WASTE MINIMIZATION AT CHALK RIVER LABORATORIES

Pamela Kranz and Pierre C.F. Wong
Atomic Energy of Canada Limited
Chalk River, Ontario, Canada

ABSTRACT

Waste minimization supports Atomic Energy of Canada Limited (AECL) Environment Policy with regard to pollution prevention and has positive impacts on the environment, human health and safety, and economy. In accordance with the principle of pollution prevention, the quantities and degree of hazard of wastes requiring storage or disposition at facilities within or external to AECL sites shall be minimized, following the principles of Prevent, Reduce, Reuse, and Recycle, to the extent practical.

Waste minimization is an important element in the Waste Management Program. The Waste Management Program has implemented various initiatives for waste minimization since 2007. The key initiatives have focused on waste reduction, segregation and recycling, and included: 1) developed waste minimization requirements and recycling procedure to establish the framework for applying the Waste Minimization Hierarchy; 2) performed waste minimization assessments for the facilities, which generate significant amounts of waste, to identify the opportunities for waste reduction and assist the waste generators to develop waste reduction targets and action plans to achieve the targets; 3) implemented the colour-coded, standardized waste and recycling containers to enhance waste segregation; 4) established partnership with external agents for recycling; 5) extended the likely clean waste and recyclables collection to selected active areas; 6) provided on-going communications to promote waste reduction and increase awareness for recycling; and 7) continually monitored performance, with respect to waste minimization, to identify opportunities for improvement and to communicate these improvements.

After implementation of waste minimization initiatives at CRL, the solid waste volume generated from routine operations at CRL has significantly decreased, while the amount of recyclables diverted from the on-site landfill has significantly increased since 2007. The overall refuse volume generated at CRL (including solid radioactive waste, inactive waste and recyclables) decreased by 14% from 2007 to 2010. It should be noted that the workforce at CRL increased by approximately 15% during the same period. When considering the refuse volume data on a per capita basis, the volume of overall refuse per person was reduced from 3.03 m^3/person in 2007 to 2.25 m^3/person in 2010. This represents a 26% reduction in refuse in three years. This paper describes the waste minimization initiatives and the achievements at CRL in details, and also the planned initiatives in future.

Subject key words: Waste Minimization; Pollution Prevention; Waste Reduction; Recycling.

1. INTRODUCTION

The Chalk River Laboratories (CRL) site is a large nuclear site operated by Atomic Energy of Canada Limited (AECL). The CRL site is located in Renfrew County in the Province of Ontario on the south shore of the Ottawa River, and is physically complex comprising more than 165 buildings. The complexity is a result of a wide variety of operations carried out at CRL, including nuclear research reactor operation, radioisotope production, hot cell operations, nuclear fuel fabrication, Research & Development (R&D) activities, waste management operations, etc. These diversified operations occur in both Controlled Area 1 (CA1) and Controlled Area 2 (CA2; i.e., active area) and generate different types of waste including radioactive waste, hazardous waste, mixed waste, likely clean waste and traditional waste (including recyclable materials).

Waste minimization supports AECL's Environment Policy with regard to pollution prevention and has positive impacts on the environment, human health and safety, and economy. AECL's Environment Policy states that:

> "We are committed to pollution prevention";
>
> "We comply with environmental laws, requirements, and recognized standards and guidelines applicable to our activities"; and
>
> "We also focus our environmental efforts on minimizing nuclear legacy obligations for future generations".

In accordance with the principle of pollution prevention, the quantities and degree of hazard of wastes requiring storage or disposition at facilities within or external to AECL sites shall be minimized, following the principles, in order of most favourable option first, of Prevent, Reduce, Reuse, and Recycle, to the extent practical.

While an informal waste minimization program was in existence at CRL for decades, a formal Waste Management (WM) Program was established in 2007 in recognition of a need to address the waste issues in a more focused and disciplined manner, and to establish a framework for continual improvement. Waste minimization at CRL is an important element in the WM Program.

The WM Program has implemented various initiatives for waste minimization since 2007. This paper describes the waste minimization initiatives and the achievements at CRL, and plans for future initiatives.

2. WASTE MINIMIZATION FRAMEWORK

Waste minimization means the reduction, to the extent feasible, of waste that is generated prior to treatment, storage and disposition. It is defined as any source reduction or recycling activity that results in either 1) minimization of the total volume of waste, 2) minimization of radioactive and hazardous waste content, or 3) both. To the extent practical, waste that cannot be reused or recycled should be processed for storage or disposition. Practices that are considered waste minimization include source reduction and separation, process changes, the use of less hazardous materials, reuse and recycle, etc.

After the WM Program was formed, the waste minimization requirements were documented to establish the framework for applying the Waste Minimization Hierarchy within AECL as shown in Figure 1. A requirement of AECL's WM Program is that facilities and activities at AECL sites shall be planned, designed and operated or conducted in a manner that minimizes both the volumes and the hazard of wastes generated and wherever practical, the principle of Prevent, Reduce, Reuse, and Recycle are to be applied.

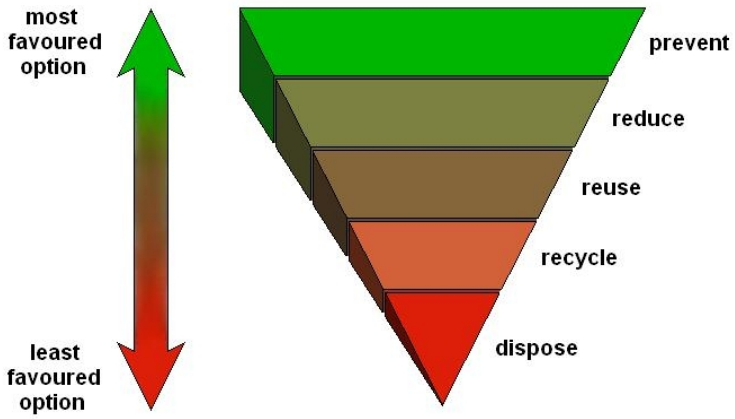

Figure 1. Waste Minimization Hierarchy

The WM Program has committed to achieve the following goals for waste minimization:

- Reducing the amount of solid waste generated;
- Implementing effective and sustainable waste reduction processes and procedures; and
- Continuing to monitor the performance and improve in the area of solid waste diversion.

Implementation of the waste minimization initiatives is centered on community-based social marketing techniques. This involves four key steps: 1) identifying the barriers and benefits to an activity; 2) developing a strategy that utilizes "tools" that have been shown to be effective in changing behaviour; 3) piloting the strategy; and 4) evaluating the strategy once it has been implemented across a community. Following these steps creates effective initiatives to foster sustainable behavior.

3. WASTE MINIMIZATION INITIATIVES

The WM Program has successfully implemented various initiatives for waste minimization since 2007, based on the Waste Minimization Hierarchy, through Prevent, Reduce, Reuse and Recycle.

3.1 Prevent

Pollution Prevention is the use of materials, processes, or practices that reduce or eliminate the creation of pollutants or wastes at the source. It includes practices that reduce the use of hazardous and non-hazardous materials or other resources, as well as practices that protect natural resources through conservation or more efficient use.

At CRL, waste prevention is previously achieved through prevention of contamination, and is sustained through extensive use of communications and waste minimization assessments.

3.1.1 Prevention of contamination

It is important to minimize the spread of contamination with a view to reducing the need for decontamination and disposition of materials as radioactive waste. It is desirable to prevent contamination to the extent that can be economically justified taking into account of possible additional risks and complications in operations. A single and effective example is removal of packaging materials for equipment or supplies in the inactive area prior to shipping materials to the facilities within the active areas at CRL. This prevents having to treat packaging materials as contaminated materials and promotes reuse and recycling of packaging materials.

Segregation of waste within a nuclear facility is also vitally important for prevention of cross contamination. Restricting radioactive work to as small an area as possible and ensuring that materials are adequately segregated enables waste minimization to be effectively implemented.

3.1.2 Communication and training

Communication and training are important tools for providing all stakeholders with the standards, knowledge and support for waste minimization. Communications on this topic are generally aided by the fact that staff wish to apply good practices in their homes to their workplace. The tools used at CRL include:

- Presentations at branch and safety meetings for waste management awareness; and
- Waste management awareness training to describe the importance of waste segregation and waste minimization to reduce future liability;
- Training for waste officers from various facilities and buildings to promote the culture changes in waste minimization;
- The WM Program webpage on AECL's internal web site for information on waste minimization requirements;
- Communication bulletins on AECL's internal web site and articles in AECL's publications to promote waste reduction; and
- AECL's sites participation in Waste Reduction Week (WRW) in Canada as an opportunity to promote waste minimization, to educate staff on the costs of wastes and how waste is processed, and improvements being implemented.

The WM Program continues to undertake benchmarking comparisons with external organizations to adopt best practices in the industry. Communications with various municipal and provincial waste management organizations have been established to share experiences, as well as to understand and discuss issues of common concern.

Particularly the WM Program has established partnerships with external recycling agents such as Ottawa Valley Waste Recovery Centre (OVWRC) to improve the recycling practices. The WM Program has developed good rapport and communications with OVWRC, which receives the bulk of CRL recyclables, that has allowed data sharing, to record, analyze and trend waste minimization efforts.

3.1.3 Waste minimization assessment

The WM Program has developed a process for conducting waste minimization assessments in facilities. The intent of this process is to identify the opportunities to prevent the generation of waste where possible, reduce volumes of waste generated, and maximize reuse and recycle. The outcome of the waste minimization assessment is a Waste Reduction Work Plan to identify the opportunities for waste prevention or reduction and assist the waste generator to develop waste reduction targets and action plans to achieve the targets. The WM Program staff will conduct periodic reviews to assess progress towards meeting targets and provide advice and assistance as required.

3.2 Reduce

At CRL, emphasis is placed on the segregation of different waste types in order to reduce the volumes of radioactive waste and hazardous waste requiring long-term management. In addition, AECL may utilize non-AECL facilities within Canada and the United States to volume reduce radioactive, hazardous and mixed waste requiring long-term management at CRL. This option will only be taken if it is demonstrated that the waste will be volume reduced in a safe and environmentally acceptable manner and if there is a favourable business case. For example, in the first few months of 2011 CRL sent approximately 180 m^3 of

legacy waste to off-site facilities in the United States for incineration and metal melt. The volume-reduced secondary waste from the incineration is returned to CRL for storage. The metal melt is recycled for use in the nuclear industry.

3.2.1 Colour coding system for waste containers

Proper segregation of waste is a key step to minimize the radioactive and hazardous wastes that require long-term management. The initiative to standardize the waste containers and establish a colour-coding system to improve waste segregation at the source has been implemented at CRL and will be implemented at AECL's Whiteshell Laboratories (WL). Through this color-coding system, the containers for radioactive waste, likely clean waste, clean waste, organic waste and recyclables are easily identified to enhance waste segregation. Figure 2 illustrates the colour-coding waste containers at CRL.

Figure 2. Colour-Coding Waste Containers Used at CRL (a): Radioactive Waste, (b) Likely Clean Waste, (c) Clean Waste, (d) Container Recycling, (e) Paper Recycling (f) Desk-side Paper Recycling, (g) Battery Recycling, (h) Organic Waste for Composting

3.2.2 Likely clean waste collection

A robust process is required for segregation of likely clean waste from radioactive waste in CA2. Likely clean waste is material that is not expected to be contaminated or radioactive as determined by its history, location and use, and requires suitable radiological clearance monitoring to be declared clean. The entire process is in support of AECL's obligations to protect the health and safety of the public, the workers and the environment, and to minimize nuclear legacy obligations for future generations. Working with the Radiation Protection Program, a process for approval of suitable likely clean waste collection locations in CA2 has been developed and is being used in CA2 at CRL.

The process identifies the radionuclides possibly present at the potential collection location in a facility and utilizes the radionuclide fingerprint of the facility to determine whether the waste collected at this location qualifies as likely clean waste, and can be cleared by the waste analysis facility at CRL based on its detection capabilities and operating procedures. Currently, CRL clears waste based on the history of the collection location and the unconditional clearance levels, as specified in the CNSC Nuclear Substances and Radiation Devices Regulations [1]. For example, a known history of equipment contamination incidents and personal contamination incidents increases the risk of waste being contaminated and thus, very little of

the waste from that facility, if any, would be classified as likely clean waste. Changes in facility operations, equipment contamination incidents or personal contamination incidents may also trigger a review of the approved collection locations of likely clean waste at any time during the two-year review cycle.

3.2.3 Waste reduction monitoring

The volumes of solid radioactive waste and inactive waste, generated from routine operations (i.e., excluding wastes generated from decommissioning activities) at CRL are carefully tracked and provide a basis for measuring waste minimization performance. The WM Program has aligned its initiatives and activities to the waste minimization performance measure in order to reduce the life-cycle waste management and future liability costs at CRL.

The annual volumes of solid radioactive and inactive wastes generated from routine operations at CRL from 2007 to 2010 are shown in Figure 3. The data show a reduction of 26% in solid waste volume generated from routine operations at CRL during the reporting period. This is a notable achievement in view of the fact that the workforce at CRL increased by about 15% during the same period. When considering the waste volume data on a per capita basis, the volume of solid waste generated per person was reduced from 2.23 m^3/person in 2007 to 1.43 m^3/person in 2010. This represents a 36% reduction in waste volume in three years.

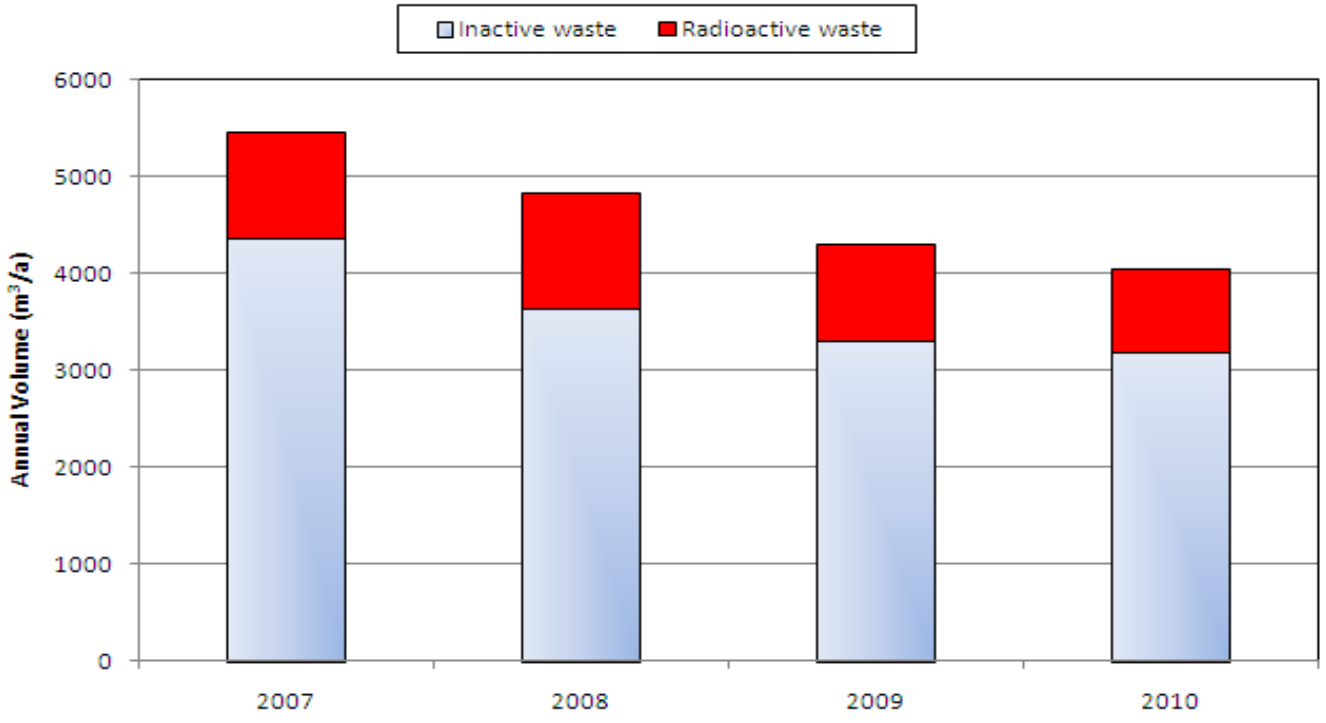

Figure 3. Annual Volumes of Solid Waste Generated from Routine Operations at CRL from 2007 to 2010

3.3 Reuse

Reuse of sites, facilities, installations or materials for other purposes should be considered and practiced whenever practical to do so. Examples for reuse practices at CRL include:

- Large plotter paper rolls are usually replaced before the paper runs out. These "roll ends" have several meters of high quality paper remaining that would have otherwise gone as unused. Over the last few years, more than 150 of these roll ends have been donated to local community childcare centres or schools for poster projects.
- The site library was previously discarding several hundred magazine boxes. The boxes could not be recycled, as they were a composite material. As an alternative, truckloads of these magazine boxes were delivered to local municipal and school libraries for reuse.
- White clothing used at the whole body count facility was replaced with a more practical style. Subsequently, a total of twelve boxes of used white shirts and pants were transferred to the site paint shop for reuse.
- Business, facility and lab supplies are currently distributed around CRL in reusable plastic totes or reusable plastic bags instead of cardboard boxes that would become non-recyclable waste in CA2 areas.
- Concrete slab waste represents approximately 75% of all building decommissioning waste volume and as a result, over 140,000 m^3 of likely clean waste concrete will be generated from building decommissioning activities at CRL over the next 70 years. Mobile concrete crushing equipment has been acquired at CRL that will provide the capability to cost effectively process the likely clean concrete waste. This equipment will crush the concrete to a form that permits final clearance assessment. The cleared crushed concrete is a valuable product suitable for reuse for road and fire-break maintenance on site and the rebar from the concrete slabs is sent to metal recyclers.

3.4 Recycle

In 2007, a comprehensive review of recycling practices at CRL was performed to identify process gaps and opportunities for improvement. This involved communications with building occupants and waste pickup staff, evaluation of location, quantity, signage of the recyclable bins and input from an external recycling agent. Based on the findings, a list of actions were identified and taken to improve recycling practices. These included:

- Issuing a procedure for recycling at CRL to describe the requirements, responsibilities and process for collecting recyclables at CRL;
- Informing employees about recycling requirements, responsibilities and process through use of posters, presentations, communication bulletins, articles in AECL's internal publications;
- Implementing standardized, colour-coded recyclables collection bins with clear signage showing the types of recyclables accepted (i.e., bins (d) to (g) in Figure 2);
- Partnering with OVWRC to improve and maximize recycling at CRL;
- Participating in Waste Reduction Week in Canada, which included various promotional activities for waste reduction and recycle;
- Extending the recyclable collection to selected active areas; and
- Implementing collection of organic, compostable waste at CRL.

After implementation of the above waste minimization initiatives at CRL, the amounts of the clean materials shipped to OVWRC for recycling increased significantly in 2008, as shown in Figure 4. The materials for recycling in the blue box program include corrugated cardboard, paper and containers (cans, bottles, plastic jugs, foam). The organics (food waste from the cafeteria kitchen and paper towel waste from selected bathroom areas) are collected in green carts for composting.

Other non-blue box items for recycle at CRL include scrap metal, Waste Electrical and Electronic Equipment (WEEE), secure shredded paper, printer toner cartridge compact, wood pallets, fluorescent light

tubes and batteries. For examples, approximately 1,000 m^3 of the clean scrap metal is sent off-site for recycling each year (Figure 5**).** A total of 123,800 kg of lead was shipped off-site for recycle and use elsewhere in the nuclear industry in last four years. A total of 87,000 kg of security documents were shredded and recycled in last two years (2009 - 2010). Approximately 1,000 toners are sent back to the manufacturers for refill or recycle per year. Wood pallets are taken back by the suppliers.

The key benefit from the diversion of recyclables and organic waste from the CRL on-site landfill is to extend the service life of the on-site inactive landfill. Recent estimates indicate that the on-site inactive landfill service life has been extended by approximately seven years owing to waste minimization activities and improved operating procedures.

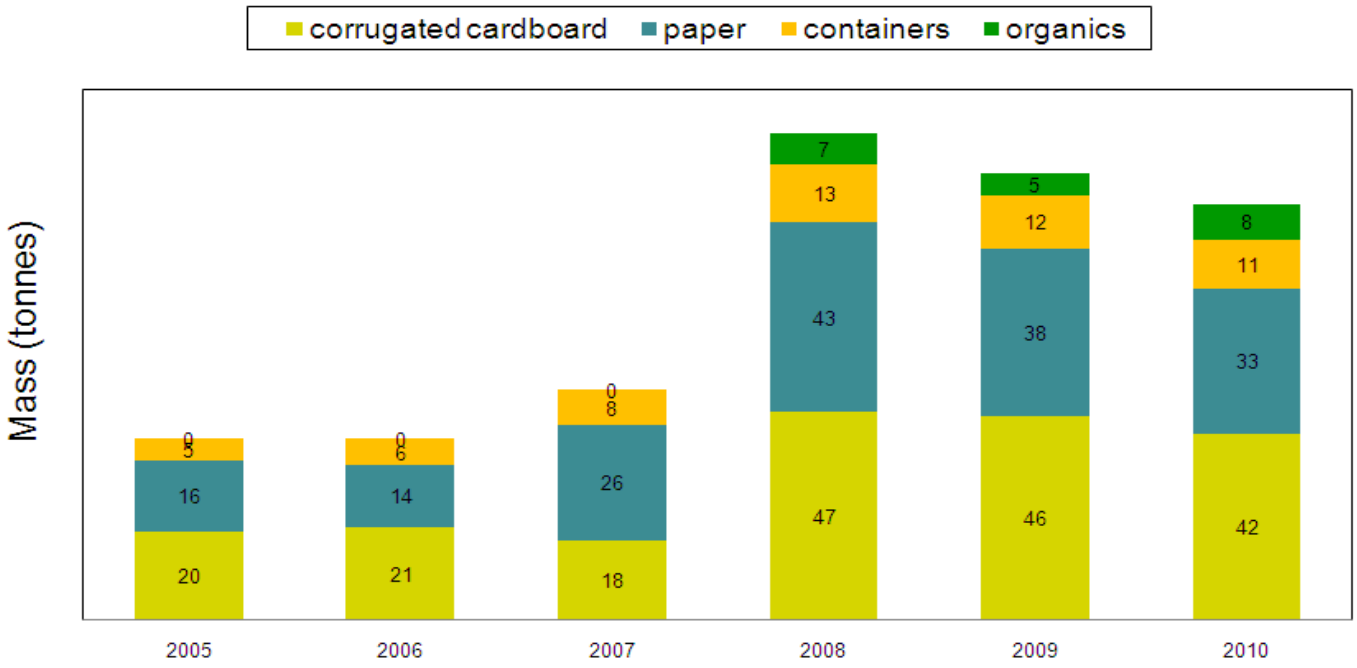

Figure 4. Amounts of Materials Shipped from CRL to OVWRC for Recycling or Composting from 2005 to 2010

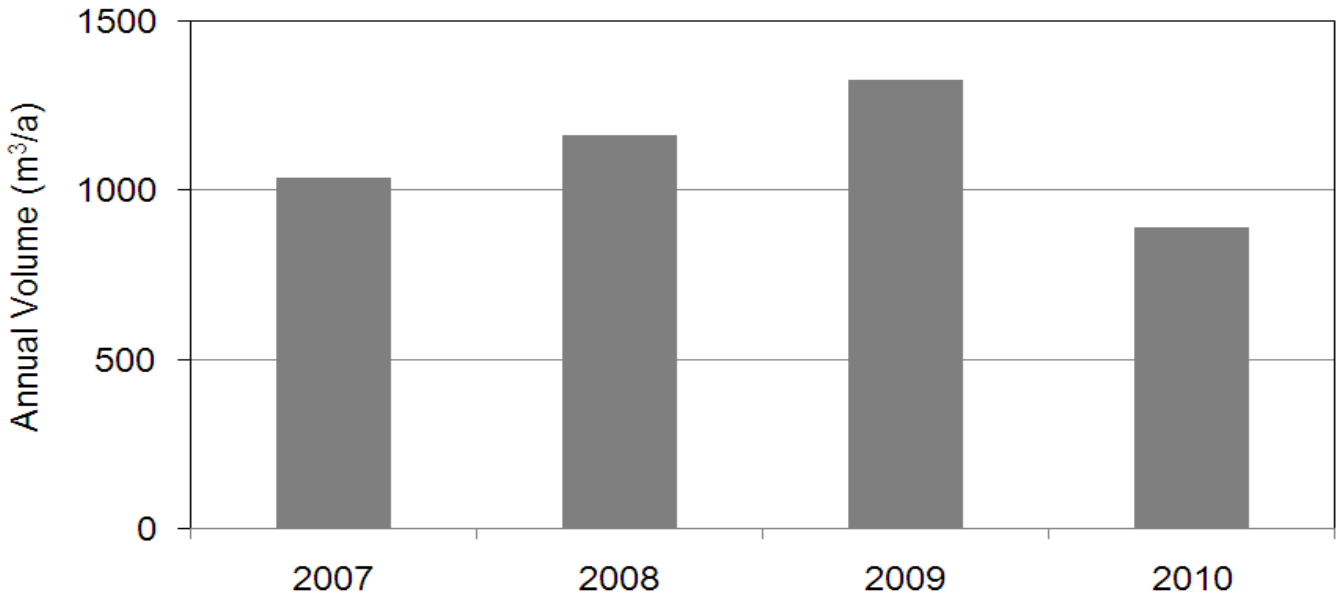

Figure 5. Amount of Metal Shipped from CRL to Off-site Agents for Recycling from 2007 to 2010

4. PERFORMANCE MEASURES AND ACHIEVEMENTS

In 2008, AECL received a Gold Ontario Waste Minimization Award from the Recycling Council of Ontario (RCO) in recognition of the leadership and innovation of waste reduction programs.

From 2007 to 2010, the overall refuse volume (including solid waste and recyclables) generated from routine operations at CRL, decreased by 14%. It should be noted that the workforce at CRL increased by approximately 15% during the same period. When considering the refuse (solid waste and recyclables) volume data on a per capita basis, the volume of overall refuse per person was reduced from 3.03 m^3/person in 2007 to 2.25 m^3/person in 2010. This represents a 26% reduction in refuse in three years.

The total saving in waste management costs resulting from waste volume reduction from 2008 to 2010 is at least one million dollars (using 2007 waste management costs as the reference).

Starting in 2010, CRL also uses the Waste Minimization Index (WMI) to monitor the waste minimization performance per quarter.

$$WMI\ in\ Q_n = \frac{Volume\ per\ Person\ in\ Q_{n-1}}{Volume\ per\ Person\ in\ Q_n}$$

Where Q_n is the quarter number n. The objective is to keep the index equal or greater than 1. This is a challenging goal and the WMIs ranged from 0.97 to 1.04 in the last four quarters.

5. PLAN FOR FUTURE INITIATIVES

There are many future initiatives that are being considered for waste minimization at CRL. Some examples are given below:

- Expanding the organic waste collection (i.e., including food waste in building kitchen areas) at CRL;
- Improving the green procurement procedure and enhancing the communication to reduce potential waste coming to CRL from the suppliers;
- Expanding the list of recyclables to include tires, paints, oils, and other household hazardous waste;

- Increasing re-use of facilities, installations or materials such as electrical cable reels, cleaning solutions, etc.
- Introducing compostable utensils in the cafeteria, such as durable forks and spoons made of corn or potato starch; and
- Introducing desk-top mini trash bins to employees. Each mini-bin holds about three cups of waste. The effect of this mini-bin is to raise awareness in each employee of the volume of waste they generate and to promote, on an individual basis, a conscious effort to produce as little garbage as possible.

6. SUMMARY

After implementation of waste minimization initiatives at CRL in 2007, the waste volume generated from routine operations at CRL has significantly decreased, while the amount of recyclables diverted from the on-site landfill has significantly increased.

From 2007 to 2010, the annual volume of solid waste (including inactive and radioactive wastes) generated from routine operations at CRL decreased by 26%, and the annual amount of recyclables sent to off-site recycling agents increased by 19%, thus showing a significant amount of waste diverted from landfill.

The overall refuse volume generated at CRL (including solid waste and recyclables) decreased by 14% from 2007 to 2010. This is a notable achievement in view of the fact that the workforce at CRL has increased by about 15% during the same period.

The total saving in waste management costs resulting from waste volume reduction from 2008 to 2010 is at least one million dollars (using 2007 waste management costs as the reference), and the estimated service life of the on-site inactive landfill has been extended by approximately seven years.

A number of initiatives are currently being considered to further improve waste minimization processes at CRL in the future.

7. REFERENCES

[1.] Canadian Nuclear Safety Commission, "Nuclear Substances and Radiation Devices Regulations", SOR/2000-207, 2011. Canada.Minister of Justice. Available from URL: http://laws-lois.justice.gc.ca/PDF/SOR-2000-207.pdf