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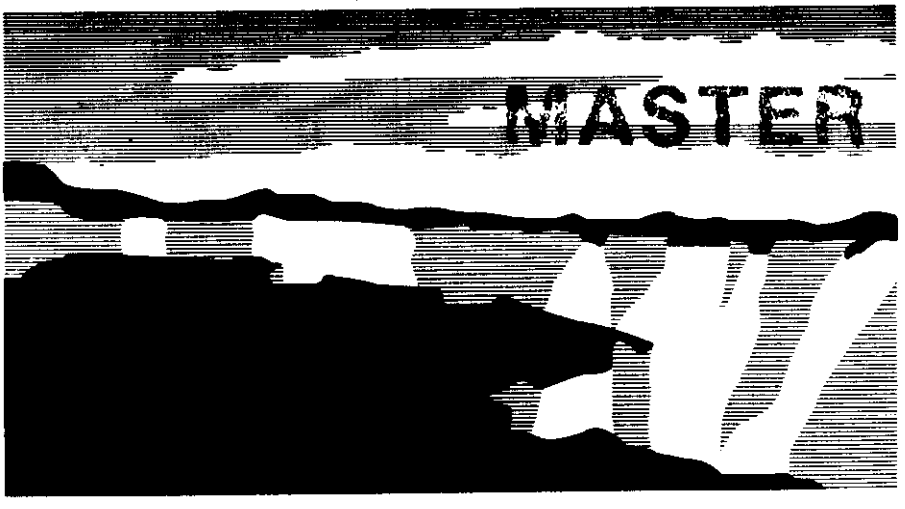

Los Alamos
NATIONAL LABORATORY

CHARACTERIZATION OF LOW-LEVEL MIXED WASTES AT THE LOS ALAMOS NATIONAL LABORATORY

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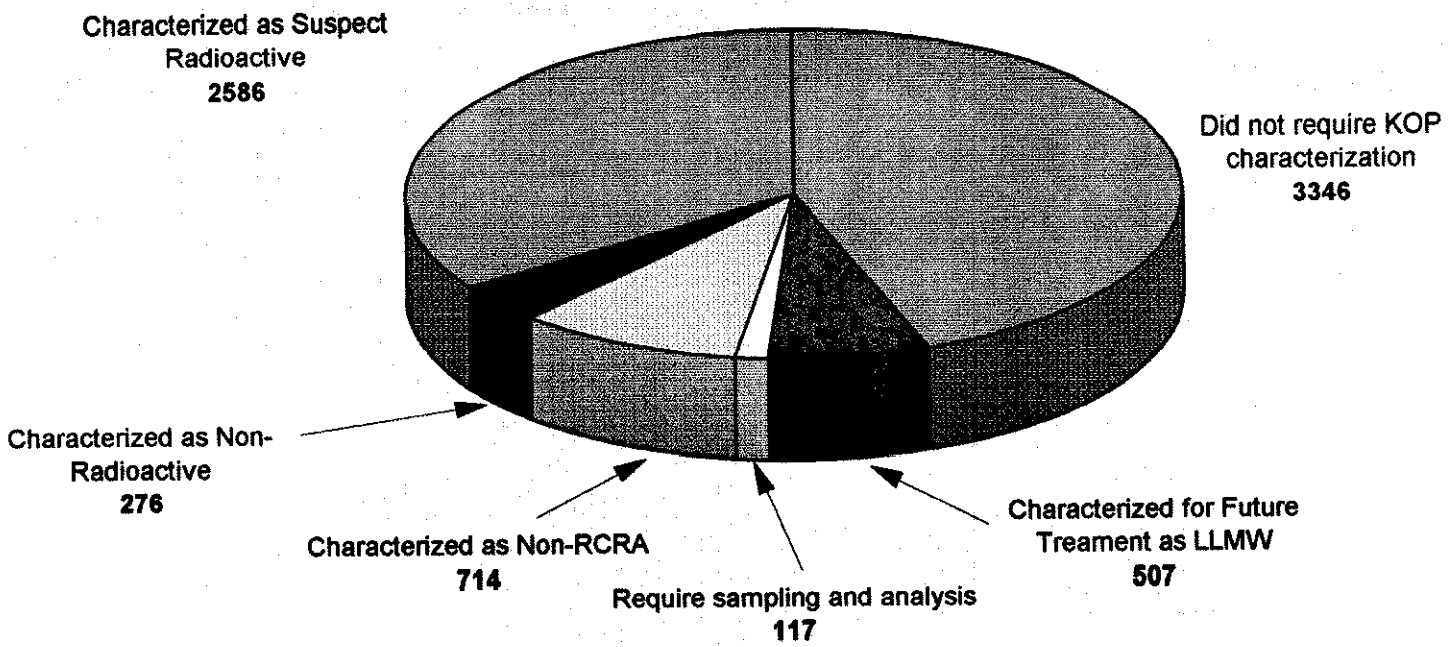
I. INTRODUCTION

This paper discusses the purpose and results of a program to characterize low-level mixed wastes (LLMWs) in storage at Los Alamos National Laboratory. The program was conducted to maintain regulatory compliance and to support ongoing waste treatment and disposal activities. The characterization team conducted a characterization review of wastes stored at the Laboratory that contain both a low-level radioactive and a hazardous component. The team addressed only those wastes that were generated prior to January of 1993. The wastes which were reviewed, referred to as legacy wastes, had been generated before the implementation of comprehensive waste acceptance documentation procedures which assure regulatory compliance for more recently generated wastes. The review was performed to verify existing RCRA code assignments and was required as a component of the Laboratory's Federal Facility Compliance Agreement (FFCA). The review entailed identifying all legacy LLMW items in storage, collecting existing documentation, contacting and interviewing generators, and reviewing code assignments based upon information from knowledge of process (KOP) as allowed by RCRA. Project findings were entered into tracking and characterization databases.

The characterization team identified 7,546 legacy waste items in the current inventory, and determined that 4,200 required further RCRA characterization and documentation to satisfy the FFCA requirement. The remaining waste items had already been characterized by sampling or appropriately identified for treatment by existing or planned treatment methods. KOP characterization was successful for accurately assigning RCRA codes for all but 117 of the 4,200 items within the scope of work. Sampling and analysis requirements for complete characterization of the 117 remaining items were outlined in the project report. As a result of KOP interviews, 714 waste items were determined to be non-hazardous, while 276 were determined to be non-radioactive. Other wastes were found to be stored as suspect radioactive because of administrative requirements due to their generation in an area of incident isotope usage which was not likely to have contaminated them. Many of the suspect radioactive wastes were certified by the generators as non-radioactive and will eventually be removed from the mixed-waste inventory following radioactivity screening.

Figure 1 provides a breakdown of the Laboratory's legacy wastes.

FIGURE 1: BREAKDOWN OF ITEMS STORED AS LLMW AS OF 1/1/93



II. THE PURPOSE AND BASIS OF CHARACTERIZATION

Characterization of the Laboratory's legacy LLMW was necessary not only to satisfy regulatory requirements, but also to provide important waste profile information for a rigorous schedule set forth in the FFCA to treat all LLMW in the inventory. The Laboratory's FFCA currently requires that it initiate the design of two new skid-mounted treatment processes each fiscal year through fiscal year 1997 and that it have full characterization and planned treatment for every waste item in its inventory by March, 1995. The required treatment designs can not be effectively performed without prior detailed knowledge of the nature of the waste streams involved, including much more information than the RCRA code for each waste would provide. Properties such as physical state, waste matrix, packaging, and radionuclide contamination are of critical importance when designing a safe and effective waste treatment. The capture of these types of data was an equally important task to the satisfaction of RCRA in successfully completing the characterization effort.

The diversity of waste streams encountered by the team reflects the Laboratory's mission of research and development. Much of the waste in storage was generated by such uncommon research activities as nuclear rocket propulsion, biological effects of radiation, and radioisotope power sources for space stations and medical applications. The matrix and nature of these waste streams are often such that available treatment technologies do not directly apply. Much of the characterization effort was focused on identifying similarities in the diverse inventory so that organized treatment could proceed, while maintaining distinction between truly differing wastes. Prior to the characterization task, the Laboratory's more than 7,000 legacy LLMW had been segregated into only 23 broad treatment categories, based primarily on RCRA codes. Much more definition was required to accurately plan for waste treatment, for, as the characterization data now indicates, there are more than two hundred distinct waste streams which will require unique consideration for appropriate treatment.

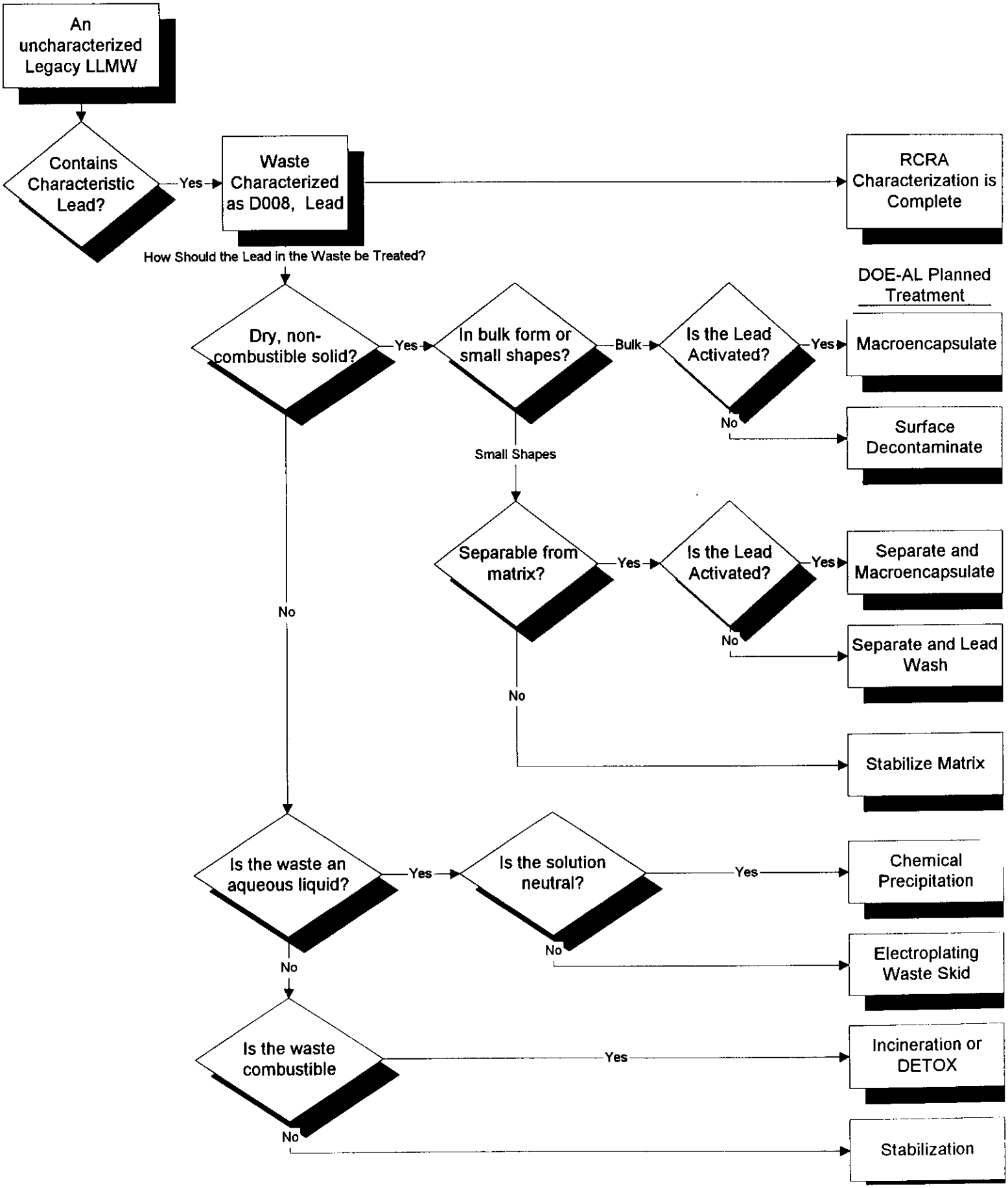
Figure 2 depicts an example of characterization by RCRA code versus characterization for treatment.

A. RCRA CHARACTERIZATION

The RCRA regulations allow waste generators to apply knowledge of the hazardous characteristics of the materials in the waste and the waste generating process to determine whether the wastes are hazardous. In the case of the Laboratory, this waste characterization process consisted of reviewing existing Laboratory waste data and new process knowledge information gathered from the generator interviews. The comprehensive data were then evaluated to confirm that the Laboratory-assigned RCRA hazardous waste codes were appropriate.

FIGURE 2: RCRA CHARACTERIZATION VERSUS TREATABILITY CHARACTERIZATION

A Simplified Example for a Waste Containing Lead



The process knowledge approach was chosen by the Laboratory as the most efficient means for characterization for several reasons, including:

- the need to maintain personnel exposure that is required for sampling and analysis as low as reasonably achievable;
- the need to keep characterization costs as low as possible; and
- the notion that generator-supplied information about process wastes would be more effective than typical statistical sampling, especially when evaluating RCRA-listed properties. For example, sampling and analysis cannot distinguish between D021 characteristic and F002 chlorobenzene, which have differing treatment standards.

B. CHARACTERIZATION FOR TREATMENT

In addition to assigning RCRA hazardous waste codes, the characterization process included a compilation of the data necessary to satisfy treatment technology acceptance criteria. The questionnaires which were used to conduct the generator interviews were developed with the assistance of waste treatment design staff members at the Laboratory to provide details about packaging, complete chemical constituency, and radionuclide content. The recently developed DOE treatability coding scheme was used to segregate characterized wastes into standardized waste stream types. Process knowledge interviews also verified proper assignment of waste storage codes, and Department of Transportation (DOT) container codes to ensure safe waste storage and transportation.

See **Figure 3** for a chart of the types of DOE Treatability codes used by the characterization team.

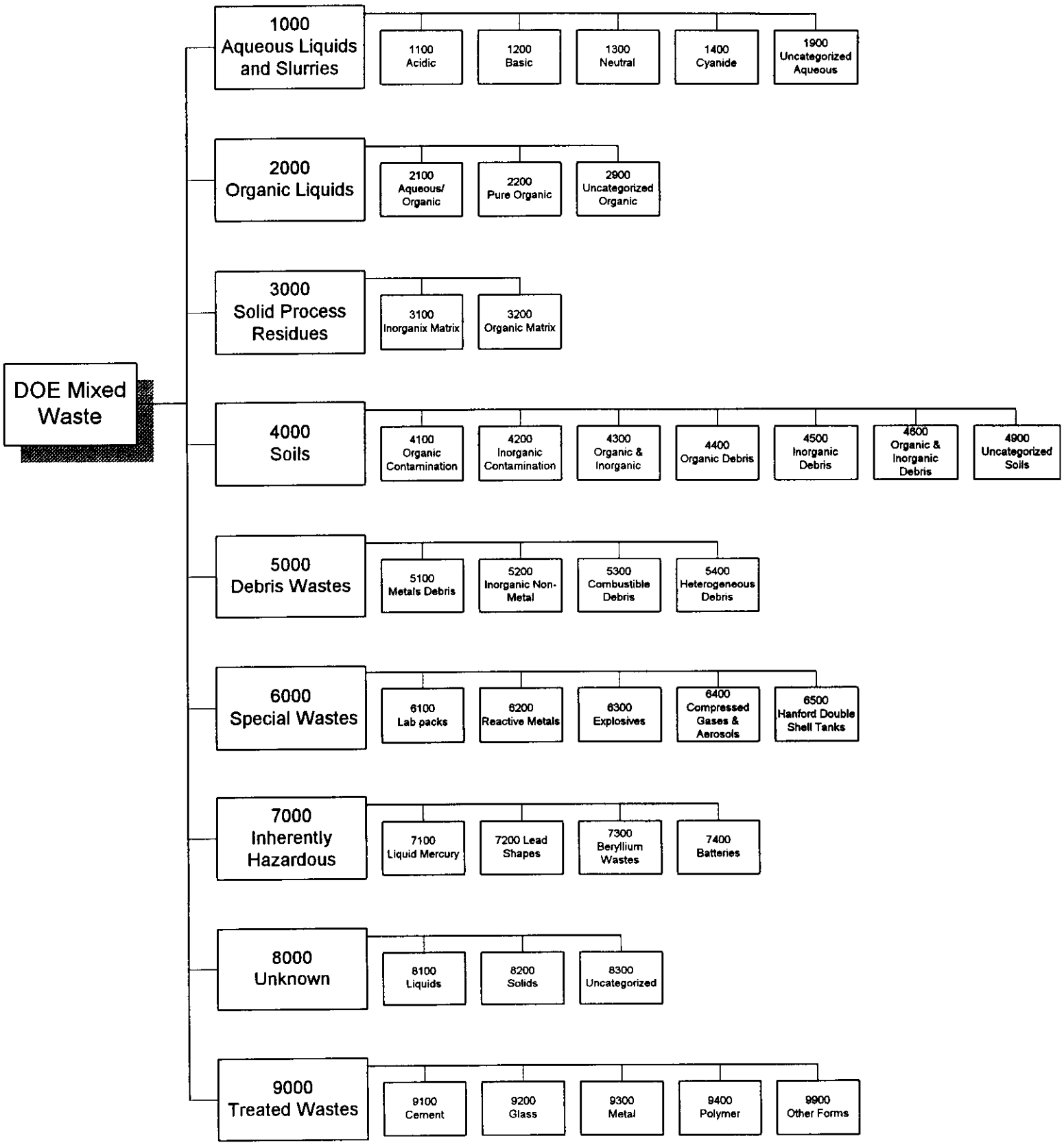
III. RETRIEVAL AND MANAGEMENT OF INFORMATION

A. HARDCOPY RECORDS AND KNOWLEDGE OF PROCESS FORMS

Documentation for generated wastes at the Laboratory had been developed over a period of time as new regulatory and waste storage requirements became more relevant issues. Legacy wastes which were generated prior to the implementation of the comprehensive waste management system had little information available in the waste management records to support RCRA or treatability characterization. For many of wastes, generators were not required to document process knowledge nor did the waste acceptance criteria always identify all the hazardous properties of the waste. The characterization team was tasked to supplement any existing waste profile information with a standardized questionnaire, which included information such as:

- complete description of the waste and its generating process;
- a process flow diagram, where applicable;
- chemical constituents and concentrations;
- detailed packaging information, both at the primary container level and at the drum level;

FIGURE 3: DOE TREATABILITY CODES USED FOR CHARACTERIZATION



- radionuclide identification including activity level;
- information about the area of waste generation;
- physical properties of the waste including:
  - physical state;
  - flash point;
  - pH;
  - reactivity; and
  - PCBs;
  - heavy metal identification and content; and
  - organic content with respect to listed halogenated and non-halogenated compounds.

Because legacy drums often contained many waste items of differing chemical, physical and radiological properties, interviews were conducted on an item basis rather than on a drum basis. Often many separate sets of characterization forms were required for one drum. Some of the legacy labpacks contained as many as 50 distinct waste items. Drums of identical wastes from the same generator were grouped together where possible into one data folder. All characterization forms and related Laboratory data were assembled into packages referred to by the team as *folders*. Each folder was a stand-alone document for a drum or drum group. LLMW Characterization folders were organized with new process knowledge and characterization segregated from existing Laboratory hardcopy data on the two sides of a double-sided binder. Material Safety Data Sheets (MSDSs) were also included in the files and often proved to be difficult to obtain, since many of the original suppliers had long since ceased to exist. **Figure 4** outlines the organization of waste information into data folders.

B. QUALITY ASSURANCE

The assurance of accurate and precise information was the most important criteria in the success of the characterization task. Quality assurance reviews were performed during each step of the program. The first QA/QC review was conducted after folder assembly was completed, before the folders were issued to the field team for the KOP interview. Each folder was evaluated to determine if the assembled data package was consistent and to its verify status as a stand-alone document for a drum or drum group of like wastes. Particular attention was directed toward ensuring that all available existing Laboratory documents associated with the identified waste items were present.

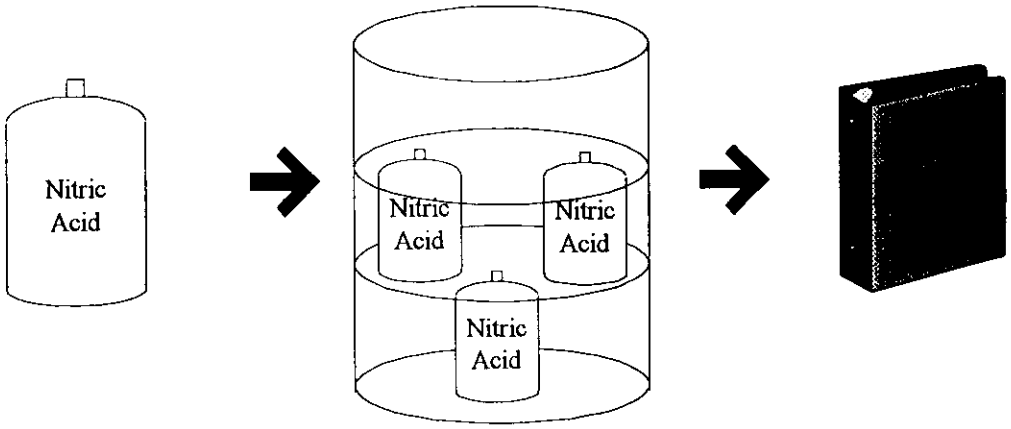
The second critical QA/QC review was conducted on a folder-by-folder basis following successful completion of the KOP interview. The interview forms were reviewed to verify that the level of detail was adequate to verify or legitimately modify existing Laboratory data, confirm RCRA characterization, and provide additional data in sufficient detail to meet waste treatment objectives. After it was established that the folder was complete with respect to Laboratory and Team-generated documentation, a review of the existing Laboratory data was made to compare information obtained during the KOP interview with the information contained on Laboratory documentation. In general, if inconsistencies

FIGURE 4: THE ORGANIZATION OF INFORMATION INTO FOLDERS

ITEM
A Bottle of Reagent Nitric Acid, Partially Full

DRUM
Sometimes contains many items

FOLDER
One Interview concerning various combinations of drums and items



Key Information:

Net Weight & Volume
Physical State (Gas, Liquid, Solid)
Gross Container Weight & Volume

Key Information:

Gross Drum Volume & Weight
Overpacking Information
Fill Material

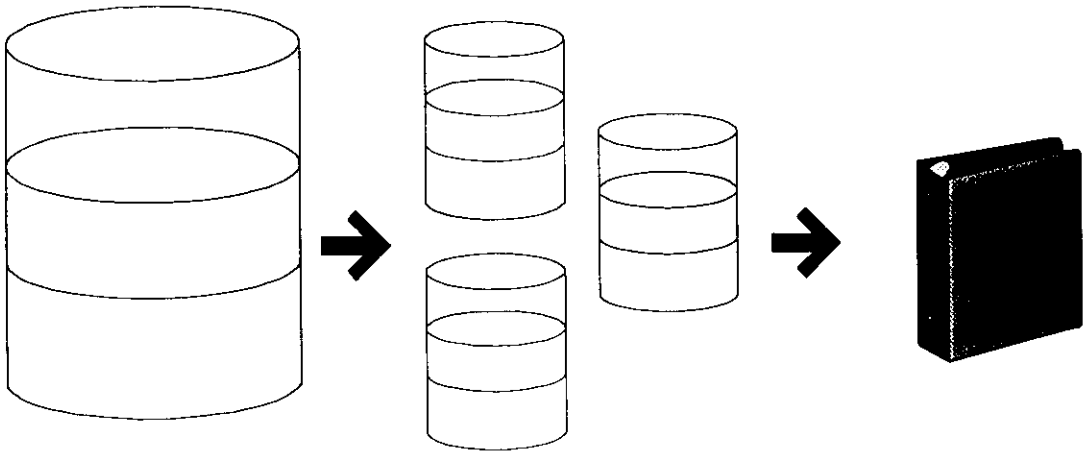
Key Information:

A detailed correlation of all existing Laboratory data and the generator's recollection of the waste

SINGLE ITEM DRUM
A single item drum with one homogenous waste has only one item

DRUM GROUP
Several single-item drums with similar waste

GROUP FOLDER
One interview to discuss a group of similar drums.



Key Information:

Net Weight & Volume
Physical State (Liquid or Solid)
Fill Material

Key Information:

Subtle differences between drums

were present, the QA/QC team verified that an explanation of the inconsistency was included in the folder. A related review was conducted of the a waste summary form which would later be used to modify electronic data pertaining to each waste item. Each data field of this form, which included all of the Laboratory's databased information for a particular item, was evaluated for consistency with the KOP interview forms and existing Laboratory data. A rationale sheet was then completed to document the reason for any modification to the electronic data.

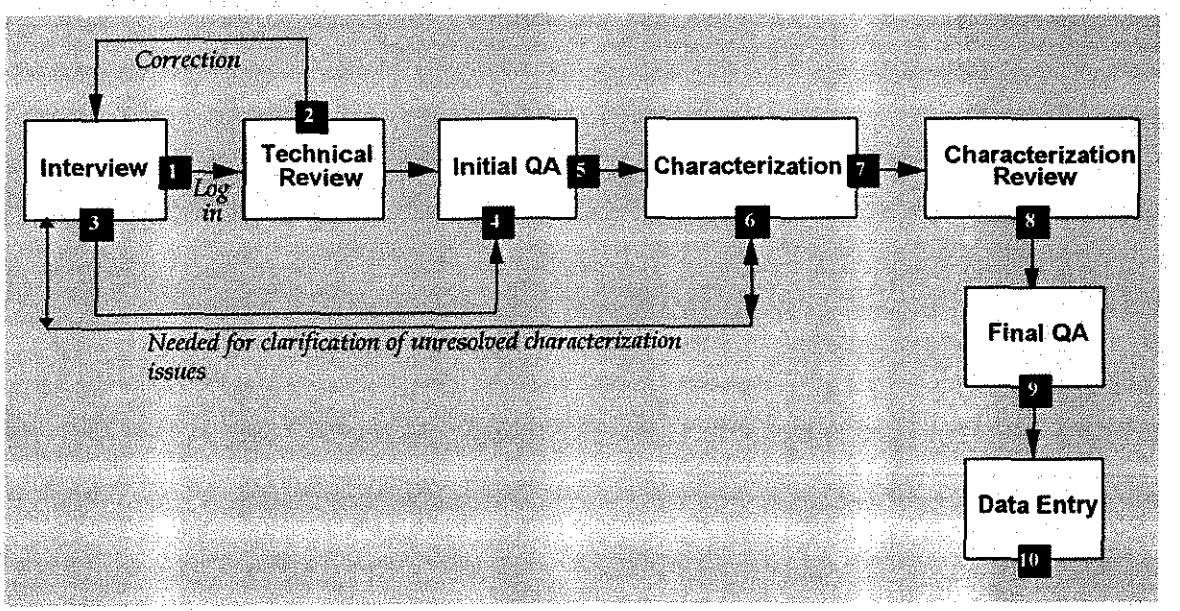
A third critical QA/QC review was conducted following waste characterization. Waste items were characterized based on a review of all physical, chemical, and KOP information available; a waste characterization form was completed for each waste item or group of similar waste items. The form identified the RCRA hazardous waste code and the rationale for assigning the code, and also listed all Laboratory-assigned waste codes that were not properly assigned and provides an explanation. The waste characterization form also contained a DOE Mixed Waste Treatability Code assignment for each waste item and provided a rationale for that assignment. All information on the form was subject to a complete QA/QC to verify all responses. Due to the specialized expertise necessary to determine proper characterization of waste items, this review was performed by an independent member of the Characterization staff using the same review procedures employed by the QA/QC staff. **Figure 5** depicts the interview, quality assurance, and characterization loop.

C. CONDUCTING THE INTERVIEWS

The coordination and completion of accurate generator interviews was the most challenging aspect of the program. Over 1,500 separate interviews were necessary to complete characterization at a level consistent with the FFCA requirements. Interviewing activities were organized with the use of a tracking database and were conducted by a team of eight process- and RCRA-knowledgeable engineers. Most of the field team had prior experience with certain groups at the Laboratory from earlier tasks. The project tracking database included preliminary descriptions of waste items, as well as information about the generating groups and locations. This information allowed for efficient coordination of interviews for many different wastes and many different generators in a short period of time. Interview assignments to team members were prioritized based upon familiarity with generators, understanding of waste streams, and specific interviewer backgrounds.

Throughout the interviewing phase, problems arose when generators perceived the necessary exchange of information as a potential for personal liability regardless of the fact that they had correctly adhered to waste management practices at the time of waste acceptance into storage. Other difficulties arose when generators had retired or moved to other facilities. The team relied heavily on the support and cooperation of Laboratory management in resolving these issues. As a result, the team was able to meet with individuals who were both familiar with wastes and willing to discuss generation details in all but the most difficult cases. A handful of drums still remains that will require sampling and analysis due to lack of generator process knowledge documentation. Most of the drums requiring sampling and analysis were insufficiently characterized because of complexities in the generating process that could not be resolved through KOP.

FIGURE 5: KOP FOLDER REVIEW PROCESS



1. Upon completion of folder, folder is logged in and filed in the cabinet drawer "folders awaiting QA".
2. Following QA, folder is either returned to interviewer for additional data or sent to technical review.
3. Interviewer finalizes folder if necessary and delivers to technical review staff.
4. Folder reviewed for technical content.
5. Drum folder is sent to characterization.
6. If there are any unresolved issues concerning characterization information, folder is returned to interviewer.
7. Folder is sent to characterization review.
8. Final QA of all forms and data within the folder is now performed. All unresolved issues have been resolved.
9. Drum is now logged in as complete. Final QA form is signed.
10. Waste summary form is copied and sent to data entry.

IV. CHARACTERIZATION APPROACH

RCRA characterization was performed in accordance with the provisions of 40 CFR 261. **Figure 6** details the process used to assign RCRA hazardous waste codes. After a complete review of all physical, chemical, process, and generator information, the Laboratory-specific waste characterization form was completed for each waste item, or group of similar wastes in each drum. The form identifies the RCRA hazardous waste code and the rationale for assigning the code. In addition, the form lists all Laboratory assigned hazardous waste codes that did not reflect waste characteristics and were properly assigned. Rationale were provided to explain why the codes did not apply to that particular waste item.

To complete characterization, each waste was evaluated to determine if it contained any regulated spent components or if it was an unused commercial chemical or spill residue. In addition, each waste was evaluated for ignitability, corrosivity, reactivity, and toxicity characteristics. MSDS sheets were helpful in many cases in providing property information for labpacks and unused materials. The team utilized RCRA-experienced chemists in determining the properties of mixtures, when necessary. The pH, flashpoint, and chemicals of concern were evaluated to identify any hazardous characteristics. Listed and characteristic codes were assigned to each waste as appropriate.

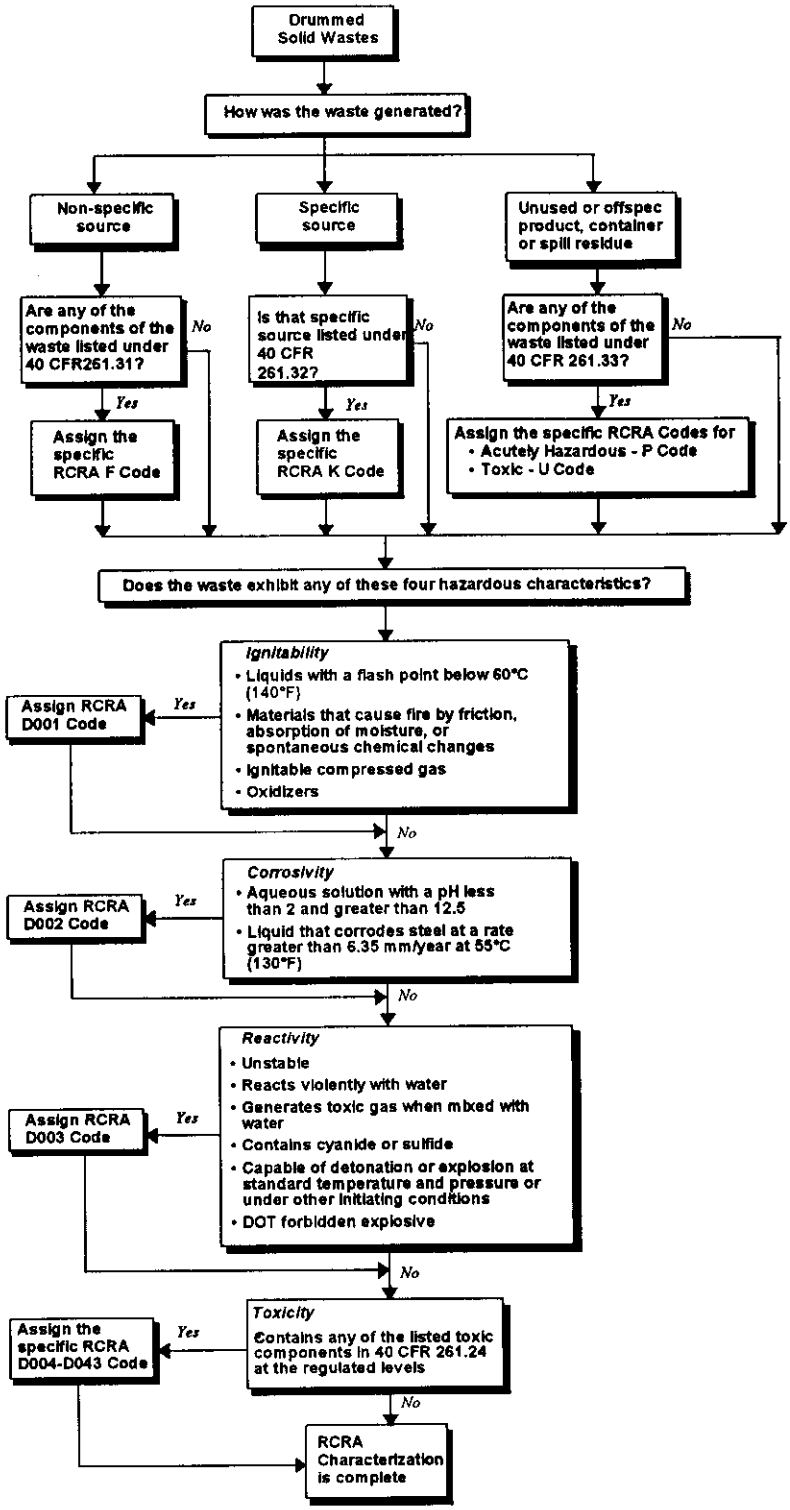
A conservative approach was applied while characterizing LLMW to ensure that all the potential waste codes were assigned. In situations where the Laboratory-assigned RCRA code could not be confirmed as correct or not, the code was left as assigned and a notation made. Due to the fact that RCRA characterization regulations and waste codes are somewhat ambiguous, EPA has developed and issued guidance materials over the years that clarify questions on various waste codes and waste management issues. The team subscribed to several guidance periodicals and solicited Laboratory policy guidance in many of the more difficult cases.

Approximately fifty percent of the RCRA hazardous waste codes originally assigned by the Laboratory were confirmed in the characterization process. Several waste streams were consistently assigned an incorrect waste code in the absence of detailed process knowledge. These waste streams are discussed in the paragraphs below. Some examples are listed below.

1. Many wastes had originally been assigned a D001 ignitable solid code. This code is easily assigned to liquids but it is more difficult call to assign this code to solid wastes because the wastes have to be spontaneously combustible, or create a fire upon exposure to moisture and burn so vigorously and persistently as to create a hazard. Often times this code is applied to wastes that can cause a dust explosion that flashes and burns out. According to EPA, this is not the intention of this hazardous waste code. Solid wastes that were assigned the D001 code were evaluated to determine if the code was applicable. In addition, the D001 code was applied to unused chemicals that had not been identified as DOT oxidizers.

2. Many legacy cylinders of gas were assigned a D002 corrosive waste code. These codes were changed based on the fact that the RCRA corrosivity characteristic is applicable only to liquid or aqueous wastes. Also, a D002 waste code was applied to solid wastes which is not the intention of the RCRA regulations, therefore the codes were changed.

FIGURE 6: ASSIGNMENT OF RCRA WASTE CODES



3. Several toxicity characteristic codes were deleted due to concentrations of the component in the waste or simply because the component was not in the waste. For example, several wastes were assigned a D009-mercury or D008-lead waste code and the Laboratory data and generator interview both noted that these contaminants were not in the waste. Frequently, wastes from analysis for heavy metals were coded with the analyte metal code, which was reversed based upon KOP. For example, a waste originally labeled as *UV SPEC WASTES FROM LEAD ANALYSIS* would be assumed to contain lead because of the description when it was actually just a dilute buffer solution. The waste codes were changed in these situations.

4. Spent solvents that were used for degreasing parts or cleaning oily or greasy equipment were identified as F001 if the solvent appeared on the F001 list. Although EPA's intention with this F001 category was to regulate solvents used in large scale degreasing operations (such as vapor cleaning), the Laboratory policy was to remain conservative and identify these wastes as F001 listed for degreasing. Wastes that were identified as F002 and were used for degreasing/cleaning parts were changed to F001 to remain consistent with Laboratory policy.

5. The F003 spent solvent code was incorrectly applied in several situations. This is a common area of confusion. The F003 code applies to those listed solvents only if one of the following is true: (1) the waste consists of solely an F003 listed component, (2) the waste consists of a mixture of F003 listed components, or (3) an F003 listed component is mixed with an F001, F002, F004 or F005 listed waste, or a combination of those listed wastes.

6. Wastes which were originally assigned solvent F-listings but were actually generated by a cooling process were changed to non-regulated or assigned an appropriate characteristic code. Cooling is not a solvent property according to EPA regulations.

In all cases, any changes in RCRA coding were documented and databased with an appropriate rationale. All of the routine errors in original RCRA coding were reported to the Laboratory waste acceptance managers to avoid the potential for similar instances in the future.

V. PROJECT RESULTS

Of the 7,546 legacy LLMW items in the inventory, 4,083 were RCRA and radiologically characterized by KOP at the conclusion of the project. These items were also assigned DOE treatability codes. 117 items could not be KOP-characterized due to insufficient information. The remaining items fall into other categories and will not require characterization. A significant fraction of the wastes which were reviewed by the team may be eliminated from the LLMW inventory after certification either as non-radioactive or non-hazardous. Many more unused, labpacked waste items may be re-evaluated after surface decontamination.

A preliminary sampling and analysis plan has been prepared to address the remaining legacy items. The majority of the items were RCRA-characterized by KOP but were not adequately radiologically profiled. The team has recommended varying degrees of radiological screening for these waste items, and interviews support the conclusion that most of them are surface contaminated only. Most of the RCRA-uncharacterized items are labpacked unused chemicals

that will require a visual inspection to read container labels and screening to verify radioactivity data.

VI. USING THE CHARACTERIZATION DATA

As mentioned above, the characterization task was only one element of a broad compliance effort set forth in the Laboratory's FFCA. Since completion of the characterization program, the Laboratory has continued to implement several programs which pertain to the FFCA and make use of characterization information. Many of the data from the characterization program have been captured in an electronic database, which is being made available to process engineers and waste treatment planning staff. The waste folders and all of the documentation they contain have been digitally imaged on CD-ROM and converted microfilm to provide a format which is shareable by many individuals.

The characterization information is currently being used for the conceptual and detailed design of several skid treatment processes. The feed handling systems in these designs rely on accurate packaging and matrix information from the folders. Characterization information has been provided to operators of existing treatment programs at the Laboratory. A few waste streams are currently being treated on-site including surface contaminated lead and scintillation vials. The volume and nature of these streams was estimated prior to the development of treatment; whereas complete characterization data has now allowed detailed feed information and an inventory of all applicable wastes for these treatments.

The Laboratory is also using characterization data to store drums in the most compatible and efficient groupings. Several wastes for which RCRA coding changes were made were relocated to provide more consistency in the waste inventory. Similarly, future storage requirements are being evaluated based upon waste generation history and projections from the characterization program.

VII. EVOLUTION OF LABORATORY WASTE MANAGEMENT

While most of the inventory of stored wastes has been addressed by KOP or other means, the continuation of environmental restoration and R&D activities suggests that the generation of LLMW will not decrease substantially in the near future. As a result of the characterization team's experience with waste generators and the historical waste management and documentation practices, the Laboratory has been able to make several improvements in maximizing the effectiveness of the waste acceptance process. Several measures have been implemented and continue to be developed to ensure that future wastes are fully documented as received and to minimize the need for characterization activities in the future.

Historically, the Laboratory's Waste Management groups have had to maintain responsibility as *generator* for large amounts of waste which the groups themselves did not produce. These groups have had important custodial responsibilities, but did not necessarily have much authority or control over the waste streams they receive. Much of the Los Alamos waste management structure was implemented prior to the promulgation of current waste regulations and was not prepared to follow the cradle-to-grave approach to waste stewardship. In addition, management of the waste was distributed amongst several different groups, making coordination of information difficult.

Efforts are now under way to provide a more centralized and complete tracking mechanism for generation-to-treatment waste documentation. More complete documentation is being required of waste generators, using concepts which were introduced in the characterization effort. The two databases which in the past have separately maintained storage and characterization data have been linked together to provide a more focused source for waste information. Most importantly, the Laboratory is pursuing a system to increase generator awareness and involvement in the management of their own wastes. Waste generator training has been revised to increase awareness of RCRA regulations and Laboratory policies regarding waste generation. Each waste-generating group now has a full-time waste coordinator who provides support to both the generator and the waste management groups. An interactive waste management system is being studied to allow waste generators or waste coordinators to log on to an intelligent database to characterize their waste for appropriate storage and treatment with a series of guidance questions.