LOW LEVEL RADIOACTIVE WASTE DISPOSAL IN THE ABSENCE OF A DISPOSAL SITE

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ABSTRACT

This paper describes a six-step strategy to dispose of the large quantity and diverse waste types produced at Cameco's Port Hope uranium conversion facility. The strategy provides a logical step by step process to first characterize a waste, then identify and assess feasible options and select a preferred disposal or recycle route. Regulatory and financial approvals are obtained and, finally, implementation of the preferred route takes place.

A total of 29 waste types have been identified at the facility. By employing the waste disposal strategy, some 16 wastes are now disposed of or routinely recycled . This represents about 3000 tons of waste material annually. The waste disposal strategy is currently being applied to another ten of the wastes: oils, non-usable drums, scrap metal, zirconium tetrafluoride (ZrF_4), PCB liquids, PCB solids, magnesium fluoride, miscellaneous chemicals, waste solvents and calcium fluoride. The strategy is described for three of these: non-usable drums, scrap metal and ZrF_4.

INTRODUCTION

Radioactive materials have been processed at Port Hope, Ontario, Canada (Fig.1) since 1932. In the early years, uranium ore from Canada's Northwest Territories was processed to recover radium. By the late 1960's, the emphasis had shifted to the production of uranium dioxide fuel for CANDU nuclear power reactors and, by 1970, included the production of uranium hexafluoride the feed material for the enriched fuel used in light water reactors. For most of this 57 year period, the wastes were buried at a Company owned waste management facility located near the Port Hope plant. However, within the last ten years, limited space at this facility has forced the Company to store, on the plant site, many of the wastes which had previously been buried at the waste management facility. This paper describes actions taken to deal with this recent

Fig. 1. Location Map.

accumulation of various wastes and to ensure that future wastes are disposed of as they are produced.

A major program to dispose of about one million tons of wastes and associated contaminated soils stored at the Company's waste management facilities was initiated in 1982, and had progressed to the site selection stage. In 1986, however, in response to vocal public opposition, the Government of Canada directed the Company to halt all activity associated with the selection and development of a new low level radioactive waste disposal site. The Government took over the task of identifying and selecting a suitable site and building the disposal facility. Because the site selection process is not yet completed, and, consequently, no timeframe for operating the facility has been decided, the Company has been placed in a difficult position with respect towaste management. Faced with this uncertainty, a strategy has been chosen which seeks to dispose of historical and future wastes by a variety of routes that do not depend upon the ready availability of a Canadian low level radioactive waste disposal site. This waste disposal strategy and its application to wastes at the Company's conversion facility in Port Hope are described in the following sections.

WASTE DISPOSAL STRATEGY

The waste disposal strategy, shown schematically in Fig. 2, comprises the following six steps:

1. Characterize wastes
2. Identify disposal concepts
3. Assess most promising options
4. Select preferred disposal route
5. Obtain regulatory approval
6. Obtain financial approvals and implement

A total of 29 waste types have been identified at Port Hope. The six-step disposal strategy is currently being followed for ten of the wastes as listed in Table I. Its application to the ten wastes is summarized in Table II. This table demonstrates that significant progress has been made to date on eight of these: oils, drums, scrap metal, zirconium tetrafluoride, PCB liquids, PCB solids, magnesium fluoride and calcium fluoride. In the following sections, the application of the disposal strategy will be described in detail for three of the wastes: drums, scrap metal and zirconium tetrafluoride (ZrF_4).

Step 1
Characterize Wastes

Step 2
Identify Disposal Concepts

Step 3
Assess Most Promising Options

Step 4
Select Preferred Disposal Route

Step 5
Obtain Regulatory Approval

Step 6
Obtain Financial Approvals
and Implement

Fig. 2. Waste Disposal Strategy.

APPLICATION OF WASTE DISPOSAL STRATEGY

Step 1. Characterize Wastes

Actions taken to fully characterize a waste include the following:

(i) Review historical plant records
(ii) Visually inspect suspected wastes
(iii) Measure surface radiation contamination
(iv) Carry out decontamination trials
(v) Sample for chemical analysis
(vi) Determine uranium isotopic ratio
(vii) Carry out leachate toxicity test
(viii) Carry out preliminary pathways analysis

The selection of appropriate actions depends on the nature of the waste being evaluated and the most feasible disposal options available.

For drums and scrap metal, wastes normally produced in a chemical processing plant, four actions were taken to characterize the wastes as shown in Table II. Because of the similarity of these wastes, the actions taken were identical. First, a visual inspection was done to determine their physical state. Second, the wastes were segregated. A total of 55,000 drums were identified as non-usable and 1440 tons of scrap metal were divided into four categories: 10 tons of

Table I
List of Ten Waste Types.

Waste Type	Inventory/Annual Production*	Brief Description
1. Waste Oils	600 Drums	Waste lubricating oils, grease,vacuum pump oils contaminated with 15 to 13000 ppm uranium and/or 50 ppm PCB
2. NonUsable Durms	55000 Drums	Rusty, nonusable 55 gallon steel drums with uranium contamination
3. Scrap Metal	1440 Tons	Copper, stainless steel, carbon steel and aluminum with uranium contaminationon the surfaces
4. Zirconium Tetrafluoride	8 Drums	Impure zirconium tetrafluoride solid contaminated with rust
5. PCB Liquids	2500 Litres	Transformer/capacitor oil
6. PCB Solids	200 Kilograms	PCB contaminated rags, soil and debris
7. Magnesium Floride	13000 Drums	Solid residue produced in the uranium metal making process contaminated with 5% depleted uranium (depleted uranium contains less than 0.7% uranium235)
8. Miscellaneous Chemicals	8 Drums	Mainly ethylene glycol contaminated with low
9. Waste Solvents	12 Drums	Organic solvents such as butanol and pyridine contaminated with low levels of uranium
10. Calcium Floride	1400 Tons*	Solid residue produced in the regeneration of gaseous fluorides scrubbing circuit; this

Note: Unless specified, the uranium contains 99.3% U238 and no less than 0.7% U235 also called natural uranium.

copper, 120 tons of stainless steel, 1285 tons of carbon steel and 25 tons of aluminum. Third, each waste was monitored for surface radiation to quantify the extent of uranium-based contamination, the predominant source of contamination likely to be found at Port Hope. All non-usable drums were found to be contaminated with some level of uranium. Specifically, they exceeded the surface uranium contamination criteria of 3.7 Bq/cm^2. The drums were used previously to ship uranium mine concentrates from both Ontario and Saskatchewan mines to Port Hope for refining.Most of the scrap metal was also contaminated with uranium.

Finally, small scale decontamination tests were carried out on both the contaminated drums and the scrap metal to establish levels of non-removable contamination. The most appropriate disposal concepts were identified based on the results of this characterization work.

Zirconium tetrafluoride was classified as a waste because the chemical had been stored, out of doors, for over a decade and the containers had deteriorated. Also, there was no identified future use for the material. As shown in Table II, a total of five characterization actions were carried out. The first action, a review of plant records showed that this material had been an input chemical for a zirconium metal making process which was operated briefly in the early 1970's. Secondly, a visual inspection of the waste revealed the presence of iron oxides in all drums. The third action consisted of sampling the waste and analyzing for uranium contamination. No uranium contamination was found. Fourthly, leachate toxicity tests, specifically for fluoride content, were performed on composite samples of the drums. The test results indicated that the waste did not present a hazard. The fifth and final action was a tally; a total of eight drums of material were identified as a waste. This example illustrates that detailed characterization work is done even when only small waste volumes are being assessed.

Step 2. Identify Disposal Concepts

The results of the waste characterization work were used to determine a category for each waste. The wastes were classified into one of the following:

TABLE II
Application of the Six Step Waste Disposal Strategy

Waste Type	Step 1 Characterize Wastes	Step 2 Identify Disposal Concepts	Step 3 Assess Most Promising Options	Step 4 Select Preferred Disposal Route	Step 5 Obtain Regulatory Approval	Step 6 Obtain Financial Approvals And Implement
1. Waste Oils	Sampling and analysis program on the 600 drums to determine uranium and PCB concentrations	(i) Incineration and storage of ash at company facility	Not feasible; volumes do not justify incinerator costs	Disposal to commercial facility in Ontario, Canada	Regulatory approval to release the waste oils from the Port Hope plant to be obtained from the Atomic Energy Control Board (AECB)	Corporate financial approvals expected in 1989 Implementation in 1989
	Segregation into 2 categories: 1) 58 drums U,PCB contaminated oils 2) 542 drums U contaminated oils	(ii) Incineration and storage of ash at commercial facility	Feasible because AECL has the technology and licenses to operate			
		(iii) Disposal at facility elsewhere in Canada or U.S.	Not feasible; transborder or interprovincial highway shipments of PCB are banned			
		(iv) Incineration at sea	Volume is too small			
2. Non-Usable Drums	Visual inspection of drums to determine if reuse was possible	(i) Recycle to scrap steel outlets	Not feasible because U contamination cannot practicably be removed	Disposal in U mine tailings in Ontario and Saskatchewan	Regulatory approvals from AECB, Ontario Ministry of Environment, and Saskatchewan Environment were obtained	Corporate financial approvals obtained in 1987 Implementation began in 1987 with expected completion in 1989
	Segregation of 55,000 non-usable drums Beta/Gamma survey to identify those contaminated with U	(ii) Disposal at a radioactive waste disposal facility	Large volumes and low U contamination levels unsuitable for radioactive waste disposal facility			
	Decontamination trials to remove uranium	(iii) Disposal in U mine tailings in Ontario and Saskatchewan	Feasible because of lower cost and compatibility with materials disposed in mine tailings			
3. Scrap Metal	Visual inspection and segregation into metal types	(i) Recycle uncontaminated metal through established outlets	Feasible for clean metal or easily decontaminated metal	Recycle of metal through established/regulated outlets is preferred	Regulatory approvals from AECB and Ontario Ministry of Environment were obtained	Corporate financial approvals obtained in 1981 Implementation began in 1981
	Segregation of 1440 T of metal into the following categories: - 10 T copper - 120 T stainless steel - 1285 T carbon steel - 25 T aluminum	(ii) Recycle mildly U contaminated metal to a regulated outlet	Feasible for metal which retains some contamination after thorough cleaning			
	Beta/Gamma survey to determine U contamination	(iii) Disposal at a radioactive waste disposal facility	Large volumes and low U contamination levels unsuitable for radioactive waste disposal facility			
	Decontamination trials to remove uranium	(iv) Disposal in U mine tailings in Ontario	Feasible because of compatibility with major materials disposed in mine tailings			

TABLE II, Cont'd

4. Zirconium Tetrafluoride (ZrF_4)	Review plant records to determine age of ZrF_4 Visual inspection to determine material's condition Sampling and analysis to determine U contamination Performed leachate toxicity testwork to determine if hazardous A total of 8 205 L (55 gallon) drums were identified	(i) Recycle to external facility (ii) Disposal at a chemical waste management landfill facility	Not feasible; an outlet was not identified within a reasonable timeframe Feasible because of compatibility with other wastes disposed of at landfill facility	Disposal at licensed chemical waste management landfill facility	The Ontario Ministry of Environment was notified; No AECB regulatory approvals required	Corporate financial approvals obtained in July 1988 Implementation took place in August 1988
5. PCB Liquids stored in transformers/ capacitors	Review plant records to determine PCB oil types Sampling and analysis to determine U contamination Beta/Gamma survey to identify equipment contaminated with U	(i) Incineration and storage of ash at company facility (ii) Disposal at facility elsewhere in Canada or U.S. (iii) Disposal at licensed facility in the UK	Not feasible; volumes do not justify incinerator costs Not feasible; transborder or interprovincial PCB shipments are banned Feasible because UK facility has the technology and licenses to operate	Disposal at a licensed facility in the U.K.	A licensed carrier must be identified to transport the PCB to a Canadian port	Corporate financial approvals expected in 1989 Implementation is planned for 1989
6. PCB Solids (soils, rags)	Review plant records to determine source of material Visual inspection to determine type and volume of waste Sampling and analysis to determine U contamination	(i) Incineration and storage of ash at company facility (ii) Disposal at facility elsewhere in Canada or U.S. (iii) Disposal at licensed facility in the UK	Not feasible; volumes do not justify incinerator costs Not feasible; transborder or interprovincial PCB shipments are banned Feasible because UK facility has the technology and licenses to operate	Disposal at a licensed facility in the U.K.	A licensed carrier must be identified to transport the PCB to a Canadian port	Corporate financial approvals expected in 1989 Implementation is planned for 1989
7. Magnesium Fluoride	Visual inspection to determine physical state of drums Sampling and analysis to determine (a) Total U (b) U-235 and (c) impurities	(i) Removal of U contamination and recycle to steel mills as slagging material (ii) Recycle to a U processing facility in France	Not feasible because U contamination cannot be practicably removed Feasible because the French company seems to have the technology to recycle this waste	Recycle to a U processing facility in France is preferred	Export permits from Canada and import permits into France will be required; AECB must be notified of the company's plans	Once testwork has been completed successfully, and the French determine that the material is suitable, financial approvals will be obtained.

TABLE II, Cont'd

	Performed leachate toxicity testwork to determine if hazardous	(iii) Disposal at a commercial facility in Canada or U.S.	Feasible at a U.S. licensed disposal site because of compatibility with similar wastes disposed currently			Implementation is planned to begin in the second half of 1989
8. Miscellaneous Chemicals	Sampling and analysis program on the 8 drums to determine uranium contamination Segregation into 2 categories: 1) U contaminated chemicals 2) Uncontaminated chemicals	(i) Incineration and storage of ash at company facility (ii) Incineration and storage of ash at commercial facility (iii) Incineration at sea	Not feasible; volumes do not justify incinerator costs Feasible for both the U contaminated and non-contaminated chemicals Volume is too small	Disposal of U contaminated to licensed radioactive treatment facility in Canada Disposal of non-contaminated to licensed hazardous treatment facility in Canada	Regulatory approval to release the chemicals from the Port Hope plant to be obtained from the Atomic Energy Control Board (AECB) Board The Ontario Ministry of Environment would be notified; no regulatory approvals required	Corporate financial approvals are expected in 1989 implementation in 1989
9. Waste Solvents	Sampling and analysis program on the 12 drums to determine uranium contamination Segregation into 2 categories: 1) U contaminated solvents 2) Uncontaminated solvents	(i) Incineration and storage of ash at company facility (ii) Incineration and storage of ash at commercial facility (iii) Incineration at sea	Not feasible; volumes do not justify incinerator costs Feasible for both the U contaminated and non-contaminated solvents Volume is too small	Disposal of U contaminated to licensed radioactive treatment facility in Canada Disposal of non-contaminated to licensed hazardous treatment facility in Canada	Regulatory approval to release the solvents from the Port Hope plant to be obtained from the Atomic Energy Control Board (AECB) Board The Ontario Ministry of Environment would be notified; no regulatory approvals required	Corporate financial approvals are expected in 1989 Implementation in 1989
10. Calcium Fluoride	Sampling and analysis to determine U, As, Th concentration Performed leachate toxicity testwork to determine if hazardous Gamma survey on waste to determine radiation levels Isotopic analysis to determine U-238/U-235 ratio	(i) Use in Ontario steel mills as fluxing agent (ii) Disposal at a commercial facility in Canada or U.S.	Not feasible because waste was not considered a suitable fluxing agent Feasible at a U.S. licensed disposal site because of compatibility with similar wastes disposed of currently	Disposal at a commercial hazardous landfill facility in U.S.	Regulatory approvals to be obtained from Atomic Energy Control Board; and U.S. state and federal regulatory authorities	Corporate financial approvals in 1989 Implementation expected to begin in March 1989

(i) Uranium contaminated wastes

(ii) Hazardous wastes including polychlorinated biphenyl (PCB)

(iii) Mixed wastes, a combination of (i) and (ii)

(iv) Uncontaminated wastes

Once the category had been assigned, suitable disposal or recycle concepts were identified. Where possible, recycling of a waste for the purpose of extracting any valuable resource is preferred to disposal. For some wastes, many concepts were suggested but only the more reasonable ones were considered further because of the limited resources available to assess concepts and propose feasible options.

The 55,000 non-usable drums were characterized as a uranium contaminated waste. As presented in Table II, three disposal/recycle concepts were identified for the drums:

- Recycle to scrap steel outlets
- Disposal at a radioactive waste disposal facility
- Disposal in uranium mine tailings

The scrap metal types were divided into two categories: uncontaminated wastes and uranium contaminated wastes. Table II lists four concepts based on the level of uranium contamination. Some combination of the following concepts will be used:

- Recycle uncontaminated metal through established outlets
- Recycle mildly contaminated metal to a regulated outlet
- Disposal of contaminated metal at a radioactive waste disposal facility
- Disposal of contaminated metal in uranium mine tailings

The zirconium tetrafluoride was categorized as an uncontaminated waste. The two most feasible concepts were:

- Recycle to an external facility
- Disposal at a licensed chemical waste management landfill facility

Step 3. Assess Most Promising Options

The merits of a particular disposal concept were evaluated on the basis of four assessment criteria:

(i) Compatibility with Company goals and objectives

(ii) Technical feasibility

(iii) Cost

(iv) Implementation within regulatory framework

The proposed concept must meet all four criteria in order to be considered an acceptable disposal option. Compatibility with the Company's goals and objectives plays an important role in assessing and selecting the most promising option. Where feasible, recycling of wastes for the purpose of extracting any valuable material is preferred. Further, any disposal concept must comprise an environmentally sound solution.

The technical feasibility of a proposed concept is assessed on the basis of one or more of the following: proven technology which is available either within the Company or at an external facility; compatibility with other waste types currently recycled or disposed of to the proposed route; and, reasonable timeframe for implementation.

The lowest cost concept is usually favoured provided, of course, that it is environmentally sound.

The selection of a disposal option must also be made on the basis of compatibility with existing environmental regulations. The Company is subject to regulation by five government agencies. These include the Atomic Energy Control Board, (the federal agency responsible for regulating radioactive materials), the federal and/or provincial environment ministries, and the federal and/or provincial agencies responsible for regulating transport related activities.

The results of the feasibility assessment are presented under Step 3 in Table II. Recycle of the drums as scrap steel was not considered feasible because uranium decontamination was not practicably achievable. Disposal at a radioactive waste management facility was not feasible either because it would not be cost effective to dispose of such large volumes (55,000 drums) with low uranium content. On the other hand, disposal in uranium mine tailings, considered to be an environmentally sound option, satisfied the four assessment criteria. Lower cost and compatibility with wastes currently being disposed of in mine tailings made this an attractive and technically feasible option. In addition, this concept can be implemented within existing Atomic Control Board Regulations. However, specific approvals from the Ontario and Saskatchewan Regulatory Agencies would be required prior to disposal in uranium mine tailings sites located in either of the provinces.

For scrap metal, recycle through established and regulated outlets met all four assessment criteria. This option also fulfilled the Company goal of recycle whenever possible. It was technically feasible because of compatibility with other recycled metals. The costs were reasonable and the option could be implemented within the existing regulatory framework. Metal which cannot be sufficiently decontaminated to allow recycle would be disposed of in uranium mine tailings.

While recycle of zirconium tetrafluoride would have been preferred, an acceptable outlet could not be found. Therefore, the only realistic option for this waste, which met all four assessment criteria, was disposal at a chemical waste management landfill facility. There are several licensed facilities in Canada and the one located closest to the Port Hope plant provides the most cost effective disposal route.

Step 4. Select Preferred Disposal Route

A preferred disposal/recycle route is selected on the basis of meeting the four assessment criteria listed in Step

3. For each waste type, the preferred route is listed below.

Waste Type	Preferred Route
Non Usable Drums	Disposal in uranium mine tailings
Scrap Metal	Recycle through established/regulated outlets
ZrF_4	Disposal at licensed chemical waste management landfill facility

Step 5. Obtain Regulatory Approval

As discussed previously, there are five government agencies which regulate the Company's waste management activities. These are:

(i) Atomic Energy Control Board

(ii) Environment Canada (federal environment ministry) (iii) Provincial environment ministries

(iv) Transport Canada (federal transport ministry)

(v) Provincial transport ministries

The regulatory requirements for the implementation of the preferred route are discussed below. Applicable to all routes which involve off-site waste shipments would be adherence to federal and provincial transport regulations. The required notifications and regulatory approvals for each waste are presented in Table II.

Disposal of the non-usable drums at an Ontario or Saskatchewan uranium mine tailings facility required the regulatory approval of the Atomic Energy Control Board (AECB). In addition, for disposal in Ontario, regulatory approval was obtained from the Ontario Ministry of the Environment. In Saskatchewan, approval was required from Saskatchewan Environment and Public Safety.

Notification of the Company's intention to recycle the scrap metal through established recycle routes was made to the AECB and the Ontario Ministry of the Environment. For recycle through regulated outlets, a more formal approval process was followed. This approval was obtained from the AECB. The regulatory requirements for disposal of contaminated scrap metal in uranium mine tailings would be identical to those for the non-usable drums.

The Ontario Ministry of the Environment was notified of the disposal of the zirconium tetrafluoride at the licensed chemical waste management landfill facility. AECB notification or regulatory approvals were not required because the waste is not radioactive.

Step 6. Obtain Financial Approvals and Implement

Once the regulatory approvals have been received, the next step is to obtain corporate financial approvals. Once these are given, implementation can take place. For each waste, the timetable for obtaining financial approval with subsequent implementation is presented in Table II.

To date, a total of 45,000 non-usable drums have been disposed of in Ontario and Saskatchewan uranium mine tailings. Regulatory approvals are being sought for the disposal of the remaining 10,000 drums.

Recycle of scrap metal through the developed outlets is presently taking place. About 1240 tons of scrap carbon steel has been recycled to date.

The eight 205-Litre (55-gallon U.S.) drums of zirconium tetrafluoride were sent for disposal at a licensed Canadian chemical waste management landfill facility in August 1988.

WASTE BUILDUP IN THE FUTURE

The success of waste disposal programs depends on the establishment of sound, practical routes for the waste backlog and the annually generated quantities.

The following example of empty drum management illustrates how an overall program for drum management will eliminate the buildup of this waste in the future. The program is illustrated in Fig.3.

Uranium concentrate is shipped to the Company's refining facility in Blind River, Ontario from mines in Canada and abroad (see Fig.1 for the Blind River location). There, the concentrate is purified to nuclear grade material which is then converted to UO_2 or UF_6 at Port Hope. The concentrate is shipped to the refinery in 205-Litre steel drums; in any year, as many as 60,000 drums may be received.

Agreements have been successfully negotiated with all Canadian uranium mines for the return of cleaned empty drums for recycling and reuse. On average, each drum can be used up to five times before it must be discarded. Empty drums from non-Canadian mines are also recycled to Canadian users where possible. To ensure that there is no buildup of old non-recyclable drums at the refinery, a

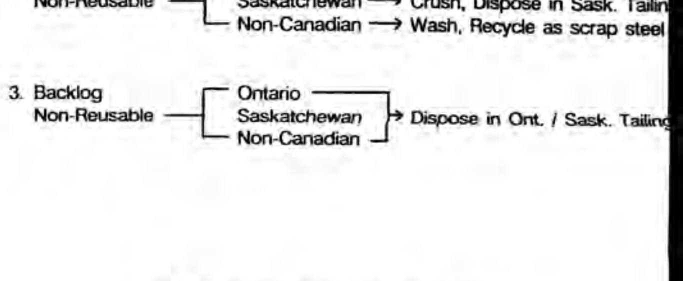

Fig. 3. Drum Disposal Program.

program has been set up with the Ontario and Saskatchewan uranium mines which allows the discarded or damaged drums to be returned to the appropriate mine for disposal. Discarded non-Canadian drums are currently stored at the refinery. Current plans call for these to be decontaminated and recycled as scrap metal.

As of 1987, 55,000 rusting non-usable drums were stored at the Company's refining and conversion facilities. These had accumulated over a period of about 10 years. In developing the drum management program, removal of this backlog was considered a priority. To date, 45,000 drums have been disposed of at uranium tailings sites in Ontario and Saskatchewan. Work on identifying a disposal route for the remaining 10,000 drums is presently ongoing.

The drum management program has emphasized three goals:

1. maximum reuse and recycle of empty drums
2. ongoing return of discarded or damaged drums to the point of origin
3. an aggressive campaign to clear the accumulated backlog. This program ensures maximum use of resources while distributing the responsibility for drum disposal in an equitable manner between producers in Ontario and Saskatchewan, Canada.

CONCLUSIONS

A logical and systematic process for finding practical disposal and recycle options for wastes has been established within the Company. This planning tool has facilitated the disposal of a number of waste types. The strategy has been particularly effective for assessing disposal or recycle concepts for the large quantity and diverse waste types generated at the Port Hope facility. To date, of the 29 wastes identified at this facility, some 16 wastes are disposed of or routinely recycled. This represents about 3000 tons of waste materials annually. Once a route has been developed for a particular waste, future quantities are also processed through the developed route. In addition, continuous monitoring of new regulations allows the Company to respond in a timely manner to regulatory changes which may impact on the established disposal and recycle routes. The success of the program coupled with active waste reduction, reuse, and recycle, will leave no undesirable waste legacy for the future.

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