to the manufacturing facilities. This number has been calculated to be 0.15 MTCE/ton of aluminum (US EPA, 2006).

When aluminum cans are created from recycled aluminum materials, the bauxite mining, alumina refining and primary aluminum smelting steps are unnecessary. Recovered aluminum is shredded and put through a heating process to remove any paint or coatings from the aluminum (ICF Consulting, 2005). The US EPA (2006) estimates that the total greenhouse gas emissions generated from using recycled aluminum is 0.28 MTCE/ton of aluminum produced.

The emission number for use of recycled aluminum in manufacturing also does not include transportation emissions. A separate calculation for transportation emissions has concluded that the total emissions due to transporting recycled materials from the curb to the manufacturer and then to the retailer. Transportation emissions for shipment of finished goods to the consumer have not been included. Total emissions from transportation of recycled materials have been estimated to be 0.02 MTCE/ton of aluminum produced (US EPA, 2006). It should be noted that these emission calculations are based on US averages and therefore the transportation emissions of recycled aluminum is not applicable to Nunavut. Table 3.1 below summarizes the emissions calculated by the US EPA (2006) for the production of aluminum from both virgin and recycled materials.

Table 3.1: US EPA Data for Greenhouse Gas Emissions Produced from Production of Aluminum Using Primary and Recycled Materials

Greenhouse Gas Emissions Per Ton of Aluminum Produced (MTCE/ton of Aluminum)		
	Virgin Materials	Recycled Materials
Process	4.11	0.28
Transportation	0.15	0.02

Source: US EPA (2006), Solid Waste Management and Greenhouse Gases, A Life-Cycle Assessment of Emissions and Sinks - Exhibit 2-3 to 2-6, Pg. 26 - 29

3.1.2 Recycling vs. Landfilling

Once the consumer has finished with the product, the aluminum beverage container can then be recycled or placed into the regular waste stream to be landfilled. The concern with recycling the product is the long transportation distance to ship aluminum from Nunavut to the recycling facility in St. Hubert, QC. Based on studies by the US EPA (2006), Franklin Associates (2004) and calculations by David Allaway, Oregon Department of Environmental Quality (personal communication February 9, 2010) it has been estimated that recyclables must travel a distance of approximately 400,000 miles (approximately 640,000 km) in order for the emissions from transporting recyclables to equal the emissions reductions for those recyclables to displace virgin materials in manufacturing. This calculation is based on shipping recyclables by barge.

Once the recyclables arrive in Montreal, however, the recyclables must travel by truck to the recycling facility in St. Hubert, QC approximately 20 km away. If the same calculation is used to calculate the emissions for transport by truck, the distance that recyclables must travel is 43,000 miles (approximately 69,000 km). Please refer to Appendix A for a detailed explanation of each calculation. Based on these calculations, the long-haul distances do not appear to have an adverse effect on environmental emissions.

When considering the option of landfilling aluminum, direct emissions from aluminum within the landfill are negligible as aluminum is an inert material (ICF Consulting, 2005). The emission considerations would be with the operation of compaction equipment within the landfill. As aluminum volumes tend to be relatively small (approximately less than 1% of the total solid waste volume), emissions produced solely from the compaction of aluminum cans would also be small when compared to the emissions produced from compacting the remainder of the solid waste in the landfill. Therefore, these emissions have a negligible impact on the scale of total environmental emissions.

3.2 Plastic Beverage Bottles (PET)

3.2.1 Production from Virgin vs. Recycled Materials

Plastic beverage bottles are made from plastic packaging known as PET (polyethylene terephthalate). Production of PET using virgin materials involves production of numerous chemicals, polymerization and pelletization. All of these contribute to high energy requirements with energy being derived mainly from natural gas and petroleum products (ICF Consulting, 2005). Preparation of products using recycled PET requires energy for grinding, washing, drying and reforming the plastic into pellets. This requires much less energy than production from virgin materials (6.00 GJ/tonne as opposed to 62.21 GJ/tonne) (ICF Consulting, 2005). However, it is important not to confuse energy with emissions as energy can be produced from a number of sources including solar, hydro, nuclear, wind and fossil fuels. Each of these sources contribute varying amounts of emissions to the atmosphere.

In order to compare production of plastic to the production of aluminum, greenhouse gas emission data produced by the US EPA (2006) will be considered. Similar to the calculation of greenhouse gas emissions for aluminum, the US EPA (2006) indicates that the data includes emissions produced from:

- Use of fuel in mining operations, furnaces, etc.;
- Fuel used to create electricity during production of materials;
- Emissions from activities such as oil exploration, coal mining, and natural gas production; and
- CH_4 emissions from natural gas processing and pipelines.

Transportation emissions have also been calculated separately from production emissions. Please refer to Table 3.2 below for emission data.

Table 3.2: US EPA Data for Greenhouse Gas Emissions from Production of PET using Primary and Recycled Materials

Greenhouse Gas Emissions Per Ton of PET Produced (MTCE/ton of PET)		
	Virgin Materials	Recycled Materials
Process	0.58	0.04
Transportation	NA	0

*NA - Transportation data were included in the process energy estimates and not provided separately

Source: US EPA (2006), Solid Waste Management and Greenhouse Gases, A Life-Cycle Assessment of Emissions and Sinks - Exhibit 2-3 to 2-6, Pg. 26 - 29

As compared to emissions from production of aluminum, production of PET materials produce much less greenhouse gas emissions.

3.2.2 Recycling vs. Landfilling

Similarly for aluminum, the transportation distance required to ship PET recyclables can be computed using the emissions data in Table 3.2. Repeating the calculation from Section 3.1.2, PET recyclables must travel a total distance of 75,500 km by barge and 8,100 km by truck. These distances are much less than those of aluminum due to the relatively low level of emissions generated from the production of PET using virgin materials as opposed to the emissions generated from the production of aluminum using virgin materials.

Landfilling PET plastic is similar to landfilling aluminum in the fact that PET plastic is an inert material and does not produced greenhouse gas emissions from being disposed of in a landfill (ICF Consulting, 2005). Also these materials do not leach, and are not a point source environmental contaminant. Percent volume of these plastic bottles is also quite small (approximately less than 1% of the total volume in the solid waste site). Emissions generated from machinery in the solid waste facility compacting bottles would also be negligible compared to the amount of compaction required by other landfill materials.

3.3 Summary of Environmental Benefits of Recycling Aluminum Cans and PET Plastic

Based on the above discussion:

- Transporting recyclable aluminum and PET plastic beverage containers from Nunavut to Montreal produces less emissions than production of aluminum and PET plastic from virgin materials; and
- Landfilling of aluminum and PET plastic produces negligible environmental impact because both are inert materials.

4 COST OF ESTABLISHING AND MAINTAINING A RECYCLING PROGRAM IN NUNAVUT

4.1 Beverage Container Distribution in Nunavut

In order to evaluate how beverage containers, including types and volume, are distributed across Nunavut this study relied on the base data provided in the Program Framework study for a Nunavut Beverage Container Recovery Program completed by Emery Paquin in 2008. The Program Framework study determined that approximately 12.5 million beverage containers (this excludes alcoholic beverage containers) are imported and consumed in Nunavut each year amounting to an estimated average consumption of 424 beverage containers per person annually. Based on this data, the Program Study determined that approximately 89% of all containers distributed to Nunavut are composed of aluminum containers, 10% are composed of plastic containers, and only 1% is composed of glass bottles.

Table 4.1: Number of Beverage Containers Imported to Nunavut Annually

Type of Container	# of Containers	% of Total Containers
Aluminum	11,164,729	89%
Plastic	1,284,189	10%
Glass	46,015	1%
Total	12,494,933	100%

4.2 Beverage Container Distribution in Nunavut by Community

In order to estimate the distribution of beverage containers in the 25 communities of Nunavut, this study combined the beverage container distribution data provided above with community population data provided by the Nunavut Bureau of Statistics, 2006. The total amount of beverage containers in each category (aluminum, plastic, and glass) was distributed across the communities proportionally to community population. The table below shows the results of this analysis.

Table 4.2: Distribution of Beverage Containers in Nunavut by Community

Communities	Population	Aluminum	Plastic	Glass	Total
Arctic Bay	690	261,602	30,090	1,078	292,770
Cape Dorset	1,236	468,609	53,900	1,931	524,441
Clyde River	820	310,890	35,759	1,281	347,930
Grise Fiord	141	53,458	6,149	220	59,827
Hall Beach	654	247,953	28,520	1,022	277,495
Igloolik	1,538	583,108	67,070	2,403	652,581
Iqaluit	6,184	2,344,563	269,676	9,663	2,623,902
Kimmirut	411	155,824	17,923	642	174,389
Pangnirtung	1,325	502,352	57,782	2,070	562,204
Pond Inlet	1,315	498,561	57,345	2,055	557,961
Qikiqtarjuaq	473	179,330	20,627	739	200,696
Resolute	229	86,822	9,986	358	97,166
Sanikiluaq	744	282,075	32,445	1,163	315,683
Arviat	2,060	781,015	89,834	3,219	874,068
Baker Lake	1,728	655,143	75,356	2,700	733,199
Chesterfield Inlet	332	125,872	14,478	519	140,869
Coral Harbour	769	291,554	33,535	1,202	326,291
Rankin Inlet	2,358	893,997	102,829	3,685	1,000,511
Repulse Bay	748	283,592	32,619	1,169	317,380
Whale Cove	353	133,834	15,394	552	149,780
Cambridge Bay	1,477	559,980	64,410	2,308	626,698
Gjoa Haven	1,064	403,398	46,400	1,663	451,460
Kugaaruk	688	260,844	30,003	1,075	291,922
Kugluktuk	1,302	493,632	56,779	2,034	552,445
Taloyoak	809	306,719	35,279	1,264	343,263
Totals	**29,448**	**11,164,729**	**1,284,189**	**46,015**	**12,494,933**

4.3 Program Components

If the beverage container recycling program is implemented, a depot would be required in all 25 communities in Nunavut. In order to successfully put this program into operation, coordination of designing, managing and implementation will have to be shared among the Department of Environment (Government of Nunavut), Community and Government Services (Government of Nunavut), Nunavut Association of Municipalities and Nunavut Municipal Training Organization. Ideally, the program will be integrated into local municipal waste management systems and accept aluminum cans, plastic bottles and glass bottles.

4.4 Beverage Container Program Delivery

As stated above, the program would be integrated as a component of the current waste management program in each community. A recycling depot would need to be established in each community to collect, process, and store containers until they are ready to be shipped to recyclers in southern Canada. The stored containers would then be transported to southern recyclers by barge each summer, or every second summer depending on volume of containers collected. Each depot would require facilities, equipment, and trained staff for handling, processing, storing the collected containers and managing operations.

4.5 Estimated Revenues

4.5.1 Deposit Revenues

The following deposit rates are the rates used during the pilot project. In Iqaluit, a $0.04 handling fee per beverage container was paid to the depot operator. In addition, transportation fees for shipping plastic beverage containers and a $1000/month incentive fee was funded by the Department of Environment. In Rankin Inlet and Kugluktuk, a handling fee was not paid to the depots, however, expenses such as space rentals, staff fees, beverage container refund fees ($0.05/container) and transportation costs of shipping aluminum and plastic beverage containers were all funded by the Department of Environment.

Table 4.3: Summary of Fees Covered by Department of Environment during the Pilot Study

Community	Type of Container	Refund	Handling Fee	Transportation Fees	Other Fees Covered by Department of Environment
Iqaluit	Aluminum	$0.05	$0.04	Plastic Beverage Containers Only	$1000/month incentive fee
	Plastic	$0.05	$0.04		
	Glass	$0.05	$0.04		
Rankin Inlet	Aluminum	$0.05	$0.00	Aluminum and Plastic Beverage Containers Only	Space Rental and Staff Fees
	Plastic	$0.05	$0.00		
	Glass	$0.05	$0.00		
Kugluktuk	Aluminum	$0.05	$0.00	Aluminum and Plastic Beverage Containers Only	Space Rental and Staff Fees
	Plastic	$0.05	$0.00		
	Glass	$0.05	$0.00		

For the purpose of estimating revenues and costs of implementing a Nunavut-wide recycling program, the following rates have been used for each community. In order to increase revenue, the Department of Environment may want to consider increasing the deposit rates.

Table 4.4: Beverage Container Deposit Rates used for Estimating Costs of a Nunavut-Wide Recycling Program

Type of Container	Deposit	Refund	Handling Fee	Department of Environment Revenue
Aluminum	$0.15	$0.10	$0.04	$0.01
Plastic	$0.15	$0.10	$0.04	$0.01
Glass	$0.15	$0.10	$0.04	$0.01

Based on calculations using a recovery rate of 80%, the estimated revenue that the Department of Environment will collect is approximately $100,000. In return, for the 20% of bottles that are not recovered during the recycling program, the Department will collect approximately $375,000. The total estimated annual revenue for the program is $475,000. The table below reports the estimated revenues generated by the program.

Table 4.5: Estimated Program Revenues based on 80% Beverage Container Return Rate

Community	Program Revenue ($0.01/returned beverage container)	Program Revenue ($0.15/non-returned beverage container)	Total Program Revenue per Community
Arctic Bay	$2,342	$8,783	$11,125
Cape Dorset	$4,196	$15,733	$19,929
Clyde River	$2,783	$10,438	$13,221
Grise Fiord	$479	$1,795	$2,273
Hall Beach	$2,220	$8,325	$10,545
Igloolik	$5,221	$19,577	$24,798
Iqaluit	$20,991	$78,717	$99,708
Kimmirut	$1,395	$5,232	$6,627
Pangnirtung	$4,498	$16,866	$21,364
Pond Inlet	$4,464	$16,739	$21,203
Qikiqtarjuaq	$1,606	$6,021	$7,626
Resolute	$777	$2,915	$3,692
Sanikiluaq	$2,525	$9,470	$11,996
Arviat	$6,993	$26,222	$33,215
Baker Lake	$5,866	$21,996	$27,862
Chesterfield Inlet	$1,127	$4,226	$5,353
Coral Harbour	$2,610	$9,789	$12,399
Rankin Inlet	$8,004	$30,015	$38,019
Repulse Bay	$2,539	$9,521	$12,060
Whale Cove	$1,198	$4,493	$5,692
Cambridge Bay	$5,014	$18,801	$23,815
Gjoa Haven	$3,612	$13,544	$17,155
Kugaaruk	$2,335	$8,758	$11,093
Kugluktuk	$4,420	$16,573	$20,993
Taloyoak	$2,746	$10,298	$13,044
Total Revenue	**$99,959**	**$374,848**	**$474,807**

4.5.2 Recycling Revenues

Recycling revenues are those revenues estimated from "selling" collected aluminum and plastic to southern recycling facilities. The intent of the program is to allow each Hamlet to retain these revenues for their community.

Recycling revenues are difficult to estimate due to the current economy. Prior to the economic downturn, market prices for aluminum and plastic were at $1.54/kg and $0.40/kg respectively. After the downturn, aluminum prices dropped to $0.77/kg and plastic dropped to "negligible" (Paquin, 2009). It is difficult to estimate the revenues based on the current economic instability. Prices will also depend on whether or not the aluminum and plastic has been crushed and baled properly. In order for the communities to gain the maximum benefit, they will need the appropriate equipment for processing of these recyclables.

For the purposes of this report, the market prices after the economic downturn ($0.77/kg for aluminum and $0.00/kg for plastic) have been used to estimate the revenue per community. The following table lists these revenues.

Table 4.6: Estimated Annual Recycling Revenues per Community

Community	Estimated Recycling Revenue from Aluminum	Estimated Revenue from Handling Fee ($0.04/beverage container)	Estimated Total Revenue per Community
Arctic Bay	$2,620	$9,369	$11,989
Cape Dorset	$4,694	$16,782	$21,476
Clyde River	$3,114	$11,134	$14,248
Grise Fiord	$535	$1,914	$2,450
Hall Beach	$2,484	$8,880	$11,363
Igloolik	$5,841	$20,883	$26,723
Iqaluit	$23,484	$83,965	$107,449
Kimmirut	$1,561	$5,580	$7,141
Pangnirtung	$5,032	$17,991	$23,022
Pond Inlet	$4,994	$17,855	$22,848
Qikiqtarjuaq	$1,796	$6,422	$8,218
Resolute	$870	$3,109	$3,979
Sanikiluaq	$2,825	$10,102	$12,927
Arviat	$7,823	$27,970	$35,793
Baker Lake	$6,562	$23,462	$30,024
Chesterfield Inlet	$1,261	$4,508	$5,769
Coral Harbour	$2,920	$10,441	$13,362
Rankin Inlet	$8,955	$32,016	$40,971
Repulse Bay	$2,841	$10,156	$12,997
Whale Cove	$1,341	$4,793	$6,133
Cambridge Bay	$5,609	$20,054	$25,663
Gjoa Haven	$4,041	$14,447	$18,487
Kugaaruk	$2,613	$9,341	$11,954
Kugluktuk	$4,944	$17,678	$22,623
Taloyoak	$3,072	$10,984	$14,057

4.6 Estimated Capital and Operational Costs

4.6.1 Operational Costs

Operational costs include the annual expenses that will be incurred by the program. The estimated annual costs for each operational expense are tabulated below. These costs are estimated on a territory wide basis.

Table 4.7: Estimated Annual Expenses for a Nunavut-Wide Beverage Container Recycling Program

Annual Operating Expenses	Annual Costs
Seacan Rental	$22,400
Sea Lift Transportation	$166,338
Road Transportation	$14,000
Utilities (Electricity and Heat)	$269,725
Promotion and Advertising Expenses	$7,362
Territorial Program Manager (Salary + Travel)	$162,500
Training (Annual)	$50,000
Financial Auditing	$50,000
Purchased Services (phone, internet, etc.)	$5,000
Equipment Maintenance	$25,000
Total Operating Expenses	**$772,325**

Costs for seacan rentals and sea lift transportation were estimated based on rates obtained from Nunavut Eastern Arctic Shipping Incorporated, Northern Transportation Company Limited, and Nunavut Sealink and Supply Incorporated. Road transportation costs were estimated using values from the Program Framework Study (Paquin, 2008). Utility expenses were based on cost estimates Dillon Consulting had generated for a water treatment plant in Taloyoak, NU. Territorial Program Manager expenses, financial auditing and equipment maintenance expense estimates were based on figures provided by DoE. Promotion and advertising expenses were based on a cost of $1/household (KPMG, 2007). Purchased services and training were added as potential extra costs that may be incurred during the operation of the depots.

4.6.2 Capital Costs

Based on information provided by Department of Environment (DoE), at the present time only seven (7) communities are equipped with sufficient building infrastructure from which they can run a recycling depot. Fourteen (14) communities would require the construction of a new recycling depot building and four (4) other communities would require substantial upgrades to existing building infrastructure. According to DoE, the cost of constructing 14 new recycling depot facilities combined with the cost of upgrading existing building infrastructure to accommodate new recycling depots amounts to approximately $17.7 million.

In addition, each community will have to be outfitted with the following equipment in order to effectively handle and prepare beverage containers for shipment to southern recyclers:

- crusher/baling machine (materials crushing);
- pallet jack or forklift truck;
- barrels, woven fibre bags, pallets and wood;
- steel strapping equipment; and
- office equipment (record keeping).

Paquin (2008) in the Program Framework report has estimated that the total cost of this equipment will contribute approximately $424,500 to the capital costs of starting up a Nunavut-wide beverage container recycling program.

In addition to equipment needs, each community will require a depot advance to cover the costs of refunds to be paid out for each returned beverage container. DoE will fund this advance, however, it is expected that within 2 to 3 years of operation, each depot will be able to pay the depot advance back to DoE.

The combined costs of constructing the necessary building infrastructure to accommodate recycling depots in each community combined with the total equipment costs amounts to approximately $18.2 million. The total capital costs are summarized in the table below.

Table 4.8: Total Estimated Capital Costs

Expense	Estimate
Building Infrastructure	$17,674,671
Equipment Costs	$424,500
Depot Advance	$102,391
Totals	$18,201,562

After a review of DoE’s capital estimates and methodologies, it has been determined that these estimates are reasonable and no further suggestions were made to change the estimate.

4.7 Summary of Nunavut Recycling Program

Annual revenues and expenses are reported in the table below. Based on costs estimates from Sections 4.5 and 4.6, the program will generate a net cost of $298,000. The initial start-up cost of the program is estimated to be $18.2 million.

Table 4.9: Summary of Estimated Annual Revenues and Expenses

Revenue (Annual)	
Refunded Bottles at $0.01/bottle	$99,959
Non-Refunded Bottles at $0.15/bottle	$374,848
Total Revenue	$474,807
Expenses (Annual)	
Seacan Rental	$22,400
Sea Lift Transportation	$166,338
Road Transportation	$14,000
Utilities (Electricity and Heat)	$269,725
Promotion and Advertising Expenses	$7,362
Territorial Program Manager (Salary + Travel)	$162,500
Training (Annual)	$50,000
Financial Auditing	$50,000
Purchased Services (phone, internet, etc.)	$5,000
Equipment Maintenance	$25,000
Total Expenses	$772,325
Revenue - Expenses	**-$297,518**

The following points summarize the measures to be considered in the implementation of a Nunavut-wide beverage container recycling program:

- If the program is implemented, a depot will be required in each community to give access to beverage container deposit-refund facilities to each resident of Nunavut;
- Coordination of the program will need to be shared and supported by the Department of Environment (Government of Nunavut), Community and Government Services (Government of Nunavut), Nunavut Association of Municipalities and Nunavut Municipal Training Organization;
- Estimated annual revenue for the program retained by the Government of Nunavut is $475,000 at a bottle recovery rate of 80% and a beverage container deposit of $0.15/container;
- Recycling revenues for the Government of Nunavut will decrease as recycling increases;
- Recycling revenues are extremely sensitive to uptake by the public with respect to recycling;
- With a beverage container deposit of $0.15/container, the program will have an estimated annual expense of $772,325, and an estimated annual revenue of $474,807 resulting in an annual cost of $297,518;
- Capital cost of implementing the project is estimated at $18.2 million; and
- With a beverage container deposit of $0.18/container, the program should be self-sustaining if recycling returns do not exceed 80%.

5 SOLID WASTE DIVERSION AND EXTENDING THE LIFE OF LANDFILLS

It is very difficult to quantitatively measure the capital and operational costs that are associated with reduction of aluminum and plastic beverage containers from solid waste sites. Based on the City of Iqaluit Solid Waste Management Plan Draft Report (2005), percent reduction by mass of aluminum and plastic beverage containers is 4.2%. This must not be confused with the reduction by volume which is significantly smaller due to the compaction of aluminum and plastic containers during the landfilling process.

Capacity of the landfill is generally the limiting factor when it comes to extending the life of the landfill and reducing costs. If it is assumed that after compaction of aluminum and plastic containers 1% of the volume in the landfill is removed per year; then over the span of a 20 year life cycle for the landfill, an additional 2 to 3 months of landfill storage space may be gained. This is a very rough estimate, but indicates that removal of aluminum and plastic bottles from the landfill produces negligible cost and operational benefits.

One final benefit to consider is the reduction of litter. When considering wind blown litter, the main contributors are plastic bags and light waste materials. Beverage containers tend not be a main source of this type of litter. However, if a recycling program is implemented, there may be a reduction in the amount of street litter.

6 LESSONS FROM THE PILOT RECYCLING PROJECTS

6.1 Lessons for Establishing a Nunavut-Wide Recycling Program

In terms of gauging public support for a beverage recycling program in Nunavut, the pilot project was very successful. Based on estimated rates of beverage container distribution within Nunavut and data on the number of recyclable beverage containers collected, percentage return rates were computed for 2008 and 2009 for Iqaluit and Rankin Inlet. An increase in these percentage rates was noted for both communities, with a surprisingly high rate of return for Rankin Inlet. This rate may be somewhat skewed due to people from neighbouring communities traveling to Rankin Inlet to return beverage containers. Either way this data is very encouraging and supports the notion that a beverage recycling program in Nunavut will be successful. Please refer to Table 6.1 for a listing of the percentages.

Table 6.1: Percentage Recovery Rates during Pilot Beverage Recycling Program

Community	Time Period	% Bottle Recovery
Iqaluit	Jan. to Dec. 2008	13.50%
	Jan. to Dec. 2009	26.32%
Rankin Inlet	Jan. to Dec. 2008	67.18%
	Jan. to Dec. 2009	71.92%
Kugluktuk	Jul. to Nov. 2008	13.43%

The pilot project depot in Kugluktuk had to close during the winter due to lack of heated space. Unfortunately only 5 months of data was collected from Kugluktuk. It is estimated that provision of a heated space would allow the program to continue due to the percentage of bottles returned within those 5 months of operation.

In Iqaluit, the Department of Environment has hired a local contractor to run the pilot program. The contractor collects recycled bottles at the depot, returns deposits to consumers, crushes, packages and ships recyclables by barge to the recycling facility in St. Hubert, QC. The Department of Environment funds the deposits paid to consumers as well as pays for the transportation costs for shipping plastic beverage containers to the recycling facility. The Department also pays the contractor a handling fee of $0.04/beverage container collected. The contractor retains any money that is paid by the recycling facility for the aluminum and plastic bottles, however is responsible for paying the transportation costs to ship aluminum cans. After a few months of operation, it was decided that compensation of $1000/month was required to be paid to the contractor as the return rate of aluminum was not as high as expected.

6.2 Public Support and Participation

Public support and participation in the pilot study has been quite significant. Percentage of beverage containers returned over the two years of the study has increased from 13.50% to 26.32% in Iqaluit. Percentage of bottles returned in Rankin Inlet increased from 67.18% to 71.92%. Percentages from Rankin Inlet may be somewhat skewed due to people from other nearby communities traveling to Rankin Inlet to return their beverage containers. However, since the Rankin Inlet program is being run by the Hamlet staff, the success from this community supports the notion of having a recycling program sustained by Hamlet staff in each community within Nunavut.

Also, based on conversations that Jamessee Moulton (Solid Waste Management Specialist, Department of Environment) has had with Senior Administrative Officers within Nunavut, Hamlets will support and run a recycling program (Personal communication February 2nd, 2010). However, setting up such a program will take collaboration from all parties involved including Department of Environment (Government of Nunavut), Community and Government Services (Government of Nunavut), Nunavut Association of Municipalities and Nunavut Municipal Training Organization.

Another important item that will come out of such a program is the issue of public awareness. When a system such as a beverage recycling program is implemented, people become more aware of the amount of beverage containers they use and also how much waste they produce. In turn, they will begin to try to reduce the amount of waste they produce. Unfortunately it is very difficult to quantify this effect as it is not a measurable quality.

A good way to begin implementing these programs is to develop a public education program for school age children. The Department of Environment has already started this process with the development of a program for the local elementary school in Iqaluit. The Department developed a contest to see which class could bring in the most beverage container recyclables. The class that brought in the most beverage containers won a prize. According to Jamessee Moulton, this program was very successful and brought in approximately 33,000 cans and plastic bottles to the recycling facility (Personal communication February 12th, 2010).

6.3 Summary of Lessons Learned

The following points summarize the lessons that have come out of the pilot study with regards to establishing a Nunavut-wide recycling program:

- Public support for the program has increased over the two years of pilot study with increases in the number of beverage containers returned in both Iqaluit and Rankin Inlet;
- Each community will require a heated space from which to run the program (Kugluktuk had to halt the program for the winter months due to a lack of heated space);
- Collaboration between the Department of Environment (Government of Nunavut), Community and Government Services (Government of Nunavut), Nunavut Association of Municipalities and Nunavut Municipal Training Organization will have to occur for the program to be successful. Currently, the Department of Environment is paying employee wages and rental fees for the pilot project in Rankin Inlet. If the program is continued and expanded territory-wide, the Department of Environment will not be funding these costs. Therefore support and vested interest from these organizations is required for each community to maintain a beverage recycling program; and
- Public awareness of waste production will be increased as a result of the program.

7 EVALUATION OF RECYCLING IN NUNAVUT

7.1 Environmental Benefits of Beverage Container Recycling in Nunavut

Based on information from Section 3, it is better from an environmental standpoint to collect and recycle both aluminum and plastic beverage containers. The emissions generated in producing these materials from virgin sources are far greater than the emissions produced from transporting recyclables to displace the virgin materials.

From a local standpoint, landfilling both aluminum and plastic bottles have a negligible effect on the environmental impact created by the landfill as they are both inert materials. Generally, aluminum does not leach contaminants of concern into the environment unless it is exposed to acidic conditions (Environmental Literacy Council, 2008; Alberta Environment, 2008) and acidic conditions are not typically present in northern landfills where most of the waste mass is below the active layer of the permafrost. However, improper disposal of materials such as car and automatic batteries at landfills, acidic conditions may occur and may cause aluminum, and other heavy metals present in the waste stream, to leach into the environment. Aluminum and other heavy metals may then leach into waterways and cause environmental contamination (Alberta Environment, 2008).

7.2 Cost of Establishing and Maintaining a Recycling Program

The cost of maintaining the program has been estimated to be approximately $298,000/year. This estimate was obtained by subtracting the annual operational costs from the annual revenue and is estimated using a bottle recovery rate of 80% with a $0.15 deposit on each beverage container. If the deposit rates were increased to $0.20 per beverage container, the net revenue would be approximately $327,000. The table below reports the estimated costs and revenues associated with varying bottle deposit rates. A bottle deposit rate of $0.18 must be charged in order for the program to generate revenue. Consideration to raising the bottle deposit is recommended.

Table 7.1: Estimated Annual Costs/Revenues for Varying Bottle Deposit Rates

Bottle Deposit Rate	Revenue	Operating Costs	Net Revenue
$0.15	$474,807	$772,325	-$297,518
$0.16	$599,757	$772,325	-$172,568
$0.17	$724,706	$772,325	-$47,619
$0.18	$849,655	$772,325	$77,330
$0.19	$974,605	$772,325	$202,280
$0.20	$1,099,554	$772,325	$327,229

One thing that must be noted is that the more people recycle, the less revenue the program will generate. If an 80% bottle recovery is experienced, then 20% of bottles are not being recovered. For that 20%, the program will generate the entire bottle deposit in revenue, $0.15/bottle. For the other 80%, the program only generates $0.01/bottle. As the number of recovered bottles increases, for example to 90%, then the program generates $0.01/bottle for 90% of the bottles distributed and $0.15/bottle for the other 10% that are not collected. Conversely, the less that people recycle, the more money the program will generate.

7.3 Impact on Cost, Operation and Maintenance of Landfills

As stated in Section 5, the impact on cost and operation of landfills from removal of aluminum and plastic beverage containers is minimal. Volume removal is estimated to be at 1% of the total landfill volume. Using this estimate, the maximum amount of space savings in the landfill over a 20 year period is an extra 2 to 3 months of storage. Therefore impact of removing these beverage containers from community landfills is negligible.

7.4 Applicability of the NWT Recycling Model

The NWT beverage recycling model is not a good fit for Nunavut for two main reasons;

- Depots in the NWT are run by private contractors; and
- There is a road system that services most of the communities in the NWT.

Having depots managed by private contractors is good for these communities as they can partner with trucking companies to transport their recyclables to southern facilities, thus reducing their shipping costs. However, the contractor then becomes responsible for the overhead costs such as rental space, utilities, supplying their own staff and paying staff wages.

Unfortunately the revenues generated by recycling in Nunavut communities are not high enough to entice private contractors to take on this work. Also, shipping costs would be much more expensive as they would not be able to use a road network to transport the recyclables.

7.5 Other Waste Management/Recycling Scenarios

There are a number of other waste management scenarios that should be considered prior to implementing a territory wide beverage recycling program. The following sections describe each of these options.

7.5.1 Removal of Hazardous Wastes from Community Landfills

Hazardous waste is a very large problem in most communities within Nunavut. Storage of old vehicle batteries, waste oil, mercury switches from old appliances, CFCs from old refrigerators and freezers and miscellaneous other hazardous wastes are piling up in Nunavut communities. While it is very difficult to quantify the environmental impacts that these materials are having in each community, it is known that many of these substances have the potential to leak into the surrounding environment and cause pollution of waterways and airways in the community.

Many of these waste items are not placed in properly lined berms or stored in appropriate containers. While a full analysis of a program of this size is not part of the scope of this report, a cost estimate can be provided from a similar program that was supervised by Dillon Consulting during the summer and fall of 2009 in Kugaaruk, NU. The intent of the project was to clean up and properly segregate the solid waste site and metal dump areas that had been in use for approximately 30 years. Specific items included:

- Construction of 3 separate lined berm cells for storage of batteries, hazardous materials and barrels filled with unclassified waste liquid;
- Mobilization of a waste oil burner to site to burn off waste oil (the equivalent of approximately 101 barrels full of waste oil was burned);
- Preparation and shipment of approximately 180 barrels with unclassified waste products to southern disposal facility; and
- Mobilization of a certified technician to remove CFCs from fridges and freezers stored in the landfill (has not been completed as of the time of publishing this report).

The estimated cost of implementing such a program is $230/person in each community. The costs estimated based on community populations are reported in the table below. Based on this table it would cost approximately $6.8 million dollars to implement this program throughout the territory.

Table 7.2: Estimated Cost per Community of Implementing a Hazardous Waste Removal Program

Community	Population	Cost of Implementing a Hazardous Waste Removal Program per Community
Arctic Bay	690	$158,700
Cape Dorset	1,236	$284,280
Clyde River	820	$188,600
Grise Fiord	141	$32,430
Hall Beach	654	$150,420
Igloolik	1,538	$353,740
Iqaluit	6,184	$1,422,320
Kimmirut	411	$94,530
Pangnirtung	1,325	$304,750
Pond Inlet	1,315	$302,450
Qikiqtarjuaq	473	$108,790
Resolute	229	$52,670
Sanikiluaq	744	$171,120
Arviat	2,060	$473,800
Baker Lake	1,728	$397,440
Chesterfield Inlet	332	$76,360
Coral Harbour	769	$176,870
Rankin Inlet	2,358	$542,340
Repulse Bay	748	$172,040
Whale Cove	353	$81,190
Cambridge Bay	1,477	$339,710
Gjoa Haven	1,064	$244,720
Kugaaruk	688	$158,240
Kugluktuk	1,302	$299,460
Taloyoak	809	$186,070
Nunavut Total	**29,448**	**$6,773,040**

7.5.2 Removal of Scrap Metal from Nunavut Communities

During the research phase for this report, a report was found that documented a pilot study conducted to determine the costs and environmental benefits of removing scrap metal from northern communities (North Central Development, 2006). The pilot study was carried out in Rankin Inlet, NU; Churchill, MB and Gillam, MB and therefore is quite relevant to the nature of this report.

Scrap metal collected during this pilot study consisted of waste vehicles and vehicle parts, crushed barrels and other waste metal items. In two years, the pilot study was able to remove 106 tons of scrap metal from Rankin Inlet at a cost of approximately $62,000 over the two year period. The cost included transportation estimates as well as “in-kind” support. The “in-kind” support was support provided by the community and included hiring and training staff to move materials, as well as providing some equipment with qualified operators. This led to the creation of 7 jobs within Rankin Inlet over the two years of the pilot study (North Central Development, 2006). Based on a population of 2177 (the population recorded in the report), this works out to the removal of 0.025 tonnes of scrap metal/person/year at a cost of

$585/ton *(*Note: The North Central Development (2006) study refers to both tonnes and tons. For estimation of amount of scrap metal removed and cost estimation purposes, it has been assumed that the study is referring to metric tonnes (tonnes) and not US short tons (tons)).* The table below estimates the cost per year to implement a scrap metal program in each community. Based on this estimate it would cost approximately $431,000 per year to implement a scrap metal removal program throughout Nunavut. It is important to note that a properly managed program would include the removal of all fluids and hazardous items prior to crushing and shipping the scrap metal.

Table 7.3: Estimated Cost to Implement a Scrap Metal Removal Program per Community

Community	Population	Annual Cost of Implementing a Scrap Metal Removal Program per Community
Arctic Bay	690	$10,091
Cape Dorset	1,236	$18,077
Clyde River	820	$11,993
Grise Fiord	141	$2,062
Hall Beach	654	$9,565
Igloolik	1,538	$22,493
Iqaluit	6,184	$90,441
Kimmirut	411	$6,011
Pangnirtung	1,325	$19,378
Pond Inlet	1,315	$19,232
Qikiqtarjuaq	473	$6,918
Resolute	229	$3,349
Sanikiluaq	744	$10,881
Arviat	2,060	$30,128
Baker Lake	1,728	$25,272
Chesterfield Inlet	332	$4,856
Coral Harbour	769	$11,247
Rankin Inlet	2,358	$34,486
Repulse Bay	748	$10,940
Whale Cove	353	$5,163
Cambridge Bay	1,477	$21,601
Gjoa Haven	1,064	$15,561
Kugaaruk	688	$10,062
Kugluktuk	1,302	$19,042
Taloyoak	809	$11,832
Nunavut Total	**29,448**	**$430,677**

The study also concluded that greenhouse gas emissions generated from shipping scrap metal was more than offset by the emissions created from producing these materials from virgin feedstock (North Central Development, 2006).

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APPENDIX A

Calculation of Greenhouse Gas Emissions Produced by Transporting Recyclable Beverage Containers

Calculation of Distance where Greenhouse Gas Emissions from Transporting Aluminum Recyclables Equals the Emissions Reductions when those Recyclables Replace Virgin Materials used in Manufacturing Aluminum

Transportation by Barge			**Transportation by Single Unit Truck**		
Greenhouse gas emissions for manufacturing one ton of aluminum cans from virgin inputs (Source USEPA (2006), *Solid Waste Management and Greenhouse Gases, A Life-Cycle Assessment of Emissions and Sinks* - Exhibit 2-3, Pg. 26):	4.11	MTCE/ton	Greenhouse gas emissions for manufacturing one ton of aluminum cans from virgin inputs (Source USEPA (2006), *Solid Waste Management and Greenhouse Gases, A Life-Cycle Assessment of Emissions and Sinks* - Exhibit 2-3, Pg. 26):	4.11	MTCE/ton
Greenhouse gas emissions for manufacturing one ton of aluminum cans from recycled inputs (Source USEPA (2006), *Solid Waste Management and Greenhouse Gases, A Life-Cycle Assessment of Emissions and Sinks* - Exhibit 2-5, Pg. 28):	0.28	MTCE/ton	Greenhouse gas emissions for manufacturing one ton of aluminum cans from recycled inputs (Source USEPA (2006), *Solid Waste Management and Greenhouse Gases, A Life-Cycle Assessment of Emissions and Sinks* - Exhibit 2-5, Pg. 28):	0.28	MTCE/ton
Difference (Greenhouse gas emission reductions from using recycled materials instead of virgin materials):	3.83	MTCE/ton	Difference (Greenhouse gas emission reductions from using recycled materials instead of virgin materials):	3.83	MTCE/ton
Tons of aluminum cans made per ton of recycled aluminum *(Source USEPA (2006), Solid Waste Management and Greenhouse Gases, A Life-Cycle Assessment of Emissions and Sinks - Exhibit 3-3, Pg. 36):*	0.93	93%	Tons of aluminum cans made per ton of recycled aluminum *(Source USEPA (2006), Solid Waste Management and Greenhouse Gases, A Life-Cycle Assessment of Emissions and Sinks - Exhibit 3-3, Pg. 36):*	0.93	93%
Greenhouse gas emissions reduction at the manufacturing level from collection of one ton of recycled aluminum cans (3.83 MTCE/ton x 0.93):	3.5619	MTCE/ton	Greenhouse gas emissions reduction at the manufacturing level from collection of one ton of recycled aluminum cans (3.83 MTCE/ton x 0.93):	3.5619	MTCE/ton
Metric Ton of Carbon Dioxide Equivalent (3.56 MTCE/ton x 44/12 $MTCO_2e$/MTCE):	13.0603	$MTCO_2e$/ton	Metric Ton of Carbon Dioxide Equivalent (3.56 MTCE/ton x 44/12 $MTCO_2e$/MTCE):	13.0603	$MTCO_2e$/ton
Fuel consumed per 1000 ton-miles for a barge (2.0 gal diesel +0.8 gal residual) *(Source: Franklin Associates (2004), Life Cycle Inventory of Packaging Options for Shipment of Retail Mail-Order Soft Goods - Table A-5, Pg. A-18*):	2.8	gal/1000 ton-miles	Fuel consumed per 1000 ton-miles for a single unit truck (26.5 gal diesel) *(Source: Franklin Associates (2004), Life Cycle Inventory of Packaging Options for Shipment of Retail Mail-Order Soft Goods - Table A-5, Pg. A-18*):	26.5	gal/1000 ton-miles
Fossil CO_2 emissions for barges per gallon of fuel used (25,780 lbs/1000 gallons of fuel) *(Source: Franklin Associates (2004), Life Cycle Inventory of Packaging Options for Shipment of Retail Mail-Order Soft Goods - Table A-31, Pg. A-83):*	25.78	lbs/gal	Fossil CO_2 emissions for barges per gallon of fuel used (25,330 lbs/1000 gallons of fuel) *(Source: Franklin Associates (2004), Life Cycle Inventory of Packaging Options for Shipment of Retail Mail-Order Soft Goods - Table A-29b, Pg. A-79):*	25.33	lbs/gal
lbs of CO_2 emissions/ton-mile (2.8 gal/1000 ton-miles x 25.78lbs/gal):	0.072184	lbs/ton-mile	lbs of CO_2 emissions/ton-mile (26.5 gal/1000 ton-miles x 25.33lbs/gal):	0.671245	lbs/ton-mile
Metric tonnes of CO_2/ton-mile (0.072lbs x 1MT/2205lbs):	3.274E-05	$MTCO_2$/ton-mile	Metric tonnes of CO_2/ton-mile (0.67lbs x 1MT/2205lbs):	3.044E-04	$MTCO_2$/ton-mile
"Break-even Point" for transportation miles of recyclables:	398,952	miles	"Break-even Point" for transportation miles of recyclables:	42,902	miles
Conversion to km (miles x 1.6km/mile):	638,323	kiliometers	Conversion to km (miles x 1.6km/mile):	68,644	kiliometers

Source: David Allaway, Oregon Department of Environmental Quality, Solid Waste Policy and Program Development. Personal communication February 9, 2010

Calculation of Distance where Greenhouse Gas Emissions from Transporting Plastic (PET) Bottle Recyclables Equals the Emissions Reductions when those Recyclables Replace Virgin Materials used in Manufacturing Plastic (PET)

Transportation by Barge			Transportation by Single Unit Truck		
Greenhouse gas emissions for manufacturing one ton of PET plastic from virgin inputs (Source USEPA (2006), *Solid Waste Management and Greenhouse Gases, A Life-Cycle Assessment of Emissions and Sinks* - Exhibit 2-3, Pg. 26):	0.58	MTCE/ton	Greenhouse gas emissions for manufacturing one ton of PET plastic from virgin inputs (Source USEPA (2006), *Solid Waste Management and Greenhouse Gases, A Life-Cycle Assessment of Emissions and Sinks* - Exhibit 2-3, Pg. 26):	0.58	MTCE/ton
Greenhouse gas emissions for manufacturing one ton of PET plastic from recycled inputs (Source USEPA (2006), *Solid Waste Management and Greenhouse Gases, A Life-Cycle Assessment of Emissions and Sinks* - Exhibit 2-5, Pg. 28):	0.04	MTCE/ton	Greenhouse gas emissions for manufacturing one ton of PET plastic from recycled inputs (Source USEPA (2006), *Solid Waste Management and Greenhouse Gases, A Life-Cycle Assessment of Emissions and Sinks* - Exhibit 2-5, Pg. 28):	0.04	MTCE/ton
Difference (Greenhouse gas emission reductions from using recycled materials instead of virgin materials):	0.54	MTCE/ton	Difference (Greenhouse gas emission reductions from using recycled materials instead of virgin materials):	0.54	MTCE/ton
Tons of aluminum cans made per ton of recycled aluminum *(Source USEPA (2006), Solid Waste Management and Greenhouse Gases, A Life-Cycle Assessment of Emissions and Sinks - Exhibit 3-3, Pg. 36):*	0.78	78%	Tons of aluminum cans made per ton of recycled aluminum *(Source USEPA (2006), Solid Waste Management and Greenhouse Gases, A Life-Cycle Assessment of Emissions and Sinks - Exhibit 3-3, Pg. 36):*	0.78	78%
Greenhouse gas emissions reduction at the manufacturing level from collection of one ton of recycled aluminum cans (0.54 MTCE/ton x 0.78):	0.4212	MTCE/ton	Greenhouse gas emissions reduction at the manufacturing level from collection of one ton of recycled aluminum cans (0.54 MTCE/ton x 0.78):	0.4212	MTCE/ton
Metric Ton of Carbon Dioxide Equivalent (0.42 MTCE/ton x 44/12 $MTCO_2e$/MTCE):	1.5444	$MTCO_2e$/ton	Metric Ton of Carbon Dioxide Equivalent (0.42 MTCE/ton x 44/12 $MTCO_2e$/MTCE):	1.5444	$MTCO_2e$/ton
Fuel consumed per 1000 ton-miles for a barge (2.0 gal diesel + 0.8 gal residual) *(Source: Franklin Associates (2004), Life Cycle Inventory of Packaging Options for Shipment of Retail Mail-Order Soft Goods - Table A-5, Pg. A-18*):	2.8	gal/1000 ton-miles	Fuel consumed per 1000 ton-miles for a single unit truck (26.5 gal diesel) *(Source: Franklin Associates (2004), Life Cycle Inventory of Packaging Options for Shipment of Retail Mail-Order Soft Goods - Table A-5, Pg. A-18*):	26.5	gal/1000 ton-miles
Fossil CO_2 emissions for barges per gallon of fuel used (25,780 lbs/1000 gallons of fuel) *(Source: Franklin Associates (2004), Life Cycle Inventory of Packaging Options for Shipment of Retail Mail-Order Soft Goods - Table A-31, Pg. A-83):*	25.78	lbs/gal	Fossil CO_2 emissions for barges per gallon of fuel used (25,330 lbs/1000 gallons of fuel) *(Source: Franklin Associates (2004), Life Cycle Inventory of Packaging Options for Shipment of Retail Mail-Order Soft Goods - Table A-29b, Pg. A-79):*	25.33	lbs/gal
lbs of CO_2 emissions/ton-mile (2.8 gal/1000 ton-miles x 25.78lbs/gal):	0.072184	lbs/ton-mile	lbs of CO_2 emissions/ton-mile (26.5 gal/1000 ton-miles x 25.33lbs/gal):	0.671245	lbs/ton-mile
Metric tonnes of CO_2/ton-mile (0.072lbs x 1MT/2205lbs):	3.274E-05	$MTCO_2$/ton-mile	Metric tonnes of CO_2/ton-mile (0.67lbs x 1MT/2205lbs):	3.044E-04	$MTCO_2$/ton-mile
"Break-even Point" for transportation miles of recyclables:	47,177	miles	"Break-even Point" for transportation miles of recyclables:	5,073	miles
Conversion to km (miles x 1.6km/mile):	75,483	kiliometers	Conversion to km (miles x 1.6km/mile):	8,117	kiliometers

Source: David Allaway, Oregon Department of Environmental Quality, Solid Waste Policy and Program Development. Personal communication February 9, 2010

APPENDIX B

Container Weights and Volumes

APPENDIX H - CONTAINER WEIGHTS AND VOLUMES

		Containers Recovered	Weight per 1000 (kg)	Total Weight (kg)	Volume per 1000 (m3)	Total volume (m3)
Non-alcoholic	Aluminum	8,931,783	17	151,840	0.53	4,734
	Plastic <1L	939,348	25	23,484	0.82	770
	Plastic >=1L	88,003	50	4,400	3.05	268
	Tetra Pak <1L	636,638	14	8,913	0.31	197
	Tetra Pak >=1L	117,896	31	3,655	1.21	143
	Glass	36,812	178	6,553	0.7	26
	Bimetal <1L	34,182	50	1,709	1.18	40
	Bimetal >=1L	0	100	0	2.37	0
Alcoholic	Aluminum	1,025,476	17	17,433	0.53	544
	Glass - beer and coolers	24,512	227	5,564	0.9	22
	Wine/Spirits - glass	67,670	549	37,151	1.78	120
	Wine/Spirits - plastic	0	40	0	1.78	0
TOTALS		11,902,322		260,702		6,865

Notes
1. Number of containers recovered are based on an 80% recovery rate
2. Volume is calculated as uncrushed 'air containers'
3. Weight and volume conversion rate source - NWT Beverage Container Recovery Discussion Paper (2001)

Source: Paquin, E. (2008). *Program Framework: Nunavut Beverage Container Recovery Program*. Yellowknife, Northwest Territories.

*Data taken from Appendix H of the report

APPENDIX C

Storage and Transportation Costs

Storage and Transportation Costs

Community	Recovered Aluminum (ton)	Recovered Plastic (ton)	Recovered Aluminum + Plastic (ton)	Number of Seacans Required	Cost of Seacans ($800/unit)	Cost of Sealift/Community (Full Rate)	Road Transport ($500/seacan)	Total Storage and Transportation	Service Provider
Arctic Bay	3.40	0.87	4.28	1.0	$800	$6,132	$500	$6,632	NEAS
Cape Dorset	6.10	1.57	7.66	1.0	$800	$5,402	$500	$5,902	NEAS
Clyde River	4.04	1.04	5.08	1.0	$800	$6,132	$500	$6,632	NEAS
Grise Fiord	0.70	0.18	0.87	1.0	$800	$6,132	$500	$6,632	NEAS
Hall Beach	3.23	0.83	4.05	1.0	$800	$5,880	$500	$6,380	NEAS
Igloolik	7.59	1.95	9.53	1.0	$800	$5,880	$500	$6,380	NEAS
Iqaluit	30.50	7.83	38.33	3.0	$2,400	$4,519	$1,500	$15,057	NEAS
Kimmirut	2.03	0.52	2.55	1.0	$800	$5,402	$500	$5,902	NEAS
Pangnirtung	6.53	1.68	8.21	1.0	$800	$5,402	$500	$5,902	NEAS
Pond Inlet	6.49	1.67	8.15	1.0	$800	$6,132	$500	$6,632	NEAS
Qikiqtarjuaq	2.33	0.60	2.93	1.0	$800	$6,132	$500	$6,632	NEAS
Resolute	1.13	0.29	1.42	1.0	$800	$6,132	$500	$6,632	NEAS
Sanikiluaq	3.67	0.94	4.61	1.0	$800	$5,879	$500	$6,379	NEAS
Arviat	10.16	2.61	12.77	1.0	$800	$5,880	$500	$6,380	NEAS
Baker Lake	8.52	2.19	10.71	1.0	$800	$5,880	$500	$6,380	NEAS
Chesterfield Inlet	1.64	0.42	2.06	1.0	$800	$5,880	$500	$6,380	NEAS
Coral Harbour	3.79	0.97	4.77	1.0	$800	$5,880	$500	$6,380	NEAS
Rankin Inlet	11.63	2.99	14.62	2.0	$1,600	$5,880	$1,000	$12,760	NEAS
Repulse Bay	3.69	0.95	4.64	1.0	$800	$5,880	$500	$6,380	NEAS
Whale Cove	1.74	0.45	2.19	1.0	$800	$5,880	$500	$6,380	NSSI
Cambridge Bay	7.28	1.87	9.15	1.0	$800	$7,047	$500	$7,547	NEAS
Gjoa Haven	5.25	1.35	6.59	1.0	$800	$7,439	$500	$7,939	NEAS
Kugaaruk	3.39	0.87	4.26	1.0	$800	$6,132	$500	$6,632	NEAS
Kugluktuk	6.42	1.65	8.07	1.0	$800	$7,047	$500	$7,547	NEAS
Taloyoak	3.99	1.02	5.01	1.0	$800	$7,439	$500	$7,939	NEAS
Totals	145.23	37.29	182.52	28.0	$22,400	$151,420	$14,000	$180,338	

Sources:

1. Nunavut Eastern Arctic Shipping Incorporated (2010). Shipping rates and seacan rental fees. Personal communication on February 9, 2010.
2. Nunavut Sealink and Supply Incorporated (2010). Shipping rates and seacan rental fees. Personal communication on February 9, 2010.

APPENDIX D

Aluminum and Plastic Beverage Containers Collected by Pilot Projects

Pilot Beverage Container Recycling Project – Iqaluit
Total Aluminum, Plastic and Glass Containers Collected in 2008 and 2009
(Non-Alcoholic Beverage Containers Only)

IQALUIT	Total Bottles/Cans Collected for 2008				IQALUIT	Total Bottles/Cans Collected for 2009			
Month	**Aluminum**	**Plastics**	**Glass**	**Total**	**Month**	**Aluminum**	**Plastics**	**Glass**	**Total**
January	6389	4133	99	10621	January	42475	15784	888	58259
February	18849	7144	211	25993	February	27094	9202	212	36296
March	39847	13162	932	53941	March	27572	14958	561	42530
April	11395	6934	531	18860	April	41094	16721	745	57815
May	23632	10989	790	35411	May	38520	15943	183	54463
June	19209	11348	663	31220	June	42627	21815	504	64442
July	19412	17171	152	36735	July	35300	50619	738	85919
August	21124	8886	148	30158	August	23752	13660	345	37412
September	21124	8886	148	30158	September	49677	23498	240	73175
November	17111	3458	210	20779	October	45994	16879	449	62873
December	17549	7767	169	25485	November	41339	8712	138	50051
October	25394	9080	368	34842	December	60023	7370	617	67393
Total Recovery	241035	108958	4421	354203	Total Recovery	475467	215161	5620	690628
Total Distribution	2344563	269676	9663	2623902	Total Distribution	2344563	269676	9663	2623902
Recovery Rate	10.28%	40.40%	45.76%	13.50%	Recovery Rate	20.28%	79.79%	58.16%	26.32%

Source: Department of Environment, Government of Nunavut (2010). [Number of bottles collected during beverage container pilot recycling program]. Unpublished data.

Pilot Beverage Container Recycling Project – Rankin Inlet
Total Aluminum, Plastic and Glass Containers Collected in 2008 and 2009
(Non-Alcoholic Beverage Containers Only)

RANKIN INLET	Total Bottles/Cans Collected for 2008				RANKIN INLET	Total Bottles/Cans Collected for 2009			
Month	**Aluminum**	**Plastics**	**Glass**	**Total**	**Month**	**Aluminum**	**Plastics**	**Glass**	**Total**
January	38539	4804	586	43929	January	38672	3078	210	41750
February	42646	5045	422	48113	February	46907	3851	848	50758
March	26126	3402	104	29632	March	40377	4740	360	45117
April	43401	3129	153	46683	April	60427	6161	421	66588
May	67471	5326	280	73077	May	52205	3888	731	56093
June	65600	6819	913	73332	June	67503	5768	1423	73271
July	65667	7233	1178	74078	July	65678	11214	1991	76892
August	52592	7497	1588	61677	August	67512	12864	1134	80376
September	64381	7249	1080	72710	September	68759	11021	756	79780
October	54160	5340	746	60246	October	46182	4140	284	50322
November	43883	4676	387	48946	November	35888	2805	431	38693
December	37353	2077	300	39730	December	53646	6321	781	59967
Total Recovery	601819	62597	7737	672153	Total Recovery	643756	75851	9370	719607
Total Distribution	893997	102829	3685	1000511	Total Distribution	893997	102829	3685	1000511
Recovery Rate	67.32%	60.87%	209.96%	67.18%	Recovery Rate	72.01%	73.76%	254.27%	71.92%

Source: Department of Environment, Government of Nunavut (2010). [Number of bottles collected during beverage container pilot recycling program]. Unpublished data.

Pilot Beverage Container Recycling Project – Kugluktuk
Total Aluminum, Plastic and Glass Containers Collected in 2008
(Non-Alcoholic Beverage Containers Only)

KUGLUKTUK	Total Bottles/Cans Collected for 2008			
Month	**Aluminum**	**Plastics**	**Glass**	**Total**
July	953	125	2	1080
August	12506	2039	177	14722
September	13715	2880	432	17027
October	15096	3695	347	19138
November	19702	2380	157	22239
Total Recovery	61972	11119	1115	74206
Total Distribution	493,632	56,779	2,034	552445
Recovery Rate	12.55%	19.58%	54.81%	13.43%

Source: Department of Environment, Government of Nunavut (2010). [Number of bottles collected during beverage container pilot recycling program]. Unpublished data.

APPENDIX E

Estimated Cost of Required Recycling Depot Building Infrastructure and Equipment

Estimated Cost of Required Recycling Depot Building Infrastructure and Equipment

Community	Cost of New Recycling Depot or Upgrades to Existing Infrastructure	Equipment Cost	Depot Advance	Cost of Required Building Infrastructure and Equipment
Arctic Bay	$1,092,856	$11,250	$2,355	$1,106,461
Cape Dorset	$1,092,856	$11,250	$4,300	$1,108,406
Clyde River	$1,092,856	$11,250	$2,867	$1,106,973
Grise Fiord	$802,795	$11,250	$512	$814,557
Hall Beach	$1,092,856	$11,250	$2,253	$1,106,359
Igloolik	$557,659	$11,250	$5,324	$574,233
Iqaluit	$0	$154,500	$21,502	$176,002
Kimmirut	$1,070,394	$11,250	$1,536	$1,083,180
Pangnirtung	$1,092,856	$11,250	$4,608	$1,108,714
Pond Inlet	$546,428	$11,250	$4,608	$562,286
Qikiqtarjuaq	$535,197	$11,250	$1,638	$548,085
Resolute bay	$1,070,394	$11,250	$922	$1,082,566
Sanikiluaq	$1,092,856	$11,250	$2,560	$1,106,666
Cambridge Bay	$1,092,856	$11,250	$5,119	$1,109,225
Gjoa Haven	$1,092,856	$11,250	$3,686	$1,107,792
Kugaaruk	$1,092,856	$11,250	$2,355	$1,106,461
Kugluktuk	$0	$11,250	$4,505	$15,755
Taloyoak	$0	$11,250	$2,765	$14,015
Arviat	$0	$11,250	$7,167	$18,417
Baker Lake	$0	$11,250	$6,041	$17,291
Chesterfield Inlet	$1,070,394	$11,250	$1,126	$1,082,770
Coral Harbour	$1,092,856	$11,250	$2,662	$1,106,768
Rankin Inlet	$0	$11,250	$8,191	$19,441
Repulse Bay	$1,092,856	$11,250	$2,560	$1,106,666
Whale Cove	$0	$11,250	$1,229	$12,479
Totals	**$17,674,671**	**$424,500**	**$102,391**	**$18,201,562**

Source: Department of Environment, Government of Nunavut (2010). [Estimated capital costs to implement a beverage container recycling program in Nunavut]. Unpublished data.