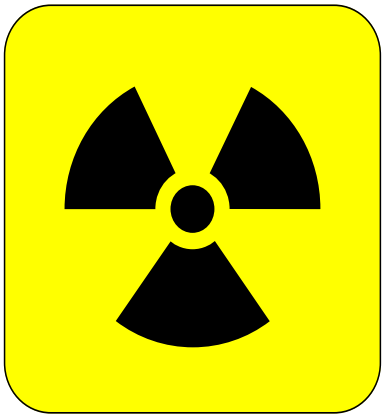
Radioactive Waste Disposal Manual 2016



Environmental Health and Safety

UNIVERSITY OF COLORADO

DENVER | ANSCHUTZ MEDICAL CAMPUS

FOREWORD

This radioactive waste disposal manual has been prepared by the Radiation Safety Program of the Environmental Health and Safety Department (EHS). Its purpose is to inform the University of Colorado Denver | Anschutz Medical Campus research community of safe radioactive waste handling and disposal procedures. These practices and procedures must be used by individuals who generate radioactive waste at CU Denver | Anschutz and its satellite facilities.

We have attempted to provide moderately detailed information about proper radioactive waste disposal practices and ask each authorized member of the research community utilizing radioisotopes to consult appropriate sections of this manual prior to disposing radioactive waste. This applies to faculty, staff, research fellows, and students. Therefore, this manual must be easily accessible in the laboratory using isotopes.

We wish to thank those individuals who took time to assist with the preparation of this manual.

This manual will be revised periodically.

EMERGENCY TELEPHONE NUMBERS

Where to call for:	Weekdays 8 a.m – 5 p.m.	After Hours, Weekends, & Holidays
	Extension Number	**Extension Number**
UCD Police	911	911
Fire	911	911
Medical Emergencies	911	911
Hazardous Materials Spills	4-0345	911
Radiation Safety	4-0345	911
Biological Safety	4-0345	911
Occupational Safety	4-0345	911
Other	4-0345	911
Colorado Department of Public Health and Environment	(303) 692-3320 (303) 692-3300 *Toll Free (888) 569-1831*	(303) 877-9757

RADIATION SAFETY ROUTINE TELEPHONE NUMBERS

Where to call for:	Weekdays 8 a.m – 5 p.m.	After Hours, Weekends, & Holidays
	Extension Number	**Extension Number**
Radiation Safety Officer (RSO)	4-0234	911
Alternate RSO	4-0128	911
Radioactive Waste Pickups	4-0109 *(or submit RAM Waste Pickup Request form)*	*******
Radioactive Materials Inventory and Paperwork	4-0109, or 4-0345	*******
General Questions	4-0345	911
Personal Dosimeters	4-0345	*******

Note: The Environmental Health and Safety Department has someone on-call 24 hours a day, 7 days a week to provide assistance to the university community

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I. INTRODUCTION

Radioactive wastes that are generated at CU Denver | Anschutz, as they are commonly described for regulatory and policy-making purposes fall into the class of "low level radioactive waste (LLRW)".

The management of radioactive wastes is a complex and exacting task, as it is governed by issues concerning both safety and public opinion. It is the intent of EHS and this manual to help facilitate the safe and legal management of radioactive waste at the university. For laboratories using only single or a few isotopes and always generating the same form of waste, the disposal routine does not have to be difficult. However, this requires constant waste generator participation and reassessment of the evolving requirements of regulatory agencies, disposal vendors, and other parties involved in the waste disposal process.

Generators of mixed wastes (radioactive wastes also containing hazardous chemicals) must also comply with the Colorado Hazardous Waste Regulations which requires classroom and on-the-job training. Other Colorado Hazardous Waste Regulations pertaining to Satellite Accumulation Areas must also be followed, including those pertaining to proper segregation, labeling and storage. Special labels for mixed waste must be placed on containers used to store wastes in the laboratory (including scintillation vial wastes containing regulated chemicals such as Toluene, Xylene and pseudocumene based cocktails). Distinctive mixed waste pickup request forms must be used to request pickup of all mixed waste except liquid scintillation vials that are classified as hazardous solely because they contain RCRA regulated ignitable (flammable) cocktails.

Finally, the waste manager in EHS must consider the constraints imposed by limitations on space, personnel, and other resources available for waste management. A list of agencies and organizations involved in radioactive waste management is is attached as Appendix I.

It is very important that radioactive waste generators keep the university RSO advised concerning the wastes that they ***intend*** to generate so that appropriate disposal options can be investigated and arranged ***prior*** to the generation of such wastes.

II. RADIOACTIVE MATERIALS MANAGEMENT AT CU Denver | Anschutz

A. CONTROL AND AUTHORITY

All radioactive materials and resulting wastes at the university are managed by EHS under the exclusive authority of the university's radioactive materials licenses, as issued by the Colorado Department of Public Health and the Environment (CDPHE), and are subject to the local authority of the Radiation Safety Officer (RSO) and Committee on Ionizing Radiation (CIR). The CIR reviews each new application for authorization to use radioactive materials to assure minimization of waste generation, regulatory compliance, and sound practice by the authorized principal investigator. Disposal is accomplished by EHS, in a manner consistent with all local, state, and federal regulations and the authority of the Rocky Mountain Low Level Radioactive

Waste Board. All radioactive materials used by investigators are tracked from purchase request through final disposal by the radioisotope inventory system maintained by EHS.

B. OCCUPATIONAL EXPOSURE TO RADIATION

The university's Radioactive Materials License requires that all occupational exposure to radiation be in compliance with the As Low As Reasonably Achievable (ALARA) program. In general, internal sources are not considered in applications for RAM use, except when bioassay measurements indicate the presence of some measurable amount of a radionuclide in a worker's body. For further information refer to Section 2.7 of the *Radiation Safety Manual*.

C. SECURITY OF RADIOACTIVE MATERIALS AND WASTE

The actual regulations regarding security of radioactive materials are complicated and depend on semantic distinctions between "restricted areas" and "unrestricted areas," as well as distinctions between radiation workers (occupational radiation dose) and doses received by members of the public. **However, it is inescapably clear from the regulations that licensed radioactive materials must never be left unsecured and unattended in any location, for any reason, at any time.**

Most importantly, for operating laboratories utilizing unsealed sources of radioactive material in research or clinical assays, the only generally-acceptable solution to the security issue is to emphasize the discipline of requiring that the last person who leaves a given laboratory area at any time must either lock the doors to that area or, in the case of an open setting, ensure that all lockable storage areas are secured.

Principal Investigators' laboratories are subject to unannounced spot checks of security by EHS staff, the results of which are reported to the CIR. For more information on Radioactive Materials Security please refer to Section 3.4.2.8 of the *Radiation Safety Manual.*

D. EHS RADIOACTIVE MATERIALS PACKAGE RECEIVING PROCEDURES AND LABORATORY PERSONNEL RECIEPT OF RADIOACTIVE MATERIALS

EHS personnel **must** perform a number of tasks prior to laboratory staff receiving each RAM package to ensure proper accounting and compliance with all applicable regulations. Please refer to Appendix III of the *Radiation Safety Manual* for more complete information.

E. RADIOACTIVE MATERIALS AND WASTE TRANSPORT

The transport of hazardous wastes, including radioactive materials and wastes, over public roadways is governed by the U. S. Department of Transportation. These regulations specify details concerning packaging, labeling, marking and the preparation of proper shipping papers. **ONLY EHS PERSONNEL ARE AUTHORIZED TO MOVE RADIOACTIVE MATERIALS AND RADIOACTIVE WASTES ON PUBLIC ROADWAYS**

F. THE EHS INVENTORY SYSTEM

The EHS Department is required by the radioactive materials license to maintain a centralized inventory system to track all radioactive materials used on campus, from purchase request, through final disposal. Each order of radioactive material is tracked by a completely unique number called the RSO number (RSO#). This number is issued by EHS after receipt and processing by EHS. When dealing with EHS on questions of radioisotope inventory, please refer to the unique RSO# issued by EHS.

The "User's Radioactive Material Accounting Sheet" provides a complete written record of the receipt and disposal of each radioisotope order. For detailed information on the use of this document please refer to the information in the section on waste accounting in Section V, C and Appendix VI in this manual. See also Section 3.2.3 and Appendix IV in the *Radiation Safety Manual.*

G. WASTE DEFINITION AND TYPES

Radioactive Waste is defined as any waste material that is known or suspected to contain any **licensed** radioactive material in any quantity whatsoever (as opposed to radioactivity that occurs naturally in the environment - i.e., all radioactive materials purchased for use at CU Denver | Anschutz are licensed materials). It must be emphasized that such wastes must be treated as radioactive waste until and unless they are determined otherwise. If there is any suspicion that an item of waste is contaminated with licensed radioactive material, it is the responsibility of the authorized investigator to use appropriate and sufficiently sensitive assay methods to determine that it is not so contaminated before treating it as non-radioactive. In particular, the issues of so-called "trace quantities" of radioactive materials in glassware, aqueous washes, etc., often arises. Such classifications may not be made arbitrarily but must be done quantitatively with appropriate assay methods, as explained and defined in Appendix III.

Mixed Wastes are those wastes that contain radioactive materials and hazardous chemicals regulated by the Resource Conservation and Recovery Act and the Colorado Hazardous Waste Regulations. These hazardous chemicals are named in the regulations on one of four lists (F, P, U and K) or exhibit one or more of the following characteristics, e.g., Ignitability, Corrosivity, Toxicity and Reactivity. An example is provided by the case of bulk organic solvents that have been contaminated with radioactive materials. Such wastes must be managed with respect to their radiological and chemical hazards. Mixed wastes are generally received as part of the radioactive waste stream, and require additional chemical information from the laboratory presenting the waste for disposal. Investigators are asked to take all possible steps to avoid generating such wastes, as the disposal process for them may be very difficult and expensive.

Laboratory personnel are strongly encouraged to consult EHS prior to requesting disposal of such wastes, especially if they involve some chemical class other than scintillation cocktails and bulk organic solvents.

Infectious Radioactive Wastes are wastes containing pathogens or biologically active material which because of its type, concentration and quantity could present a potential hazard to human health when improperly handled, stored, processed, transported or disposed of. **Wastes**

presumed to be infectious medical waste include blood and body fluids, potentially infectious waste, pathological waste, sharps, in addition to the property of being radioactive.

H. WASTE FORMS

Radioactive wastes occur in a number of forms. Different waste forms, such as those listed below, must never be mixed together. Doing so may make waste disposal very expensive and perhaps impossible.

- Dry Solids
- Aqueous Liquids
- Organic Liquids
- Scintillation Vials
- Animal Tissue
- Biological Materials
- Bactec Vials

III. GENERAL INSTRUCTIONS

A. CONTAINERS

Current EHS policy requires that certain types of containers be used for most waste forms; these are described in detail under the sections for specific forms. This policy assures that the containers in use are reasonably likely to avoid leakage, spillage, and breakage. The use of standard containers with prominent Radioactive Materials markings is of considerable value in assuring that radioactive waste containers are easily recognizable to all persons who may enter the laboratory, including service (i.e., custodial staff or maintenance) personnel and visitors.

Containers must not be overfilled. This requirement will be re-emphasized in detail in the sections below on specific waste forms.

B. STORAGE IN THE LABORATORY

1. Labeling of Containers

Regardless of the type of container, it must be properly labeled. Each container must bear a standard "Radioactive Materials" caution label. For the reasons detailed below under waste accounting, each generator's container should generally have a running list attached describing the contents that have been placed into the container. This is particularly important in laboratories that have multiple users sharing the same waste containers. (See Appendix VIII for examples of labeling.)

2. Placement of Containers

- Waste containers should be kept in a single area for purposes of organization and,

- It is preferable to have the area as out of the way as possible, particularly if there is any potential for accumulation of gamma emitting isotopes that may create appreciable radiation exposure rates near the waste.

- The use of fume hoods for storage of waste may be appropriate in some applications, if there is potential for the material to become airborne. An example is the unbound liquid fraction collected from some iodination reactions.

- The use of fume hoods as general waste repositories is discouraged, because it clutters the hood and degrades its air flow characteristics, making the hood less functional for applications that really require local exhaust ventilation.

3. Use of Shielding

Shielding is always desirable for isotopes that emit penetrating radiation, in order to keep radiation exposures to persons in the area As Low As Reasonably Achievable (ALARA). Additional technical information and reference data on shielding is included in the *Radiation Safety Manual* and the *Radiation Safety Training Manual*.

<u>High-energy beta emitters (e.g., ^{32}P)</u>

Are easily shielded with a centimeter thickness of plastic, and a wide variety of commercially supplied products is available for this purpose. Such shielding should definitely be considered if milliCurie (mCi) quantities of such isotopes will be accumulated.

<u>Gamma Emitters (e.g., ^{125}I, ^{57}Co, ^{86}Rb,)</u>

- Shielding of sizable quantities of gamma emitters may be a difficult practical problem, especially with higher-energy photons.

- The need for such shielding depends on factors besides the mCi amount in storage, that may vary widely, such as the gamma constant of the isotope involved, and the distances and occupancy times associated with the nearest occupied areas.

- For any accumulation of gamma emitters that could produce exposure rates exceeding 0.1 mR/hour in any frequently occupied area, <u>OR</u> more than 0.2 mR/hr in <u>ANY</u> area that may be occupied by personnel, the need for shielding must be evaluated. The Health Physics staff of EHS can readily assist in this analysis.

4. *In Situ* Decay in the Laboratory

The process of *In Situ* decay, also referred to as "*decay in storage*", can be very useful with shorter-lived isotopes, such as ^{32}P. However, it is a potential source of serious public concern, for obvious reasons. Therefore, if it is to be done in the user's laboratory, it must be done with

scrupulous attention to the details of labeling packages, logging them, and surveying them after the appropriate holding period. Such a procedure may only be performed if the authorized investigator has submitted a signed copy of the form in Appendix IV to EHS.

5. Closure of Containers

- Containers in storage in the laboratory should be kept closed to avoid spillage and reduce the likelihood that the contents will become dispersed into room air or otherwise cause contamination.

- Containers must be securely closed and sealed for transport before waste pickup by EHS personnel.

6. Spillage or Leakage in the Laboratory

- Spillage or leakage in the laboratory should be treated like any other contamination incident, with appropriate decontamination, as described in the *Radiation Safety Manual*.

- Areas where liquids are poured should be recognized as being particularly susceptible to contamination, and should be checked frequently and decontaminated as necessary. This applies to the exterior surfaces of the containers as well as the other laboratory surfaces in the area.

7. Excessive Accumulation of Waste

Radioactive waste should not be allowed to accumulate to very large volumes or for an excessive length of time. The major concerns of EHS in this regard are to avoid potentially hazardous accumulations and to minimize the loss of radioactive waste accounting information.

The hazards of large accumulations can include both internal and external radiation exposure hazards, as well as fire and inhalation hazards from accumulations of liquid scintillation fluids.

C. SPECIAL PRECAUTIONS FOR USE OF UNBOUND FORMS OF RADIOIODINES

Radioactive iodine (most notably ^{125}I and ^{131}I, but also including ^{123}I) is vastly more hazardous in unbound form than in those forms in which the iodine is covalently bound to proteins or other large molecules (e.g., commercially pre-labeled proteins and radioimmunoassay kits). For this reason, iodine labeling reactions and other uses involving sodium iodide or other unbound forms, including radiothyroidectomy of experimental animals, require special precautions.

The following precautions should be followed by all users of unbound radioiodines:

1. When opening stock vials or preparing to withdraw aliquots with a syringe, all vials of iodine radioisotopes, even bound forms, should be vented to atmospheric pressure in a certified fume hood. Any quantity of 100 microCuries or more of unbound radioiodine should initially be vented through a charcoal-filled syringe to trap volatile iodine. Most vendors provide charcoal filled syringes with iodine orders. The charcoal filled syringes could also be obtained from EHS. Even NaI shipped in solution at appropriately basic pH has been demonstrated to have considerable gaseous radioactive iodine in the air in the stock vial (typical values of 0.1% to 0.2% and extreme values up to 2% of the total radioactivity in the vial).

2. All vials of NaI or other unbound forms should be kept tightly capped in a certified hood or stored frozen. When NaI solution is left open to the atmosphere and allowed to dry out, the radioactive iodine will volatilize. The release of substantial fractions of a milliCurie or more into air in this way, even in a properly operating fume hood, could result in a serious license violation.

3. **Iodination should, of course, be carried out in a certified hood.**

    - Reaction systems, in which the labeling reaction can be confined to a closed vial, by introducing reagents via needles inserted through a septum, are most preferable.

    - Columns, after removal of all liquid content, should be wrapped in parafilm or another airtight seal before being discarded as dry solid radioactive waste.

    - **All liquids containing radioiodine in unbound forms, including wastes, should be kept at basic pH and stored in tightly-capped containers in a fume hood.**

4. **Protective apparel, especially double or triple gloves, should be worn during handling, and great care should be taken to avoid any contamination of skin or clothing.** Past incidents have indicated that the predominant mechanism of self-contamination resulting in thyroid uptake has been inadvertent skin contamination of the hands by touching items contaminated with unbound radionuclide. Some unbound forms are highly mobile in regard to percutaneous uptake (across intact skin) into the underlying tissues, after which they are transported by systemic circulation and deposited in thyroid.

5. **All persons performing iodination or handling unbound forms in other ways are required to schedule a thyroid bioassay after each labeling or other use** (please call EHS at x4-0345 to schedule).

    - Persons possessing sensitive scintillation detectors appropriate for the radioactive iodine isotope in use are encouraged to survey themselves after use; however, a thyroid measurement by EHS is required. The equipment used by EHS is specially calibrated with a thyroid neck phantom, and the procedures used are designed to obtain accurate and reproducible results in terms of thyroid radioactivity content.

- Bioassay measurements should be made within 24-72 hours after the affected individual's use of the unbound material.

- These measurements require only about five minutes to perform, and can typically be scheduled at the requester's convenience; however, an appointment should be made by calling EHS beforehand, to ensure that a health physicist will be present to perform and interpret the measurement.

IV. SEGREGATION, CLASSIFICATION AND PACKAGING OF RADIOACTIVE WASTE

All radioactive wastes must be further segregated into one of the following classifications and packaged accordingly as described below:

A. **Dry lab trash** includes paper, plastic, glass, and metals other than lead or the other excluded metals as listed below and which is radioactive. Laboratories must segregate radionuclides in dry solids with half-lives less than 90 days from those with longer half lives, for economic reasons unless approved by EHS. Radionuclides with half lives less than 90 days include ^{32}P, ^{33}P, ^{51}Cr, ^{125}I, and ^{35}S. Dry lab trash **must not contain:**

- **Freestanding liquids, wet absorbent materials, or wet gels.** Containers, regardless of size, must have been emptied of liquids to the maximum practical extent. Wet absorbent materials and gels must be dried in a certified fume hood unless potentially volatile radioactive materials are involved, in which case EHS should be contacted at x4-0345 for advice.

- **Organic solvents must not be present in any amount whatsoever.**

- **Regulated metals such as arsenic, barium, cadmium, chromium, lead, mercury, selenium or silver.**

- **Empty scintillation vials.**

- **Biological materials or infectious materials (see below)**

- **Sharps, such as blades or needles.** Glass with sharp edges may be included if it has not been in contact with human blood or serum or other infectious material, but must be packaged in a rigid plastic container to avoid injury to EHS personnel.

For questionable items, it is easy to specify a common-sense rule of thumb: if the item contains material that, if it were left at room temperature for an extended time, would putrefy to an extent that would be detectable upon opening and inspection, it does not belong in dry solids.

Dry lab trash must be packaged in special clear, stenciled polyethylene liners that are available from EHS. **A secondary outer container, prominently marked on all sides with the yellow and magenta "Caution: Radioactive Materials" wording and trefoil symbol** (See Appendix VIII), must be used for all storage in laboratories. Bright yellow containers of this type are prepared and offered for sale at minimal prices by EHS, in 5-gal and 20-gal sizes, and are strongly recommended.

B. **Aqueous liquids** consist of solutions involving water as the only solvent. Such liquids **must not contain any organic solvents (including alcohols) or infectious materials. In the case of benzene (0.5ppm), chloroform (6ppm), and pyridine (5ppm), ppm concentrations, as noted, require classification as organic liquids.** Aqueous liquids should be accumulated in the 1.5-gal polyethylene jerrican containers provided by EHS or in sturdy, tightly-closed containers that meet the specifications of EHS as detailed in Appendix V. Small containers of less than 100 ml volume are not acceptable for disposal because they are generally not acceptable for transport, and EHS does not have the personnel resources to empty large numbers of small vials and tubes.

Each container should be dedicated to one isotope (or a combination of isotopes, if compatible and approved by EHS), and should be labeled as such. This avoids problems with cross-contamination and other potential disposal difficulties.

Containers should not be filled completely. Regardless of the type of container, it must not be filled to a level above the point at which the top of the container begins to narrow, or it cannot be emptied without creating turbulence and splashes. Overfilled containers present an unacceptable contamination hazard to our facility and personnel and will NOT be accepted for disposal.

C. **Chemically hazardous radioactive wastes** (often called “organic” or "mixed wastes") include all wastes whose chemical attributes alone would classify them as a "hazardous waste" under the Colorado Hazardous Waste Regulations, and Federal regulations and which are also radioactive. Therefore, in addition to the usual information on radioisotope and radioactivity, EHS requires information on the chemical composition of such wastes so that they can be properly managed. These wastes are difficult and expensive to dispose. EHS must be consulted prior to any new type of RAM contaminated organic liquid is generated (contact EHS at 303-724-0345)

- The most common wastes in this category are radiocontaminated organic solvent wastes. **In general, any liquid or solid wastes that contain any amount of any organic solvent, including water-miscible organic liquids, should be considered to fall in this category, until otherwise classified by EHS**.

- The 1-1/2 gallon jerrican containers may be used for mixtures that are chemically suitable for polyethylene containers. When in doubt about the issue of compatibility, users should resort to the type of container, usually glass or metal, in which the bulk solvent was originally supplied. In the case of glass containers, special care should be taken to guard against breakage. Small containers of less than 100 ml volume are generally not accepted for disposal, because they are often not acceptable for transport, and EHS does not have the personnel resources to empty large numbers of small vials and tubes.

- Each container should be dedicated to one isotope (or a combination of isotopes, if compatible and approved by EHS), and should be durably marked as such. This avoids problems with cross-contamination and other potential disposal difficulties.

Researchers are asked to avoid, as much as possible, the generation of mixed wastes, especially those that involve halogenated solvents, or other toxic or ignitable (flammable) organics or:

- Wastes that contain any amount of the regulated metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium or silver)

- liquid wastes with pH values equal to or less than 2.0 or equal to or greater than 12.5.

Mixed wastes require a written request for disposal filed with EHS on the form entitled "Radioactive Mixed Chemical Waste Disposal Form". The waste container must be labeled with the orange "**Mixed Chemical/Radioactive Waste**" label as soon as waste is first placed into the container. **Every effort should be made to minimize the volume and complexity of mixed wastes, as they typically create uniquely difficult disposal problems**. EHS should be contacted at x4-0345 for advice on safe storage in the laboratory Satellite Accumulation Area whenever this type of waste will be generated.

D. **Non-hazardous scintillation vials** include vials containing non-hazardous cocktails and no hazardous chemicals (see the listing in Appendix V for Hazardous and Non-Hazardous Scintillation Cocktails). Vials should be tightly capped and stored upright in a tray or other container that keeps them upright. EHS recycles such trays for use by laboratories.

E. **Hazardous scintillation vials** include those containing ignitable (flash point less than 140°F) cocktails, other organic solvents, or regulated metals such as arsenic, barium, cadmium, chromium, lead, mercury, selenium or silver.

Older scintillation cocktails based on toluene, xylene, pseudocumene, and, in a few rare cases, dioxane are flammable, volatile, and toxic. Anintroduction of "new generation" cocktails are biodegradable, nonvolatile, and non-toxic and not regulated as hazardous by the RCRA regulations. Users who anticipate the need for use of hazardous type cocktails are required to get approval from the CIR before generating such wastes.

The use of toluene or xylene-based cocktails with plastic counting vials is a particularly problematic practice and is strongly discouraged. Even when vial caps are tightly secured, these solvent vapors transpire through the plastic of the vials, leading to the buildup of airborne vapor concentrations. These vapors can be a fire or inhalation hazard. The dedication of fume hoods to the storage of stacks of such vial trays is not an environmentally acceptable solution.

Hazardous scintillation vials should be packaged the same as non-hazardous ones, but orange labels entitled **"Mixed Chemical/Radioactive Waste: Flammable/Toxic Scintillation Vial Waste"** are required on each tray or other container when vials are first added to the container. No stock solutions should be mixed with this waste.

F. **Animal carcasses or tissue** is a classification that applies to any substantial amount of tissue, including blood. Animal carcasses or tissue should be kept frozen in minimal and easily-removed packaging, e.g., multiple small carcasses together in a plastic bag, with any liquid blood fully absorbed in absorbent or in disposable bottles. Researchers generating such wastes are strongly encouraged to contact EHS at x4-0345 to make prior arrangements for packaging these wastes.

G. **Infectious Radioactive Wastes**

Infectious radioactive wastes include all radioactive wastes that have **ever been in contact** with

- Human blood,
- Human serum,
- Other infectious human bodily fluids, or
- Human pathogens, **and**
- **Human cell culture lines** (considered infectious unless they have been specifically demonstrated to be free of infectious potential and documentation is provided) **as well as any other cell culture line known to be infectious.**

Infectious radioactive wastes must be disinfected by appropriate methods and classified as biological non-carcass wastes. Briefly,

- Liquids are typically disinfected by the addition of appropriate amounts/strengths of bleach (sodium hypochlorite solution), phenolic or other types of EPA approved disinfectants. EHS can provide a list upon request.

- Solid materials, including absorptive materials, are typically treated by immersion for appropriate periods of time in the same disinfectants, followed by pouring out or decanting off the disinfectant liquid into a liquid waste container.

- Autoclaving may be feasible as a means of disinfecting, but EHS should be contacted at x4-0345 for advice on the potential for release of radioactive material in specific cases.

- Radioactive sharps contaminated with human blood or other infectious materials must be disinfected before or after being placed into a radioactive materials labeled sharps container, and the resulting container of disinfected sharps can then be presented to Environmental Health and Safety as "biological non-carcass waste" (see Section H. below).

Further specific guidance is available from the Biosafety Officer at x4-0235.

H. **Biological non-carcass waste** is a classification that includes all radioactive waste materials that were ever previously classifiable as infectious (see Section G above) before they were disinfected, as well as any biological material that does not qualify as "animal carcasses or tissue," no matter how clean and dry these materials may appear to be after the process of disinfecting them is completed.

Examples:

- animal bedding,

- biologically contaminated sharps in approved sharps containers,

- plastic tubing, culture vessels of various types, and all other liquids and solid materials contaminated with small amounts of biological materials

Biological non-carcass **solids** if dry may be packaged in the same manner as dry lab trash. However, if the material, when left at room temperature for an extended time would putrefy to an extent that would be detectable upon opening and inspection, should be packaged in the same manner as animal carcasses or tissue. Remember to indicate Biological non-carcass on your waste tickets when these solids are presented to EHS for pickup.

Biological non-carcass **sharps** must be packaged in approved sharps containers and labeled as radioactive using either “Caution Radioactive Materials” Stickers or length of tape.

Biological non-carcass **liquids** (note that blood is classified as "animal tissue," not "biological non-carcass"), apart from their classification, are packaged the same as aqueous liquid wastes.

I. **Unused stock quantities of radiolabeled material** applies to vials containing unused radioactive materials as supplied by vendors. These materials should be placed into any sturdy outer container, with appropriate shielding if indicated, for pickup by EHS. Contact EHS at x4-0345 for further information. Unused stock materials **should never be placed into, or mixed with, scintillation vial wastes or added to the aqueous waste**.

J. **Lead "pigs" and shielding** will be picked up as is for recycling, if they are not contaminated. If they are contaminated, EHS will need to assist in making a determination of how to handle them. Metallic lead is not allowed in dry solid radioactive waste because it is regulated as a TCLP (Toxicity Characteristic) hazardous waste according to Colorado Hazardous Waste Regulations and Federal regulations.

K. Bactec Vials

Bactec vials constitute a unique waste form that derives from a procedure used in clinical microbiology. They consist of ^{14}C-labeled substrates in culture media, contained in small (~35 ml) glass vials, ranging from 2 to 4 uCi per vial. These vials are currently handled by special arrangement between the user and EHS. They require sterilization and careful transport to avoid spillage. Any questions about Bactec vials as a hazard or concerning disposal should directed to the EHS staff.

V. RADIOACTIVE WASTE PICKUP AND DISPOSAL PROGRAM

A. RADIOACTIVITY CONCENTRATION LIMITS FOR WASTE DESIGNATED FOR DISPOSAL

Concentrations above 0.05 uCi/ml of scintillation fluid (111,000 DPM/ml) are not acceptable.

Because liquid scintillation vials are ultimately disposed of by incineration, the disposal vendor is held to very strict accountability for their radioactive content. The university is correspondingly required to observe strict limits on the allowable radioactivity concentrations in scintillation vial waste. Past experience has shown that almost all cases

of vials with estimated activities above this level, when assayed by EHS personnel, showed erroneously high estimates by laboratory personnel.

Determining the radioactivity content of scintillation vials is a straightforward matter. Detailed information on the calculation is given in the Appendix VII.

B. RADIOACTIVE WASTE PICKUP REQUESTS

EHS picks up radioactive waste at the request of laboratory personnel. Pickups are typically available within a few working days of request, but service is not guaranteed in less than ten working days; hence, some prior planning is necessary.

Researchers should note that concerns about radiation levels from wastes are not considered to constitute an emergency in regard to removal of wastes by EHS. Authorized Principal Investigators are required by the Committee on Ionizing Radiation to maintain adequate shielding and distance between waste storage locations and occupied areas. The use of shielding and distance for radiation workers and the general public must meet all applicable radiation dose limits for the maximum amounts of specified radionuclides that could possibly be accumulated as wastes (in conformance with the PI's on-hand possession limits). Questions about safe storage should be directed to EHS at 303-724-0345.

To make a request for radioactive waste pickup, call 303-724-0109 or submit a waste pickup request form, available on our website:

`http://www.ucdenver.edu/research/EHS/Forms/Pages/RadSafetyForms.aspx`

When calling or filling out form, please be prepared to specify

- the PI's name(s),
- your name
- your telephone number
- the room number where the waste is located, and
- the types and numbers of waste containers for pickup.

C. REQUIRED DOCUMENTATION FOR RADIOACTIVE WASTE DISPOSAL

The accounting process for radioactive materials, especially their disposal, is a critical area in the university's ability to defend the use of radioactive materials in research on the CU Denver | Anschutz campus. Without this information it is impossible to assure regulatory agencies and the general public that the radioactive materials in use at the

university are being properly controlled, and that they are being disposed of in ways that are legal, environmentally sound, and protective of the public health.

It is the responsibility of each principal investigator to train and equip the persons in his or her laboratory to understand all of the assays in which they employ radioactive material, thereby enabling them to render proper waste accounting information to the EHS upon disposal.

The radioactivity counting efficiencies of all sample counters in the laboratory should be well known for all of the radioisotopes for which they are employed. This is as critical for competent radiological hygiene in the laboratory as it is for the scientific defensibility of the data being derived from the assays. More detailed instructions for determining the radioactivity content of wastes are given in Appendix VII.

Principal investigators and their workers should be aware that increasingly sophisticated quality assurance checks on the radioactivity contents, chemical contents, and other pertinent aspects of wastes collected by EHS are being performed by both EHS and external agencies. They should also be aware that EHS requires emphasis on quality control in radioactive waste accounting information. Radioisotope inventory discrepancies are scrutinized with regard to indications of possible improper or unauthorized disposal methods or failure to dispose of waste. Inventory discrepancies may result in potentially hazardous accumulations of waste and increases the likelihood that waste accounting information will be lost.

User's Radioactive Material Accounting Sheet

Each time that you withdraw/aliquot an amount from a stock vial of radioactive material for use, write down an entry in the top section of the corresponding User's Radioactive Material Accounting Sheet.

When waste is generated and added to a waste container, write down an entry in the bottom section of the corresponding User's Radioactive Materials Accounting Sheet. Do not consider radioactive decay when accounting for radioactivity used. If 1mCi of RAM is used in your experiment and 20% is accounted for in the dry waste, then record 0.2mCi as dry waste on the accounting sheet.

The User's Radioactive Material Accounting Sheet should be completed daily when radioactivity is used and maintained current to reflect the activity remaining in stock vials and waste.

EHS can help with information about how much of your radioactivity is expected to end up in which waste form (partitioning fractions). PI's are REQUIRED to submit this information on their applications to the Committee on Ionizing Radiation.

Pre-coded Waste Tickets

Pre-coded waste tickets are supplied by EHS with your order. Complete at least one waste ticket for each waste form generated for each RSO# contained in the waste and provide your completed waste tickets to EHS at the waste pick up. You can use as many pre-coded waste tickets as you like, and each waste container may have many tickets attached by the time it is picked up by EHS. Record dates and activity amounts of each waste pick up on the accounting sheet. **REMEMBER, EHS will not give credit for disposal after the fact. We want to see the radioactive material that is in your waste recorded appropriately on tickets at the time we pick up the waste!** The User's Radioactive Material Accounting Sheet does not need to be submitted to EHS but should be maintained for a period of one year in a file kept in the lab.

You may photocopy pre-coded waste tickets for any specific order, or request new originals from EHS at 303-724-0109. DO NOT use tickets on which the preprinted information has been altered. **Only the pre-coded waste tickets documenting radioactive materials disposed by sewer or administered to patients may be mailed to EHS at campus mailbox F484.**

Radioactive Mixed Chemical Waste Disposal Form

Mixed waste pickup requests must be made on a Radioactive Mixed Chemical Waste Disposal Form as found in Appendix VI, the form may also be found electronically in the Forms section of the EHS website. This form is not required for liquid scintillation vials that are classifiable as hazardous solely because they contain ignitable (flammable) cocktails.

Contamination Surveys

The Committee on Ionizing Radiation requires EHS to review a copy of the PI's latest contamination survey at the time of waste pickup for every laboratory area authorized for use or storage of radioactive materials.

All radioactive materials and wastes must be returned to the EHS with the following exceptions noted below.

D. SINK DISPOSAL OF RADIOACTIVE MATERIALS AND WASTES

Pursuant to the ruling of the Committee on Ionizing Radiation, certain aqueous solutions of ^{3}H may be disposed of into the sink in the laboratory by laboratory personnel. Such disposals must conform to the following stipulations:

- The material to be disposed *must contain only* ^{3}H and the total *radioactivity must be diluted to a concentration less than* 0.01 *uCi/ml* (= 10 microCi/liter) **before** being poured into the sink.

- **It is not acceptable to dump radioactive material in small volumes and simply allow the water to run** - the dilution requirement is designed to preclude having substantial mCi amounts of materials in the plumbing at any one time, in case a blockage should occur.

- The radioactive material must be in a form that is readily soluble or dispersible in water, and must not possess any chemically or biologically hazardous attributes that would preclude its disposal by sewage under other university guidelines, Denver Metropolitan Wastewater Regulations, or the Colorado Hazardous Waste Regulations.

- Appropriate entries must be made on all associated *User's Radioactive Material Accounting Sheets*. Waste tickets for amounts of radioactivity that were disposed by sink (sanitary sewer) for ^{3}H may be mailed directly to EHS at mailstop F484 or may be presented at the time of waste pickup. In this manner individual and total institutional disposal of radioactive materials can be tracked on the EHS inventory system.

- The sink must be labeled as a radioactive materials disposal sink, using standard Radioactive Materials caution signs, and a log showing sink disposal history must be placed in a readily accessible location near the sink. *Radioactive Materials Sink Disposal Log* forms are available from EHS. The sink must be swipe tested for contamination after each disposal and kept free of removable contamination on the accessible surfaces.

- Sink Disposal of Other Isotopes apart from ^{3}H is allowed for extremely dilute solutions containing radioactivity concentrations below the trace quantity limits published in Appendix III of this *Manual*, "Laboratory Procedures for Disposal of Trace Quantities of Radioactive Material."

    - Materials disposed under these provisions must be properly assayed and records of those assays must be maintained by the PI.

    - Any such disposal of series of disposals for which the quantity of radioactivity so disposed, that derives form any single item of radioactive stock material as supplied by the vendor, equals or exceeds one microCurie in the aggregate must be accompanied by submission of a waste ticket to Environmental Health and Safety.

E. EVAPORATIVE VOLUME REDUCTION

Users are permitted to employ evaporative volume reduction of strictly aqueous solutions (no organic solvent content) by drying down liquids in fume hoods to reduce liquid volume or completely remove the water content. Several precautions apply in this situation:

- The radioactivity must not have any component that could off-gas in a volatile form, such as some compounds of C, H, S, and I.

- The process must not result in a semisolid or gelatinous mass, as such forms are a disposal problem.

APPENDIX I

REGULATORY GROUPS OR AGENCIES GOVERNING RADIOACTIVE WASTE MATERIAL

REGULATORY GROUPS OR AGENCIES GOVERNING RADIOACTIVE WASTE MATERIAL

INTRA CAMPUS

CU Denver | Anschutz Committee on Ionizing Radiation
CU Denver | Anschutz Radiation Safety Officer
Director of the Environmental Health and Safety Department

GOVERNMENTAL

LOCAL

City or County Health Department
Sewage District
Other Municipal Jurisdictions

STATE

Colorado Department of Public Health and the Environment, Radiation Services
Colorado Department of Public Health and the Environment, Air Pollution Division
Colorado Department of Public Health and the Environment, Hazardous Materials and Waste Management Division Colorado State Patrol
Other State Agencies Licensing Disposal Sites in Other States Where Access is Required

REGIONAL

Rocky Mountain Low Level Radioactive Waste Board

FEDERAL

U.S. Nuclear Regulatory Commission
U.S. Environmental Protection Agency
U.S. Department of Transportation

PRIVATE

Disposal Site Operator
Disposal Vendor/Broker
Motor Carriers
Insurers

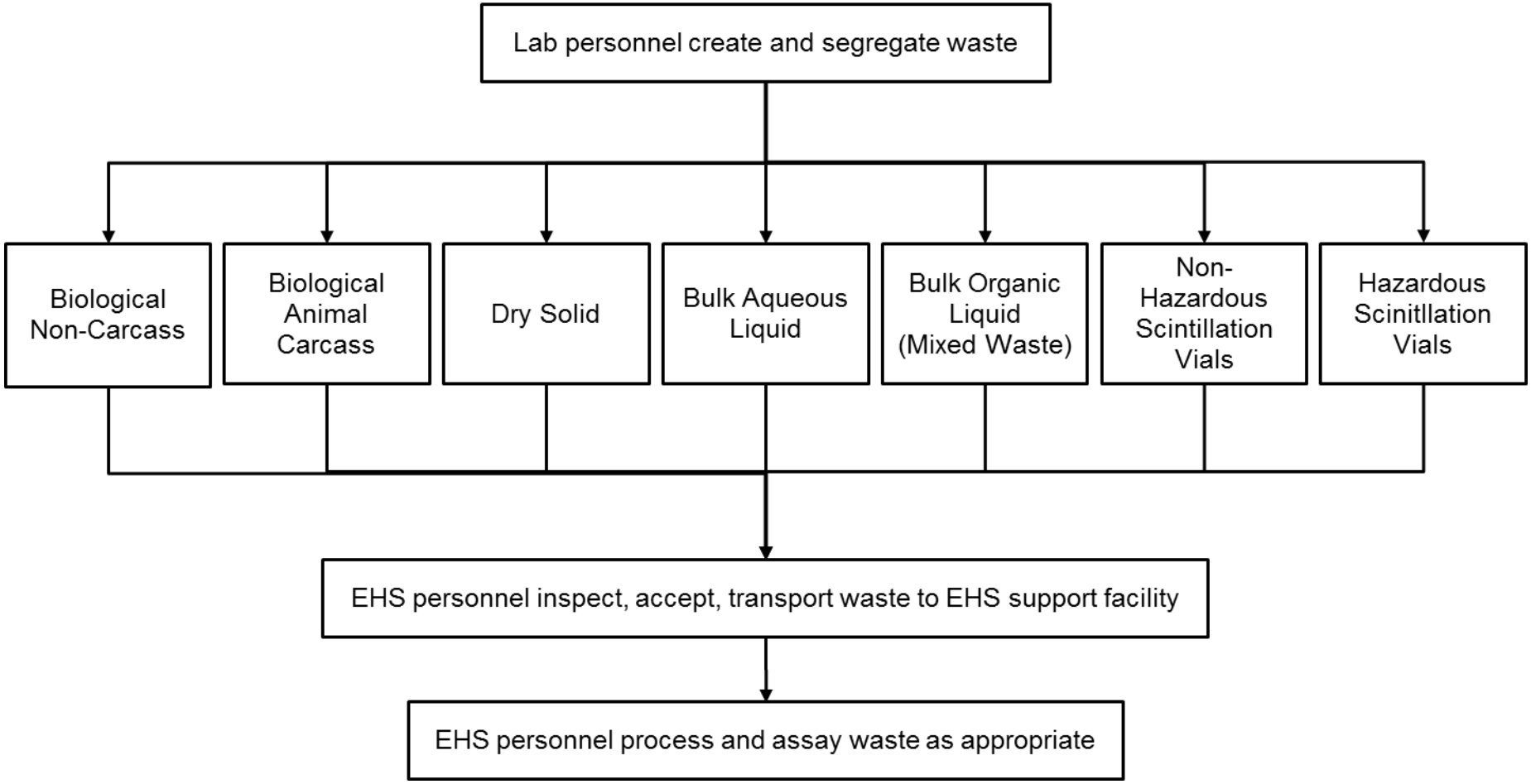
APPENDIX II

RADIOACTIVE WASTE MANAGEMENT FLOWCHARTS

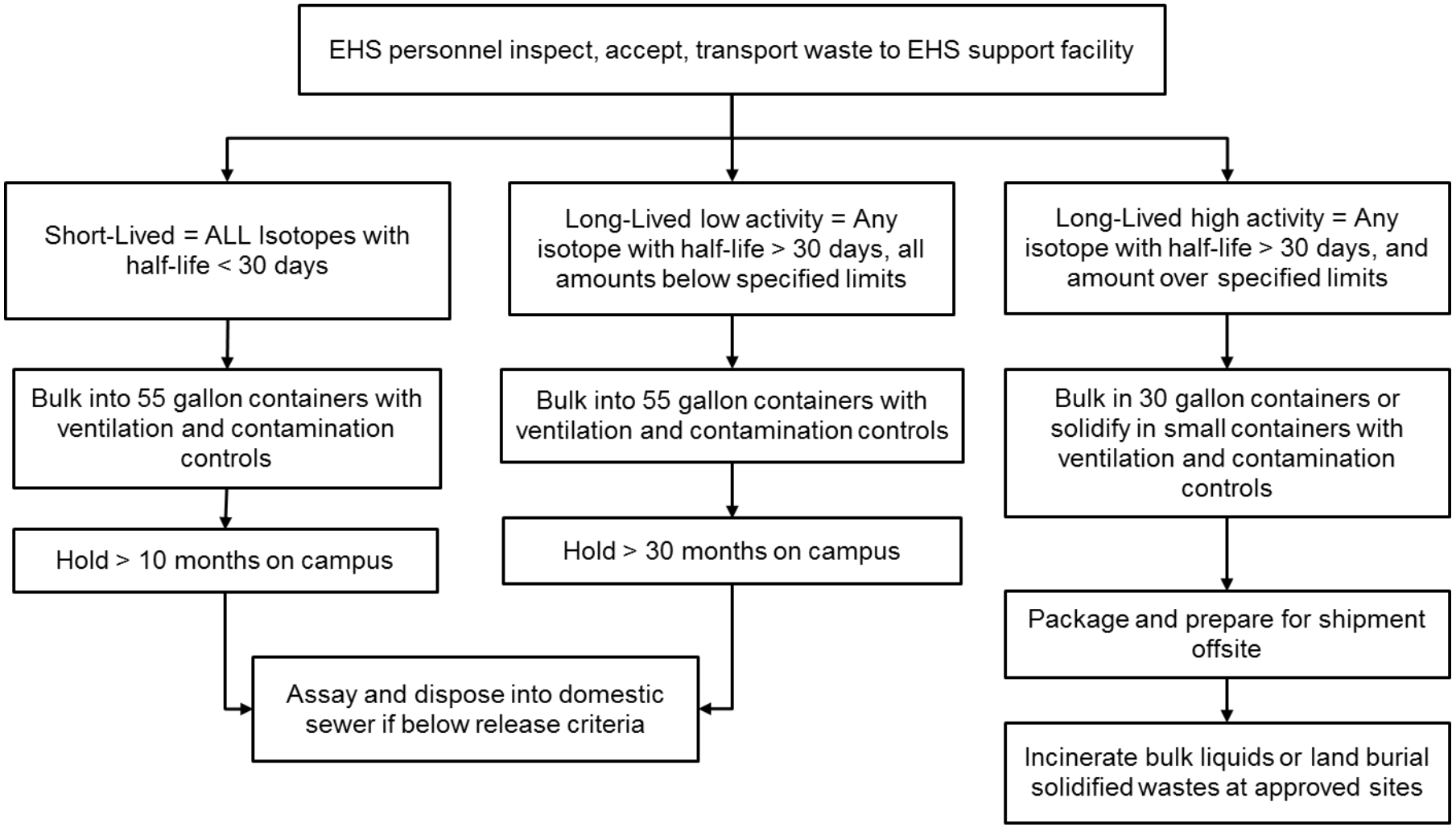
1. **Radioactive Waste Stream Flowchart**
2. **Bulk Aqueous Radioactive Liquids Flowchart**
3. **Bulk Organic Radioactive Liquids Flowchart**
4. **Dry Solid Radioactive Waste Flowchart**
5. **Biological Animal Carcass Radioactive Waste Flowchart**
6. **Biological Non-Carcass Radioactive Waste Flowchart**
7. **Radioactive Scintillation Vial Waste**

The following flowcharts depict the current methods that EHS uses to manage radioactive waste at CU Denver | Anschutz. The details of radiometric assays, numerical standards and guidelines, packaging procedures, and manifesting and documentation are far too voluminous to include here but they are documented in the internal procedures of EHS.

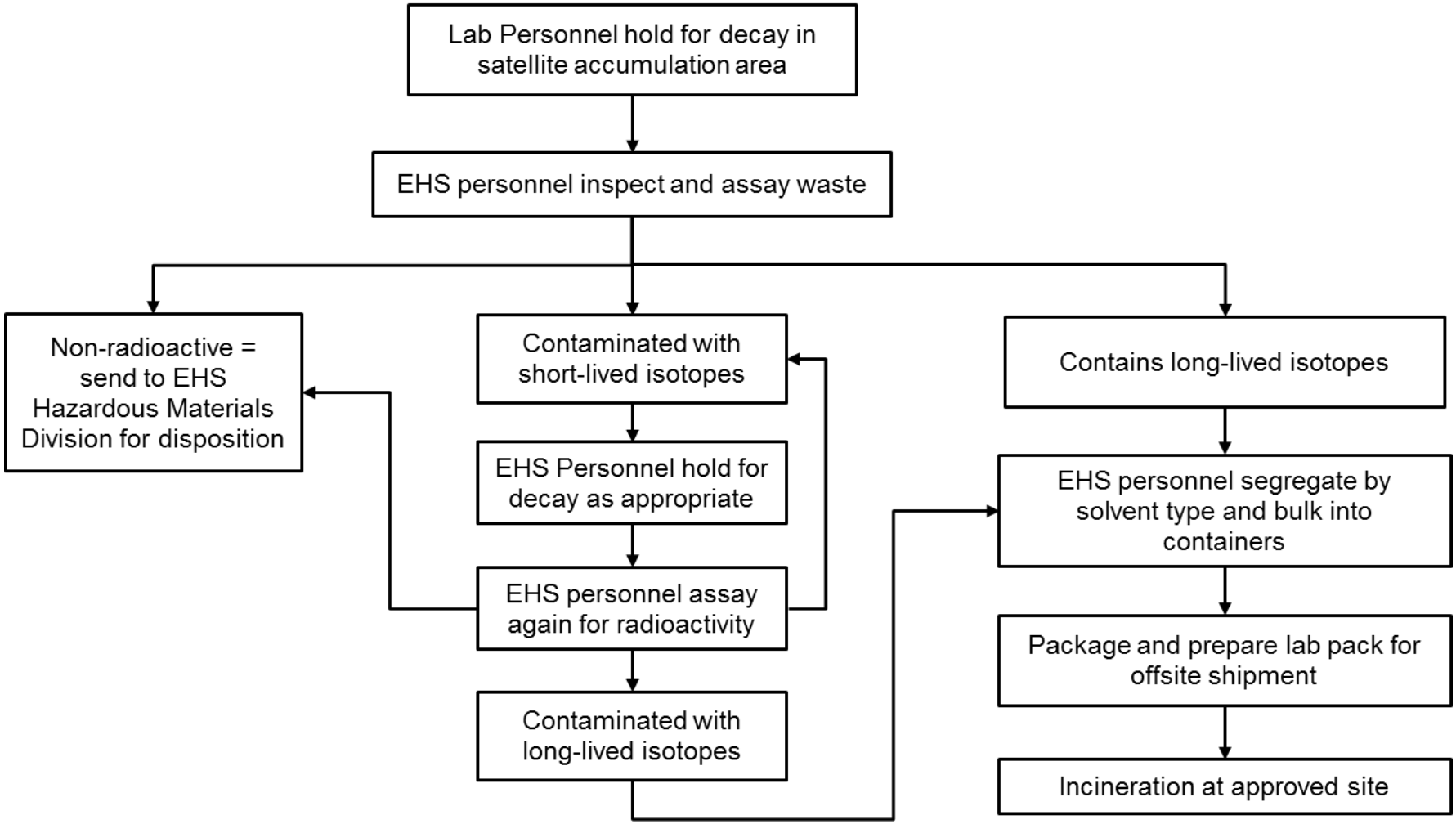
RADIOACTIVE WASTE STREAM FLOWCHART



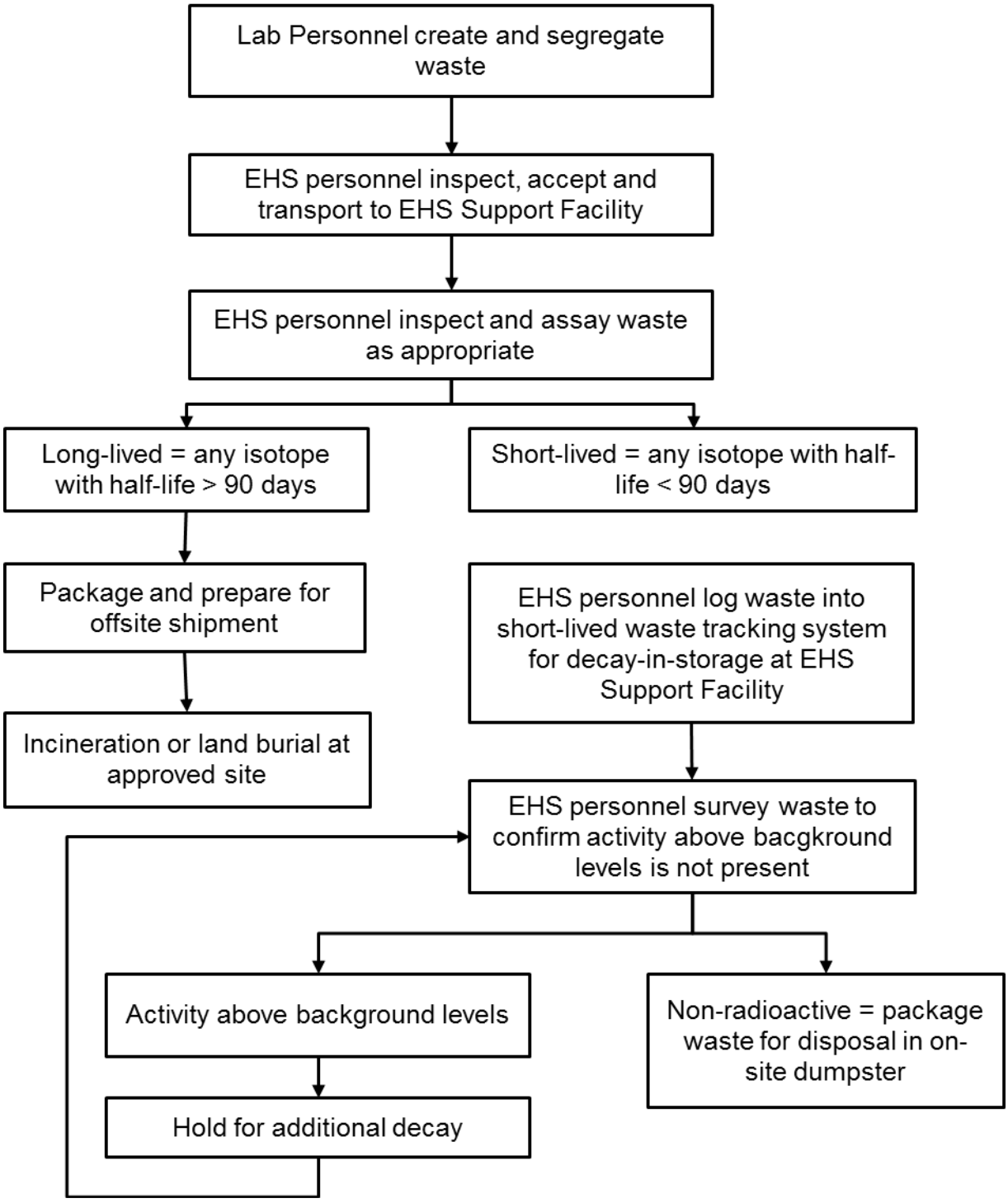
BULK AQUEOUS RADIOACTIVE LIQUIDS



BULK ORGANIC RADIOACTIVE LIQUIDS



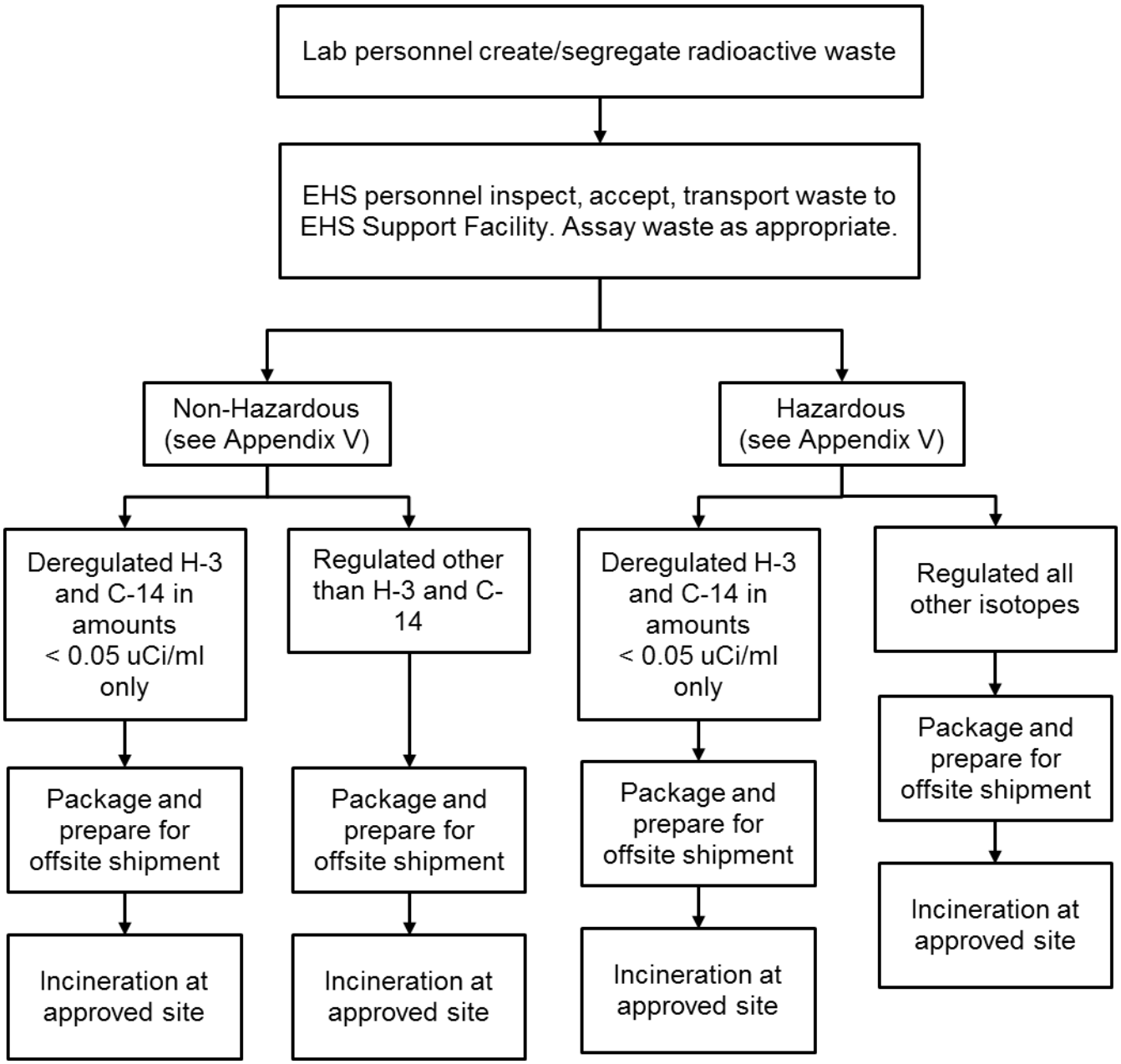
DRY SOLID RADIOACTIVE WASTE



BIOLOGICAL ANIMAL CARCASS RADIOACTIVE WASTE

BIOLOGICAL NON-CARCASS RADIOACTIVE WASTE

RADIOACTIVE SCINTILLATION VIAL WASTE



APPENDIX III

LABORATORY PROCEDURES FOR DISPOSAL OF TRACE QUANTITIES OF RADIOACTIVE MATERIAL

1. **General Information**

2. **TABLE 1 - Concentration Limits For Sewer Disposal of Aqueous Wastes**

3. **TABLE 2 - Acceptable Surface Contamination Levels For Uncontrolled Use Release of Equipment**

GENERAL INFORMATION CONCERNING MATERIAL SUSPECTED OF BEING RADIOACTIVE

It is never appropriate to use a subjective appraisal of the radioactive contents of a waste item to justify its disposal as "non-radioactive" or a "trace quantity." As noted in the introduction to these procedures, any material that is known or suspected of being contaminated with licensed radioactive material in any amount whatsoever is to be considered radioactive waste until and unless proven otherwise. If items containing detectable but insignificant levels of contamination are to be discarded as non-radioactive, such actions must be rigorously justified on a quantitative basis, in order to be defensible to the regulatory agencies and the general public. Two basic criteria are of utmost importance:

1. Items to be discarded must be assayed.

2. Assays must be corrected for detection efficiency, so as to yield results in true units of radioactivity.

The overall detection efficiency for the assay must be known and applied, so as to yield radioactivity estimates in units of Disintegrations Per Minute (DPM), Curies or subdivisions thereof, or Becquerel (Bq, = disintegrations per second) or multiples thereof. The use of uncorrected Counts Per Minute (CPM) or merely "counts" is **NEVER** acceptable. For counting or detecting efficiency that applies in a particular situation, the Radiation Safety staff at EHS should be consulted.

When experiments are repeated under exacting conditions (i.e., the amount of radioactive materials is the same), several initial waste assays may serve as a determination for waste that is subsequently created, thus sparing the researcher from assaying wastes which will yield essentially the same radioactivity estimates.

LIQUIDS

Liquid wastes may be assayed in a straightforward manner by counting a one-milliliter aliquot by liquid scintillation or gamma well counting in the same manner as the related experimental sample. If more than one phase is present, all phases must be sampled. Care must be taken in liquid scintillation counting to prepare a monophasic sample that is not excessively quenched. Consultation is available from EHS in this regard.

Acceptable upper limits for sink disposal of liquids are given in **TABLE 1**. With the exception of ^{3}H, the concentrations given are derived from the Maximum Permissible Concentration (MPC's) for water effluents to unrestricted areas given in the regulations of the Colorado State Department of Public Health and the Environment and the U.S. Nuclear Regulatory Commission. These MPC's are the strictest ones published and have been used widely by EHS, with the approval of the Committee on Ionizing Radiation, as effective *de minimis* levels for distinguishing trace-contaminated aqueous wastes that can be sink-disposed with few restrictions from those containing sufficient radioactivity to require more rigorous management by EHS.

The limit given for ^{3}H are those cited in Section V.D above, and any disposal of this isotope must be performed in accordance with that section.

NOTE: Any liquids that are determined to be acceptable for disposal as non-radioactive per the provisions of this section must be disposed of in accordance with any other EHS requirements that apply because of the biological or chemically hazardous properties that they possess. This may require disposal as infectious or chemical waste. See the appropriate EHS procedures in Section IV.B of this manual or the Chemical Waste Disposal Manual.

SOLID ARTICLES

Large Items

Large items that are known or suspected of being contaminated must meet the standards for both fixed and removable contamination in TABLE 2, "Acceptable Surface Contamination Levels for Uncontrolled Release of Equipment," extracted form U.S. Nuclear Regulatory Commission Regulatory Guide 8.23, before being discarded or released for unrestricted use. The EHS Health Physicist should be consulted if there is any doubt about appropriate choice of survey instrument and assumptions about detection efficiency and calculation of DPM form survey instrument results.

Small Items

Small items should be discarded with radioactive waste if they are known or suspected of being contaminated. It there is a large volume of such items, the EHS Health Physicist should be consulted to determine if there is an assay method that is suitable for determining whether the items may be discarded as non-radioactive.

Note: both large and small items (equipment) may contain chemically hazardous. Please refer to the green tag procedure or call x4-0345 prior to disposing of items suspected of containing hazardous materials.

TABLE 1

CONCENTRATION LIMITS FOR SEWER DISPOSAL OF AQUEOUS RADIOACTIVE WASTES AS NON-RADIOACTIVE

Radioisotope	microCuries/liter	DPM/milliliter
^{3}H*	10	22200
^{14}C*	0.03	666
^{22}Na	0.006*	13**
^{32}P	0.009**	20
^{33}P	0.08	180
^{35}S	0.1	220
^{36}Cl	0.02	44
^{45}Ca	0.02	44
^{46}Sc	0.01	22
^{51}Cr	0.5	1,100
^{57}Co	0.06	130
^{59}Fe	0.01	22
^{63}Ni	0.1	220
^{65}Zn	0.005**	11**
^{85}Sr	0.04	89
^{86}Rb	0.007**	16**
^{95}Nb	0.03	67
^{103}Ru	0.03	67
^{109}Cd	0.006**	13**
^{113}Sn	0.03	67
^{125}I	0.002**	4**
^{131}I	0.001**	2**
^{153}Gd	0.06	130

***** disposal must be per Section V. D of these Procedures

****** because of the precision required for assay at these low levels, samples should be submitted to EHS for analysis.

TABLE 2

ACCEPTABLE SURFACE CONTAMINATION LEVELS FOR UNCONTROLLED USE RELEASE OF EQUIPMENT
Adapted from Regulatory Guide 1.86 (Ref. 30)

Nuclide[a]	**Average[b,c]**	**Maximum[b,d]**	**Removable[b,e]**
U-nat,U-235,U-238, and associated decay products	5,000 dpm $\alpha/100cm^2$	15,000 dpm $\alpha/100cm^2$	1,000 dpm $\alpha/100cm^2$
Transuranics, Ra-225, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	100 dpm/$100cm^2$	300 dpm/$100cm^2$	20 dpm/$100cm^2$
Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1,000 dpm/$100cm^2$	3,000 dpm/$100cm^2$	200 dpm/$100cm^2$
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and other noted above	5,000 dpm $\beta\gamma/100cm^2$	15,000 dpm$\beta\gamma/100cm^2$	1,000 dpm $\beta\gamma/100cm^2$

a Where surface contamination by both alpha and beta-gamma-emitting nuclides exists, the limits established for alpha and beta-gamma-emitting nuclides should apply independently.

b As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

c Measurements of average contaminant should not be averaged over more than 1 square meter. For objects of less surface area, the average should be derived for each such object.

d The maximum contamination level applies to an area of not more than $100cm^2$.

e The amount of removable radioactive material per $100cm^2$ of surface area should be determined by wiping that are with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination objects of less surface is determined, the pertinent levels should be reduced proportionately and the entire surface should be wiped.

APPENDIX IV

IN SITU DECAY PROCEDURES

1. *In Situ* Decay Procedure

2. Request for Permission to Dispose of Radioactive Waste by *In Situ* Decay

IN SITU DECAY PROCEDURE

GUIDELINES

In Situ decay may be utilized in the investigator's laboratory for isotopes with half-lives of 30 days or less if approved by Radiation Safety. The "Request for RAM Waste Disposal by *In Situ* Decay" must be completed and filed with EHS. Radiation safety will review the request and make a determination if approval is granted.

PROCEDURE

1. Containers - select containers that do not contain any integral shielding, as all shielding must be removed before surveying waste for disposal after decay. Storage of liquids must be done carefully to guard against leakage. Mark the container with a unique identifying number, such as "YY-XXX" where "YY" is equal to the last two digits of the calendar year the waste is generated and "XXX" is a sequential number starting at "001". Containers must also be marked with a "Caution Radioactive Materials" label.

2. Placing containers into storage - before placing a container into storage, seal it with tape and attach a tag that identifies the container by number. The tag should list the isotopes and amounts present, the date that the container was placed into storage, and the name of the person that processed the container.

3. Log - keep a log with an entry for each container, identified by container number. Each entry should contain the information on the container tag (date, isotopes and amounts). See Appendix VI for an example of such a log.

4. Hold each container for at least ten half-lives of the longest-lived isotope in the container.

5. Survey the container as follows:

    a. Select an appropriate survey instrument for the isotope(s) in the container. (If in doubt, consult EHS.)

    b. Check the operation of the survey instrument before proceeding. Survey in a low-background area - **NOT** in the vicinity of containers that still contain undecayed radioactive materials.

    c. Remove any shielding from around the container.

    d. Survey all surfaces of the container. Record the manufacturer, model, serial number, and the calibration due date for the detection instrument(s) used to survey the waste. Attach all hard copies of the instrument results and any calculation to estimate the final activity to the log sheet. Per 6 CCR 1007-1 Part 4.42.2.4, these records must be maintained until CDPHE terminates the university radioactive material license.

    e. Discard only containers that cannot be distinguished from background. Before discarding, remove or obliterate any labels or markings indicating the presence of radioactive material. Annotate the log entry for the container being discarded, indicating date of disposal and initials of the person performing disposal.

6. Any container that fails the survey by producing radiation levels distinguishably above background should be referred to EHS for further evaluation.

Request for RAM Waste Disposal by *In Situ* Decay

Submit completed form to EHS, mailstop F484 for review. Half-life of the isotope must be < 30 days for consideration. For guidance to completing this form, see *Radioactive Waste Disposal Manual*, Appendix IV.

Container Number:_____

Investigator:_____ Phone:_____ Mail Stop:_____

Building:_____ Storage Location:_____

1. Isotope: _____ Half Life: ____ days Intended decay period _____days
   Maximum quantity to be stored: _____mCi

2. Isotope: _____ Half Life: ____ days Intended decay period _____days
   Maximum quantity to be stored: _____mCi

3. Isotope: _____ Half Life: ____ days Intended decay period _____days
   Maximum quantity to be stored: _____mCi

4. Isotope: _____ Half Life: ____ days Intended decay period _____days
   Maximum quantity to be stored: _____mCi

I hereby certify that the disposal indicated above will be performed in accordance with the procedure in Appendix IV of the *Radioactive Waste Disposal Manual*, including maintenance of all required labeling and logs.

Signed:_____ Date: _____

EHS Approval:_____ Date: _____

A copy of this form will be retained by EHS and should also be available for inspection in the storage room.

APPENDIX V

CONTAINER SPECIFICATIONS, CHARGES AND SCINTILLATION COCKTAIL VENDORS

1. **Specification of Containers for Radioactive Liquid Waste**
2. **Charges For Approved Radioactive Waste Containers**
3. **Scintillation Cocktail Vendor List**

SPECIFICATION OF CONTAINERS FOR RADIOACTIVE LIQUID WASTE

Type of Container

The approved liquid container is the 1-1/2 gallon jerrican made of polyethylene that we sell at cost and return to users after we empty it. We recognize that this container is not easy to use if a funnel is required, because the opening is at an angle, but this can be solved by securing the funnel with tape or some other means. For example, a holder can be constructed to position the container so that the spout is vertical (contact EHS for instructions). We choose these containers because we must transport and empty them in very large numbers, and jugs with upright spouts are much more difficult to use.

If an experiment generates an unexpectedly large volume of liquid waste, you may collect the waste in glass or plastic jugs that you may have in the lab temporarily (contact EHS at x4-0345 immediately). The containers so used should be capable of being tightly capped. One-gallon plastic pails and other such containers are unacceptable. We cannot generally accommodate containers larger than two-gallon capacity, except by special arrangement, because they are too heavy to lift to a 3-4 foot height and pour with great care.

Filling of Container

Regardless of the type of container, it must not be filled to a level above the point at which the top of the container begins to narrow, or it cannot be poured back out without turbulence and splashing. Because such containers present an unacceptable contamination hazard to our facilities and personnel, **OVERFILLED LIQUID CONTAINERS CANNOT BE ACCEPTED FOR DISPOSAL BY THIS DIVISION.**

CHARGES FOR APPROVED RADIOACTIVE WASTE CONTAINERS AVAILABLE FROM EHS

(All Charges Are Subject To Change)

RADIOACTIVE MATERIALS CONTAINERS

BAGS

10 Can Liners	$10.00

CONTAINERS

5 Gallon Yellow Container	$12.00/each
20 Gallon Yellow Container	$18.00/each

AQUEOUS LIQUID JUGS

Used, Recycled	$20.00/each
New	$45.00/each

HDPE jugs issued by EHS will be accepted as returns for a $10.00 credit if EHS determines that they are reusable. Such jugs will also be re-labeled for new radionuclide(s) at no charge, *if* EHS determines that they are in good condition and that residual contamination from previous radionuclides will not pose a problem.

SCINTILLATION COCKTAILS

NOTE: The use of hazardous scintillation cocktails requires prior approval by the Committee on Ionizing Radiation.

Hazardous		Non-Hazardous	
Cocktail	Vendor	Cocktail	Vendor
3A20	RPI	BCS	AMR
3A70B	RPI	BCS-NA	AMR
Aquasol-2	PE (NEN)	BetaMax ES	ICN
Bio Count	RPI	Biosafe II	RPI
Biofluor	PE (NEN)	Cytoscint ES	ICN
Budget Solve	RPI	Ecolite	ICN
Cytoscint	Fisher	Ecolume	ICN
Econo Fluor II	PE	Econo-Safe	RPI
Hionic-fluor	Packard	Ecoscint	NDI
Insta-Fluor	Packard	Ecoscint A	NDI
Insta-Gel	Packard	Ecoscint H	NDI
Liquiscint	NDI	Ecoscint O	NDI
RIA-Solve II	RPI	Microscint 20	PE
Scintiverse	Fisher	Microscint E	PE
Scintiverse BIO-HP	Fisher	Opti-Fluor	Packard
Scintiverse II	Fisher	Ready Safe	Beckman
Universol	ICN	Safety-Solve	RPI
		Scintisafe 30%	Fisher
		Scintisafe 50%	Fisher
		Scintisafe Econo I	Fisher
		Scintisafe Plus	Fisher
		Scintiverse BD	Fisher
		Ultima Gold	Packard
		Ultima Gold XR	Packard
		Universol ES	ICN

APPENDIX VI

RADIONUCLIDE MATERIALS INVENTORY AND DISPOSAL SYSTEM

1. **Example User's Radioactive Material Accounting Sheet**
2. **EHS Radioactive Waste Ticket**
3. **Form For Tracking Radioactive Material Usage by Multiple Users**
4. **Example of Form for Tracking Radioactive Material Usage by Multiple Users**
5. **Example of Running List of Radioactive Waste Container Contents**
6. **Radioactive Mixed Chemical Waste Disposal Form**

University of Colorado
Environmental Health and Safety Department
User's Radioactive Material Accounting Sheet

PI NAME **RSO#:**

RSO# issued to PI on for mCi

from on PO No. Lot # received by lab on

Swipe test on vial performed by:____________________________ Date: ________________

Attach LSC printout to accounting sheet. Be sure to identify the appropriate RSO# for each vial tested.

User Name: ____ Lab Phone: ______________________

Use this section to keep a record of amounts withdrawn from the stock vial

Date:____________	amount (mCi):__________	Date:____________	amount (mCi):__________
Date:____________	amount (mCi):__________	Date:____________	amount (mCi):__________
Date:____________	amount (mCi):__________	Date:____________	amount (mCi):__________
Date:____________	amount (mCi):__________	Date:____________	amount (mCi):__________
Date:____________	amount (mCi):__________	Date:____________	amount (mCi):__________

Use this section to keep track of the amounts reported as waste on the coded waste tickets supplied with this order. Use the following abbreviations for the indicated waste forms (these are the ONLY acceptable forms) below and on the waste tickets:

AQU	aqueous liquid	ORG	organic liquid
STK	unused stock in stock vials	NHV	non-hazardous scintillation vials
HZV	hazardous scintillation vials	ANI	animal carcasses/tissue
BIO	non-carcass biological waste	DRY	dry lab trash
PAT	administered to patients	BAC	Bactec vials
SEW	sewer disposal (H-3 ONLY)		

*****DO NOT CONSIDER DECAY IN ENTERING THE MILLICURIE AMOUNTS*****

Date: _______	form: _______	amt (mCi): _______	Date: ________	form:_______	amt (mCi): ________
Date: _______	form: _______	amt (mCi): _______	Date: ________	form:_______	amt (mCi): ________
Date: _______	form: _______	amt (mCi): _______	Date: ________	form:_______	amt (mCi): ________
Date: _______	form: _______	amt (mCi): _______	Date: ________	form:_______	amt (mCi): ________
Date: _______	form: _______	amt (mCi): _______	Date: ________	form:_______	amt (mCi): ________
Date: _______	form: _______	amt (mCi): _______	Date: ________	form:_______	amt (mCi): ________
Date: _______	form: _______	amt (mCi): _______	Date: ________	form:________	amt (mCi): _______

MAINTAIN THIS FORM FOR YOUR RECORDS - DO NOT SUBMIT THIS FORM TO EHS.
Inventory credit will be given ONLY for amounts submitted on properly completed RSO# pre-coded waste tickets. (Tickets for patient administration and sewer disposal may be mailed to EHS ATTN: RADWASTE at F-484.)

Pre-printed waste tickets are specific to each RSO#. Photocopy this form to create additional waste tickets for this specific RSO#. Waste tickets are also available from EHS, x4-0345.
*** ***Waste WILL NOT be accepted with tickets bearing altered RSO#s***. ***

RADIOACTIVE WASTE TICKET FOR RSO#

RSO# issued to PI on for mCi
from on PO No. Lot # received by lab on

By completing and submitting this waste ticket, I certify that the materials in this container do not constitute a hazardous or infectious waste as defined by the Radioactive Waste Disposal Manual.

Date: _____ Form: _____ Waste amount (mCi): _____ Phone: _____

Name: _____ Signature: _____

If scintillation vials, cocktail brand name: _____ # trays: _____

Comments: _____

_____

RADIOACTIVE WASTE TICKET FOR RSO#

RSO# issued to PI on for mCi
from on PO No. Lot # received by lab on

By completing and submitting this waste ticket, I certify that the materials in this container do not constitute a hazardous or infectious waste as defined by the Radioactive Waste Disposal Manual..

Date: _____ Form: _____ Waste amount (mCi): _____ Phone: _____

Name: _____ Signature: _____

If scintillation vials, cocktail brand name: _____ # trays: _____

Comments: _____

_____

RADIOACTIVE WASTE TICKET FOR RSO#

RSO# issued to PI on for mCi
from on PO No. Lot # received by lab on

By completing and submitting this waste ticket, I certify that the materials in this container do not constitute a hazardous or infectious waste as defined by the Radioactive Waste Disposal Manual.

Date: _____ Form: _____ Waste amount (mCi): _____ Phone: _____

Name: _____ Signature: _____

If scintillation vials, cocktail brand name: _____ # trays: _____

Comments: _____

_____

CU DENVER | ANSCHUTZ ENVIRONMENTAL HEALTH AND SAFETY DEPARTMENT

Radioactive Materials Inventory System

Form for Tracking Radioactive Material Usage by Multiple Users

RSO No.:	**Radionuclide:**	**Date rec'd:**	**Vendor:**
Original amount in vial (mCi):	Compound:	Lot No.:	Original assay (μCi per μliter):

Record of Amounts Withdrawn from Stock Vial for Use			
Amount withdrawn (μliters)	**Date**	**Initials**	**Check below when reported as waste**

Use of the Form for Tracking Radioactive Material Usage by Multiple Users

I. Tape a copy of this form to the refrigerator/freezer in which the stock vial is stored.

II. Require each person withdrawing an amount from the stock vial to make an entry on this form.

III. At the time when a waste pickup is requested from EHS,

A. Check the boxes in the right-most column that were not already reported as waste and add up the mCi amounts corresponding to the μliters used, in terms of the original assay of μCi per μliter (NO CORRECTION FOR DECAY),

B. Multiply the resulting amount (sum) by the partitioning fractions for the various waste forms generated by the type of experiment for which the material is used (these partitioning fractions are typically available from the PI or from EHS and

C. Make corresponding entries on the User's Radioactive Material Accounting Sheet and on the waste tickets to be associated with the waste containers containing waste from this order of radioactive material.

SEE EXAMPLE ON THE NEXT PAGE.

Example: Suppose the form has been completed as follows:

ENVIRONMENTAL HEALTH AND SAFETY DEPARTMENT
Radioactive Materials Inventory System

Form for Tracking Radioactive Material Usage by Multiple Users

RSO No.: 99999	Radionuclide: S-35	Date rec'd: 8/8/98	Vendor: XYZ
Original amount in vial (mCi): 0.250	Compound: dATP	Lot No.: ZZZ8888	Original assay (μCi per μliter): 1.0

Record of Amounts Withdrawn from Stock Vial for Use			
Amount withdrawn (μliters)	**Date**	**Initials**	**Check below when reported as waste**
30	8/9/98	BBB	/
20	8/9/98	DDD	/
20	8/19/98	BBB	/
30	8/22/98	DDD	/
30	8/29/98	BBB	
50	9/9/98	CCC	
50	9/11/98	BBB	

****

If waste is being prepared for pickup on or after 9/11/98, a review of the entries indicates that there are three entries totaling **130 microliters**, that relate to use since the last waste pickup. This equates to 130 microCuries = **0.130 milliCuries** that have been used and must be accounted for on the ticket(s) that will be submitted for this order of radioactive material, RSO # 99999. If the assay utilizing this material produces scintillation vials that contain 2 % of the starting radioactivity, aqueous liquid waste that contains 88 % of the starting radioactivity, and dry solid lab trash that contains 10% of the starting radioactivity, then the three tickets submitted for RSO # 99999 on this occasion will be for the following amounts:

First ticket:	scintillation vials, regulated	0.130 mCi x 0.02 = 0.0026 ≅	**0.003 mCi**
Second ticket:	aqueous liquids	0.130 mCi x 0.88 = 0.1144 ≅	**0.114 mCi**
Third ticket:	dry solids, short-lived	0.130 mCi x 0.10 = 0.013 ≅	**0.013 mCi**
		TOTAL	**0.130 mCi**

Example of Running List of Radioactive Waste Container Contents

Jones Lab - Dry Solids **ONLY!**

DATE	ISOTOPE	mCi	INTLS
11/13	3H	1.500	HMC
11/13	35S	0.025	JCC
11/13	35S (methionine)	1.900	HMC

Note: The only proper alternative is to attach individual Pre-Coded Waste Tickets to the waste container.

Radioactive Mixed Chemical Waste Disposal

Send completed form to: **Mixed Waste, Box F-484** (Anschutz)
(Read instructions on back before filling out form; improperly filled out forms will be returned.)

Your Name: _____ Phone #: _____ Campus Mail Box: _____

Your Signature: _____ Date: _____

Principal Investigator: _____ Phone #: _____ Department: _____

Location of Waste (Building and Room #): _____

Location within Room: _____

Chemical name (no abbreviations)	**Isotope**	**mCi**	**Percent Content.**	**Total volume (liters, grams)**	**Physical State (S, L, G)**	**Contaminants present?**	***EHS USE ONLY***	
							HC	***RCRA***
Draw a line between different containers of waste.								

Comments:

EHS Use Only	***Date Waste***
Date Received:	***Picked up:***

Instructions for Radioactive Mixed Chemical Waste Disposal at UCD (Questions? call x4-0345)

1. General Radioactive Mixed Chemical Waste Disposal Guidelines

a. Waste must be collected in a chemically compatible container which is leak free and has a proper lid (corks, rubber stoppers, paraf and loose fitting lids are not acceptable). Call Environmental Health and Safety (x4-0345) if you need a waste container or you nee proper lid. Free waste containers and lids will be provided whenever they are available.
b. Do not fill liquid waste containers completely full. Leave an air gap of five to ten percent in the waste container to allow for expansion the liquid.
c. Waste containers will not be picked up if they are leaking, have improper lids, are completely full, or if the outside of the containe contaminated with any waste product (radioactive contamination problem). Transfer waste to new container whenever necessary, properly decontaminate the affected area.
d. Waste containers must be properly labeled. Place a properly filled out radioactive mixed chemical waste label on every waste contai submitted for disposal. Do not use abbreviations for the proper chemical name.
e. Place the mixed waste label over any existing labels on the waste container prior to collecting any waste in the laboratory. For scintillat cocktails which are flammable (flashpoint less than 140 degrees Fahrenheit), corrosive, or otherwise hazardous, place a mixed waste la on the side of every tray of vials. Information on the label must match exactly the information on the waste disposal form.
f. Separate liquids from solids. All liquids must be free of solids to facilitate bulking of waste solvents by Health & Safety. If solids cannot separated from liquids, tape a note to the waste container stating the composition of the solid.
g. Segregate sharps, hypodermics, razors, and needles from all waste products and place them in a rigid plastic needle bucket. Dispose needle bucket in normal solid radioactive waste stream.
h. Segregate aqueous radioactive wastes from organic wastes. In general practice do not mix radioactive wastes with organic solvents ot than normal scintillation cocktails.
i. Schedule waste pickups well before exceeding 55 gallons of toxic waste or 1 kilogram of acutely toxic waste. Call Environmental Healt Safety immediately (x4-0345) if you have exceeded these threshold amounts.

2. Filling Out the Radioactive Mixed Chemical Waste Disposal Form

a. Fill out the form completely. Improperly filled out forms will be returned for corrections.
b. Chemical name. Write out the complete chemical name (do not use abbreviations). List all components of the waste along with th concentration in percentage by weight or volume. Unknown waste materials cannot be picked up until they are properly identified. C Health & Safety for the procedure for handling unknown wastes.

> Example #1: tritiated scintillation vials containing Econofluor TM. Write EconofluorTM, pseudocumene 90%, surfactants 10%.
> Example #2: S-35 scintillation vials containing Flo-Scint II: Write Flo-Scint II, pseudocumene 10%, petroleum distillates 50%, surfactants 40%.
> Example #3: C-14 in a phenol/chloroform mixture: Write phenol 30%, chloroform 70%.

c. Isotope. Write the name of the isotope (S-35, C-14, P-32, etc.)
d. Activity. Write the amount of each isotope present in the waste container in milliCuries (mCi).
e. Percent concentration. For pure materials write “100” percent for the concentration. For chemical mixtures write the perc concentration for each component present. For wastes in concentrations of less than 0.01% list concentration in milligrams per liter micrograms per liter. For trace contaminated wastes write “trace” for the concentration.
f. Total Volume. Write the total quantity of waste to be disposed. Write total in gallons, liters, kilograms, or grams. If there are three 4 bottles of the same waste, enter one waste entry along with total volume.
g. Physical state. Designate the waste as being a solid (s), liquid (L), or gas (G).
h. Contaminants present? Indicate if the waste contains any infectious agents (e.g. human serum), heavy metals (arsenic, bariu cadmium, chromium, lead, mercury, selenium, uranium, etc.), PCBs, dioxin, asbestos, water reactive drying agents (e.g. sodium hydride) other significant contaminants. If waste contains none write “no”. If contaminants are present write “yes” and include a note with the na and concentration of the hazardous material present. Tape copy of note to the waste container.
i. Waste pickup scheduling. Mail completed form to Radiation Safety officer, Box F-484 (Anschutz). Chemical wastes are generally pic up by Environmental Health & Safety personnel once a week. EHS may request that the items be kept in your SAA for a short period of ti so that the materials can be shipped to a disposal site within 90 days of removal from the lab. This will depend on our waste shipp schedule. If you have any waste pickup restrictions regarding time or access, write instructions in the comments section.

APPENDIX VII

DETERMINING THE CONTENTS OF RADIOACTIVE WASTE

1. Guidelines for Estimating The Radioactivity Content of Biomedical Research Waste

2. Procedure for Determining Whether Liquid Waste is Radioactive

GUIDELINES FOR ESTIMATING THE RADIOACTIVITY CONTENT OF BIOMEDICAL RESEARCH WASTES

These guidelines are intended as a general instructional aid and must be supplemented by the careful attention of the responsible principal investigator, who has specialized and detailed knowledge of the radioactive materials, procedures, and radioactivity counting instruments in use in his or her laboratory's experiments.

DECAY

Laboratory personnel need not correct for radioactive decay of materials being delivered as waste to Environmental Health and Safety. All accounting may be done on the basis of subdivisions of the original activity as supplied by the vendor. If you are estimating the activity of a sample of your waste by using counting results, by which you are automatically correcting for the decay that has occurred, please inform the person receiving the waste at EHS.

ASSAY APPROACHES FOR TYPICAL WASTE FORMS

SCINTILLATION VIALS

Scintillation vials usually contain far less of your experiment's starting radioactivity than you might suspect. Fortunately, the radioactivity present in your vials can be easily and directly determined from the counting results of your experiment. Take the average number of Counts Per Minute (CPM) that was obtained for those vials in your experiment, in the counting "window" or "channel" for the isotope(s) present. You should be able to determine the efficiency for each isotope by using quenched standards and some indicator of quench level that the machine provides by the external standard. These steps must be taken anyway, in order to get your experimental results in a scientifically tenable format. By dividing the CPM in a sample by the counting efficiency, you obtain the number of Disintegrations Per Minute (DPM) actually occurring in a sample. Dividing the number of DPM by 2.22 million DPM per microCurie, you obtain the number of microCuries per sample.

Thus, the steps are:

1. Estimate average CPM in channel of isotope being calculated
2. Divide by efficiency to obtain DPM.

    Efficiency should usually be 30-45% = 0.30 to 0.45 for ^{3}H
    Efficiency will be at least 80% = 0.80 for most other beta emitters

3. Divide DPM by 2,220,000 DPM/uCi to get number of uCi per vial.

As discussed in the attached memo, levels above 0.05 microCuries per milliliter of scintillation cocktail are generally unacceptable for disposal. Disposal vendors consider such levels to be indications of poorly designed (unnecessarily "hot") assays or illicit disposal of stock solutions in scintillation waste. Substantial quantities of vials that are truly that high in radioactivity content, especially ^{3}H or ^{14}C, may not be disposable by EHS without extraordinary expense. (Note that 0.05 uCi per ml is 110,000 DPM per ml, which can range from 20,000 - 30,000 CPM per ml of cocktail, for a heavily quenched ^{3}H sample, to 100,000 CPM per ml of cocktail for the kinds of counting efficiencies that usually obtain for ^{32}P.)

LIQUIDS

Bulk aqueous and organic liquids can easily be assayed by counting a one milliliter aliquot in the same manner as your experimental samples, with the calculations being that same as those described above for liquid scintillation vials, except that they results apply to one ml of the liquid waste in question. If you are using liquid scintillation counting, you must of course choose a cocktail that will dissolve the waste liquid and yield a countable, monophasic sample. Assistance is available from EHS in this regard. Bulk liquids often contain the vast majority of the experiment's radioactivity, and it is important to establish the amount of radioactivity present in the liquid wastes from each type of experiment that you perform. This is especially critical in determining which wastes, such as washes, are acceptable for sink disposal, and which are not.

ANIMALS

When radioactivity is administered to animals, the amount given to each animal is known as part of the experiment. However, some of the material is inevitably metabolized and excreted, and it is important to know how much is actually present in animal carcasses, as opposed to bedding and excreta, or tissues that are resected for analysis. These matters are generally addressed in the principal investigator's application to the Committee on Ionizing Radiation. However, it may also be desirable to take some samples of these materials and analyze their radioactive content, on the first performance of the experiment. You should contact the principal investigator or the EHS health physicist to determine appropriate assay methods.

UNUSED RADIOACTIVE STOCK

When any appreciable quantity of unused radioactive stock solution remains in the vial supplied by the vendor, it is not appropriate to simply discard the vial in dry solids. It is most preferable to deliver it as such, in its original outer container, to EHS. The remaining activity in the stock vial can be readily determined by subtracting the total amount withdrawn by users from the original order amount indicated on the accounting sheet supplied with the order.

DRY SOLIDS

Dry solids are often difficult to assay, by the nature of the materials that comprise them. The principal investigator will often have a good idea of how much radioactivity is contained in specific items that are likely to contain substantial amounts, such as gels or purification and separation columns. In the absence of any other information, you can determine that amount in dry solids by a process of elimination, knowing the amount in all of the other forms above that are involved.

ASSISTANCE

Assistance and consultation is available from the staff of EHS, ext. 4-0345. Reasonably small numbers of properly identified samples will be analyzed free of charge in the EHS counting lab for radioactive content. You should provide the identities of the radioisotopes thought to be present, along with the chemical composition of the samples.

An *ad hoc* Working Procedure for Determining whether a Liquid Waste Generated in the Laboratory is "Radioactive"

This procedure is intended to provide guidance to investigators in regard to liquid waste mixtures of various types that are generated in the laboratory. Sometimes, such mixtures must be considered suspect of being radioactive because the experimental procedure that generated them involved the use of radioactive materials, *BUT the investigator believes that the physical partitioning of the radioactivity in the experiment is such that the liquid waste in question contains only extremely minute amounts of the radioactivity, or none at all*. In such cases, if this intuition can be verified in a quantitative way that determines the radioactivity concentration in the waste to be below the "trace quantity" limits, the management of the waste is greatly simplified. That is, *some* wastes that are so determined to be "non-radioactive" or to contain only a "trace amount" of radioactivity can be treated as infectious or hazardous wastes *instead* of mixed wastes, and *some* other such wastes can be treated as innocuous aqueous wastes that are suitable for sink disposal.

STEP 1: Obtain a sample of the liquid in question. Use a pipette to put one ml of the waste into a clear, 20-ml borosilicate glass vial for liquid scintillation counting. Note that

- **if the mixture is multi-phasic, you need to sample each phase separately**, and

- if there is material suspended in the liquid that is not homogeneously distributed throughout the liquid, you should take care to include some of it in the sample.

STEP 2: Prepare a liquid scintillation sample for counting. Add 10 to 20 ml of some universal liquid scintillation cocktail. The resulting mixture, after shaking to insure mixing, should be a reasonably translucent, monophasic solution. If you cannot obtain an acceptable liquid scintillation sample in this manner, try starting with 0.1 ml of the waste instead of 1 ml.

STEP 3: Count the sample by liquid scintillation. If you do not have your liquid scintillation counter set for the particular radionuclide of interest, you should set three windows or "channels" in your counter, for ^{3}H, ^{14}C, and ^{32}P. Almost any radionuclide used in biomedical research will show up in one of these windows, even if it is traditionally thought of as a "gamma emitter." For example, ^{51}Cr shows up in the lower end of the ^{3}H window, and ^{125}I shows up in the ^{3}H and ^{14}C windows. A **counting time** of 1 to 2 minutes should suffice for samples that are based on 1 ml of the waste. For 0.1ml samples, count for at least 10 minutes to increase the counting precision.

STEP 4: verify that the sample you prepared was not too quenched to give reliable results. Your liquid scintillation counter should have some parameter that indicates quenching, or gives you an error indication for results automatically computed in DPM if the sample is too quenched to give reliable results. If the sample was too heavily quenched, and you started with a 1ml sample of the waste, try starting with a 0.1ml sample.

STEP 5: compare your results to background. If the results do not significantly exceed background (i.e., not more than a few CPM above background-plus-two-standard-deviations-of-background), you may consider the waste to be non-radioactive. YOU NEED TO BE AWARE THAT CHEMILUMINESCENCE IN THE SAMPLE MAY PRODUCE FALSE POSITIVE RESULTS IN THE ^{3}H CHANNEL, AND, TO A MUCH LESSER EXTENT, THE ^{14}C CHANNEL. Your counter *may* have a means to indicate when it thinks that some or all of the counts in these channels are due to chemiluminescence. Contact EHS for advice on suspected chemiluminescence artifacts.

If the sample indicates a few tens or hundreds of CPM or DPM above background, it MAY be sink disposable if the waste is an aqueous solution that is chemically and biologically acceptable for sink disposal, and the amount

of radioactivity present does not exceed the following levels (*Note that you will need to convert CPM to DPM if your counter does not provide results in DPM*. This may require consultation with EHS):

Table: Radioactivity Concentrations Acceptable for Sink Disposal

Radionuclide	^{3}H	^{14}C	^{32}P	^{35}S	^{51}Cr	^{125}I
DPM per ml	22,200	666	20	220	1,100	N/A*

*allowable levels are too low to be sure that amounts exceeding the limits will be detected by the method described in this procedure. Wastes known or suspected to contain ^{125}I should be assayed by EHS, using gamma-spectroscopy methods that allow lower limits of detection.

- **If the waste being assayed is below the listed radioactivity concentration limits, but is biologically subject to classification as infectious waste, it must be sterilized with a bleach solution before sink disposal.**

- **If the waste being assayed is below the listed radioactivity concentration limits, but is chemically unacceptable for sink disposal, you should contact EHS (x 4-0345) for guidance on disposal. Please be prepared to discuss your radioassay results.**

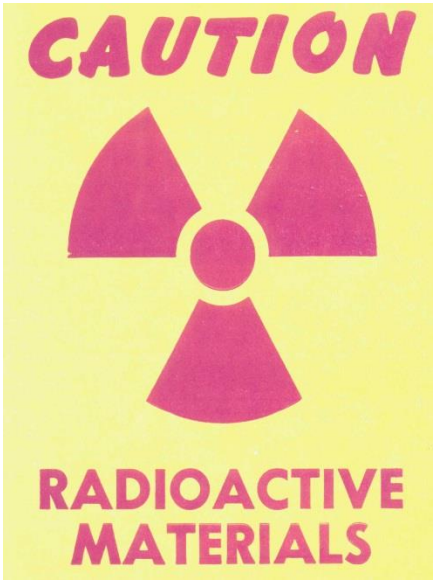
STEP 6: DISPOSE OF YOUR LIQUID SCINTILLATION SAMPLES PROPERLY. If the liquid waste being assayed qualifies chemically as RCRA regulated hazardous waste, present the liquid scintillation samples to EHS as HAZARDOUS SCINT VIAL WASTE.

EHS will be happy to provide additional guidance, provide glass counting vials, or even count samples for you if you cannot do so. Contact EHS at x 4-0345.

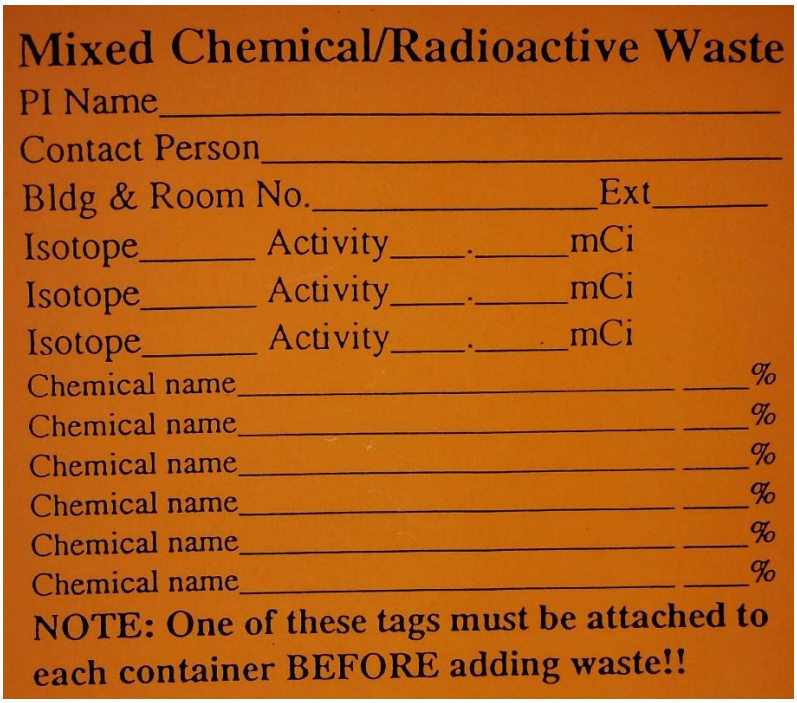
APPENDIX VIII

RADIOACTIVE WASTE CONTAINER LABELS

LABEL REQUIRED FOR RADIOACTIVE WASTE CONTAINERS
(Size may vary; colors must be magenta on yellow)



LABEL REQUIRED FOR MIXED RADIOACTIVE WASTE
(Sizes and shapes may vary, orange in color)



APPENDIX IX

CLEARANCE FORM FOR DEPARTING LABORATORY PERSONNEL

UNIVERSITY OF COLORADO DENVER
Environmental Health and Safety Department, Office of the Assistant Vice Chancellor for Regulatory Compliance

(303) 724-0345 (office)
(303) 724-0388 (fax)

CLEARANCE FORM FOR DEPARTING PERSONNEL

Instructions: Please complete this form at least 2 weeks prior to departure from UCD campus and mail to: **Environmental Health & Safety Department – Attn: Clearance Form, Campus Box F- 484.** If there are less than 2 weeks remaining until your departure, Fax form to EHS or drop the completed form off in person at either of the above Environmental Health & Safety Office locations (8:00 a.m. – 5:00 p.m.).

Print Your Name: _____ Employee ID#: _____

Dept. Name: _____ P.I. Name: _____

Work phone#. _____ Campus Box#: _____ Date of Departure: _____

Building:_____ Room#: _____

Please provide us a forwarding address:
STREET/NO./APT. _____

CITY _____ STATE _____ ZIP _____

Phone number _____

1. Have you worked with and/or handled radioactive isotopes? ☐ yes ☐ no

If yes, please send all remaining film badges and ring badges to Environmental Health and Safety, Box F484.

2. Were you listed as an emergency contact for your lab? ☐ Yes ☐ no

If yes, provide replacement's name, office #, home # _____

3. Is your entire laboratory staff leaving the UCD campus (moving to a non-UCD entity)?
   ☐ Yes
   ☐ No

4. If you answered **Yes** to question #3, your laboratory, in most cases, must remove all remaining wastes, supplies, equipment, and furniture. Equipment or lab surfaces that were in contact with chemicals, biological materials or radioactive materials must be properly decontaminated by the researchers according to the Environmental Health & Safety Departments Decontamination Procedures for Laboratory Equipment/Lab Surfaces. Please decontaminate your laboratory equipment and surfaces according to these procedures so that your area will be safe for the new occupants. You can find the laboratory decontamination procedures by going to the Web Page www.uchsc.edu/safety, and clicking on "Disposal of Surplus Laboratory Equipment, Computers, Furniture and Closing Down Laboratories ("Green-Tagging")."

5. If you answered **No** to question #3, make sure you have clearly labeled and transferred all radioactive, chemical, reagent containers to another approved investigator in your lab/department **or** have properly disposed all of these materials as waste through the Environmental Health and Safety Department. **Important: Clearly label chemical contents: stock solutions, sample containers and micro-centrifuge tubes. Do not abandon containers labeled with cryptic markings that only you can decipher.**

I certify that I have not abandoned any research materials (chemicals, biological materials, radioactive isotopes) including waste containers, prepared stock solutions or sample containers in any of the laboratories that I have worked in the past.

Print your name **Your Signature** **Date**

APPENDIX X

REQUIREMENTS FOR LABORATORY CONTAMINATION SURVEYS

1. **Documentation of Contamination Surveys**
2. **An Example Laboratory Survey Form**
3. **Laboratory Survey Instructions**

DOCUMENTATION OF CONTAMINATION SURVEYS AND REQUIREMENT FOR AVAILABILITY AT TIME OF RADIOACTIVE WASTE PICKUP

Radioactive Material Authorizations carry a requirement to perform and document contamination surveys at the frequency indicated on the authorization document. Documentation must be present and follow the prescribed frequency. Environmental Health and Safety (EHS) will review recent contamination surveys prior to removing waste from the lab to verify compliance with this requirement.

Cases in which the required contamination survey is unavailable or does not appear to be current will be reported to the RSO.

- **The RSO's *first* determination that a given PI cannot produce a current survey will result in a *written notice* to the PI.**

- **The RSO's *second* determination that a given PI cannot produce a current survey will result in *automatic suspension* of the PI's procurement privileges for radioactive material until a copy of a proper and current contamination survey for all of the PI's authorized radioactive materials laboratory areas is furnished to the RSO.**

Comprehensive contamination surveys represent a basic and universal requirement for radioactive materials work.

- Surveys are required to be performed in accordance with the laboratory Tri-level Hazard Classification System (monthly, weekly, or daily for low, medium, or high hazard levels respectively).

- An instrument sweep of laboratory surfaces and a sampling of 4 to 10 swipes from surfaces throughout the area, as appropriate based on the surfaces susceptible to contamination, should take no longer than 30 to 45 minutes to perform and document.

- If tritium is the ONLY radionuclide in use, only the swipe test is necessary. *However,* a larger number of swipes will typically be necessary than in cases in which an instrument survey serves to demonstrate complete coverage of the surface areas of all potentially-contaminated laboratory surfaces.

Surveys are **not** required to be performed during periods when radioactive materials are not being used, if a survey was performed *after* the last use of radioactive materials. These surveys must be *current*, viz., within the last day, week or month, depending on the required frequency. Any waiver of the requirement for the availability of a *current* survey at the time of a given waste pickup, on the premise that radioactive materials have not been used but radioactive wastes have remained in the laboratory, is subject to the judgment of the Radiation Safety Officer and the ultimate authority of the Committee on Ionizing Radiation. In such cases, the RSO will review the Principal Investigator's records of the surveys that *have* been performed and consider the elapsed time since the last documented survey, in light of such information as

- the Environmental Health and Safety inventory system's information on the PI's acquisitions of radioactive materials during the period in question,

- Environmental Health and Safety's records of the PI's disposals of the resulting wastes, and

- Environmental Health and Safety's records of any contamination found on the PI's waste containers at times of waste pickups.

Most cases of a PI's personnel arranging a disposal of radioactive wastes after an *extended* period of no use of radioactive materials involve changes in personnel or responsibilities, and the simplest and most appropriate approach is for the person(s) assuming such responsibility to perform a confirmatory contamination survey of the authorized areas involved.

When it is known that radioactive materials will not be used for an extended period of time in a particular authorized area, the Principal Investigator's personnel should arrange disposal of any radioactive wastes, perform surveys and decontamination as appropriate, and remove any unnecessary labeling on benchtops and appliances.

LABORATORY SURVEY FOR RADIOACTIVE CONTAMINATION

Swipe test surveys must be performed monthly, weekly, or daily for low, medium or high hazard levels respectively. **Results, even if negative, must be recorded, and the records must be maintained for at least three years and made available for inspection during audits by the Radiation Safety Officer**. Follow a map unless a reasonable description of the surveyed area is given for each swipe. Counting machine printouts, properly annotated to indicate locations sampled, should be attached to this form in addition to transcribing results onto the form. All instruments used to assess radioactive contamination must be calibrated annually.

Principal Investigator	**Laboratory (Bldg & Room No.)**	**Survey Date**	**Individual Performing Survey**
Instrument Manufacturer	**Model**	**Serial Number**	**Calibration Due Date**

Sample #	Location	Background (CPM)	Net CPM (result - bkgd)

***Radioactive contamination levels that *exceed twice background* must be decontaminated by laboratory personnel.**

****Persistent contamination that defies repeated attempts at removal by proper techniques (see *Radiation Safety Manual*) must be reported to the Radiation Safety Officer at extension 4-0345.**

INSTRUCTIONS FOR EXAMPLE FORM
"Laboratory Survey for Radioactive Contamination"

What Type of Survey to Perform, Instrument Survey vs. Swipe Testing. BOTH types of survey should be performed (unless only ^{3}H is in use):

- An instrument (e.g., GM, LEG) should be used to slowly sweep all suspect surfaces. Despite having a relatively poor detection efficiency (and is useless for ^{3}H) and inability to distinguish fixed from removable contamination, it can cover wide areas effectively. It can also check absorptive surfaces that cannot be effectively swipe tested. An instrument should also be used to survey one's hands and clothing after each use of radioactive material.

- A swipe test survey should be performed by using cotton-tipped swabs or filter paper. Take swipes of areas of about 100 sq cmand count by liquid scintillation (or in gamma well counter, if appropriate). Swipe testing has superior detecting efficiency for the targeted areas so tested, and identifies removable contamination. Remember to include a background so that you can determine the actual activity from your survey results.

Selection of Areas to Survey
Surveys should cover all suspect areas that may be contaminated (i.e. benchtops, sinks, floors, fume hoods, and various lab appliances such as centrifuges/speed vac's, water baths, incubators, gel dryers, refrigerators, and freezers. You should also survey areas that may be contaminated by touching, such as light switches, doorknobs, and telephones. Select a few different areas for testing each time you survey. A map or diagram of your work area with the specific areas that you are swiping marked by number is a very efficient method of surveying and provides good documentation.

Recording Results
Record your results on the form, subtracting background from gross CPM to get net CPM for the last column. Ideally, you might use the form to record instrument survey results and attach a counting machine printout of corresponding swipe tests.

When You Must Take Action
If either type of survey indicates a result exceeding **twice background**, redo the test. ("Twice background" is a crude criterion for statistically significant results, indicating the presence of something other than background.) You should make every reasonable effort, using appropriate techniques (see *Radiation Safety Manual*) to remove all contamination. Annotate your decontamination efforts and retain all subsequent surveys along with the original survey in order to document the decontamination. You should try to remove all contamination. **Any persistent problems, such that either instrument surveys or swipe testing repeatedly indicate contamination, should be reported to the Radiation Safety Officer, x4-0345.**