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DOE/LLW-208

National Institutes of Health: Mixed Waste Stream Analysis

**N. P. Kirner
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Published August 1994

**Idaho National Engineering Laboratory
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**Prepared for EG&G Idaho, Inc.
Under Subcontract No. C90-132744
and for the
U.S. Department of Energy
Assistant Secretary for Environmental Management
Contract DE-AC07-76ID01570
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ABSTRACT

This report presents the methodology and findings of a technical analysis conducted on the many biomedical mixed waste streams generated by the National Institutes of Health (NIH) that are believed to be representative of the biomedical mixed waste community. The analysis included the characterization of the mixed waste streams based on information contained in an NIH mixed waste management database; the report combines the characterization information into similar process categories. The resulting information will help define and characterize the mixed waste streams generated by the biomedical community so that an identification can be made of the waste streams that can and cannot be minimized and treated by current options.

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ACRONYMS

ATP	Adenosine triphosphate
DNA	Deoxyribonucleic acid
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
HPLC	High performance liquid chromatography
LLW	Low-level radioactive waste
LLRWPA	Low-Level Radioactive Waste Policy Act of 1980
NIH	National Institutes of Health
NLLWMP	National Low-Level Waste Management Program
RCRA	Resource Conservation and Recovery Act
RNA	Ribonucleic acid

National Institutes of Health: Mixed Waste Stream Analysis

1. INTRODUCTION

1.1 Background and Purpose

The Low-Level Radioactive Waste Policy Amendments Act of 1985 requires that the U.S. Department of Energy (DOE) provide technical assistance to host States, compact regions, and unaffiliated States to fulfill their responsibilities under the Act. The National Low-Level Waste Management Program (NLLWMP) operated for DOE by EG&G Idaho, Inc. provides technical assistance in the development of new commercial low-level radioactive waste disposal capacity.

The NLLWMP has been requested by the Appalachian Compact to help the biomedical community become better acquainted with its mixed waste streams, to help minimize the mixed waste streams generated by the biomedical community, and to provide applicable treatment technologies to those particular mixed waste streams. Mixed waste is waste that satisfies the definition of low-level radioactive waste (LLW) in the Low-Level Radioactive Waste Policy Act of 1980 (LLRWPA) and contains hazardous waste that either (a) is listed as a hazardous waste in Subpart D of 40 CFR 261, or (b) causes the LLW to exhibit any of the hazardous waste characteristics identified in 40 CFR 261.

The purpose of this report is to clearly define and characterize the mixed waste streams generated by the biomedical community so that an identification can be made of the waste streams that can and cannot be minimized and treated by current options. An understanding of the processes and complexities of generation of mixed waste in the biomedical community may encourage more treatment and storage options to become available.

Specifically, the report includes a technical analysis of the many biomedical mixed waste streams generated by the National Institutes of Health (NIH) that are believed to be representative of the biomedical mixed waste community.

The NIH has numerous processes that generate mixed wastes. The NIH has created a detailed database for use in tracking the low-level radioactive containerized mixed waste generated by these processes. This database contains detailed information on waste origination, hazardous waste numbers, chemical properties, radionuclide assays, waste volume, waste generation processes, treatment processes used on the wastes, and waste storage, shipping, and handling requirements. The database is maintained using dBASE IV and contains approximately 3,800 records.

In addition to the containerized mixed waste that is tracked by the database, there are two supplemental mixed waste streams that were not included in the database as of July 1993. These two supplemental waste streams are tracked outside of the database based on their properties,

waste stream size, and methods of handling and disposal. The supplemental mixed waste is discussed further in Section 2.2 and Section 4.

1.2 Methodology

1.2.1 Preliminary Analyses

Ebasco Environmental performed a preliminary analysis of mixed waste streams using the database maintained by the NIH. The database received from NIH is in a dBASE IV format and contains 17 database groups within a "mixed waste" catalog. The 17 databases contain approximately 4,000 records dating from 1989 through June 1993. In most cases, one database record was created for each waste container received by the waste management group at NIH. Three of the 17 databases contain the majority of the database records. The waste management group at NIH uses the 17 individual database groups to track the waste through the waste handling steps in the NIH waste management process and to separate the database information according to chronological period and container number.

The 17 databases used for the analysis contain records with a total of 187 fields each. The field identifiers used in the records required some clarification for the databases as received. A detailed list of questions was prepared and forwarded to NIH for the fields that were subject to variable interpretation. NIH responded with information that was used to clarify the interpretation of the fields. Copies of these communications were included in an earlier letter report to EG&G Idaho, Inc. on August 27, 1993. Ebasco Environmental personnel also participated in a tour of the NIH Building 21 waste processing area that was conducted by NIH staff. Procedures for mixed waste acceptance, management, and disposal were outlined, as well as use and maintenance of the database.

The NIH database information was used to group the waste streams into process groups that appeared to be derived from similar activities. The processes were grouped based on a comparison of the descriptions of the waste generating processes provided for each container of mixed waste in the database. The groups were used to identify the major process sources and develop characterizations of the waste produced. Preliminary information was developed and presented to the Biomedical Mixed Waste Workshop held in Bethesda, Maryland, on August 4 and 5, 1993. Some of the key preliminary findings were (a) relatively few waste generating processes produced the large majority of the waste, and (b) wastes produced by these processes have similar properties and compositions.

1.2.2 Subtask 1—Identify Processes Responsible for Waste Generation

A waste generating process was identified for each of the database records in two sequential fields containing a total of 128 characters. Generally, the process descriptions consisted of less than 10 words and were therefore somewhat cryptic. A problem with this data was that the descriptive words for the waste generating processes varied between records from what appeared to be similar processes. This created some difficulty in extracting and comparing the process data.

This difficulty was overcome by using key words for each process group to identify records, which described waste that appeared to originate from each of the particular process groups.

When the key word was found in the process description, the record was selected for inclusion in the process group. Section 2 presents the waste generating process groups that were identified in this way.

1.2.3 Subtask 2—Combine Similar Processes

After the waste generating processes had been identified, similar processes were combined based on similar process activities. Wastes were grouped into 31 similar process categories, based on database information, and one unknown category. These 32 categories are used throughout the report for analytical purposes.

1.2.4 Subtask 3—Segregate Waste Streams Generated by One-time Operations

"One-time" waste streams were those waste streams that were produced relatively infrequently with properties and compositions that were markedly dissimilar from other waste streams. The process description information and the waste composition and waste properties data were used to identify these streams. The results from Subtasks 1 and 2 were used to identify and characterize the one-time waste streams. The one-time wastes are discussed in Section 3.

1.2.5 Subtask 4—Assemble Detailed Waste Stream Characterizations

The process information, waste composition data, and waste properties data developed in Subtasks 1 and 2 were used to develop the waste stream characterization for each of the waste generating processes. The available data limited the degree of detail that could be provided for the waste characterization. The characterizations are limited to radioassay parameters, pH, flashpoint, chemical composition data, and U.S. Environmental Protection Agency (EPA) hazardous waste codes. Section 4 presents this information.

1.2.6 Subtask 5—Identify and Categorize Mixed Waste Streams for Which No Current Treatment/Disposal Options are Available

Information was available in the NIH database for treatment and disposal options that have been used for the mixed wastes generated at NIH. This information was combined with information developed in Subtask 4 to identify the waste streams that do not have current treatment and disposal options. This information was used to categorize the waste according to treatment and disposal options. Section 5 includes a discussion of this information.

1.2.7 Development of Final Report

The preparation of the final report required that the five subtasks be completed for all of the information from the databases. Essentially, the required data from each of the databases were combined into a focused database that was then used to complete the analyses of the data required to complete the subtasks. The fields used in this final analysis were primarily the process description, waste volume, generator location, radioassay information, physical properties of pH and flashpoint, waste composition data, and the Resource Conservation and Recovery Act (RCRA) hazardous waste codes. This report presents the results of the analysis.

1.3 Report Organization

Information on the waste generating processes is presented in Section 2 along with the results of an analysis of the waste volume produced by each of the main process groups. Section 3 presents information on the one-time processes that have produced mixed waste. Detailed characterization information by process group is presented on the waste streams in Section 4. Additional detailed information is provided in Section 5 on waste streams that apparently have no current treatment and disposal options. Section 6 presents the conclusions of the analysis and briefly describes the subsequent steps in a waste minimization process.

2. IDENTIFICATION AND COMBINATION OF THE PROCESSES RESPONSIBLE FOR WASTE GENERATION

Radioactively labeled chemicals are widely used in biomedical research to trace the movement of substances through analytical equipment and processes and through biological processes. Technical information about the use of radioactively labeled substances in biomedical research was obtained from references listed at the end of this document. The NIH performs biomedical research activities in many different areas using radioactively labeled chemicals and generates mixed waste from a variety of biochemical research techniques. This section presents a brief overview of these research activities and discusses the interrelationships of the waste generation activities.

The NIH provides a centralized waste management group that is responsible for properly treating, storing, recording, and disposing of all wastes generated at NIH. As part of this responsibility, the waste management group maintains a detailed database on each radioactive and hazardous waste container generated at the NIH. The NIH mixed waste database contains information for the containerized mixed waste received by the waste management group between early 1989 and June 1993 and contains approximately 3,800 records for this period. However, as noted previously, this database does not include data on two supplemental mixed waste streams that are discussed in Section 2.2. The database was set up with a very large number of fields to provide the flexibility necessary to systematically document all of the waste management activities for the mixed wastes. A total of 187 fields were created for each record in the database and, in most cases, one record had been created for each container of waste received at the NIH. A supporting waste tracking system is used at the NIH to gather and enter the data into the database as they become available during the waste management activities.

The NIH waste tracking system begins with the generation of waste at one of the many laboratory and research facilities at the NIH. The facility that is generating the waste contacts the waste management group and completes a waste tracking form for each container of waste that is being generated. The waste tracking form requires the generator to provide complete process and waste composition information. The waste management group then collects the waste and transports it to the waste management building. Liquid wastes are then sampled and tested for pH and flashpoint. A radioassay is performed on the waste that indicates the activity of the radionuclides found to be present. The results of this analytical testing and the information provided on the waste tracking form are entered into the NIH database. A determination is made of the regulatory status and classification of the waste and of the treatment and disposal options available for the waste. The waste then moves through the NIH waste management system based on this determination and is tracked by the waste management group using the computer database.

Because of the complexity of the research activities at the NIH, the information on the process that was used to generate the waste must, by necessity, be provided by the generator. This is because the research activities can be varied, unpredictable, and at the forefront in using heretofore unknown procedures. In the past, the generators have tended to provide very limited and general information about the waste generating activities. This information is entered into

the database in two character fields, each with a length of 76 characters. For most of the records, however, the information entered is sufficiently limited so that only one field is required.

The processes used for waste generation at the NIH were primarily characterized for this study by using key words contained in the process description field. The key words were extracted from the field, grouped according to apparent process similarities, and then sorted and combined to develop groupings of similar activities that seemed to be from similar waste generating processes. Thirty-two process groupings were ultimately developed in this way. These process groups were then used throughout the remainder of the report to analyze and track the waste management activities. Most of these 32 groupings seem to represent unique and distinct process activities. Nonetheless, several of the groups may be subsets of other groups. These subsets could not be combined, however, based on the information available. For example, a significant portion of the waste contains general information such as "radioassay" and is therefore not specific enough to include into one of the more specific process groups. Some of the 32 groupings represent groupings of processes that are dissimilar. An example would be deoxyribonucleic acid/ribonucleic acid (DNA/RNA) extractions/sequencing. While the extraction and sequencing activities are distinct, there appear to be sufficient similarities to justify combining them as a single process group. This method of combining was also used for the gel fixing/washing and staining/destaining processes. For another significant portion of the data, the process information provided is incomplete or lacking and cannot be used to assign the waste to one of the process groups. Generally, this waste is some of the older waste and obtaining detailed information from the generator as the program was being initiated was probably difficult. Waste with incomplete process information is grouped in an "unknown" category.

Figure 2-1 graphically depicts the relative volumes of the containerized mixed wastes received at the NIH in 21 of the largest process groups. This figure does not include the two supplemental mixed waste streams that are described in Section 2.2. The remaining 11 process groups contain a relatively small amount of waste and are grouped as "all others." Table 2-1 lists the waste volume for each of the 32 waste generating processes and lists the relative percentages of each process. As Table 2-1 shows, 67% of the waste is produced by the three largest processes and over 90% of the waste volume is produced by the 10 largest processes. A brief discussion of the largest waste generating processes is presented below. Table 2-2 contains the waste volumes generated for the two supplemental mixed waste streams.

2.1 Description of Waste Generating Processes

The mixed waste generating processes at NIH are highly specialized and complex research techniques that are used by researchers to investigate specific areas of interest. The development of such research techniques is an ongoing process that results in large changes in the procedures in a relatively short period of time. Therefore, any discussion of the processes and techniques used is likely to become quickly dated. A large variety of such processes is used at the NIH as a part of its research activities. However, the analysis of the mixed waste database indicates that most of the processes are variations of a few research techniques and that these techniques produce the majority of the total mixed waste volume. Following are brief and simplified discussions of these research processes that describe the techniques in a general way, but do not represent the full scope and scale of research activities at the NIH. Researchers at the NIH are at the forefront of developing improved biochemical techniques and procedures and are

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Figure 2-1. Distribution of waste volume by process for containerized mixed waste generated at NIH.

Table 2-1. Volume of NIH mixed waste by process category.

Waste generating process	Contents volume (L)	Container volume (L)	Contents volume percent of total	Cumulative percent
Gel fixing/washing	18,201	20,054	28.4	28.4
HPLC scintillation counting	16,614	18,396	25.9	54.3
Filter washes	8,261	9,230	12.9	67.2
Unknown	4,342	5,392	6.8	73.9
Cell culture labeling	3,913	4,798	6.1	80.0
DNA/RNA extractions/sequencing	1,793	2,070	2.8	82.8
One-time processes	1,652	1,491	2.6	85.4
Radioassay	1,344	1,582	2.1	87.5
Deprobing membranes	1,209	1,336	1.9	89.4
Protein precipitation	1,010	1,200	1.6	90.9
Reverse transcriptase assays	990	1,040	1.5	92.5
Autoradiography	852	1,020	1.3	93.8
Electron microscopy	601	714	0.9	94.8
Silver staining	508	468	0.8	95.5
Perfusion fixation	453	486	0.7	96.3
Blot washing	349	772	0.5	96.8
Equipment cleaning	344	396	0.5	97.3
Staining/destaining	292	305	0.5	97.8
Tissue assay	223	313	0.3	98.1
Electrophoresis	223	246	0.3	98.5
Radioimmunoassay	161	180	0.3	98.7
Operating room wastes	156	156	0.2	99.0
Tissue staining	149	170	0.2	99.2
Cancer treatment	101	101	0.2	99.4
Cell assays	95	131	0.1	99.5
Lipid extraction	88	106	0.1	99.7
ATP extractions	56	60	0.1	99.7
Phosphorylation	50	52	0.1	99.8
Membrane washing	42	68	0.1	99.9
Protein harvesting	34	64	0.1	99.9
Hormonal labeling	31	41	0.0	100.0
Automated amino assay	12	20	0.0	100.0

Total	64,146	72,458	100.0
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HPLC = high-performance liquid chromatography
 DNA/RNA = deoxyribonucleic acid/ribonucleic acid
 ATP = adenosine triphosphate.

Table 2-2. Volume of supplemental mixed wastes disposed of by NIH.

	Number of containers shipped for disposal	Shipping container volume (L)	Volume shipped (L)
Liquid scintillation vials			
1986	1,212	212	257,392
1987	987	212	209,609
1988	931	212	197,716
1989	850	212	180,515
1990	829	212	176,055
1991	733	212	155,667
1992	612	212	129,970
1993 (Jan.-June)	255	212	54,154
Total			1,361,078
Solid medical pathological waste ^a	220	74	46,721
Vials with mercury/ ³ H	25	0.005-0.5	0.81

a. Solid medical pathological waste is contaminated with cytotoxic agents (melphalan), thus making it a mixed waste.

continuously striving to develop completely new techniques while improving the capabilities of existing ones.

2.1.1 Gel Fixing/Washing Wastes

Gel electrophoresis is a valuable tool for effecting separations of protein or DNA/RNA fragments and is often used to determine the sequence of peptides in a protein or bases in nucleic acids. In this technique, DNA, RNA, or a protein is labeled with nuclides such as ^{32}P or ^{35}S and is broken up into fragments. The mixture of fragments is then placed on a gel where separation occurs due to the differential rates of migration of the fragments across and through the gel medium. After the separation has progressed sufficiently, the gel is "fixed" or washed with solvents such as methanol to remove undesirable impurities that would otherwise decrease the sensitivity of the subsequent photographic analysis. It is the fixing of the gels that can produce a mixed waste depending on the chemicals that are used. Different types of gels and fixing chemicals are used for DNA/RNA sequencing and for protein sequencing. However, the available data do not allow differentiation between these areas.

In the analysis, the fixed gel is exposed to photographic film that is sensitive to the radiation emitted by the radionuclides incorporated in the radioactively labeled peptides or bases. The sequence of peptides or bases in the original DNA, RNA, or protein is determined by an analysis of the exposed film and the repetition of the procedure. In some cases, researchers at NIH have been successful in analyzing gels without first fixing them by using specialized substitute gels that can be analyzed with certain impurities present. This type of procedural modification is dependent upon the particular research application of gel electrophoresis to be successfully implemented.

2.1.2 High-Performance Liquid Chromatography Scintillation Counting Fluids

High-performance liquid chromatography (HPLC) scintillation counting fluid wastes are generated when two powerful analytical techniques, HPLC and liquid scintillation counting, are used. HPLC is a type of liquid chromatography in which liquid samples to be analyzed are injected directly into a column through which a solvent is pumped at high speeds and pressures. The various types of molecules contained within the sample are separated as they pass through the column, depending on the specificity of the column, and exit the column at different times, which are characteristic of the different molecular species.

Liquid scintillation counting is a technique to detect beta radiation (also alpha radiation, positrons, and weak X-rays) emitted by radioactively labeled chemicals. In this technique, ionizing radiation passing through a dilute solution of an organic substance causes ionization and excitation of some of the solvent molecules through promotion of pi-orbital electrons to higher energy states. If a suitable solute is present in the solution, these electrons will transfer their excitation energy to the solute molecules, which then emit multiple light flashes (scintillations) through solute fluorescence as they return to lower energy states. The scintillations are then recorded with photomultiplier tubes. In biomedical research, the technique is widely used to measure ^{14}C and ^3H , as well as other nuclides. When the scintillation counting technique is applied to solvents from an HPLC column, it provides a powerful technique for quantitatively detecting the presence of biochemical species of interest. The key points with respect to waste

generation are that the use of a suitable solvent with pi-orbital electrons is required together with a solute appropriate for the solvent being used. Many of these solvents are regulated under RCRA as F-listed spent solvents or as characteristic wastes.

2.1.3 Filter/Blot Washing

Protein residues that are separated using gel electrophoresis techniques as described in Section 2.1.1 can be transferred from the sequencing gel to a glass fiber filter media substrate coated with a thin layer of noncovalently adsorbed polybase or other media such as sheets of polyvinylidene difluoride. This procedure is referred to as "protein blotting" or "Western blotting" and provides a method of identifying gel-separated proteins with specific binding properties. It provides a replica of the protein separation pattern present in the separation gel. After the protein is transferred to the filter paper, it is washed using a variety of chemicals to remove impurities before further analysis. The filter washings can produce a mixed waste depending on the chemicals used. Again, many of these chemicals are regulated as F-listed spent solvents or as characteristic wastes.

2.1.4 Cell Culture Labeling

Many of the research techniques using radioactive labeling of biological molecules require that the radioactive nuclide be biologically incorporated into the structures of cells. This can be done by allowing photosynthesis to occur in an atmosphere containing $^{14}\text{CO}_2$, using ^3H -labeled water in the culturing of cells, or by using $^{32}\text{PO}_4$ as a nutrient in a cell culture. The radiologically labeled biological molecules can be recovered from the cell cultures with techniques that require the use of a variety of chemicals. This process can produce a mixed waste if the chemicals are regulated as F-listed spent solvents or as characteristic wastes.

2.1.5 Protein Precipitation

Protein solutions are developed and used for a variety of analytical purposes. It is often necessary to ultimately precipitate the proteins from solution as a prelude to separating them from the solution or performing a further step. A common protein-precipitating agent is trichloroacetic acid. The anion of trichloroacetic acid and other acids forms an insoluble salt with proteins when the proteins are in solution in the form of cations. Proteins can also be precipitated from solution by solvents that are miscible in water such as methanol, ethanol, and acetone. Methanol and acetone are regulated as F003 spent solvents. A decomposition product of trichloroacetic acid is chloroform, which is regulated as a toxicity characteristic RCRA waste.

2.1.6 Autoradiography

Autoradiography is a technique that allows the resolution and study of structures on the intracellular level. In this procedure, a tissue is cultured and radioactively labeled. Then photographic film is applied to a cut section of the tissue. The portions of the film that are close to radioactive areas in the tissue will darken. When nuclides with suitable characteristics are used, intracellular structures can be resolved to allow the study of cellular structures and functions. Mixed waste can be generated from autoradiography if chemicals, such as methanol, are used to prepare the samples before filming.

2.1.7 Radioimmunoassay

Radioimmunoassays are a technique for detecting the presence and concentration of a variety of biological proteins using a radioactively labeled antigen molecule that binds with specificity to a receptor molecule in a biological system of interest. The technique is used for several hundred different applications such as determining the presence of various hormones, viruses, or other substances. Nuclides commonly used for this procedure are ^3H and ^{125}I . Mixed wastes are generated with the procedure by the need to separate the antigen from the receptor to complete the test. This is usually done by some type of differential precipitation of proteins or by using other separation techniques such as gel electrophoresis or chromatography. If F-listed solvents, such as methanol, are used in this process, then mixed wastes can be generated.

2.2 Supplemental Mixed Waste Streams

The NIH generates two large, and one smaller, supplemental mixed waste streams that are not tracked in the mixed waste database. The first waste stream consists of liquid scintillation fluids contained in vials instead of bulk liquid containers. These vials are used in scintillation counting and then placed in shipping containers for shipment to an offsite incinerator. The total volume of the liquid scintillation fluid vials shipped offsite from 1986 to 1993 (January to June) is shown in Table 2-2.

The second supplemental mixed waste stream was created recently as a result of a research study that began in 1993. This waste stream consists of solid medical pathological waste containing melphalan (a carcinogen) and ^{131}I used as a tracer. This waste is placed in shipping containers for radioactive decay and storage before shipment offsite. The NIH will integrate this waste stream into the mixed waste database tracking system in 1994. Table 2-2 lists the waste volume generated for this waste stream from the study inception through June 1993.

The third mixed waste stream consists of small vials of mercury and other compounds contaminated with ^3H that were generated in 1989-1990. These wastes are also listed in Table 2-2.

3. DESCRIPTION OF WASTE STREAMS GENERATED BY ONE-TIME OPERATIONS

A significant number of the mixed waste streams generated at the NIH are from activities that could be described as one-time activities. These waste streams are produced relatively infrequently and are produced by activities that appear to be dissimilar. Table 3-1 contains a summary list of one-time waste streams, the dates they were received by the NIH waste management group, and the waste volume produced. The data suggest that a relatively large proportion of the waste streams are produced as a result of spills and activities of an unplanned nature. Other sources of one-time waste are special projects and activities that produce relatively small amounts of waste and maintenance activities for equipment.

The one-time waste streams are characterized and described further in later portions of the report as the one-time process group. Characterization data for the one-time process group are presented in Sections 4 and 5.

Table 3-1. Summary of one-time waste generating processes at the NIH.

Date received	Waste volume (L)	Waste generation process activity
22 October 1991	1	Abandoned vials
9 June 1992	3	Accidental contamination
31 March 1992	18	Accidental contamination of aqueous waste
17 September 1991	20	Affinity chromatograph binding studies
6 August 1991	1	Aldehyde reduction
6 August 1991	<1	Aldehyde reduction
2 April 1991	20	Alkaline glucose
2 April 1991	20	Animal destruction
2 April 1991	20	Animal destruction
20 June 1990	20	Animal destruction (prebiopsy)
20 June 1990	20	Animal injection
4 June 1991	20	Animal injection experiment
4 June 1991	20	Animal injection experiment
8 April 1991	8	Animal studies
8 January 1991	3	Aqueous waste aspirated and unintentionally contaminated with vacuum pump oil
23 October 1990	16	Aspiration dispersion
5 March 1991	4	Aspiration mishap
20 November 1990	2	Broken speed vacuum trap
5 November 1991	1	Broken thermometer contaminated with ³² P
17 January 1989	4	Buffer RNA separation
30 July 1991	<1	Cardiac cell experiments
12 April 1991	12	Cell culture waste
22 January 1993	7	Cell staining
5 December 1990	20	Centrifuge waste
27 November 1990	20	Centrifuge waste
27 November 1990	20	Centrifuge waste
15 January 1991	4	Cesium chloride gradients
19 March 1991	20	Chemical assays
16 June 1992	<1	Chemical mishap
4 May 1993	500	Chemical reactive
28 January 1992	1	Cholesterol extractions

Table 3-1. (continued).

Date received	Waste volume (L)	Waste generation process activity
16 July 1991	20	Chromatography
12 February 1991	1	Chromatography waste
9 February 1993	20	Chromium release assays
5 June 1991	10	Clean up of broken bottle
5 June 1991	10	Clean up of broken bottle
5 June 1991	10	Clean up of broken bottle
5 June 1991	10	Clean up of broken tritiated ethyl ether bottle
12 February 1991	20	Cleaning cages
12 February 1991	20	Cleaning cages
21 July 1992	20	Column chromatography solvents
23 August 1990	20	Conjugation of viruses
15 October 1991	4	Contaminated photography chemicals
24 March 1992	4	Contaminated pump oil
9 June 1992	1	Contaminated vacuum pump oil
8 December 1992	2	Copper metabolism in marker
28 January 1992	4	Culture media/unused scintillation fluid
13 August 1991	20	Culture washes and extractions
30 July 1991	18	Cytotoxicity assay
7 May 1991	8	Cytotoxicity assay
21 October 1991	<1	Discarding reagent chemicals
31 March 1992	10	Disinfecting labware
27 March 1990	20	Dismantled film developer
27 March 1990	20	Dismantled film developer
4 May 1993	<1	Animal death
30 March 1993	<1	Animal death
30 March 1993	<1	Animal death
30 March 1993	<1	Animal death
4 April 1993	18	Enhancer radioactive enhancement
8 May 1990	8	Fluorography
16 June 1992	19	Fluorography
16 June 1992	19	Fluorography
27 September 1990	20	Gamma flow through detector
20 August 1991	20	Glassware cleaning mishap

Table 3-1. (continued).

Date received	Waste volume (L)	Waste generation process activity
15 September 1992	18	Immunoprecipitation
10 March 1992	1	Leftover source vials
12 March 1991	1	Lymphilizer waste
12 March 1991	1	Lymphilizer waste
12 March 1991	1	Lymphilizer waste
17 September 1991	1	Lypholizer waste
22 January 1991	20	Microsphere injection
27 April 1993	16	Miltepoposal
2 April 1991	2	Mishap with lipholizer (cleaned up and placed in a flimsy plastic jug)
17 February 1993	18	Mistake
20 April 1993	1	Mistake
26 December 1990	16	Molecular extractions/washings
5 September 1990	1	Oil change
25 February 1989	2	Oil change mishap
29 January 1991	1	Oil contaminated in aspiration mishap
23 August 1990	4	Oil replacement
27 April 1993	20	Overshot neutralization washes
12 February 1993	20	Overshot neutralization washes
2 March 1993	4	Overshot pH
2 March 1993	4	Overshot pH water wash
19 November 1991	2	Peptide iodination
26 December 1990	20	Peptide synthesis
26 December 1990	20	Peptide synthesis
31 October 1990	8	Peptide synthesis, paper fixing
13 November 1991	20	Plate washes
16 May 1990	2	Protein labeling
29 January 1991	8	Radioactive drugs tests
29 August 1990	16	Radiolabeling ³⁵ S
13 August 1991	4	Rat plasma extractions
23 October 1990	20	Receptor binding assays
19 November 1991	<1	Resin absorption
1 June 1993	35	Resume breakdown

Table 3-1. (continued).

Date received	Waste volume (L)	Waste generation process activity
1 February 1991	2	Rinsate from pH meter probe
8 August 1990	16	Scintillation counting waste accidentally put in aqueous waste container
26 January 1993	16	Solvent extractions
4 June 1991	<1	Source vial
25 February 1992	18	Spectrophotometry
7 March 1990	6	Spill cleanup
7 January 1992	8	Spill cleanup
22 October 1991	1	Spill cleanup
25 February 1992	18	Spill cleanup
19 February 1991	<1	Spill cleanup
5 November 1991	19	Tagged probe waste
7 May 1990	4	Thin layer chromatography
21 July 1987	4	Unknown container
27 February 1991	20	Unused buffer solution
30 October 1991	1	Uptake assay
21 May 1991	1	Urea buffering
21 May 1991	1	Urea buffering
7 August 1992	3	Used filter
7 August 1992	3	Used filter
24 October 1989	4	Vacuum pump oil change
27 June 1989	<1	Vacuum pump oil change

4. WASTE STREAM CHARACTERIZATIONS OF THE WASTE GENERATING PROCESSES

This section presents a chemical and physical characterization of each of the 32 waste generating process groups. These characterizations have been prepared by processing all of the available database information and summarizing the results in compilations that are presented in tabular form. Table 4-1 presents summary information on the chemical properties of pH and flashpoint of the waste stream processes. The flashpoint was entered in the database using comparative operators in many cases. For comparative analytical purposes, these operators were converted to the first possible true value, and this value was used for numerical comparisons. For example, a value of $>140^{\circ}\text{F}$ would be converted in the numerical analysis to 141°F and this value would be reported.

Table 4-2 presents information on chemicals present in the waste streams. For the most part, the database information does not include numerical quantitative chemical composition information. It does contain chemical composition information that generators have provided on tags attached to the waste containers. This information is entered as character data for each record and is inconsistent in format, completeness, and presentation. As a result, comparative numerical data generally cannot be extracted for analytical purposes from this information. However, what can be extracted is the presence or absence of a specific chemical species, which was done. Table 4-2 presents the volumetric percentages of each of the waste streams that contained the chemical species mentioned. For example, HPLC scintillation counting wastes are shown with a value of 55.1% under methanol. This means that 55.1% of all of the waste produced by this process was mentioned as containing methanol. Similarly, a value of 60.6% is shown for this waste under pseudocumene, which means that this percentage of the total waste stream contained pseudocumene.

Information is presented in this way for methanol, acetone, ethanol, phosphoric acid, sodium hydroxide, pseudocumene, acetic acid, trichloroacetic acid, chloroform, acetonitrile, and xylene. These chemicals were selected based on their relatively high frequency of occurrence in the waste stream descriptive data. However, many other chemical species are also present in the waste streams including a wide variety of buffering solutions and a number of proprietary scintillation cocktail fluids such as Flow Scint III, Flow Scint IV, Pico-Aqual, Enhance, and Trucount. Because of the proprietary nature of these fluids, a detailed chemical characterization was not possible.

Table 4-3 presents information on the EPA hazardous waste numbers that were provided for the different waste streams. Multiple waste numbers were used for many waste streams based on the descriptive waste composition data provided by the generators and by testing performed on the waste. Nine waste numbers are presented based on their frequency of occurrence. The percentages shown for each of the waste numbers represent the volume percentage of the waste stream that was designated with the particular EPA waste number. This information therefore shows that a relatively large proportion of the mixed waste received is in the D001, D002, and F003 categories and very little is in the other categories. Some of the wastes do not have an EPA hazardous waste number associated with them. This is particularly true for wastes in the "Cancer Treatment" and "Operating Room" process groups. It is possible that in addition to being

Table 4-1. Chemical properties of NIH mixed waste.

Waste generating process	Waste volume (L)	pH minimum	pH maximum	Flashpoint minimum (°F)
ATP extractions	56	1.6	1.8	96
Automated amino assay	12	4.0	4.0	141
Autoradiography	852	0.2	13.0	84
Blot washing	349	1.0	12.9	135
Cancer treatment	101	N/A	N/A	N/A
Cell assays	95	1.0	12.6	120
Cell culture labeling	3,913	0.1	13.1	83
Deprobing membranes	1,209	1.3	13.0	99
DNA/RNA extractions/sequencing	1,793	0.3	12.5	75
Electron microscopy	601	1.4	8.0	139
Electrophoresis	223	0.9	8.0	70
Equipment cleaning	344	0.5	14.0	90
Filter washes	8,261	0.1	14.0	65
Gel fixing/washing	18,201	0.0	13.9	72
Hormonal labeling	31	1.6	6.8	92
HPLC scintillation counting	16,614	0.2	13.1	60
Lipid extraction	88	1.9	10.1	70
Membrane washing	42	1.0	4.1	141
One-time processes	1,652	0.6	13.1	78
Operating room wastes	156	N/A	N/A	N/A
Perfusion fixation	453	2.7	9.6	99
Phosphorylation	50	1.0	5.7	99
Protein harvesting	34	1.1	4.1	95
Protein precipitation	1,010	0.0	10.6	78
Radioassay	1,344	0.1	12.6	63
Radioimmunoassay	161	1.3	12.5	99
Reverse transcriptase assays	990	0.5	5.8	99
Silver staining	508	1.2	6.7	70
Staining/destaining	292	0.1	9.4	92
Tissue assay	223	0.5	9.1	84
Tissue staining	149	1.3	13.0	138
Unknown	4,342	0.3	14.0	58

N/A = Data not available.

Table 4-2. Chemicals typically present in NIH mixed waste.

Waste generating process	Waste volume (L)	Volume percent of waste with chemicals present										
		Methanol	Acetone	Ethanol	Phosphoric acid	Sodium hydroxide	Pseudo-cumene	Acetic acid	Trichloro-acetic acid	Chloroform	Acetonitrile	Xylene
ATP extractions	56	100.0	100.0	—	—	—	—	100.0	—	—	—	—
Automated amino assay	12	—	—	—	—	—	—	—	—	—	—	—
Autoradiography	852	56.5	2.2	4.5	—	0.2	3.3	87.0	4.5	2.3	—	—
Blot washing	349	12.6	—	—	27.8	22.6	2.0	11.7	5.7	—	—	—
Cancer treatment	101	—	—	—	—	—	—	—	—	—	—	—
Cell assays	95	22.1	—	12.6	—	18.9	13.7	12.6	12.6	—	—	—
Cell culture labeling	3,913	46.1	6.7	22.5	5.5	3.1	5.5	30.2	28.3	24.4	0.7	—
Deprobing membranes	1,209	3.0	—	—	1.6	94.6	—	—	—	—	12.9	—
DNA/RNA extractions/sequencing	1,793	53.5	0.4	18.6	1.1	2.3	12.3	49.9	7.6	12.9	0.0	—
Electron microscopy	601	—	—	3.6	—	—	—	—	—	—	3.5	—
Electrophoresis	223	54.7	—	17.9	—	9.0	—	61.8	9.0	9.0	—	—
Equipment cleaning	344	16.3	10.8	10.5	—	6.3	2.3	2.3	—	7.0	—	—
Filter washes	8,261	48.4	1.6	19.4	18.8	4.8	0.8	18.6	58.4	43.4	3.8	—
Gel fixing/washing	18,201	76.7	2.4	8.9	1.7	2.1	3.7	78.4	9.8	4.2	0.0	—
Hormonal labeling	31	—	—	41.2	—	—	—	1.6	—	58.8	—	—
HPLC scintillation counting	16,614	55.1	0.3	4.0	36.0	0.0	60.6	8.6	0.6	2.9	9.7	6.4
Lipid extraction	88	85.2	2.3	2.3	—	20.5	—	—	—	94.3	3.4	—
Membrane washing	42	41.0	—	—	—	—	—	41.0	1.2	—	—	—
One-time processes	1,652	13.7	2.0	9.4	1.1	9.1	3.6	9.2	8.3	9.1	2.5	0.2
Operating room wastes	156	—	—	—	—	—	—	—	—	—	—	—
Perfusion fixation	453	19.4	—	0.9	—	37.1	—	5.3	—	—	—	—
Phosphorylation	50	40.0	—	16.0	56.0	—	—	—	36.0	—	8.0	—
Protein harvesting	34	—	13.4	23.9	—	—	—	11.9	25.4	—	—	—
Protein precipitation	1,010	14.1	4.4	12.4	2.8	2.5	1.7	6.6	49.3	14.1	—	—
Radioassay	1,344	17.3	3.0	11.2	10.4	2.8	0.4	7.1	18.4	29.2	2.7	—

Table 4-2. (continued).

Table 4-21 (continued).

Waste generating process	Waste volume (L)	Volume percent of waste with chemicals present										
		Methanol	Acetone	Ethanol	Phosphoric acid	Sodium hydroxide	Pseudo-cumene	Acetic acid	Trichloro-acetic acid	Chloroform	Acetonitrile	Xylene
Radioimmunoassay	161	64.6	—	60.2	—	12.4	—	12.4	—	—	23.0	—
Reverse transcriptase assays	990	87.9	—	2.0	—	—	—	20.2	96.0	87.9	—	—
Silver staining	508	35.6	—	28.9	—	—	—	14.0	—	—	3.9	—
Staining/destaining	292	17.8	55.6	2.7	15.1	—	—	19.2	—	—	—	—
Tissue assay	223	11.2	3.1	15.0	—	2.7	—	3.1	4.5	28.0	9.4	—
Tissue staining	149	10.8	—	—	—	—	—	20.2	—	—	—	—
Unknown	4,342	11.6	1.6	1.4	4.1	0.8	2.8	9.2	2.6	4.4	2.4	0.5

Note: A blank indicates the specified waste parameter is not applicable to the indicated waste generating process.

Table 4-3. Typical EPA hazardous waste numbers for NIH mixed waste.

Waste generating process	Waste volume (L)	Volume percent of waste using EPA hazardous waste number									
		D001	D002	D007	D008	D009	D011	D022	F001	F003	F005
ATP extractions	56	100	100	—	—	—	—	—	—	100	68
Automated amino assay	12	—	—	—	—	—	—	—	—	—	—
Autoradiography	852	89	38	—	—	—	—	2	—	63	2
Blot washing	349	7	28	—	—	—	—	11	—	13	—
Cancer treatment	101	—	—	—	—	—	—	—	—	—	—
Cell assays	95	36	54	—	—	—	—	—	—	15	—
Cell culture labeling	3,913	54	31	0.4	—	—	—	39	5.1	47	12
Deprobing membranes	1,209	16	12	—	—	—	—	—	—	2	—
DNA/RNA extractions/sequencing	1,793	37	16	—	—	—	—	13	0.5	55	3
Electron microscopy	601	4	7	—	67.8	—	—	—	—	—	—
Electrophoresis	223	69	38	—	—	—	—	9	—	59	—
Equipment cleaning	344	32	33	—	—	—	—	7	—	26	5
Filter washes	8,261	48	58	—	—	—	—	60	—	48	3
Gel fixing/washing	18,201	60	23	—	—	—	1.1	16	1.3	74	1
Hormonal labeling	31	41	60	—	—	—	—	59	—	—	—
HPLC scintillation counting	16,614	90	42	—	—	—	—	6	0.1	62	2
Lipid extraction	88	47	3	—	—	—	—	60	—	81	36
Membrane washing	42	—	1	—	—	—	—	1	—	—	—
One-time processes	1,652	26	15	—	0.4	1.2	—	10	0.1	17	5
Operating room wastes	156	—	—	—	—	—	—	—	—	—	—
Perfusion fixation	453	17	—	—	—	—	—	—	—	19	—

Table 4-3. (continued).

Waste generating process	Waste volume (L)	Volume percent of waste using EPA hazardous waste number									
		D001	D002	D007	D008	D009	D011	D022	F001	F003	F005
Phosphorylation	50	48	52	—	—	—	—	36	—	40	—
Protein harvesting	34	27	27	—	—	—	—	—	—	12	—
Protein precipitation	1,010	21	58	—	—	—	—	46	—	17	—
Radioassay	1,344	26	36	—	—	—	—	38	—	20	6
Radioimmunoassay	161	63	22	—	—	—	—	—	—	65	12
Reverse transcriptase assays	990	80	58	—	—	—	—	88	—	86	—
Silver staining	508	70	19	53.7	—	—	51.2	—	—	44	—
Staining/destaining	292	12	8	—	—	—	0.2	—	—	11	—
Tissue assay	223	26	15	—	—	4.5	—	27	—	13	—
Tissue staining	149	11	61	—	57.9	—	—	—	—	11	—
Unknown	4,342	14	21	—	0.5	—	—	4	—	12	1

Note: A blank indicates the specified waste parameter is not applicable to the indicated waste generating process.

low-level radioactive waste, these wastes may be infectious wastes rather than RCRA wastes and may not meet the definition of mixed waste as discussed in Section 1.

Radiological waste properties are presented in Table 4-4. Information is provided for seven radionuclides based on their frequency of use. The percentages shown for each nuclide are the volumetric percentage of the waste stream from a particular process that contained the nuclide. The activity information shown is the volumetric average of the activity information for only that portion of the waste stream which contained the nuclide. These average activities are derived from the radioassay information performed on each waste sample at the NIH. For example, data on the use of tritium with autoradiography indicate that in 44% of the volume of waste generated, tritium was used with an average activity concentration of 0.009 mCi/L. As this information shows, ^3H is the most commonly used nuclide and ^{35}S is the next most common. The characterization information presented here provides insight into the types of waste being generated from biomedical research activities such as those occurring at the NIH.

Table 4-5 presents radiological properties for the two supplemental mixed waste streams described in Section 2.2. Information is provided for the seven radionuclides presented for the mixed wastes described in Table 4-4. The liquid scintillation vials also contain other radionuclides at generally lower activity levels including ^{22}Na , ^{36}Cl , ^{51}Cr , ^{46}Sc , ^{45}Ca , and ^{86}Rb .

Table 4-4. Radiological properties of NIH mixed waste.

Waste generating process	Waste volume (L)	³ H		¹⁴ C		³² P		³⁵ S		¹²⁵ I		¹³¹ I		²³⁸ U	
		% of volume	Average activity (mCi/L)	% of volume	Average activity (mCi/L)	% of volume	Average activity (mCi/L)	% of volume	Average activity (mCi/L)	% of volume	Average activity (mCi/L)	% of volume	Average activity (mCi/L)	% of volume	Average activity (mCi/L)
ATP extractions	56	—	—	—	—	100.0	0.012	—	—	—	—	—	—	—	—
Automated amino assay	12	—	—	—	—	—	—	—	—	100.0	0.001	—	—	—	—
Autoradiography	852	44.0	0.009	5.4	0.000	30.6	0.000	75.2	0.020	2.1	—	—	—	—	—
Blot washing	349	22.9	0.015	—	—	75.4	0.004	28.4	0.004	2.0	0.004	—	—	—	—
Cancer treatment	101	—	—	—	—	—	—	—	—	—	—	100.0	0.085	—	—
Cell assays	95	33.1	0.053	1.1	0.000	31.5	0.012	45.8	0.183	—	—	—	—	—	—
Cell culture labelling	3,913	77.0	0.081	14.0	0.011	9.6	0.019	29.7	0.030	4.3	0.015	—	—	—	—
Deprobing membranes	1,209	29.9	0.022	—	—	70.1	0.009	3.7	0.000	0.3	0.015	—	—	—	—
DNA/RNA extractions/sequencing	1,793	30.4	0.054	2.7	0.009	23.6	0.008	64.7	0.015	0.2	0.015	—	—	—	—
Electron microscopy	601	28.6	0.027	2.8	0.001	—	—	3.3	0.001	—	—	—	—	89.8	0.008
Electrophoresis	223	27.0	0.018	9.0	0.001	49.3	0.020	40.8	0.048	8.1	0.001	—	—	—	—
Equipment cleaning	344	69.0	0.177	11.9	0.006	17.9	0.052	7.0	0.156	—	—	—	—	—	—
Filter washes	8,261	55.3	0.073	6.6	0.021	34.1	0.012	32.6	0.022	1.5	0.016	—	—	—	—
Gel fixing/washing	18,201	26.5	0.060	4.5	0.002	21.1	0.010	69.1	0.025	3.7	0.004	—	—	—	—
Hormonal labeling	31	39.2	0.000	58.8	0.000	—	—	—	—	—	—	—	—	—	—
HPLC scintillation counting	16,614	86.5	0.023	12.8	0.004	3.0	0.012	9.4	0.047	1.7	0.007	—	—	—	—
Lipid extraction	88	97.7	0.829	20.5	0.151	8.0	0.003	—	—	—	—	—	—	—	—
Membrane washing	42	41.0	0.104	—	—	25.3	0.001	—	—	33.7	0.003	—	—	—	—
One-time processes	1,652	32.7	0.080	6.8	0.282	8.9	0.032	20.0	0.078	4.3	0.015	—	—	—	—
Operating room wastes	156	—	—	—	—	—	—	—	—	—	—	100.0	0.086	—	—
Perfusion fixation	453	41.1	0.005	—	—	0.9	—	0.9	—	7.7	0.002	—	—	—	—
Phosphorylation	50	8.0	0.000	—	—	52.0	0.006	40.0	0.000	—	—	—	—	—	—
Protein harvesting	34	86.6	0.011	—	—	—	—	1.5	2.120	11.9	0.000	—	—	—	—
Protein precipitation	1,010	52.2	0.282	5.7	0.004	21.9	0.179	22.5	0.041	8.6	0.018	—	—	—	—
Radioassay	1,344	71.3	0.174	22.2	0.022	8.7	0.014	44.5	0.019	2.4	0.054	—	—	—	—
Radioimmunoassay	161	47.2	0.246	—	—	12.4	0.003	34.8	0.154	62.7	0.004	—	—	—	—
Reverse transcriptase assays	990	100.0	0.130	—	—	—	—	20.2	—	—	—	—	—	—	—

Table 4-4. (continued).

Waste generating process	Waste volume (L)	³ H		¹⁴ C		³² P		³⁵ S		¹²⁵ I		¹³¹ I		²³⁸ U	
		% of volume	Average activity (mCi/L)	% of volume	Average activity (mCi/L)	% of volume	Average activity (mCi/L)	% of volume	Average activity (mCi/L)	% of volume	Average activity (mCi/L)	% of volume	Average activity (mCi/L)	% of volume	Average activity (mCi/L)
Silver staining	508	40.9	0.001	—	—	59.8	0.005	11.4	0.013	—	—	—	—	—	—
Staining/destaining	292	8.2	0.260	—	—	36.4	0.025	29.3	0.157	6.9	0.065	—	—	—	—
Tissue assay	223	52.6	0.073	10.8	0.022	—	—	22.5	0.016	16.1	0.003	—	—	—	—
Tissue staining	149	1.0	0.003	9.4	0.020	12.8	0.008	23.6	0.020	—	—	—	—	57.9	0.001
Unknown	4,342	53.3	0.048	17.7	0.020	20.1	0.039	26.5	0.048	3.7	0.006	—	—	1.1	0.001

Note: A blank indicates the specified waste parameter is not applicable to the indicated waste generating process.

Table 4-5. Radiological properties of supplemental NIH mixed waste.

Waste generating process	Container volume (L)	³ H		¹⁴ C		³² P	
		Total activity (mCi)	Average activity (mCi/L)	Total activity (mCi)	Average activity (mCi/L)	Total activity (mCi)	Average activity (mCi/L)
Liquid scintillation vials—1986	257,392	43.030	0.0002	21.720	0.0001	1.879	0.0000
Liquid scintillation vials—1987	209,609	36.400	0.0002	21.300	0.0001	0.860	0.0000
Liquid scintillation vials—1988	197,716	33.484	0.0002	16.314	0.0001	3.273	0.0000
Liquid scintillation vials—1989	180,515	25.140	0.0001	13.000	0.0001	1.580	0.0000
Liquid scintillation vials—1990	176,055	33.400	0.0002	18.840	0.0001	4.870	0.0000
Liquid scintillation vials—1991	155,667	345.145	0.0022	75.555	0.0005	81.289	0.0005
Liquid scintillation vials—1992	129,970	604.586	0.0047	79.437	0.0006	129.997	0.0010
Liquid scintillation vials—1993 (January–June)	54,154	328.420	0.0061	39.960	0.0007	47.248	0.0009
Solid medical pathological waste	46,721	0.000	0.0000	0.000	0.0000	0.000	0.0000
Waste generating process	Container volume (L)	³⁵ S		¹²⁵ I		¹³¹ I	
		Total activity (mCi)	Average activity (mCi/L)	Total activity (mCi)	Average activity (mCi/L)	Total activity (mCi)	Average activity (mCi/L)
Liquid scintillation vials—1986	257,392	1.110	0.0000	0.507	0.0000	0.020	0.0000
Liquid scintillation vials—1987	209,609	0.540	0.0000	0.170	0.0000	0.000	0.0000
Liquid scintillation vials—1988	197,716	1.039	0.0000	0.425	0.0000	0.000	0.0000
Liquid scintillation vials—1989	180,515	0.970	0.0000	0.390	0.0000	0.000	0.0000
Liquid scintillation vials—1990	176,055	3.630	0.0000	1.010	0.0000	0.000	0.0000
Liquid scintillation vials—1991	155,667	42.191	0.0003	17.607	0.0001	0.001	0.0000
Liquid scintillation vials—1992	129,970	101.141	0.0008	14.514	0.0001	0.166	0.0000
Liquid scintillation vials—1993 (January–June)	54,154	42.032	0.0008	1.833	0.0000	0.072	0.0000
Solid medical pathological waste	46,721	0.000	0.0000	0.000	0.0000	11.000	0.0002

Table 4-5. (continued).

Waste generating process	²³⁸ U		
	Container volume (L)	Total activity (mCi)	Average activity (mCi/L)
Liquid scintillation vials—1986	257,392	0.000	0.0000
Liquid scintillation vials—1987	209,609	0.000	0.0000
Liquid scintillation vials—1988	197,716	0.000	0.0000
Liquid scintillation vials—1989	180,515	0.000	0.0000
Liquid scintillation vials—1990	176,055	0.000	0.0000
Liquid scintillation vials—1991	155,667	0.000	0.0000
Liquid scintillation vials—1992	129,970	0.000	0.0000
Liquid scintillation vials—1993 (January–June)	54,154	0.000	0.0000
Solid medical pathological waste	46,721	0.000	0.0000

5. IDENTIFICATION AND CATEGORIZATION OF WASTE STREAMS WITH LIMITED TREATMENT/DISPOSAL OPTIONS

The NIH waste management facility includes an extensive waste processing capability. A carbon adsorption system has been successfully tested and placed into operation for removing trace chloroform and phenol contaminants from aqueous waste streams. Tanks and equipment are available for neutralizing acidic and alkaline waste streams. Other tanks can be used for holding waste to allow radioactive decay of nuclides with short half-lives to take place before sewer discharge. Onsite incineration capability exists for a few of the wastes, including facilities to place small volumes of other wastes in bulk containers and transport them to offsite waste treatment and disposal facilities. NIH is currently reevaluating the continuation of onsite medical waste incineration, including radioactive medical waste, and this option may not be available in the future.

The NIH evaluates mixed waste as it is received at the waste processing facility. Based on this evaluation, a determination is made as to whether disposal options exist for the waste, and recommended NIH treatment codes are assigned to the waste. An NIH treatment code of 02 indicates that no treatment or disposal options are available for the waste. The waste is packaged and labeled for indefinite long-term onsite storage until treatment or disposal facilities become available. The NIH determined that approximately one-third of the waste received during the 1989 to 1993 study period cannot be disposed of using currently available disposal options for mixed waste. Because no disposal options are available, this waste has been placed into bulk containers and is currently being stored at the NIH. Tables 5-1 through 5-4 present chemical properties, chemicals present, EPA hazardous waste numbers, and radiological properties for this waste. Generally, the radiological activity levels of this waste are higher than the comparable activity levels of the overall waste stream characterized in Section 4. Since the no disposal option waste is a subset of the overall waste stream, this indicates that the waste streams with the highest activities are being diverted to storage at NIH.

Some of the waste shown as having no disposal options in the database records is produced by waste generating processes that have typically not produced such wastes. An example of this would be HPLC scintillation counting wastes. Even though disposal options exist for HPLC scintillation counting wastes, a small volume of these wastes (approximately 4%) are described in the database and shown in Tables 5-1 through 5-4 as having no disposal options. It appears likely that a small amount of the HPLC scintillation counting wastes were combined with wastes from other processes to produce a combined waste that does not presently have a disposal option.

Another significant proportion of the overall waste stream contains wastes that are believed to have treatment and disposal options but that have not been disposed of and are currently being stored. These wastes are referred to as "waste in process" in this report and are described in detail in Tables 5-5 through 5-8. This waste has not been disposed of due to treatment capacity limitations, transportation limitations, processing and handling limitations, or the recent arrival of the waste at the NIH waste processing area.

Table 5-1. Chemical properties of NIH mixed waste with no disposal options.

Waste generating process	Waste volume (L)	pH minimum	pH maximum	Flashpoint minimum (°F)
ATP extractions	0	N/A	N/A	N/A
Automated amino assay	0	N/A	N/A	N/A
Autoradiography	513	1.0	13.0	94
Blot washing	89	1.0	11.3	135
Cancer treatment	0	N/A	N/A	N/A
Cell assays	35	1.0	4.4	120
Cell culture labeling	1,842	0.3	13.1	88
Deprobing membranes	154	9.4	12.9	99
DNA/RNA extractions/sequencing	729	0.3	12.5	78
Electron microscopy	29	5.4	7.5	139
Electrophoresis	101	1.9	6.7	80
Equipment cleaning	97	3.1	14.0	99
Filter washes	3,798	0.1	12.8	82
Gel fixing/washing	9,721	0.0	13.4	72
Hormonal labeling	30	1.6	6.8	92
HPLC scintillation counting	616	0.9	8.2	70
Lipid extraction	72	1.9	10.1	70
Membrane washing	17	3.1	3.1	141
One-time processes	512	0.6	12.5	78
Operating room wastes	0	N/A	N/A	N/A
Perfusion fixation	110	2.7	9.6	99
Phosphorylation	24	3.8	5.7	99
Protein harvesting	5	1.8	3.7	141
Protein precipitation	455	0.0	6.0	78
Radioassay	562	0.2	12.6	96
Radioimmunoassay	124	1.3	7.7	99
Reverse transcriptase assays	670	0.8	5.8	99
Silver staining	306	1.2	6.7	70
Staining/destaining	45	2.0	9.4	139
Tissue assay	103	0.5	9.1	84
Tissue staining	35	1.3	11.6	139
Unknown	735	0.3	14.0	60

N/A = Data not available.

Table 5-2. Chemicals typically present in NIH mixed waste with no disposal options.

Waste generating process	Waste volume (L)	Volume percent of waste with chemicals present										
		Methanol	Acetone	Ethanol	Phosphoric acid	Sodium hydroxide	Pseudo-cumene	Acetic acid	Trichloro-acetic acid	Chloroform	Acetonitrile	Xylene
ATP extractions	—	—	—	—	—	—	—	—	—	—	—	—
Automated amino assay	—	—	—	—	—	—	—	—	—	—	—	—
Autoradiography	513	47.4	3.7	7.4	—	0.4	1.6	93.6	3.5	—	—	—
Blot washing	89	49.4	—	—	22.5	7.9	7.9	27.0	22.5	—	—	—
Cancer treatment	—	—	—	—	—	—	—	—	—	—	—	—
Cell assays	35	59.8	—	34.2	—	—	37.0	34.2	34.2	—	—	—
Cell culture labeling	1,842	57.0	2.9	28.8	5.2	2.6	1.4	19.4	44.0	39.8	1.6	—
Deprobing membranes	154	10.4	—	—	—	88.3	—	—	—	—	89.6	—
DNA/RNA/extractions/sequencing	729	63.8	1.1	13.0	—	3.3	2.7	52.8	10.4	25.2	0.0	—
Electron microscopy	29	—	—	—	—	—	—	—	—	—	28.4	—
Electrophoresis	101	45.5	—	19.8	—	—	—	63.4	—	19.8	—	—
Equipment cleaning	97	24.7	34.0	37.1	—	—	8.2	—	—	16.5	—	—
Filter washes	3,798	60.0	1.4	19.2	1.7	1.8	1.8	10.1	89.0	75.9	1.5	—
Gel fixing/washing	9,721	93.1	1.2	3.6	1.1	2.2	0.5	86.2	5.4	6.4	0.1	—
Hormonal labeling	30	—	—	40.0	—	—	—	—	—	60.0	—	—
HPLC scintillation counting	616	50.1	—	5.5	27.7	—	41.1	6.7	1.3	7.1	16.2	8.3
Lipid extraction	72	81.9	2.8	2.8	—	25.0	—	—	—	93.1	4.2	—
Membrane washing	17	100.0	—	—	—	—	—	100.0	—	—	—	—
One-time processes	512	44.0	3.3	26.7	—	12.3	8.2	15.8	26.8	29.3	8.2	0.8
Operating room wastes	—	—	—	—	—	—	—	—	—	—	—	—
Perfusion fixation	110	80.0	—	3.6	—	16.4	—	3.6	—	—	—	—
Phosphorylation	24	83.3	—	—	83.3	—	—	—	—	—	16.7	—
Protein harvesting	5	—	100.0	—	—	—	—	88.9	11.1	—	—	—
Protein precipitation	455	31.2	8.8	23.5	—	—	3.7	14.7	74.5	24.2	—	—
Radioassay	562	39.6	5.0	18.7	3.6	4.4	0.9	7.2	36.8	66.7	6.4	—
Radioimmunoassay	124	83.9	—	64.5	—	—	—	—	—	—	16.1	—

Table 5-2. (continued).

Waste generating process	Waste volume (L)	Volume percent of waste with chemicals present										
		Methanol	Acetone	Ethanol	Phosphoric acid	Sodium hydroxide	Pseudo-cumene	Acetic acid	Trichloro-acetic acid	Chloroform	Acetonitrile	Xylene
Reverse transcriptase assays	670	97.0	—	3.0	—	—	—	—	100.0	100.0	—	—
Silver staining	306	42.5	—	37.9	—	—	—	13.1	—	—	6.5	—
Staining/destaining	45	98.9	—	18.0	36.0	—	—	98.9	—	—	—	—
Tissue assay	103	20.3	6.8	24.7	—	—	—	6.8	9.7	60.5	20.3	—
Tissue staining	35	45.7	—	—	—	—	—	45.7	—	—	—	—
Unknown	735	29.0	6.6	6.8	5.4	0.8	5.8	15.5	4.7	22.1	8.7	2.7

Note: A blank indicates the specified waste parameter is not applicable to the indicated waste generating process.

Table 5-3. Typical EPA hazardous waste numbers for NIH mixed waste with no disposal options.

Waste generating process	Waste volume (L)	Volume percent of waste using EPA hazardous waste number									
		D001	D002	D007	D008	D009	D011	D022	F001	F003	F005
ATP extractions	—	—	—	—	—	—	—	—	—	—	—
Automated amino assay	—	—	—	—	—	—	—	—	—	—	—
Autoradiography	513	90	52	—	—	—	—	—	—	55	3
Blot washing	89	27	45	—	—	—	—	45	—	49	—
Cancer treatment	—	—	—	—	—	—	—	—	—	—	—
Cell assays	35	99	4	—	—	—	—	—	—	40	—
Cell culture labeling	1,842	68	54	0.9	—	—	—	48	0.0	59	2
Deprobing membranes	154	100	6	—	—	—	—	—	—	—	—
DNA/RNA extractions/sequencing	729	53	19	—	—	—	—	26	1.2	66	6
Electron microscopy	29	28	—	—	27.9	—	—	—	—	—	—
Electrophoresis	101	71	28	—	—	—	—	20	—	47	—
Equipment cleaning	97	79	21	—	—	—	—	16	—	59	16
Filter washes	3,798	63	80	—	—	—	—	87	—	60	0.4
Gel fixing/washing	9,721	68	29	—	—	—	—	8	0.2	89	0.2
Hormonal labeling	30	40	60	—	—	—	—	60	—	—	—
HPLC scintillation counting	616	78	55	—	—	—	—	6	—	58	—
Lipid extraction	72	54	4	—	—	—	—	71	—	96	44
Membrane washing	17	—	—	—	—	—	—	—	—	—	—
One-time processes	512	76	40	—	—	3.9	—	33	0.2	54	12
Operating room wastes	—	—	—	—	—	—	—	—	—	—	—
Perfusion fixation	110	51	—	—	—	—	—	—	—	80	—
Phosphorylation	24	100	—	—	—	—	—	—	—	83	—

Table 5-3. (continued).

Waste generating process	Waste volume (L)	Volume percent of waste using EPA hazardous waste number									
		D001	D002	D007	D008	D009	D011	D022	F001	F003	F005
Protein harvesting	5	—	—	—	—	—	—	—	—	89	—
Protein precipitation	455	46	82	—	—	—	—	87	—	33	—
Radioassay	562	49	66	—	—	—	—	81	—	45	11
Radioimmunoassay	124	68	13	—	—	—	—	—	—	84	16
Reverse transcriptase assays	670	88	76	—	—	—	—	100	—	94	—
Silver staining	306	69	13	52.3	—	—	54.2	—	—	49	—
Staining/destaining	45	54	36	—	—	—	1.1	—	—	54	—
Tissue assay	103	56	14	—	—	9.7	—	58	—	27	—
Tissue staining	35	46	46	—	—	—	—	—	—	46	—
Unknown	735	36	23	—	2.7	—	—	18	—	25	1

Note: A blank indicates the specified waste parameter is not applicable to the indicated waste generating process.

Table 5-4. Radiological properties of NIH mixed waste with no disposal options.

Waste generating process	³ H		¹⁴ C		³² P		³⁵ S		¹²⁵ I		¹³¹ I		²³⁸ U	
	Waste volume (L)	% of volume	Average activity (mCi/L)	% of volume	Average activity (mCi/L)	% of volume	Average activity (mCi/L)	% of volume	Average activity (mCi/L)	% of volume	Average activity (mCi/L)	% of volume	Average activity (mCi/L)	% of volume
ATP extractions	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Automated amino assay	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Autoradiography	513	30.4	0.022	4.8	0.000	9.9	0.000	64.7	0.032	3.5	—	—	—	—
Blot washing	89	42.7	0.004	—	—	44.9	0.004	92.1	0.002	7.9	0.004	—	—	—
Cancer treatment	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cell assays	35	61.3	0.073	2.8	0.000	—	—	38.7	0.221	—	—	—	—	—
Cell culture labeling	1,842	85.6	0.134	9.2	0.026	6.8	0.023	16.6	0.088	8.1	0.013	—	—	—
Deprobing membranes	154	93.5	0.000	—	—	—	—	16.9	0.000	—	—	—	—	—
DNA/RNA extractions/sequencing	729	39.8	0.058	6.6	0.009	8.3	0.004	60.6	0.020	—	—	—	—	—
Electron microscopy	29	—	—	—	—	—	—	—	—	—	—	—	100.0	0.000
Electrophoresis	101	19.8	0.000	19.8	0.001	15.8	0.002	62.4	0.064	17.8	0.001	—	—	—
Equipment cleaning	97	83.5	0.393	16.5	0.015	—	—	20.6	0.183	—	—	—	—	—
Filter washes	3,798	72.1	0.110	10.6	0.025	11.2	0.022	30.9	0.041	1.1	0.001	—	—	—
Gel fixing/washing	9,721	20.0	0.127	3.4	0.004	16.2	0.005	80.3	0.031	5.6	0.003	—	—	—
Hormonal labeling	30	40.0	0.000	60.0	0.000	—	—	—	—	—	—	—	—	—
HPLC scintillation counting	616	85.4	0.176	1.3	0.002	7.1	0.102	23.0	0.394	11.5	0.011	—	—	—
Lipid extraction	72	97.2	0.783	25.0	0.151	—	—	—	—	—	—	—	—	—
Membrane washing	17	100.0	0.104	—	—	—	—	—	—	—	—	—	—	—
One-time processes	512	68.2	0.033	7.8	0.076	5.1	0.018	27.9	0.069	1.6	0.001	—	3.1	0.123
Operating room wastes	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Perfusion fixation	110	45.5	0.016	—	—	3.6	—	3.6	—	16.4	0.001	—	—	—
Phosphorylation	24	16.7	0.000	—	—	—	—	83.3	0.000	—	—	—	—	—
Protein harvesting	5	—	—	—	—	—	—	11.1	2.120	88.9	0.000	—	—	—
Protein precipitation	455	81.3	0.292	11.0	0.004	6.6	0.044	35.9	0.021	4.4	0.007	—	—	—
Radioassay	562	65.6	0.326	39.4	0.020	0.1	0.000	8.2	0.004	3.5	0.087	—	—	—
Radioimmunoassay	124	61.3	0.246	—	—	16.1	0.003	45.2	0.154	51.6	0.001	—	—	—
Reverse transcriptase Assays	670	100.0	0.155	—	—	—	—	—	—	—	—	—	—	—
Silver staining	306	61.4	0.001	—	—	44.4	0.006	19.0	0.013	—	—	—	—	—
Staining/destaining	45	18.0	0.006	—	—	80.9	0.002	82.0	0.004	—	—	—	—	—
Tissue assay	103	61.5	0.107	20.3	0.025	—	—	31.2	0.024	—	—	—	—	—

Table 5-4. (continued).

Waste generating process	^3H		^{14}C		^{32}P		^{35}S		^{125}I		^{131}I		^{238}U	
	Waste volume (L)	% of volume	Average activity (mCi/L)	% of volume	Average activity (mCi/L)	% of volume	Average activity (mCi/L)	% of volume	Average activity (mCi/L)	% of volume	Average activity (mCi/L)	% of volume	Average activity (mCi/L)	% of volume
Tissue staining	35	—	—	—	—	54.3	0.008	100.0	0.020	—	—	—	—	—
Unknown	735	67.1	0.097	7.5	0.223	12.9	0.001	25.3	0.177	5.8	0.000	—	—	2.7

Note: A blank indicates the specified waste parameter is not applicable to the indicated waste generating process.

Table 5-5. Chemical properties of NIH mixed waste in process.

Waste generating process	Waste volume (L)	pH minimum	pH maximum	Flashpoint minimum (°F)
ATP extractions	56	1.6	1.8	96
Automated amino assay	0	N/A	N/A	N/A
Autoradiography	103	0.2	3.8	84
Blot washing	0	N/A	N/A	N/A
Cancer treatment	101	N/A	N/A	N/A
Cell assays	10	N/A	N/A	N/A
Cell culture labeling	560	0.1	4.7	83
Deprobing membranes	0	N/A	N/A	N/A
DNA/RNA extractions/sequencing	422	1.2	8.9	75
Electron microscopy	317	2.1	8.0	139
Electrophoresis	40	0.9	8.0	80
Equipment cleaning	32	2.8	7.4	90
Filter washes	394	0.4	8.4	65
Gel fixing/washing	2,193	0.1	7.8	76
Hormonal labeling	0	N/A	N/A	N/A
HPLC scintillation counting	2,188	0.5	9.2	65
Lipid extraction	16	2.4	2.4	86
Membrane washing	1	1.0	1.0	141
One-time processes	766	3.9	7.6	99
Operating room wastes	81	N/A	N/A	N/A
Perfusion fixation	55	4.5	7.1	105
Phosphorylation	26	1.0	1.9	141
Protein harvesting	8	1.7	1.7	95
Protein precipitation	347	0.1	6.8	139
Radioassay	647	1.0	8.7	63
Radioimmunoassay	17	6.7	6.7	99
Reverse transcriptase assays	40	0.7	1.6	141
Silver staining	52	3.8	9.7	99
Staining/destaining	247	0.1	3.2	92
Tissue assay	10	6.7	6.7	141
Tissue staining	38	5.4	5.9	138
Unknown	1,122	0.5	8.6	58

N/A = Data not available.

Table 5-6. Chemicals typically present in NIH mixed waste in process.

Waste generating process	Waste volume (L)	Volume percent of waste with chemicals present										
		Methanol	Acetone	Ethanol	Phosphoric acid	Sodium hydroxide	Pseudo-cumene	Acetic acid	Trichloro-acetic acid	Chloroform	Acetonitrile	Xylene
ATP extractions	56	100.0	100.0	—	—	—	—	100.0	—	—	—	—
Automated amino assay	—	—	—	—	—	—	—	—	—	—	—	—
Autoradiography	103	27.2	—	0.5	—	—	19.5	25.1	19.5	19.5	—	—
Blot washing	—	—	—	—	—	—	—	—	—	—	—	—
Cancer treatment	101	—	—	—	—	—	—	—	—	—	—	—
Cell assays	10	—	—	—	—	—	—	—	—	—	—	—
Cell culture labeling	560	14.7	—	5.9	3.4	—	—	6.4	3.6	2.9	—	—
Deprobing membranes	—	—	—	—	—	—	—	—	—	—	—	—
DNA/RNA extractions/sequencing	422	68.7	—	0.2	—	—	—	59.2	4.7	0.4	—	—
Electron microscopy	317	—	—	6.3	—	—	—	—	—	—	4.1	—
Electrophoresis	40	99.5	—	—	—	49.8	—	49.8	—	—	—	—
Equipment cleaning	32	100.0	12.5	—	—	—	—	—	—	25.0	—	—
Filter washes	394	34.8	5.1	5.1	11.2	—	—	15.5	38.8	18.3	—	—
Gel fixing/washing	2,193	60.2	2.1	6.7	6.0	—	0.5	54.2	7.4	2.9	—	—
Hormonal labeling	—	—	—	—	—	—	—	—	—	—	—	—
HPLC scintillation counting	2,188	37.7	0.4	6.3	2.7	—	45.4	7.6	1.8	1.6	11.5	5.4
Lipid extraction	16	100.0	—	—	—	—	—	—	—	100.0	—	—
Membrane washing	1	—	—	—	—	—	—	—	100.0	—	—	—
One-time processes	766	0.2	2.1	—	2.5	2.5	2.3	3.0	—	—	—	—
Operating room wastes	81	—	—	—	—	—	—	—	—	—	—	—
Perfusion fixation	55	—	—	—	—	61.8	—	—	—	—	—	—
Phosphorylation	26	—	—	30.8	30.8	—	—	—	69.2	—	—	—
Protein harvesting	8	—	—	100.0	—	—	—	—	100.0	—	—	—
Protein precipitation	347	—	1.2	2.9	—	—	—	—	23.1	9.2	—	—
Radioassay	647	1.5	—	4.3	6.2	—	—	3.1	6.2	2.8	—	—
Radioimmunoassay	17	—	—	100.0	—	—	—	—	—	—	100.0	—
Reverse transcriptase assays	40	50.0	—	—	—	—	—	—	50.0	—	—	—
Silver staining	52	26.9	—	26.9	—	—	—	26.9	—	—	—	—

Table 5-6. (continued).

Waste generating process	Waste volume (L)	Volume percent of waste with chemicals present										
		Methanol	Acetone	Ethanol	Phosphoric acid	Sodium hydroxide	Pseudo- cumene	Acetic acid	Trichloro- acetic acid	Chloroform	Acetonitrile	Xylene
Staining/destaining	247	3.2	65.6	—	11.3	—	—	4.9	—	—	—	—
Tissue assay	10	—	—	—	—	—	—	—	—	—	—	—
Tissue staining	38	—	—	—	—	—	—	—	—	—	—	—
Unknown	1,122	18.8	1.8	1.1	0.4	0.7	1.8	9.9	2.5	2.7	3.2	—

Note: A blank indicates the specified waste parameter is not applicable to the indicated waste generating process.

Table 5-7. Typical EPA hazardous waste numbers for NIH mixed waste in process.

Waste generating process	Waste volume (L)	Volume percent of waste using EPA hazardous waste number								
		D001	D002	D007	D008	D011	D022	F001	F003	F005
ATP extractions	56	100	100	—	—	—	—	—	100	68
Automated amino assay	—	—	—	—	—	—	—	—	—	—
Autoradiography	103	80	47	—	—	—	19	—	47	—
Blot washing	—	—	—	—	—	—	—	—	—	—
Cancer treatment	101	—	—	—	—	—	—	—	—	—
Cell assays	10	—	—	—	—	—	—	—	—	—
Cell culture labeling	560	24	21	—	—	—	3	—	18	—
Deprobing membranes	—	—	—	—	—	—	—	—	—	—
DNA/RNA extractions/sequencing	422	55	18	—	—	—	0	—	64	—
Electron microscopy	317	4	0	—	45.7	—	—	—	—	—
Electrophoresis	40	50	50	—	—	—	—	—	100	—
Equipment cleaning	32	100	—	—	—	—	25	—	100	—
Filter washes	394	6	51	—	—	—	39	—	21	—
Gel fixing/washing	2,193	51	27	—	—	—	9	—	55	—
Hormonal labeling	—	—	—	—	—	—	—	—	—	—
HPLC scintillation counting	2,188	82	15	—	—	—	3	—	49	1
Lipid extraction	16	13	—	—	—	—	13	—	13	—
Membrane washing	1	—	100	—	—	—	100	—	—	—
One-time processes	766	6	—	—	0.8	—	—	—	1	3
Operating room wastes	81	—	—	—	—	—	—	—	—	—
Perfusion fixation	55	36	—	—	—	—	—	—	—	—
Phosphorylation	26	—	100	—	—	—	69	—	—	—
Protein harvesting	8	100	100	—	—	—	—	—	—	—
Protein precipitation	347	1	17	—	—	—	15	—	1	—
Radioassay	647	9	6	—	—	—	9	—	2	3

Table 5-7. (continued).

Waste generating process	Waste volume (L)	Volume percent of waste using EPA hazardous waste number								
		D001	D002	D007	D008	D011	D022	F001	F003	F005
Radioimmunoassay	17	100	—	—	—	—	—	—	—	—
Reverse transcriptase assays	40	—	100	—	—	—	—	—	50	—
Silver staining	52	65	—	—	—	34.6	—	—	27	—
Staining/destaining	247	5	3	—	—	—	—	—	3	—
Tissue assay	10	—	—	—	—	—	—	—	—	—
Tissue staining	38	—	—	—	68.4	—	—	—	—	—
Unknown	1,122	18	5	—	—	—	3	—	19	1

Note: A blank indicates the specified waste parameter is not applicable to the indicated waste generating process.

Table 5-8. Radiological properties of NIH mixed waste in process.

Waste generating process	^3H		^{14}C		^{32}P		^{35}S		^{125}I		^{131}I		^{238}U	
	Waste volume (L)	% of volume	Average activity (mCi/L)	% of volume	Average activity (mCi/L)	% of volume	Average activity (mCi/L)	% of volume	Average activity (mCi/L)	% of volume	Average activity (mCi/L)	% of volume	Average activity (mCi/L)	% of volume
ATP extractions	56	—	—	—	—	100.0	0.012	—	—	—	—	—	—	—
Automated amino assay	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Autoradiography	103	1.5	0.020	19.5	0.000	—	—	79.1	0.012	—	—	—	—	—
Blot washing	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cancer treatment	101	—	—	—	—	—	—	—	—	—	100.0	0.085	—	—
Cell assays	10	100.0	0.012	—	—	—	—	100.0	0.006	—	—	—	—	—
Cell culture labeling	560	69.0	0.049	51.1	0.003	13.0	0.041	14.8	0.084	—	—	—	—	—
Deprobing membranes	—	—	—	—	—	—	—	—	—	—	—	—	—	—
DNA/RNA extractions/sequencing	422	7.6	0.397	—	—	35.5	0.009	69.2	0.013	—	—	—	—	—
Electron microscopy	317	41.1	0.034	5.4	0.001	—	—	6.3	0.001	—	—	—	80.6	0.002
Electrophoresis	40	50.2	0.017	—	—	99.5	0.041	49.8	0.015	—	—	—	—	—
Equipment cleaning	32	87.5	0.242	—	—	—	—	12.5	0.025	—	—	—	—	—
Filter washes	394	25.4	0.115	4.6	0.019	60.4	0.028	2.0	0.016	4.1	0.094	—	—	—
Gel fixing/washing	2,193	15.0	0.072	1.0	0.005	43.9	0.024	25.4	0.074	2.4	0.015	—	—	—
Hormonal labeling	—	—	—	—	—	—	—	—	—	—	—	—	—	—
HPLC scintillation counting	2,188	67.0	0.030	15.8	0.003	2.7	0.002	14.8	0.014	4.8	0.003	—	—	—
Lipid extraction	16	100.0	1.027	—	—	43.8	0.003	—	—	—	—	—	—	—
Membrane washing	1	—	—	—	—	100.0	0.010	—	—	—	—	—	—	—
One-time processes	766	8.6	0.323	0.1	28.800	9.5	0.011	11.0	0.030	5.3	0.000	—	—	—
Operating room wastes	81	—	—	—	—	—	—	—	—	—	100.0	0.087	—	—
Perfusion fixation	55	69.1	0.000	—	—	—	—	—	—	30.9	0.003	—	—	—
Phosphorylation	26	—	—	—	—	100.0	0.006	—	—	—	—	—	—	—
Protein harvesting	8	100.0	0.005	—	—	—	—	—	—	—	—	—	—	—
Protein precipitation	347	34.3	0.339	—	—	19.6	0.493	7.5	0.168	5.8	0.032	—	—	—
Radioassay	647	86.9	0.082	9.3	0.023	6.8	0.018	78.2	0.000	—	—	—	—	—
Radioimmunoassay	17	—	—	—	—	—	—	—	—	100.0	0.004	—	—	—
Reverse transcriptase assays	40	100.0	0.227	—	—	—	—	—	—	—	—	—	—	—
Silver staining	52	38.5	0.003	—	—	100.0	0.001	—	—	—	—	—	—	—

Table 5-8. (continued).

Waste generating process	Waste volume (L)	^3H		^{14}C		^{32}P		^{35}S		^{125}I		^{131}I		^{238}U	
		% of volume	Average activity (mCi/L)	% of volume	Average activity (mCi/L)	% of volume	Average activity (mCi/L)	% of volume	Average activity (mCi/L)	% of volume	Average activity (mCi/L)	% of volume	Average activity (mCi/L)	% of volume	Average activity (mCi/L)
Staining/destaining	247	66.5	0.388	—	—	28.3	0.036	19.8	0.271	8.1	0.065	—	—	—	—
Tissue assay	10	—	—	—	—	—	—	—	—	100.0	0.009	—	—	—	—
Tissue staining	38	—	—	—	—	—	—	—	—	—	—	—	—	68.4	0.000
Unknown	1,122	69.1	0.064	48.9	0.001	19.8	0.012	14.7	0.012	2.6	0.005	—	—	2.3	0.000

Note: A blank indicates the specified waste parameter is not applicable to the indicated waste generating process.

Table 5-9 presents a summary by process of the overall waste stream, waste disposed of, waste in process, and waste with no disposal options. As can be seen, approximately one-third of the overall waste stream has no disposal options. About 15% of the overall waste stream exists as waste in process and slightly over one-half of the waste has been disposed of using one of the disposal options available. Figures 5-1, 5-2, and 5-3 graphically depict the distribution of the waste streams by process category. Generally, gel fixing/washing and filter washes produce the largest proportionate volume of wastes with no disposal options. In contrast, HPLC scintillation counting wastes generally have disposal options available.

Table 5-9. Volume of NIH mixed waste by handling steps.

Waste generating process	Total waste received by NIH (L)	Waste disposed		Waste in process		Waste with no disposal options	
		(L)	Percent of received volume	(L)	Percent of received volume	(L)	Percent of received volume
ATP extractions	56	0	N/A	56	100.0	0	N/A
Automated amino assay	12	12	100.0	0	N/A	0	N/A
Autoradiography	852	236	27.7	103	12.1	513	60.2
Blot washing	349	260	74.5	0	N/A	89	25.5
Cancer treatment	101	0	N/A	101	100.0	0	N/A
Cell assays	95	50	52.6	10	10.5	35	36.9
Cell culture labeling	3,913	1,511	38.6	560	14.3	1,842	47.1
Deprobing membranes	1,209	1,055	87.3	0	N/A	154	12.7
DNA/RNA extractions/sequencing	1,793	642	35.8	422	23.5	729	40.7
Electron microscopy	601	256	42.5	317	52.7	29	4.8
Electrophoresis	223	82	36.7	40	18.0	101	45.3
Equipment cleaning	344	215	62.4	32	9.3	97	28.2
Filter washes	8,261	4,069	49.3	394	4.8	3,798	46.0
Gel fixing/washing	18,201	6,287	34.5	2,193	12.0	9,721	53.4
Hormonal labeling	31	1	2.0	0	N/A	30	98.0
HPLC scintillation counting	16,614	13,810	83.1	2,188	13.2	616	3.7
Lipid extraction	88	0	N/A	16	18.2	72	81.8
Membrane washing	42	24	57.8	1	1.2	17	41.0
One-time processes	1,652	374	22.7	766	46.4	512	31.0
Operating room wastes	156	75	48.3	81	51.7	0	N/A
Perfusion fixation	453	288	63.6	55	12.1	110	24.3
Phosphorylation	50	0	N/A	26	52.0	24	48.0
Protein harvesting	34	21	62.7	8	23.9	5	13.4
Protein precipitation	1,010	208	20.6	347	34.4	455	45.0

Table 5-9. (continued).

Waste generating process	Total waste received by NIH (L)	Waste disposed		Waste in process		Waste with no disposal options	
		(L)	Percent of received volume	(L)	Percent of received volume	(L)	Percent of received volume
Radioassay	1,344	135	10.0	647	48.1	562	41.8
Radioimmunoassay	161	20	12.4	17	10.6	124	77.0
Reverse transcriptase assays	990	280	28.3	40	4.0	670	67.7
Silver staining	508	150	29.5	52	10.2	306	60.2
Staining/destaining	292	0	N/A	247	84.7	45	15.3
Tissue assay	223	110	49.3	10	4.5	103	46.2
Tissue staining	149	76	50.8	38	25.6	35	23.6
Unknown	4,342	2,485	57.2	1,122	25.8	735	16.9
Total	64,146	32,730	51.0	9,887	15.4	21,529	33.6

N/A = Data not available.

Figure 5-1. Distribution of waste volume by process for waste with disposal options.

Figure 5-2. Distribution of waste volume by process for waste in process at NIH.

Figure 5-3. Distribution of waste volume by process for waste with no disposal options.

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6. CONCLUSIONS

Section 2 of this report presents the results of the study in which the NIH wastes were combined into similar process groups. The results of this procedure reveal two significant findings: (a) relatively few waste generating processes produced the large majority of the mixed wastes, and (b) waste produced by these processes has relatively similar properties and compositions. In Section 3, it can be seen that a relatively small percentage (2.8%) of the total containerized mixed waste volume shown in Table 2-1 can be attributed to one-time processes. The detailed characterization information presented in Sections 4 and 5 provides a valuable insight into the chemical and radiological properties of the waste based on the waste generating processes from which it was generated. This information provides a unique picture of biomedical mixed wastes. Figures 5-1, 5-2, and 5-3 are particularly helpful in pointing out areas upon which waste minimization efforts might profitably focus. These figures show that the majority of the waste with no disposal options is generated by the gel fixing/washing process group. To a lesser extent, the filter washing group also generates a large portion of the waste with no disposal options. The remaining process groups are almost insignificant in their waste generation volume by comparison with these processes.

The two supplemental mixed waste streams constitute approximately 96% by volume of the total waste volumes listed in Tables 2-1 and 2-2. The relatively large volume of these waste streams makes them candidates for waste minimization efforts. However, disposal options currently exist for these waste streams and they are not presently being accumulated onsite.

This report presents a review of the available data regarding mixed waste generation at the NIH. A follow-on study will be conducted to fully characterize waste generating processes. Specifically, individual NIH mixed waste generators will be interviewed to gain an in-depth understanding of the processes and analytical techniques that generate the waste stream and of the chemicals used. The goal of the analysis will be to identify potential changes in procedures and materials that would reduce the volume of mixed waste with no disposal options without sacrificing the quality of the research activities.

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