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ÉNERGIE ATOMIQUE DU CANADA LIMITÉE

AN OVERVIEW OF THE WASTE CHARACTERIZATION PROGRAM AT CHALK RIVER NUCLEAR LABORATORIES

APERÇU DU PROGRAMME DE CARACTÉRISATION DES DÉCHETS AUX LABORATOIRES NUCLÉAIRES DE CHALK RIVER

G.W. CSULLOG and D.G. HARDY

Paper presented at 10th Annual DOE Low-Level Waste Management Conference, Denver, Colorado, 1988 August.

Chalk River Nuclear Laboratories

Laboratoires nucléaires de Chalk River

Chalk River, Ontario K0J 1J0

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Waste Management Systems
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RÉSUMÉ

Au cours des cinq dernières années, les Laboratoires nucléaires de Chalk River (LNCR) ont assuré le stockage provisoire de 17 000 m^3 de déchets (sol et matériaux de remplissage contaminés mis à part). Plus de la moitié de ces déchets provient de sources extérieures au site.

Aux LNCR, on travaille actuellement à deux concepts de stockage : la construction souterraine résistant à l'intrusion (CSRI) (IRUS) et la tranchée creusée dans le sable (Improved Sand Trench - IST). Ces concepts permettront de passer du stockage provisoire au stockage permanent sûr. La CSRI servira au stockage permanent de déchets dont la période radioactive est comprise entre 150 et 500 ans, alors que l'IST sera réservé aux déchets dont la période radioactive ne dépasse pas 150 ans.

On a mis en place un Programme de caractérisation des déchets (PCD) (WCP) complet qui sert de cadre à ces projets de stockage. Le PCD a pour objectif (1) d'établir les caractéristiques des manifestes pour les envois de déchets; (2) d'élaborer et tenir à jour des bases de données centrales pour les charges de déchets et les résultats analytiques; et (3) de mettre au point les techniques et procédés nécessaires à la caractérisation des propriétés radiologiques, physiques et chimiques des déchets. Les travaux relatifs au PCD s'effectuent sous l'égide du programme d'Assurance qualité (AQ) de la gestion des déchets récemment élaboré.

Cet article donne une vue d'ensemble du PCD, dans lequel on met l'accent sur les besoins de définir les quantités de radionucléides présents dans les déchets, sur la mise en application de systèmes de comptabilité et sur le maintien d'un programme d'AQ pour les opérations de stockage.

Systèmes de gestion des déchets
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ABSTRACT

In the last five years, Chalk River Nuclear Laboratories (CRNL) placed 17 000 m^3 of wastes into storage (excluding contaminated soil and fill). Almost half of the waste was generated off site.

CRNL is now developing IRUS, an Intrusion Resistant Underground Structure, and the IST, an Improved Sand Trench, to replace storage with safe, permanent disposal. IRUS will be used to dispose of wastes with radiologically hazardous lifetimes between 150 and 500 years duration, and the IST will be used for wastes with radiologically hazardous lifetimes of less than 150 years.

A comprehensive Waste Characterization Program (WCP) is in place to support disposal projects. The WCP is responsible for (1) specifying the manifests for waste shipments; (2) developing and maintaining central databases for waste inventories and analytical data; and (3) developing the technologies and procedures to characterize the radiological and the physical/chemical properties of wastes. WCP work is being performed under the umbrella of a newly developed waste management Quality Assurance (QA) program.

This paper gives an overview of the WCP with an emphasis on the requirements for determining radionuclide inventories in wastes, for implementing record-keeping systems, and for maintaining a QA program for disposal operations.

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1. INTRODUCTION

The call for papers for this conference asked that participants address a number of designated issues relevant to each of the sessions held. This paper addresses the following issues in the context of the Waste Characterization Program (WCP) now in place at Chalk River Nuclear Laboratories (CRNL):

- Who needs waste characterization data?
- What techniques are available for waste characterization? (How are characterization data generated?)
- How accessible are the data to those that need them? (Is a standardized waste manifest required?)
- How is confidence in the data established?

2. WHO NEEDS WASTE CHARACTERIZATION DATA?

First and foremost, the operator of a waste management site needs characterization data to determine if:

(i) wastes received from off-site generators meet acceptance criteria (radionuclide inventories, free liquid content, toxic and hazardous substances content, etc.),

(ii) engineered waste forms (for example, bituminized or cemented wastes) meet process specifications, for example, radionuclide loadings, leachability, stability, etc., and

(iii) radionuclide and toxic/hazardous substances inventories for waste disposal facilities remain below derived limits.

Regarding point (i) above, the feedback of characterization data to waste generators from site operators would assist generators in meeting waste disposal site acceptance criteria and in correcting situations where acceptance criteria are not being met.

The regulators of disposal sites need access to the data that site operators use to obtain and to maintain approval for operations. In addition to accessing the data, the regulators must be provided with the means for assessing the level of confidence in them. Confidence in the data is discussed later in this paper.

3. WHAT TECHNIQUES ARE AVAILABLE FOR WASTE CHARACTERIZATION? (How are characterization data generated?)

There are two types of waste characterization data. The first type defines the inventories of radionuclide contaminants in wastes and the second defines the physical/chemical properties of wastes.

Radionuclide inventory data

There are two ways of determining radionuclide inventories in wastes. The first uses inference. Based upon a knowledge of where and how wastes were generated, it is often possible to infer (i.e., estimate) their inventories by measuring total radiation fields and using scaling factors for relative abundances of individual radionuclides. In addition, by assaying radionuclides that are easily detected (e.g., Cs-137), it is possible to infer the inventory of radionuclides that are more difficult to measure (e.g., Sr-90). The second method involves the direct measurement of radionuclides by the noninvasive monitoring or the destructive, radiochemical analysis of wastes.

The optimization of costs and minimization of effort required to determine radionuclide inventories require the implementation of a well-balanced mix of inference and analytical methods.

(a) Inference

The production of the medical tracer Mo-99 at CRNL involves the irradiation of uranium targets in a reactor, the dissolution of the targets and the chemical purification of the resultant solution. The processes involved are well defined; for example, the irradiation time in the reactor is recorded, and it is possible to prepare estimates of the yields of the radionuclides generated in the targets. In addition, it is possible to estimate the fractionation of radionuclides into various product and waste streams during the dissolution and purification steps. Therefore, it is possible to infer the types and the quantities of the radionuclide contaminants in the wastes generated. Thus, it is feasible to infer standard radionuclide signatures for specific Mo-99 production waste streams.

When a site receives wastes for placement within a disposal facility, the regulator will likely allow the operator to use an inferred radionuclide inventory as the basis for acceptance for disposal if:

(i) the waste generator or the site operator has an acceptable (by the regulator) method for inferring the inventory in the wastes,

(ii) the generator or site operator has a validated alternate method for confirming the inferred inventory (for example, by direct assay), and

(iii) the wastes received are clearly labelled to allow the site operator to confirm the origin of received wastes.

In Canada, radioactive waste disposal is not practiced yet and, therefore, CRNL accepts wastes for storage only. At present, CRNL uses inference to segregate wastes into the various storage facilities in use. In general, direct assays are not performed to confirm the inferred characteristics of wastes placed into storage. However, once disposal begins at CRNL, either with the **I**mproved **S**and **T**rench (IST) [1] or the **I**ntrusion **R**esistant **U**nderground **S**tructure (IRUS)[2] disposal projects, confirmation of inferred radiological characteristics will have to become the norm rather than the exception.

A thorough review of the CRNL Waste Inventory Programs (WIP) database, which is used to file the inferred characteristics of wastes now in storage, was performed to assess the quality of the information on hand. The review of WIP data showed that in the majority of cases the inferred characteristics of wastes would be inadequate to be used as a basis for acceptance by a disposal facility. This derives from the fact that, historically, waste generators were not required to, and therefore did not supply, inventory estimates that would meet acceptance criteria for disposal (CRNL has been accepting off site wastes for storage for over 42 years).

CRNL is currently formulating guidelines for waste generators to follow for providing estimates of the radionuclide inventories in their wastes. CRNL will reject wastes from generators if the guidelines are not adhered to or it will impose a surcharge to cover the cost of estimating the radionuclide inventory in the waste. This policy should result in a dramatic increase in the percentage of wastes that can be characterized for disposal using inference. This will reduce the need for, and the cost associated with, performing waste assays (periodic, confirmatory assays will still be required).

(b) Waste assays

The second method to quantify the radionuclide inventories of wastes uses direct assays. Assays can be done on the entire population of wastes in any given stream (survey analysis) or on a representative sample of wastes. Assays can be done by noninvasive monitoring or by destructive, radiochemical analysis.

The noninvasive monitoring of wastes can be performed using neutron interrogation, gamma-ray spectrometry and gas proportional counting. Neutron interrogation methods can be used to assay alpha-emitter contaminated wastes [3]. Gas proportional counting is useful for determining radionuclides with low energy emissions, for example I-125, but it is not easily applied to the assay of radioactive wastes because of the geometries involved. WCP participants opted to direct their initial, radiological characterization efforts at CRNL to gamma-ray spectrometry [4] since Canada does not have TRU wastes generated from reprocessing and defence activities.

One advantage of monitoring is that larger quantities of wastes can be assayed than would be possible if costly radiochemical analyses were used. This permits the survey analysis of waste streams that are difficult, if not impossible, to sample for analysis. The survey analysis of wastes allows CRNL to identify specific radionuclides in individual waste items, such as bags, and to segregate these wastes prior to processing (for example, to keep Cs-137-rich bags out of bales). This technology would also be effective in meeting the requirements of 10 CFR 61 [5] for the segregation of class A, B and C wastes.

Figure 1 is a schematic of a gamma-ray waste monitor that CRNL developed. This monitor has been used to assay bags of trash prior to incineration or compaction and bales of compacted trash or drums of incinerator ash produced at the CRNL Waste Treatment Centre (WTC) [6]. A new waste monitor, based on multichannel analyzer cards in IBM-PC compatible computers, has been installed near one of the CRNL waste-receiving zones to assay wastes with activities that make them unsuitable for processing at the WTC (high fields or significant alpha- or long-lived beta-emitter contamination). Both of these monitors are being used to determine the specifications for a high-throughput waste assay station to be used to support waste disposal operations.

The disadvantage of gamma-ray monitoring is that it cannot be used to directly assay for alpha- and beta-emitting radionuclides in wastes having appreciable quantities of gamma-ray emitting radionuclides. However, if verified alpha-, beta- and gamma-emitter correlations are established via alternative methods (inference or radiochemical analysis), gamma-ray spectrometry can be used to infer alpha- and beta-emitter activities in wastes. The main objective of the CRNL ash analysis program [7] is to determine these correlations for wastes handled at the WTC.

Radiochemical assays have the potential to determine all the major radionuclides in wastes but this approach is limited by:

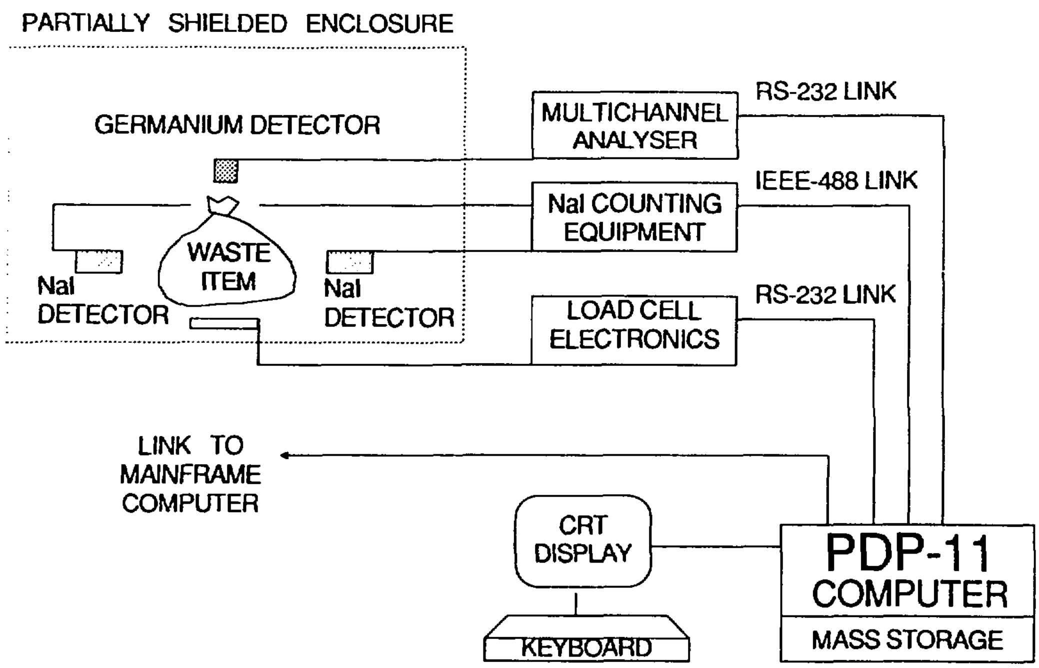

Figure 1: Configuration of the First CRNL Waste Monitor

Radiochemical assays have the potential to determine all the major radionuclides in wastes but this approach is limited to:

(i) the high cost of radiochemical analyses (about $CDN 1000 per sample for incinerator ash),

(ii) the long time required to do a complete analysis (two weeks from start to finish for ash samples), and

(iii) the difficulty in obtaining a representative sample of waste to analyse (ash is relatively easy).

Figure 2 shows the CRNL radiochemical analysis scheme for ash.

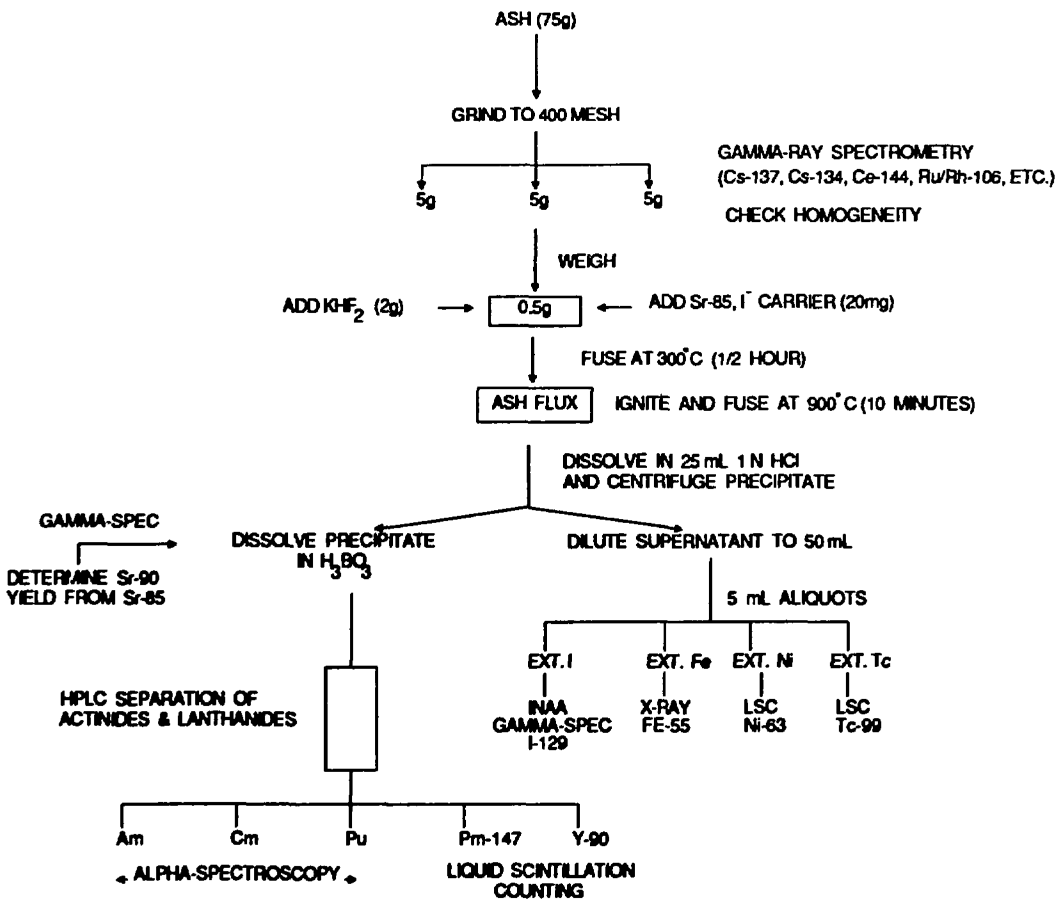

Figure 2: The CRNL Radiochemical Analysis Scheme for Ash

CRNL decided to use radiochemical analyses to determine, wherever possible, the alpha-, beta- and gamma-emitter activity correlations as a means of supplementing the gamma-ray monitoring of wastes. This is still the approach for developing characterization technology in support of disposal facilities.

Physical/chemical characterization data

Two types of physical/chemical waste characterization R&D are being done at CRNL. First, there is a program to develop stabilized waste forms that have enhanced radionuclide retention properties [8] and, second, there is a program to determine the behaviour of waste forms in repository environments [9]. Both of these programs involve the detailed characterization of the physical/chemical properties of wastes and the determination of the relationship between observed properties and waste form performance. They also provide needed information about the nonradiological, yet toxic and hazardous, components of wastes.

Currently, with storage being practiced and not disposal, CRNL relies upon the waste generator's description of the physical/chemical properties of wastes (on shipping manifests) as the basis for acceptance for storage. As with the radiological aspect, confirmation of these estimates will have to be provided by way of alternative methods, such as sampling and destructive analyses, once disposal begins.

4. HOW ACCESSIBLE ARE THE DATA TO THOSE THAT NEED THEM? (Is a standardized waste manifest required?)

The Waste Management Technology Division at CRNL is responsible for developing computer databases in support of waste storage and future waste disposal operations. The WIP database, described above, was implemented on the CRNL site's mainframe CYBER computer and is accessible by anyone who is given valid entry passwords. Passwords are required at three levels to: (1) log on to the mainframe, (2) access procedures to use the database and (3) generate reports on the database's contents.

WCP participants, CRNL managers and the site regulator can gain access to the database from terminals located either at CRNL or off site via telephone lines. Procedures have been set up to produce reports for those who are given access to WIP. This level of accessibility ensures that all who need the data can get them.

WIP data are obtained from a Waste Transfer and Storage Record form, the waste shipment form now in use at CRNL. The form, which was designed by the Waste Management Technology Division prior to developing WIP, is completed every time wastes are moved around the CRNL site, for example from a research reactor to the WTC or storage, or when wastes arrive from off site. The form, and thus the WIP database, is used to record:

- a code to identify the waste origin (down to even a building or process origin code for a site),
- when wastes were stored and in what storage facility (in the future this will be disposal as well),
- the number and types of packages and their volumes and masses,
- the type of waste material (ash, trash, resin, etc.),
- solidification agents (bitumen, cement, etc.), and
- the inferred radionuclide inventory.

The CRNL waste transfer form also has a space to record a waste item identification (ID) number. The ID number is a key component to the CRNL inventory tracking system that is under development. All wastes to be stored or disposed of will be labelled with the ID number that will be recorded on the transfer form as well. The transfer form data, including ID, will be routinely entered into the WIP database.

In addition, whenever wastes are assayed radiologically, by monitoring or sampling and analysis, or for physical/chemical properties, the analytical data will be filed in separate analytical databases along with the waste ID number. Whenever a waste item is to be placed into a disposal facility, its radionuclide inventory and physical/chemical properties can be reported from WIP by retrieving the inferred properties reported from the waste transfer form or the analytically determined properties from the cross-referenced analytical databases. The retrieved information can be used to calculate running totals of radionuclides and toxic and hazardous materials being placed into the facility.

The review of the WIP database, described earlier, pinpointed shortcomings in the database. These derived, almost exclusively, from deficiencies in the design and use of the waste transfer form. Only after a significant amount of data had been transcribed from the forms to the WIP database did these deficiencies become evident. Currently, the waste transfer form design and the WIP database structure are under review.

Since disposal is unlikely until 1991 or 1992, the use of the WIP and analytical databases and the testing of the inventory tracking system will be used to "iron out the wrinkles" in the support programs for disposal operations.

At present, the use of a standardized waste manifest at CRNL is limited to the transcribing of information from individual waste generator's manifests to the CRNL Waste Transfer and Storage Record form. Off site generators are not yet required to ship wastes with a standard manifest. Some of the data management problems that were uncovered in the WIP review may have been avoided had there been a standardized waste manifest in use.

Now that CRNL has gained considerable experience in the area of database management in support of waste management operations, it is in a position to develop and implement a standard manifest for use by all generators that send wastes to CRNL. A standard manifest would greatly simplify the task of database management in support of operations.

Waste manifests should be structured to reflect their relationships with electronic databases. That is, while it is always possible to design the structure of an electronic database to file the information from a manifest, it does not directly follow that the database's structure is suitable for proper reporting and analysis of the data filed. For example, the first CRNL waste manifest included the categories "other" for waste material type and "other" for package type. It also had a space to record comments. Upon review of the data in the WIP database there were entries for waste type "other" in package type "other" and the remarks field contained "miscellaneous waste". The quality of a database record of this sort is highly undesirable. Waste manifests should not offer ambiguous options for waste originators to select.

There were entries on CRNL's manifest such as "pipe", "metal pipe", "asbestos on piping", "pipes with alpha", and so on. Information should be recorded to clearly separate the description of <u>what an item is</u>, such as piping, from <u>what it is made of</u>, such as aluminum or steel, and from <u>what defines it as toxic or hazardous</u>, such as alpha contamination, mercury contamination, and so on.

5. HOW IS CONFIDENCE IN THE DATA ESTABLISHED?

Waste disposal site operators must satisfy operating licence requirements and they should also strive to gain the confidence of the public. To accomplish both of these tasks, operators must demonstrate that the work they performed was done according to accepted standards.

In the area of waste characterization, operators must demonstrate that all data were properly acquired, processed, filed and reported. That is, operators must show that the methods to generate data (inference, monitoring and analyses) and the methods to calculate results and to store and retrieve data in databases were quality assured.

Figure 3 shows the overall structure of the waste management Quality Assurance (QA) program at CRNL.

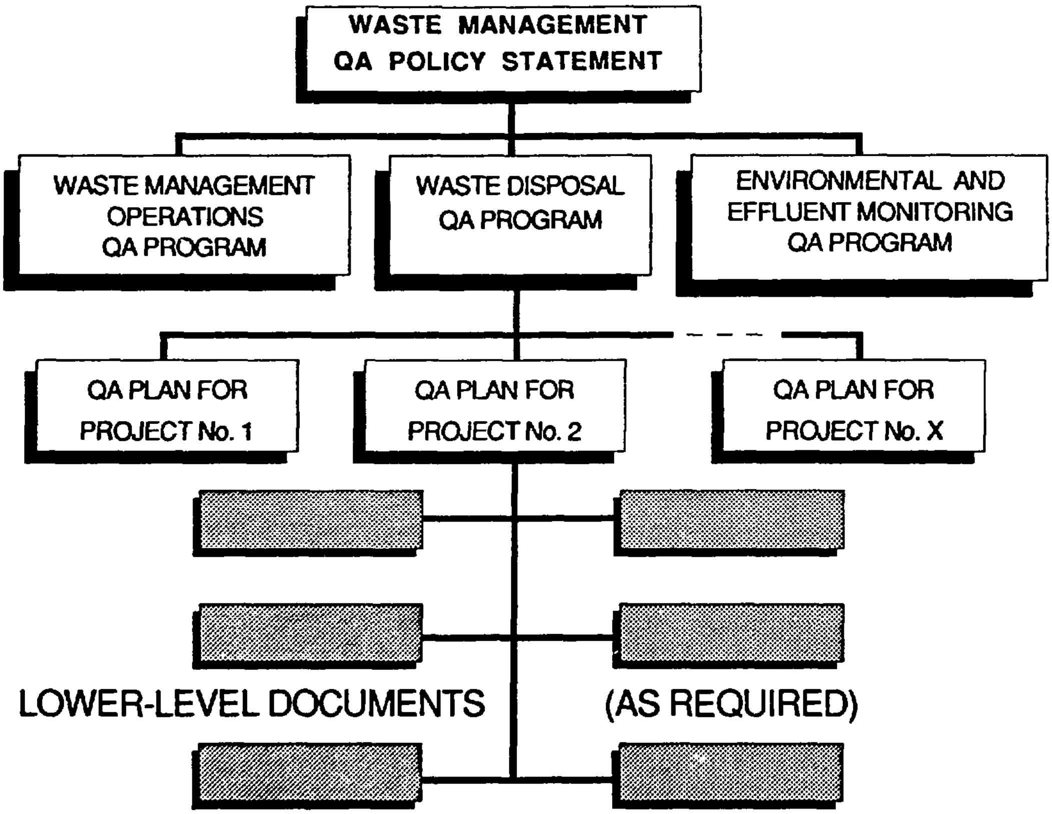

Figure 3: Structure of the Waste Management Quality Assurance Program at CRNL

The policy statement defines the operating guidelines for waste management at CRNL and formally states the site's commitment to the QA of work conducted. Since waste management encompasses many disciplines, three separate QA programs were set up within the framework of the policy statement.

The Waste Management Operations QA program focusses on assuring the quality of work associated with the routine handling of wastes (receiving, routine monitoring, data recording, storage and disposal operations, etc.), the Waste Disposal QA program focusses on assuring the quality of work specifically limited to disposal operations and the Environmental and Effluent Monitoring QA program focusses on assuring the quality of work associated with the protection of the environment, CRNL staff and the general public.

The establishment of three QA programs was carried out to accommodate the fact that greatly different tasks can be performed within each of the major areas of waste management. For example, the task of emplacing wastes in storage or disposal facilities and the recording of data on a manifest (in Waste Management Operations) is quite different from the computer modelling of waste disposal facilities (in Waste Disposal) or the mapping of groundwater flow (in Environmental and Effluent Monitoring). The diversity of tasks would require either a very complex overall QA program for waste management or the implementation of smaller, less cumbersome QA programs that could be better tailored to the type of work conducted within subprograms of waste management. CRNL opted to implement the second strategy.

Within the Waste Disposal QA program, CRNL implements QA by way of QA plans for each major disposal project undertaken. This project-by-project approach accommodates the fact that different projects can differ greatly in scope and would, therefore, require different implementations of QA. For example, the IRUS facility will require detailed engineering of the repository vault, whereas the IST facility will require much less design effort. Therefore, the QA programs for these two disposal concepts will vary greatly in scope and will be developed individually to match the scope of the work conducted.

Figure 4 shows the document hierarchy for the IRUS QA plan. Because of the large scope of the IRUS project, the QA plan is to be implemented on a phase-by-phase level for each major phase of the project. There are eight different phases to IRUS and various project participants have been assigned the responsibility for developing the QA plans for the phases. For example, the head of the design team is responsible for the Design Phase QA plan, the head of the Waste Management Operations Branch is responsible for the Operation Phase QA plan, and so on. This approach to QA implementation assures that:

- the best-qualified project participants are responsible for QA in the areas of the project they know best,

  [Approval for all QA programs, plans and procedures must be obtained from the site's Quality Management Division (QMD). Thus, even though development of QA for projects is distributed among participants, the QMD acts as the central site authority for approval of QA documents, programs, etc.]

- the QA plans for the phases are tailor-made to fit the type of work performed within project phases,

- QA plans for individual projects are matched to the scope of the projects themselves, and

- a clear and concise delineation of responsibilities for QA is set forth for the regulator.

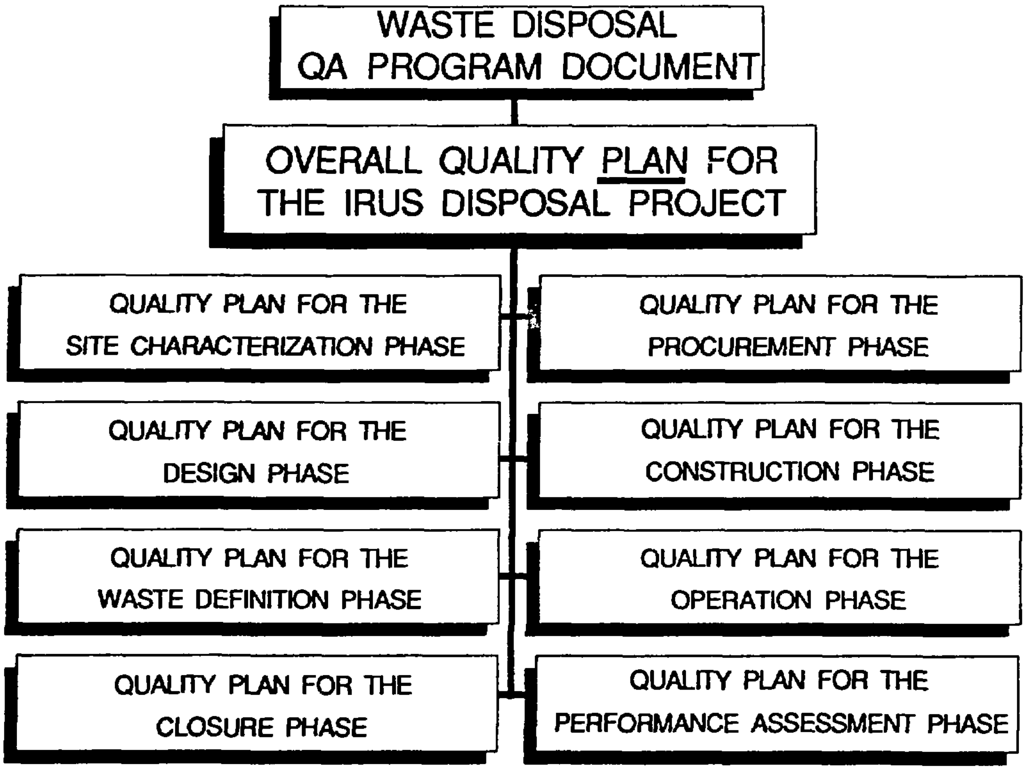

Figure 4: Document Hierarchy for the IRUS Disposal Project QA Plan

QA for waste characterization in support of the IRUS project is carried out within the Waste Definition Phase. However, since the type of characterization work to be carried out within the Waste Definition Phase of IRUS will be similar to much of the characterization work to be carried out for other waste disposal projects, most QA procedures developed to support IRUS can be applied directly to support projects such as the IST. Therefore, unlike the QA for most other phases of IRUS, the QA for the Waste Definition Phase is readily applied to other projects since the characterization work itself is readily applied across projects.

The QA program for Waste Disposal and the QA plan for IRUS were developed with close consultation by CRNL's regulator, the Atomic Energy Control Board (AECB). This consultative process should ensure that the AECB will be satisfied with the full implementation of the QA program for IRUS. It should also ensure that the AECB and the public will be able to gain full confidence in the quality of the work conducted by CRNL.

6. SUMMARY

The Waste Characterization Program at Chalk River Nuclear Laboratories, which was set up to support waste disposal projects, has been structured to ensure that:

- the information generated by the program is readily available to those who require it for operational or regulatory needs,

- the work performed within waste disposal projects, and in particular waste characterization, is quality assured, and

- prior to the start-up of disposal operations, all systems for characterization, data management and inventory tracking are tested within the waste storage program.

By implementing a balanced mix of characterization technologies, focussing on the standardization of methods across various disposal projects and consulting with the site regulator on QA issues, CRNL is confident that its characterization program will readily satisfy waste disposal site licensing requirements.

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