ENVIROGEN
New Solutions to Hazardous Waste Problems

Princeton Research Center
4100 Quakerbridge Road
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Tel: 609/936-9300
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January 2, 1991

Mr. Frank Costello
Nuclear Materials Safety Section B
Division of Radiation Safety and Safeguards
Region I
Nuclear Regulatory Commission
475 Allendale Road
King of Prussia, PA 19406

Docket No. 030-31898
Control No. 1[illegible]318

Dear Mr. Costello,

As per our conversation this morning I am sending you revised pages of our application for a byproduct license.

Pages to follow:

1. Revised copy of Item 10 of the license showing that TLD badges shall be used for personnel monitoring.

2. Revised copy of Section II.B of the Envirogen Radiation Safety Guide clarifying the methods for contamination surveys and changing the skin contamination level to 0.5 mR/hr.

Please let me know if I can provide you with any more information.

Sincerely,

Janet Klass

Janet Klass
Manager, Laboratory Services

NRC Form 313
Attachment: Item 10

Envirogen, Inc.
4100 Quakerbridge Road
Lawrenceville, NJ 08648

Radiation Safety Program

Envirogen's Radiation Safety Program is detailed in the Envirogen Radiation Safety Guide Attachment (Attachment 1), Section II. Included in the guide are radiation safety training, laboratory procedures, package handling, external and internal dose control, posting and labelling requirements, radiation waste disposal, and emergency procedures.

Personnel Monitoring:

1. External: TLD badges are supplied and monitored on a quarterly basis by Landauer Inc. 2 Science Drive, Glenwood, IL. Dosimetry records for personnel will be maintained by the Radiation Safety Officer.

2. Internal: The routine use of radioactive materials is typically in the microcurie range and the materials used are not volatile. Therefore Envirogen will perform urinalysis and other appropriate bioassays only in the event of a suspected intake of radioactive material or when the RSO determines that the use of a labelled volatile substance may result in an uptake. Urinalyses will be done by liquid scintillation counting with the appropriate controls and procedure.

Survey Program:

For routine surveying by laboratory personnel, see Envirogen Radiation Safety Guide (Attachment 1), Section II.B.6. In addition to routine surveys, the Radiation Safety Officer or his designee will perform the following:

1. Keep a log of those surveys which he performs. The log will include the date of the survey, the area being surveyed and the activity as measured in microcuries.

2. Keep routine surveys in a log book, supervise the keeping of this log, and will ascertain that the log is kept properly.

3. Keep a separate log book containing an accurate account of the inventories of the various isotopes in the form that they are received. This log will contain information concerning the date of delivery of each item, the form in which it is delivered and the results of the survey of the container. It will also note the date that the material is removed from storage to be used, along with the adjusted amount on hand.

Note: The Envirogen Radiation Safety Guide (Attachment 1), Appendix G.2 gives examples of the forms to be used.

B. Laboratory Procedures for Radioisotopes

1. Reports

The Radiation Safety Officer or his designee will maintain an inventory of radioisotopes on hand and a summary of radioisotope disposals.

2. Radioisotope Use Logs

Radioisotope Use Logs are maintained in the laboratory. These logs contain information pertaining to each vial of isotope on hand including element and mass number, date received, amount received, dates of withdrawal for use and amount withdrawn, date of disposal of waste, manner of disposal, and estimated amount of waste.

3. Survey Equipment

A person using open or sealed sources, opening packages containing radioisotopes, or performing physical or chemical manipulation of radioisotopes must have immediately available a suitable, operative radiation detector.

4. Operational Surveys

Each person using radioactive materials shall conduct contamination surveys after each procedure, or at the end of the day for a multi-day procedure, to gauge the potential for exposure to workers and to assure that no contamination exists. Contamination surveys shall be performed by wipe method for all radioisotopes except 32-P which can be monitored by G-M survey instruments. Records of each contamination survey must be kept. The radiation safety officer will conduct unannounced contamination surveys, at least monthly, in order to verify that laboratories are kept contamination-free.

Survey records must be kept in units of activity (e.g., dpm, Bq or uCi). They should include a sketch of each laboratory with the locations of each wipe point indicated. They must be made readily available for inspection by the NRC, the NJ DEP and by the RSO. These records must be kept until the facility is "decommissioned", i.e., removed from service and thoroughly surveyed to assure that no residual contamination remains. See Appendix G-2 for a sample record format.

Contamination means activity present on a wipe or a GM meter reading in excess of 1000 dpm/100 cm^2.

Steps shall be taken to lower any radiation levels greater than 0.5 mR/hr at the surface of the skin at any point on the body as measured by a GM survey instrument. Commercial decontamination products are available in the laboratory and Envirogen has arranged for medical care at Professional Medical Services in Lawrenceville, NJ.

5. Personal Surveys

Following the physical or chemical manipulation of radioisotopes, thorough checks of one's person and clothing for contamination shall be made.

6. Frequency and Type of Surveys

Work areas where radionuclides are used or stored are surveyed monthly using survey meters and the method of wipes. The definition of work area includes the liquid scintillation counter. The level of counting is calibrated by using samples of a known number of disintegrations per minute to which a control wipe has been added. Routine experimental areas will be surveyed as often as used by survey meters.

7. Smoking and Eating Restrictions

Smoking, eating and drinking in radioisotope laboratories is not permitted. Food shall not be placed or stored in any equipment such as refrigerators, freezers or ovens in which radioisotopes are stored or used.

8. Pipetting

Mouth pipetting of radioactive material is prohibited.

9. Working Surfaces

All work involving physical or chemical manipulation of open radioactive sources must be performed directly on work surfaces suitable for containment of contamination and easy decontamination. The lining of work surfaces with plastic backed absorbent paper is used to reduce the spread of contamination.

10. Ordering

All isotope orders are placed by the Manager, Laboratory Services who will check each order for consistency with Envirogen's license.

ENVIROGEN RADIATION
SAFETY GUIDE

First Edition: August, 1990

ENVIROGEN

RADIATION SAFETY GUIDE

TABLE OF CONTENTS

I. Management Policy and Organization

A. Management Policy on Radiation Protection

In order to carry out its legal, moral and regulatory responsibilities, as regards the safe use and disposal of radioisotopic substances, Envirogen establishes this Radiation Safety Guide. We also propose to maintain a Radiation Safety Program described herein for keeping individual and collective doses as low as is reasonably achievable. In accord with this commitment, we hereby describe an administrative organization for radiation safety and have developed the necessary written policy, procedures and instructions to foster this concept within our company. The organization will include a Radiation Safety Committee (RSC) and a Radiation Safety Officer (RSO). This program will be amended as is necessary to comply with updated regulations.

B. Radiation Safety Committee

1. Membership: A Radiation Safety Committee develops and recommends radiation safety policy and monitors the progress and continuity of the radiation safety program. The members of the RSC are listed in Appendix A of this guide.

2. Responsibilities: The RSC will convene a minimum of two times per annum for the purpose of recommending and developing radiation safety policy, and monitoring the progress and continuity of the radiation safety program.

3. Responsibilities of the Radiation Safety Officer: The responsibilities of the RSO include the following:

   a. Maintenance of all centralized records required by regulation and pertinent to the radiation safety program

   b. Administration of the centralized personnel monitoring program

   c. Administration of the centralized radioactive waste program

   d. Inspection and surveys of laboratories and areas where "Sources of Radiation" are used

   e. Conducting radiation safety training seminars

   f. Collection and dissemination of radiation safety information including radioisotope fact sheets, regulatory guides, regulatory changes, health and safety advisories, etc.

   g. Provision of assistance and advice in all radiation emergencies and supervision of special decontamination operations

   h. Investigation and analysis of radiation incidents, including, for example, spills of radioactive materials, releases, etc., and development of recommendations to prevent reoccurrences

   i. Auditing the progress and continuity of the radiation safety program

   j. Developing and refining radiation detection, shielding and health protection techniques

II. Radiation Safety Program

A. Radiation Safety Training

Radiation safety training is mandatory for users of radioisotopes; all laboratory personnel attend an initial radiation training session within one month of employment at Envirogen. The topics covered in the initial training course are included as Appendix G.1 of this guide. This training will take place at Rutgers University. Through its association with the University, Envirogen has been granted permission to send its employees to the Rutgers Radiation Safety Training Course. Topics covered in this course which are different for Envirogen personnel, i.e. emergency notification and ordering of radioisotopes, will be covered at introductory sessions with the employee's supervisor. These topics are also included in Appendix G.1 of this guide. Section G.2 of the same Appendix gives examples of the types of forms necessary for general handling of radionuclides: receipt, inventory, personal and area surveying, waste disposal, etc.

In addition, the required annual update sessions for laboratory personnel will also take place at Rutgers University.

Radiation Safety Training for Ancillary Personnel

During orientation sessions as new employees, ancillary personnel are instructed and made familiar with the following:

1) Potential risks of radiation exposure
2) The ALARA concept
3) Sources of radiation
4) The radiation symbol
5) A diagram of the lab facility indicating levels of radioisotope use
6) Emergency procedures
7) Waste disposal procedures which define containers for general waste pickup as separate from those which contain radiation waste

B. Laboratory Procedures for Radioisotopes

1. Reports

The Radiation Safety Officer or his designee will maintain an inventory of radioisotopes on hand and a summary of radioisotope disposals.

2. Radioisotope Use Logs

Radioisotope Use Logs are maintained in the laboratory. These logs contain information pertaining to each vial of isotope on hand including element and mass number, date received, amount received, dates of withdrawal for use and amount withdrawn, date of disposal of waste, manner of disposal, and estimated amount of waste.

3. Survey Equipment

A person using open or sealed sources, opening packages containing radioisotopes, or performing physical or chemical manipulation of radioisotopes must have immediately available a suitable, operative radiation detector.

4. Operational Surveys

Laboratory personnel shall conduct surveys, to gauge the exposure to radiation of workers performing a particular procedure and to spot check for possible areas of contamination. During any procedure in which significant radiation levels may occur, a radiation level survey should be made. After any procedure in which the possibility of contamination exists, spot checks for contamination shall be made. A record of such surveys shall be kept.

5. Personal Surveys

Following the physical or chemical manipulation of radioisotopes, thorough checks of one's person and clothing for contamination should be made.

6. Frequency and Type of Surveys

Work areas where radionuclides are used or stored are surveyed monthly using survey meters and the method of wipes. The definition of work area includes the liquid scintillation counter. The level of counting is calibrated by using samples of a known number of disintegrations per minute to which a control wipe has been added. Routine experimental areas will be surveyed as often as used by survey meters.

7. Smoking and Eating Restrictions

   Smoking, eating and drinking in radioisotope laboratories is not permitted. Food shall not be placed or stored in any equipment such as refrigerators, freezers or ovens in which radioisotopes are stored or used.

8. Pipetting

   Mouth pipetting of radioactive material is prohibited.

9. Working Surfaces

   All work involving physical or chemical manipulation of open radioactive sources must be performed directly on work surfaces suitable for containment of contamination and easy decontamination. The lining of work surfaces with plastic backed absorbent paper is used to reduce the spread of contamination.

10. Ordering

    All isotope orders are placed by the Manager, Laboratory Services who will check each order for consistency with Envirogen's license.

C. Receipt and Opening of Packages Containing Radioisotopes

The receipt of packages containing radioactive material places certain requirements on the recipient. These requirements are primarily designed to cause the detection of leaking packages and packages with excess radiation levels.

1. General Procedures for Opening Packages

a. The opening of packages must be done only in a properly equipped laboratory by the RSO or his designee.

b. Full use, as necessary, should be made of protective clothing and protective equipment such as shields, tongs, etc.

c. Before any attempt is made to open a package, the packing list, which is usually attached to the exterior of the package, should be reviewed to verify that the order's radioisotope content, quantity, and chemical composition are correct. Errors with respect to these items sometimes occur, and it is easier to return an unopened package. If the package is unfamiliar, seek out any special opening instructions.

d. If the packing slip was packed inside the outer package, verify that the contents of the package are correct as ordered before opening any inner container. Remove the inner container and verify the contents as labelled against the packing slip, checking for radioisotope content, quantity, specific activity, chemical composition, and physical form.

e. Determine the dose rate from the inner container and take appropriate precautions. Supply additional shielding as needed.

f. Leak test the inner container for gross contamination, making certain to check for broken seals, breakage, loss of contents, or change in color of the absorbent material around the container.

g. Dispose of unneeded contaminated packing materials as radioactive waste.

h. Deface or remove radioactive material labels on any empty, uncontaminated package before placing the package in the non-radioactive waste. If a package has been established to be uncontaminated, cost considerations indicate that the package should be discarded as ordinary trash.

i. No after hours receipt of radioactive packages will be accepted.

j. Place isotope in the freezer or refrigerator designated for isotope storage.

k. Enter isotope received into inventory log and start an isotope use log for that vial.

D. External Dose Control and Personnel Monitoring

1. Control

All lab personnel working with radioisotopes or those frequenting areas where isotopes are used are provided with personnel monitoring devices. The Radiation Safety Officer is responsible for insuring that all persons using sources of radiation are provided with suitable personnel monitors and that these monitors are actually worn when appropriate.

2. Centralized Personnel Monitoring Program

The Radiation Safety Officer or his designee provides personnel monitors for routine and temporary use, distributes personnel monitors, collects personnel monitors after use, ships the monitors to the personnel monitoring service vendor for interpretation, receives and distributes the dose reports to the lab director(s), maintains centralized records, investigates unusual or excessive doses, and honors requests for dose history summaries.

a. Envirogen seeks to minimize the exposure of its personnel to isotopes. In no case should the occupational dose of an Envirogen employee exceed the maximum permissible limits as specified by the NRC. These limits are shown as Appendix C.

b. A cumulative summary of the occupational radiation dose received by an individual monitored for exposure to radiation at Envirogen is available from the Radiation Safety Officer upon request. Such a summary is also available at any time following the termination of the individual's employment. The request for the cumulative summary must include the dates of employment, department of employment, and social security number.

c. Any individual who has been monitored for exposure to radiation during a calendar quarter in which he or she terminates employment at Envirogen, at the time of termination, may request a summary of the dose received during that quarter. This information may be requested of the worker by subsequent employers during that calendar quarter.

d. In accordance with Good Health Physics procedures, all employees who work with strong beta or gamma emitters or frequent areas in which these materials are used shall be badged.. Employees handling these materials will be given ring dosimeters if the RSO determines that a hand exposure in excess of 50 mrem is possible.

e. Badges will be exchanged on a quarterly basis.

3. Bioassay for Internal Contamination

A worker may be asked by the RSO to submit a urine specimen for radioanalysis if he/she works with a volatile radioactive substance or in the event of a suspected intake. The analysis is done by liquid scintillation counting and the worker is informed of the results. Any measurable activity will be grounds for a complete investigation by the RSO.

4. Suspected Overexposures

Any exposure above 50 mRem/whole body badge or 150 mRem/ring badge will be investigated by the RSO to determine the cause of such exposure and to minimize the possibility of a reoccurrence.

5. Exposure of Minors

Minors under 18 years of age will not be employed as radiation users.

6. Exposure of Pregnant Women

a. Each female radiation worker, at the time of the beginning of work with sources of radiation, is provided by the Radiation Safety Officer with an information packet containing the NRC Regulatory Guide 8.13 "Instruction Concerning Prenatal Radiation Exposure".

b. Any female employee who is thinking of becoming pregnant or knows that she is pregnant should review, with the RSO, her options to minimize exposure.

7. Exposure of Visitors

Guests, maintenance and repair personnel, etc., are informed of the hazards and must comply with all applicable rules, regulations, and procedures, and wear personnel monitors when appropriate.

E. Posting, Labelling and Tagging Requirements

1. Posting Requirements

By regulation any laboratory using radiation must have posted or otherwise readily available (except as noted below by an asterisk) the following items:

a. "10 CFR Part 19," "10 CFR Part 20," as amended, 10 CFR parts 30, 33, and 71, as amended, and 10 CFR Part 31, when appropriate

b. Envirogen Radiation Safety Guide

c.* Form NRC-3, "Notice to Employees," must be posted.

d. Envirogen Emergency Information Form: Accident Procedures & Emergency Phone Numbers. Sample forms are found in Appendix G.2.

2. Posting of Radiation Areas

Each Radiation Area shall be conspicuously posted with a sign or signs bearing the radiation symbol and the words:

CAUTION
RADIATION AREA

3. Labelling of Equipment and Containers

Any equipment (vaults, refrigerator, etc.) or container in which radioactive material is stored or used, shall bear a durable, clearly visible label bearing the radiation symbol and the words:

CAUTION
RADIOACTIVE MATERIAL

This label shall, when practicable, also identify the radioisotope, the amount in Curie units, and the date of assay.

The outside of a shielded container must also bear this label as well as the inner container.

*These items must be posted in a conspicuous place where they will be seen by all persons working in or frequenting a Restricted Area.

4. Tagging of Waste Containers

Radioactive waste must be carefully separated according to NRC guidelines and radioactive materials burial site specifications. These include:

a. large volume liquid
b. solid, waste-compactible
c. solid waste with incidental liquid
d. liquid scintillation vials

For a complete explanation of each of the above categories, refer to Appendix F of this guide. Examples of the tags for the above categories appear in Appendix G.2.

F. Radioactive Waste Disposal

There are strict requirements placed on Envirogen (as the licensee) regarding the manner and methods used for the disposal of radioactive wastes. In order to comply with these requirements the following procedures are established.

1. Centralized Radioactive Waste Disposal Program

   a. All radioactive experimental wastes and first rinses shall be placed in radioactive material waste containers.

   b. The date, radioisotope and amount of radioactive materials placed in these waste containers must be recorded on the log fastened to the can.

   c. Radioactive material waste containers should not be used for non-radioactive wastes nor should they be used as disposal containers for other toxic wastes.

   d. Each radioactive material waste container in the laboratory, once it has been designated for use for a particular type of radioactive waste, i.e., dry solid waste, small volume liquid waste, etc., should be labelled to indicate its designation.

   e. The chemical compatibility and hazard characteristics of radioactive wastes placed within the same container should always be considered.

   f. Radioactive material waste containers shall be placed in a safe location to prevent damage and should be kept separate from waste cans for non-radioactive material to avoid cross-contamination.

   g. Only authorized radioactive material waste containers provided by the vendor or approved by the Radiation Safety Officer may be used for waste shipment.

h. Each waste container used for radioactive waste collection in labs and each container used for the subsequent shipment of wastes shall be inspected for corrosion or damage which could affect the integrity of its containments, prior to its being placed in service. Containers used for the local collection of wastes and/or for extended periods of time shall be inspected regularly. Containers whose integrity is suspect shall not be used for waste collection or shipment.

i. The contents of each radioactive material waste container shall be inspected by the Radiation Safety Officer prior to pickup by the vendor to insure that the wastes are properly separated into the appropriate container in accordance with current packaging requirements.

2. Sanitary Sewage System

Use of the sewage system as a primary means of radioisotope waste disposal is prohibited. This is necessary because the permissible water concentrations established by Federal and State laws are low. However, some incidental disposal to the sewer is unavoidable and is permitted subject to the following conditions:

a. No radioactive material may be placed in the sewer unless it is readily soluble or dispersible in water.

b. Incidental disposals of isotopes will be sufficiently diluted locally to insure compliance with the daily concentration limits set forth in Appendix E, Table I, of the guide.

3. Radioactive Waste Disposal Procedures

Procedures are required by the waste disposal service vendor to insure that radioactive waste is suitable for burial at the limited number of burial sites within this country. The waste removal service vendor supplies Envirogen with detailed disposal procedures, which are included as Appendix F of this Radiation Safety Guide. Revisions of these procedures will be communicated to all employees as they occur.

G. Emergency Procedures

1. Radiation Emergency Guidelines

In the event a radioactive substance escapes from its normal confines (by spill, evaporation, vaporization, combustion, escape of gas, liquid or solid, etc.) in an amount equal to or greater than the quantities listed in Appendix D, Column A, the Radiation Safety Officer shall be notified promptly.

The following procedures apply:

a. Minor Spill

* Notify all other persons in the room at once.

* Limit the number of persons in the area to those needed to deal with the spill.

* Don protective clothing.

* Take immediate steps to confine the spill. For liquid spills drop absorbent paper on the spill. For dry spills, dampen thoroughly or place damp absorbent materials over the spill, taking care not to spread the contamination. Water may generally be used except where chemical reaction with water would generate an air contaminant. Oil may then be a reasonable substitute.

* Delineate and block off the contaminated area to insure that others will not walk through the area.

* Do not allow anyone to leave the contaminated area without being monitored. Make note of the names of all persons involved with the spill.

b. Major spill (a significant internal or external radiation hazard to personnel)

* Notify all persons not involved in the spill to vacate the room at once.

* If the spill is liquid, and the hands are protected, right the container.

* If the spill is on the skin, flush thoroughly.

* If the spill is on clothing, discard outer or protective clothing at once.

* Vacate and secure the room to prevent re-entry. Keep the area clear of spectators.

* Limit the movement of persons involved in the spill to a specified area of assembly to prevent the spread of contamination. Do not allow anyone to leave the area of assembly without being monitored. Make note of the names of all persons involved in the spill.

c. Possibility of Airborne Contamination

An airborne release of radioactive material may occur due to evaporation, vaporization, explosion, combustion, formation of a smoke, dust or spray, gas escape, etc. If an airborne release occurs:

* Evacuate all persons from the room or area immediately.

* Shut all doors to the room or area.

* Post guards, as needed, to insure that no one re-enters the room or area and to keep the general area clear of spectators.

* Assemble all persons who were present in the room or area at the time of the incident. The place of assembly should be near the contaminated area to minimize the spread of contamination, but far enough removed to prevent continued involvement. Do not permit these persons, except in instances of clear medical emergency, to leave the place of assembly until it is established by the RSO that no one of these persons is contaminated.

* If contamination of the skin or clothing is known or suspected, begin personal decontamination as follows:

  1) Remove all contaminated clothing.

  2) Wash contaminated areas of skin with mild soap and water.

* Do not allow anyone to remain in or re-enter the area in which airborne contamination occurred unless it is certain that the person has adequate respiratory and personal protection.

d. Contamination of Wounds

Flush contaminated minor cuts with large volumes of tepid running water, while spreading the edges of the gash.

e. Ingestion of Radioisotopes

Unless vomiting is contraindicated:

1. Induce vomiting by placing a finger well back in the throat.

2. Have the victim drink a pint of water, and induce vomiting again.

f. First Aid

When a serious injury requiring prompt first aid has occurred, the first aid should not be delayed or withheld because of the possibility that the victim is contaminated. Protective clothing is generally available and should be worn when appropriate.

If local efforts at decontamination have failed, individuals who are personally contaminated, but otherwise uninjured, shall be taken directly to the Princeton Medical Center.

2. Radiation Emergency Follow-Up

The guidelines provided above describe immediate action to be taken by laboratory personnel before the arrival of the Radiation Safety Officer. The Radiation Safety Officer will assist in the management of the incident by providing additional monitoring capabilities as necessary, assessing radiation doses (both internal and external), recommending decontamination plans, investigating the incident, providing required documentation, and developing recommendations to prevent reoccurrences.

3. After Hours Notification

For emergencies which occur during other than normal working hours, telephone numbers of the RSO and RSC members are posted in a central area, as well as included in the information given to each employee at time of radiation safety training.

I. Miscellaneous

A. Maintenance Work

Maintenance work and certain custodial services, such as plumbing repairs to sinks, janitorial services during the cleanup of spills, etc., should be done only after such consultation with, and in some cases, under the direct supervision of the RSO.

APPENDIX A

August, 1990

RADIATION SAFETY COMMITTEE MEMBERSHIP

Chairperson:	Dr. Ronald Unterman Vice President Research and Development Envirogen
Radiation Safety Officer:	Dr. Burt Ensley Research Manager Envirogen
Members:	Dr. E. Christman, CHP Associate Director, Programs Radiation and Environmental Health and Safety Rutgers University
	Janet Klass Manager, Laboratory Services Envirogen
	Amy Jessop Research Associate Envirogen

August, 1990

APPENDIX B

Training

- Columbia University Radiation Safety
- General Electric Laboratory Safety Course (hazardous chemical, fire, etc.)
- General Electric Radiation Safety Course
- DuPont course in general laboratory and institutional safety [at GE, CRD (included management training for oversight of research group safety practices and evaluation)].

PUBLICATIONS

Unterman, R., M.J. Brennan, R.E. Brooks, F.J. Mondello, D.P. Mobley, J.B. McDermott, and D.K. Dietrich, "Biodegradation of PCB on Contaminated Soils," Abstracts of the American Chemical Society, Dallas, Texas (1989).

Unterman, R., M.J. Brennan, R.E. Brooks, D.P. Mobley, J.B. McDermott and C.C. Schwartz, "Bacterial Degradation of PCBs in Soil," Proc. Symp. on Bioaugmentation as a Means to Enhance Waste Treatment, The Lewis Publishers (1988).

Unterman, R., M.J. Brennan, R.E. Brooks, F.J. Mondello, D.P. Mobley, J.B. McDermott, and D.K. Dietrich, "Bacterial Treatment of PCB Contaminated Soils," Abstracts of the 1988 Annual Meeting of the Society for Industrial Microbiology, Chicago, Illinois (1988).

McDermott, J.B., R. Unterman, M.J. Brennan, R.E. Brooks, D.P. Mobley, C.C. Schwartz and D.K. Dietrich, "Two Strategies for PCB Soil Remediation: Biodegradation and Surfactant Extraction," Environmental Progress, 8:46-51 (1988).

Unterman, R., D.L. Bedard, M.J. Brennan, L.H. Bopp, F.J. Mondello, R.E. Brooks, D.P. Mobley, J.B. McDermott, C.C. Schwartz and D.K. Dietrich, "Biological Approaches for PCB Degradation," Environmental Biotechnology: Reducing Risks From Environmental Chemicals Through Biotechnology, G.S. Omenn et al., (eds.), Plenum Press, New York, 253-269 (1988).

Unterman, R., F.J. Mondello, M.J. Brennan, R.E. Brooks, D.P. Mobley, J.B. McDermott and C.C. Schwartz, "Bacterial Treatment of PCB-Contaminated Soils: Prospects for the Application of Recombinant DNA Technology," Proc. Second Intl. Conf. on New Frontiers for Hazardous Waste Management, U.S. Environmental Protection Agency, Cincinatti, OH, EPA/600/9-87/018F, 259-264 (1987).

Unterman, R., M.J. Brennan, R.E. Brooks and C. Johnson, "Biological Degradation of Polychlorinated Biphenyls," Proc. Intl. Conf. on Innovative Biological Treatment of Toxic Wastewaters, R.J. Scholze, et al. (eds.), US Army, CERL, Champaign, IL, N-87/12, 379-389 (1987).

Brown, J.F., D.L. Bedard, L.H. Bopp, J.C. Carnahan, R.W. Lawton, R. Unterman and R.E. Wagner, "Human and Environmental Biodegradation of PCBs" Proc. 1985 PCB Seminar, Electric Power Research Institute, Palo Alto, CA, 10-7 to 10-10 (1986).

Unterman, R., R.E. Brooks and C. Johnson, "Modeling a PCB Biodegradation Process," Abstr. Ann. Meet. Am. Soc. Microbiol., #Q60, 74 (1986).

Bedard, D.L., R. Unterman, L.H. Bopp, M.J. Brennan, M.L. Haberl and C. Johnson, "Rapid Assay for Screening and Characterizing Microorganisms for the Ability to Degrade Polychlorinated Biphenyls," Appl. Environ. Microbiol. 51, 761-768 (1986).

Unterman, R., D.L. Bedard, L.H. Bopp, M.J. Brennan, C. Johnson and M.L. Haberl, "Microbial Degradation of Polychlorinated Biphenyls," Proc. Intl.

RONALD UNTERMAN, PH.D.

PRESENT POSITION

Vice President, Research and Development, Envirogen, Inc.
Responsible for directing Envirogen's R&D programs including both microbe and process development. Responsible for technical direction of all feasibility studies and analytical work. Among his accomplishments in the area of hazardous waste technology, Dr. Unterman managed and has been widely-recognized for an outstanding research program in the area of PCB biodegradation.

EDUCATION

1963, Molecular Biology Fellowship, Rockefeller University
B.A., 1968, Biology, Haverford College
Ph.D., 1981, Biochemistry, Columbia University

Dr. Unterman received his doctoral training in the field of biochemistry/molecular biology. His research utilized recombinant DNA technology to study the structure and expression of the gene family that encodes the urinary protein, alpha 2u globulin. The synthesis of this protein is under complex hormonal, developmental, and neoplastic control and thus offers a unique model system for the regulation of gene expression in mammals.

EXPERIENCE

Manager, General Electric Company, Environmental Technology Program, GE Corporate Research & Development Center. Responsible for management of research studies aimed at the isolation, characterization and demonstration of the activity of bacterial cultures capable of oxidizing PCBs and other substituted aromatics. These studies focused on the biochemistry and genetics of these biotransformations and ultimately on the development of site application technologies. Performed leading research, resulting in the first successful demonstration of the biodegradability of PCBs in the field. This research was in part funded by the EPA.

Graduate Research Fellow, Columbia University, Department of Biochemistry.
Performed research on the cloning, selection, and characterization of a specific liver cDNA. Experience included recombinant DNA cloning (both cDNA and genomic), DNA sequencing, nucleic acid characterization (restriction analysis, "Southern" and "Northern" blot analysis, Rot analysis), *in vitro* translation.

Research Associate, Columbia University, Department of Biochemistry.
Conducted studies on the purification and characterization of a novel peptide from the neurohypophysis. Extensive experience in protein/peptide biochemistry including gel-exclusion, ion-exchange and thin layer chromatography, peptide sequencing (Edman), mass spectroscopy, gel electrophoresis.

SAFETY EXPERIENCE

Laboratory Radiation Safety Officer, Columbia University, Professor P. Feigelson Laboratory. Responsible for all purchasing, inventory, monitoring and disposal of research radioisotopes.

Chairman, Institutional Biosafety Committee (Corporate R&D), General Electric, Corporate Research & Development. Responsible for evaluation, approval, and monitoring of all recombinant DNA research.

Member, Corporate R&D Radiation Safety Committee, General Electric. Responsible for oversight of all activities inv[illegible] radioactive materials including evaluation of site radiation safety office and officer, procedures, permitting and policy.

Conf. on New Frontiers for Hazardous Waste Management, U.S. Environmental Protection Agency, Cincinnati, OH, EPA/600/9-85/025, 481-488 (1985).

Unterman, R., D.L. Bedard, L.H. Bopp, C. Johnson, M.L. Haberl, M.J. Brennan and J. Cooper, "Bacterial Isolates Exhibit Broad Differences in Extent of PCB Degradation and Congener Specificity," Abstr. Ann. Meet. Am. Soc. Microbiol., #Q58, 267 (1985).

Bedard, D.L., M.J. Brennan and R. Unterman, "Bacterial Degradation of PCBs: Evidence of Distinct Pathways in Corynebacterium sp. MB1 and Alcaligenes eutrophus H850," G. Addis and R.Y. Komai (eds.), Proc. 1983 PCB Seminar, Electric Power Research Institute, Palo Alto, CA, 4-101 to 4-118 (1984).

Unterman, R., D.L. Bedard, M.J. Brennan, C. Johnson and J.R. Yates, "Degradation of Polychlorinated Biphenyls by a Corynebacterium Species," Abst. Ann. Meet. Am. Soc. Microbiol., #Q50, 212 (1984).

Dolan, K.P., R. Reinke, K.R. Lynch, M. McLaughlin, R. Unterman, H.L. Nakhasi, V. Laperche and P. Feigelson, "The Application of Recombinant Techniques to the Study of the Control of Alpha 2u Globulin Gene Expression," Biochemical Action of Hormones, Vol. X, Academic Press, 1-22 (1983).

Dolan, K.P., R. Unterman, M. McLaughlin, H.L. Nakhasi, K.R. Lynch and P. Feigelson, "The Structure and Expression of Very Closely Related Members of the Alpha 2u Globulin Gene Family," J. Biol. Chem. 257, 13527-13534 (1982).

Nakhasi, H.L., K.R. Lynch, K.P. Dolan, R. Unterman, T. Antakly and P. Feigelson, "Modifications in Alpha 2u Globulin Gene Structure, Transcription and mRNA Translation in Hepatomas," J. Biol. Chem. 257, 2726-2729 (1982).

Lynch, K.R., K.P. Dolan, H.L. Nakhasi, R. Unterman and P. Feigelson, "The Role of Growth Hormone in Alpha 2u Globulin Synthesis: A Reexamination," Cell 28, 155-159 (1982).

Dolan, K.P., R. Unterman, H.L. Nakhasi and P. Feigelson, "Alpha 2u Globulin is Encoded by a Very Closely Related Gene Family," J. Cell Biol. 91, 129a (1981).

Unterman, R., K.R. Lynch, H.L. Nakhasi, K.P. Dolan, J.W. Hamilton, D.V. Cohn and P. Feigelson, "Cloning and Sequence of Several Alpha 2*u* Globulin cDNAs," Proc. Nat'l. Acad. Sci., USA 78, 3478-3482 (1981).

Unterman, R., K.R. Lynch, K.P. Dolan and P. Feigelson, "The Preparation, Isolation and Characterization of a Full-length Alpha 2u Globulin cDNA Clone," Fed. Proc. 40, 1648 (1981).

Nakhasi, H.L., K.R. Lynch, K.P. Dolan, R. Unterman and P. Feigelson, "Covalent Modification and Repressed Transcription of a Gene in Hepatoma Cells," Proc. Natl. Acad. Sci. USA 78, 834-837 (1981).

Goodman, I., R. Unterman, S.M. Solomon R.B. and Hiatt, "Protein Binding of Coherin and Other Small Molecules by Thin-layer Chromatography," J. Chromatography 178, 125-138 (1979).

BURT D ENSLEY, PH.D.

CURRENT POSITION

Research Manager, Envirogen, Inc.
Responsible for research programs related to the biotreatment of chlorinated aliphatics, nitroaromatics, and hydrocarbon hazardous wastes. Dr. Ensley brings 13 years of industrial and laboratory experience to the development of hazardous waste treatment systems. He is widely-recognized for his development of organisms and systems for TCE degradation.

EDUCATION

B.S., 1974, Biology, University of New Mexico
M.S., 1976, Biology, University of New Mexico
Ph.D., 1979, Microbial Physiology, University of Georgia

EXPERIENCE

Manager, Scientific Affairs, Specialty Chemicals Group, Amgen, Inc.
Responsible for all of Amgen's research and development related to the biological treatment of hazardous wastes. Additionally, responsible for all of Amgen's development activities in the biosynthesis of specialty ch micals. His hazardous waste activities included both natural and recombinant organisms for the degradation of chlorinated aliphatics, enzymatic degradation of pesticides, and studies of novel bioreactor systems for continuous waste treatment.

Laboratory Head, Specialty Chemicals Group, Amgen, Inc.
Developed growing portfolio of new products based on application of technology in gene clusters and protein engineering.

Research Scientist I and II, Amgen, Inc.
Developed methods and applications for the genetic engineering of metabolic operons (gene cluster technology). Invented biological proc for the synthesis of the textile dye indigo. Organized Specialty Chemicals Group at Amgen.

Post Doctoral Research Associate, University of Texas at Austin with Dr. David T. Gibson. Performed research on the biochemistry of aromatic hydrocarbon degradation by bacteria and fungi.

Graduate Student, University of Georgia, Department of Microbiology, Laboratory of Dr. William R. Finnerty. Conducted studies on the biochemistry and physiology of alkane degradation by bacteria.

SAFETY EXPERIENCE

Member, Safety Committee, 2 years, Amgen, Inc. Responsible for:

- Company-wide safety practices
- Radiological safety and monitoring (S^{35} C^{14} P^{32} I^{125})
- Biological safety
- Chemical safety

- Safe laboratory practices
- Co-authored Amgen's Safety Manual
  - Policies & Procedures
  - Incident Reporting
  - Radiation Monitoring
  - Chemical Storage and Use
- Held personally accountable by Amgen for safe laboratory practices of research group of 18 scientists (8 Ph.D.'s)

PUBLICATIONS

Ensley, B.D., "Naphthalene Dioxygenase," in preparation for Methods in Enzymology, (1990).

Winter, R.B., K-M. Yen, and B.D. Ensley, "Efficient Degradation of Trichloroethylene by a Recombinant *Escherichia coli*.," Bio/Technology, 7:282-285 (1989).

Simon, M.J., D.T. Osslund, and B.D. Ensley, "The Complete Nucleotide Sequence of the Four Genes Encoding the Naphthalene Dioxygenase Enzyme System from the NAH7 Plasmid," in preparation for Nucl. Acids Res., (1989).

Ensley, B.D., T.D. Osslund, M.J. Simon, and M. Joyce, "Expression and *in vivo* Complementation of Naphthalene Dioxygenase Activity in a Recombinant *Escherichia coli*.," In: Microbial Metabolism and the Carbon Cycle, (S.R. Hagedorn et al., eds.) Harwood Academic Publishers, New York, pp. 437-455 (1988).

Ensley, B.D., "Stability of Recombinant Plasmids in Industrial Microorganisms," CRC Rev. Biotechnol., 4:263-277 (1986).

Ensley, B.D., "The Microbial Metabolism of Condensed Thiophenes," In: Biochemistry of Microbial Degradation, (D.T. Gibson, ed.), Marcel Dekker, Inc., New York (1984).

Ensley, B.D., "Construction of Synthetic Operons for the Microbial Biosynthesis of Indigo," The World Biotechnology Report, 2:441-450 (1984).

Ensley, B.D. and D.T. Gibson, "Naphthalene Dioxygenase: Purification and Properties of a Terminal Oxygenase Component," J. Bacteriol. 155:505-511 (1983).

Ensley, B.D., B.J. Ratzkin, T.D. Osslund, M.J. Simon, L.P. Wackett, and D.T. Gibson, "Expression of Naphthalene Oxidation Genes in *Escherichia coli* Results in the Biosynthesis of Indigo," Science, 222:167-169 (1983).

Ensley, B.D., A.L. Laborde, and D.T. Gibson, "Oxidation of Naphthalene by a Multicomponent Enzyme System from *Pseudomonas* NCIB 9816," J. Bacteriol. 149:948-954 (1982).

Ensley, B.D., R.M. Irwin, L.A. Carriera, P. Hoffman, T.V. Morgan, and W.R. Finnerty, "Effects of Growth Substrate and Respiratory Chain Composition on Bioenergetics in Acinetobacter HO1-N," J. Bacteriol. 148:508-513 (1981).

Hoffman, P.S., R.M. Irwin, L.A. Carriera, T.V. Morgan, B.D. Ensley, and D.V. Dervartanian, "Studies of Photochemical Action Spectra on N,N,N',N'-Tetramethyl-p-Phenylenediamine-Oxidase-Negative Mutants of Azotobacter Vinelandii," Eur. J. Biochem. 105:177-185 (1980).

Ensley, B.D. and W.R. Finnerty, "The Influence of Growth Substrates and Oxygen on the Electron Transport System in Acinetobacter sp. HO1-N," J. Bacteriol. 142:859-868 (1980).

Mayer, E.L., B.D. Ensley, and L.L. Barton, "An Assess[illegible]ent of Growth Yields and Energy Coupling in Desulfovibrio," Arch. Microbiol., 117:21-2[illegible] (1978).

Ensley, B.D., J. McHugh, and L.L. Barton, "Effect of Carbo[illegible] [illegible]ources on Formation of a-Amylase and Glucoamylase by *Clostridium acetobutylicum*," J. [illegible] Appl. Microbiol., 21:51-59 (1975).

APPENDIX C

MAXIMUM PERMISSIBLE DOSES

External Dose

The maximum permissible dose (MPD) as established by "10 CFR Part 20" and the New Jersey Radiation Protection Code is as follows:

	Rem Per Calendar Year	Rem Per Calendar Quarter
Whole Body Exposure; head and trunk; active bloodforming organs; lens of eyes; or gonads	5	1.25
Hands and forearms; feet and ankles	75	18.75
Skin of whole body	30	7.5

APPENDIX D

RSO NOTIFICATION: SPILL THRESHOLDS

Radioisotope	Quantity
Carbon-14	50 uCi
Chromium-51	10 uCi
Hydrogen-3	50 uCi
Phosphorous-32	10 uCi
Sulfur-35	50 uCi
Arsenic-77	50 uCi
Nickel-63	[illegible]
Nickel-59	50 uCi

APPENDIX E

APPENDIX B

Concentrations in Air and Water Above Natural Background

[See notes at end of appendix]

Element (atomic number)	Isotope[1]	†	Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Actinium (89)	Ac 227	S	2×10^{-12}	6×10^{-5}	8×10^{-14}	2×10^{-6}
		I	3×10^{-11}	9×10^{-3}	9×10^{-13}	3×10^{-4}
	Ac 228	S	8×10^{-8}	3×10^{-3}	3×10^{-9}	9×10^{-5}
		I	2×10^{-8}	3×10^{-3}	6×10^{-10}	9×10^{-5}
Americium (95)	Am 241	S	6×10^{-12}	1×10^{-4}	2×10^{-13}	4×10^{-6}
		I	1×10^{-10}	8×10^{-4}	4×10^{-12}	3×10^{-5}
	Am 242m	S	6×10^{-12}	1×10^{-4}	2×10^{-13}	4×10^{-6}
		I	3×10^{-10}	3×10^{-3}	9×10^{-12}	9×10^{-5}
	Am 242	S	4×10^{-8}	4×10^{-3}	1×10^{-9}	1×10^{-4}
		I	5×10^{-8}	4×10^{-3}	2×10^{-9}	1×10^{-4}
	Am 243	S	6×10^{-12}	1×10^{-4}	2×10^{-13}	4×10^{-6}
		I	1×10^{-10}	8×10^{-4}	4×10^{-12}	3×10^{-5}
	Am 244	S	4×10^{-6}	1×10^{-1}	1×10^{-7}	5×10^{-3}
		I	2×10^{-5}	1×10^{-1}	8×10^{-7}	5×10^{-3}
Antimony (51)	Sb 122	S	2×10^{-7}	8×10^{-4}	6×10^{-9}	3×10^{-5}
		I	1×10^{-7}	8×10^{-4}	5×10^{-9}	3×10^{-5}
	Sb 124	S	2×10^{-7}	7×10^{-4}	5×10^{-9}	2×10^{-5}
		I	2×10^{-8}	7×10^{-4}	7×10^{-10}	2×10^{-5}
	Sb 125	S	5×10^{-7}	3×10^{-3}	[illegible] $\times 10^{-8}$	1×10^{-4}
		I	3×10^{-8}	3×10^{-3}	[illegible] $\times 10^{-10}$	1×10^{-4}
Argon (18)	A 37	Sub[2]	6×10^{-3}		[illegible] $\times 10^{-4}$	
	A 41	Sub	2×10^{-6}		4×10^{-8}	
Arsenic (33)	As 73	S	2×10^{-6}	1×10^{-2}	7×10^{-8}	5×10^{-4}
		I	4×10^{-7}	1×10^{-2}	1×10^{-8}	5×10^{-4}
	As 74	S	3×10^{-7}	2×10^{-3}	1×10^{-8}	5×10^{-5}
		I	1×10^{-7}	2×10^{-3}	4×10^{-9}	5×10^{-5}
	As 76	S	1×10^{-7}	6×10^{-4}	4×10^{-9}	2×10^{-5}
		I	1×10^{-7}	6×10^{-4}	3×10^{-9}	2×10^{-5}
	As 77	S	5×10^{-7}	2×10^{-3}	2×10^{-8}	8×10^{-5}
		I	4×10^{-7}	2×10^{-3}	1×10^{-8}	8×10^{-5}
Astatine (85)	At 211	S	7×10^{-9}	5×10^{-5}	2×10^{-10}	2×10^{-6}
		I	3×10^{-8}	2×10^{-3}	1×10^{-9}	7×10^{-5}
Barium (56)	Ba 131	S	1×10^{-6}	5×10^{-3}	4×10^{-8}	2×10^{-4}
		I	4×10^{-7}	5×10^{-3}	1×10^{-8}	2×10^{-4}
	Ba 140	S	1×10^{-7}	8×10^{-4}	4×10^{-9}	3×10^{-5}
		I	4×10^{-8}	7×10^{-4}	1×10^{-9}	2×10^{-5}
Berkelium (97)	Bk 249	S	9×10^{-10}	2×10^{-2}	3×10^{-11}	6×10^{-4}
		I	1×10^{-7}	2×10^{-2}	4×10^{-9}	6×10^{-4}
	Bk 250	S	1×10^{-7}	6×10^{-3}	5×10^{-9}	2×10^{-4}
		I	1×10^{-6}	6×10^{-3}	4×10^{-8}	2×10^{-4}
Beryllium (4)	Be 7	S	6×10^{-6}	5×10^{-2}	2×10^{-7}	2×10^{-3}
		I	1×10^{-6}	5×10^{-2}	4×10^{-8}	2×10^{-3}
Bismuth (83)	Bi 206	S	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
		I	1×10^{-7}	1×10^{-3}	5×10^{-9}	4×10^{-5}
	Bi 207	S	2×10^{-7}	2×10^{-3}	6×10^{-9}	6×10^{-5}
		I	1×10^{-8}	2×10^{-3}	5×10^{-10}	6×10^{-5}
	Bi 210	S	6×10^{-9}	1×10^{-3}	2×10^{-10}	4×10^{-5}
		I	6×10^{-9}	1×10^{-3}	2×10^{-10}	4×10^{-5}
	Bi 212	S	1×10^{-7}	1×10^{-2}	3×10^{-9}	4×10^{-4}
		I	2×10^{-7}	1×10^{-2}	7×10^{-9}	4×10^{-4}

APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

[See notes at end of appendix]

Element (atomic number)	Isotope [1]	†	Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Bromine (35)	Br 82	S	1 × 10[illegible]	8 × 10[illegible]	4 × 10[illegible]	3 × 10[illegible]
		I	2 × 10[illegible]	1 × 10[illegible]	6 × 10[illegible]	4 × 10[illegible]
Cadmium (48)	Cd 109	S	5 × 10[illegible]	5 × 10[illegible]	2 × 10[illegible]	2 × 10[illegible]
		I	7 × 10[illegible]	5 × 10[illegible]	3 × 10[illegible]	2 × 10[illegible]
	Cd 115m	S	4 × 10[illegible]	7 × 10[illegible]	1 × 10[illegible]	3 × 10[illegible]
		I	4 × 10[illegible]	7 × 10[illegible]	1 × 10[illegible]	3 × 10[illegible]
	Cd 115	S	2 × 10[illegible]	1 × 10[illegible]	8 × 10[illegible]	3 × 10[illegible]
		I	2 × 10[illegible]	1 × 10[illegible]	6 × 10[illegible]	4 × 10[illegible]
Calcium (20)	Ca 45	S	3 × 10[illegible]	3 × 10[illegible]	1 × 10[illegible]	9 × 10[illegible]
		I	1 × 10[illegible]	5 × 10[illegible]	4 × 10[illegible]	2 × 10[illegible]
	Ca 47	S	2 × 10[illegible]	1 × 10[illegible]	6 × 10[illegible]	5 × 10[illegible]
		I	2 × 10[illegible]	1 × 10[illegible]	6 × 10[illegible]	3 × 10[illegible]
Californium (98)	Cf 249	S	2 × 10[illegible]	1 × 10[illegible]	5 × 10[illegible]	4 × 10[illegible]
		I	1 × 10[illegible]	7 × 10[illegible]	3 × 10[illegible]	2 × 10[illegible]
	Cf 250	S	5 × 10[illegible]	4 × 10[illegible]	2 × 10[illegible]	1 × 10[illegible]
		I	1 × 10[illegible]	7 × 10[illegible]	3 × 10[illegible]	3 × 10[illegible]
	Cf 251	S	2 × 10[illegible]	1 × 10[illegible]	6 × 10[illegible]	4 × 10[illegible]
		I	1 × 10[illegible]	8 × 10[illegible]	3 × 10[illegible]	3 × 10[illegible]
	Cf 252	S	6 × 10[illegible]	7 × 10[illegible]	2 × 10[illegible]	7 × 10[illegible]
		I	3 × 10[illegible]	7 × 10[illegible]	1 × 10[illegible]	7 × 10[illegible]
	Cf 253	S	8 × 10[illegible]	4 × 10[illegible]	3 × 10[illegible]	1 × 10[illegible]
		I	8 × 10[illegible]	4 × 10[illegible]	3 × 10[illegible]	1 × 10[illegible]
	Cf 254	S	5 × 10[illegible]	4 × 10[illegible]	2 × 10[illegible]	1 × 10[illegible]
		I	5 × 10[illegible]	4 × 10[illegible]	2 × 10[illegible]	1 × 10[illegible]
Carbon (6)	C 14	S	4 × 10[illegible]	2 × 10[illegible]	1 × 10[illegible]	8 × 10[illegible]
	(CO_2)	Sub	5 × 10[illegible]		1 × 10[illegible]	
Cerium (58)	Ce 141	S	4 × 10[illegible]	3 × 10[illegible]	2 × 10[illegible]	9 × 10[illegible]
		I	2 × 10[illegible]	3 × 10[illegible]	5 × 10[illegible]	9 × 10[illegible]
	Ce 143	S	3 × 10[illegible]	1 × 10[illegible]	9 × 10[illegible]	4 × 10[illegible]
		I	2 × 10[illegible]	1 × 10[illegible]	7 × 10[illegible]	4 × 10[illegible]
	Ce 144	S	1 × 10[illegible]	3 × 10[illegible]	3 × 10[illegible]	1 × 10[illegible]
		I	6 × 10[illegible]	3 × 10[illegible]	2 × 10[illegible]	1 × 10[illegible]
Cesium (55)	Cs 131	S	1 × 10[illegible]	7 × 10[illegible]	4 × 10[illegible]	2 × 10[illegible]
		I	3 × 10[illegible]	3 × 10[illegible]	1 × 10[illegible]	9 × 10[illegible]
	Cs 134m	S	4 × 10[illegible]	2 × 10[illegible]	1 × 10[illegible]	6 × 10[illegible]
		I	6 × 10[illegible]	3 × 10[illegible]	2 × 10[illegible]	1 × 10[illegible]
	Cs 134	S	4 × 10[illegible]	3 × 10[illegible]	1 × 10[illegible]	9 × 10[illegible]
		I	1 × 10[illegible]	1 × 10[illegible]	4 × 10[illegible]	4 × 10[illegible]
	Cs 135	S	5 × 10[illegible]	3 × 10[illegible]	2 × 10[illegible]	1 × 10[illegible]
		I	9 × 10[illegible]	7 × 10[illegible]	3 × 10[illegible]	2 × 10[illegible]
	Cs 136	S	4 × 10[illegible]	2 × 10[illegible]	1 × 10[illegible]	9 × 10[illegible]
		I	2 × 10[illegible]	2 × 10[illegible]	6 × 10[illegible]	6 × 10[illegible]
	Cs 137	S	6 × 10[illegible]	4 × 10[illegible]	2 × 10[illegible]	2 × 10[illegible]
		I	1 × 10[illegible]	1 × 10[illegible]	5 × 10[illegible]	4 × 10[illegible]
Chlorine (17)	Cl 36	S	4 × 10[illegible]	2 × 10[illegible]	1 × 10[illegible]	8 × 10[illegible]
		I	2 × 10[illegible]	2 × 10[illegible]	8 × 10[illegible]	6 × 10[illegible]
	Cl 38	S	3 × 10[illegible]	1 × 10[illegible]	9 × 10[illegible]	4 × 10[illegible]
		I	2 × 10[illegible]	1 × 10[illegible]	7 × 10[illegible]	4 × 10[illegible]
Chromium (24)	Cr 51	S	1 × 10[illegible]	5 × 10[illegible]	4 × 10[illegible]	2 × 10[illegible]
		I	2 × 10[illegible]	2 × 10[illegible]	8 × 10[illegible]	2 × 10[illegible]

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APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

[See notes at end of appendix]

Element (atomic number)	Isotope [1]		Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Cobalt (27)	Co 57	S	3×10^{-6}	2×10^{-2}	1×10^{-7}	5×10^{-4}
		I	2×10^{-7}	1×10^{-2}	6×10^{-9}	4×10^{-4}
	Co 58m	S	2×10^{-5}	8×10^{-2}	6×10^{-7}	3×10^{-3}
		I	9×10^{-6}	6×10^{-2}	3×10^{-7}	2×10^{-3}
	Co 58	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	5×10^{-8}	3×10^{-3}	2×10^{-9}	9×10^{-5}
	Co 60	S	3×10^{-7}	1×10^{-3}	1×10^{-8}	5×10^{-5}
		I	9×10^{-9}	1×10^{-3}	3×10^{-10}	3×10^{-5}
Copper (29)	Cu 64	S	2×10^{-6}	1×10^{-2}	7×10^{-8}	3×10^{-4}
		I	1×10^{-6}	6×10^{-3}	4×10^{-8}	2×10^{-4}
Curium (96)	Cm 242	S	1×10^{-10}	7×10^{-4}	4×10^{-12}	2×10^{-5}
		I	2×10^{-10}	7×10^{-4}	6×10^{-12}	2×10^{-5}
	Cm 243	S	6×10^{-12}	1×10^{-4}	2×10^{-13}	5×10^{-6}
		I	1×10^{-10}	7×10^{-4}	3×10^{-12}	2×10^{-5}
	Cm 244	S	9×10^{-12}	2×10^{-4}	3×10^{-13}	7×10^{-6}
		I	1×10^{-10}	8×10^{-4}	3×10^{-12}	3×10^{-5}
	Cm 245	S	5×10^{-12}	1×10^{-4}	2×10^{-13}	4×10^{-6}
		I	1×10^{-10}	8×10^{-4}	4×10^{-12}	3×10^{-5}
	Cm 246	S	5×10^{-12}	1×10^{-4}	2×10^{-13}	4×10^{-6}
		I	1×10^{-10}	8×10^{-4}	4×10^{-12}	3×10^{-5}
	Cm 247	S	5×10^{-12}	1×10^{-4}	2×10^{-13}	4×10^{-6}
		I	1×10^{-10}	6×10^{-4}	4×10^{-12}	2×10^{-5}
	Cm 248	S	6×10^{-13}	1×10^{-5}	2×10^{-14}	4×10^{-7}
		I	1×10^{-11}	4×10^{-5}	4×10^{-13}	1×10^{-6}
	Cm 249	S	1×10^{-5}	6×10^{-2}	4×10^{-7}	2×10^{-3}
		I	1×10^{-5}	6×10^{-2}	4×10^{-7}	2×10^{-3}
Dysprosium (66)	Dy 165	S	3×10^{-6}	1×10^{-2}	9×10^{-8}	4×10^{-4}
		I	2×10^{-6}	1×10^{-2}	7×10^{-8}	4×10^{-4}
	Dy 166	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-5}
		I	2×10^{-7}	1×10^{-3}	7×10^{-9}	4×10^{-5}
Einsteinium (99)	Es 253	S	8×10^{-10}	7×10^{-4}	3×10^{-11}	2×10^{-5}
		I	6×10^{-10}	7×10^{-4}	2×10^{-11}	2×10^{-5}
	Es 254m	S	5×10^{-9}	5×10^{-4}	2×10^{-10}	2×10^{-5}
		I	6×10^{-9}	5×10^{-4}	2×10^{-10}	2×10^{-5}
	Es 254	S	2×10^{-11}	4×10^{-4}	6×10^{-13}	1×10^{-5}
		I	1×10^{-10}	4×10^{-4}	4×10^{-12}	1×10^{-5}
	Es 255	S	5×10^{-10}	8×10^{-4}	2×10^{-11}	3×10^{-5}
		I	4×10^{-10}	8×10^{-4}	1×10^{-11}	3×10^{-5}
Erbium (68)	Er 169	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-5}
		I	4×10^{-7}	3×10^{-3}	1×10^{-8}	9×10^{-5}
	Er 171	S	7×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Europium (63)	Eu 152 (T/2 = 9.2 hrs)	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
	Eu 152 (T/2 = 13 yrs)	S	1×10^{-8}	2×10^{-3}	4×10^{-10}	8×10^{-5}
		I	2×10^{-8}	2×10^{-3}	6×10^{-10}	8×10^{-5}
	Eu 154	S	4×10^{-9}	6×10^{-4}	1×10^{-10}	2×10^{-5}
		I	7×10^{-9}	6×10^{-4}	2×10^{-10}	2×10^{-5}
	Eu 155	S	9×10^{-8}	6×10^{-3}	3×10^{-9}	2×10^{-4}
		I	7×10^{-8}	6×10^{-3}	3×10^{-9}	2×10^{-4}

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APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

(See notes at end of appendix)

Element (atomic number)	Isotope [1]		Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Fermium (100)	Fm 254	S	6×10^{-8}	4×10^{-3}	2×10^{-9}	1×10^{-4}
		I	7×10^{-8}	4×10^{-3}	2×10^{-9}	1×10^{-4}
	Fm 255	S	2×10^{-8}	1×10^{-3}	6×10^{-10}	3×10^{-5}
		I	1×10^{-8}	1×10^{-3}	4×10^{-10}	3×10^{-5}
	Fm 256	S	3×10^{-9}	3×10^{-5}	1×10^{-10}	9×10^{-7}
		I	2×10^{-9}	3×10^{-5}	6×10^{-11}	9×10^{-7}
Fluorine (9)	F 18	S	5×10^{-6}	2×10^{-2}	2×10^{-7}	8×10^{-4}
		I	3×10^{-6}	1×10^{-2}	9×10^{-8}	5×10^{-4}
Gadolinium (64)	Gd 153	S	2×10^{-7}	6×10^{-3}	8×10^{-9}	2×10^{-4}
		I	9×10^{-8}	6×10^{-3}	3×10^{-9}	2×10^{-4}
	Gd 159	S	5×10^{-7}	2×10^{-3}	2×10^{-8}	8×10^{-5}
		I	4×10^{-7}	2×10^{-3}	1×10^{-8}	8×10^{-5}
Gallium (31)	Ga 72	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-5}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
Germanium (32)	Ge 71	S	1×10^{-5}	5×10^{-2}	4×10^{-7}	2×10^{-3}
		I	6×10^{-6}	5×10^{-2}	2×10^{-7}	2×10^{-3}
Gold (79)	Au 196	S	1×10^{-6}	5×10^{-3}	4×10^{-8}	2×10^{-4}
		I	6×10^{-7}	4×10^{-3}	2×10^{-8}	1×10^{-4}
	Au 198	S	3×10^{-7}	2×10^{-3}	1×10^{-8}	5×10^{-5}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	5×10^{-5}
	Au 199	S	1×10^{-6}	5×10^{-3}	4×10^{-8}	2×10^{-4}
		I	8×10^{-7}	4×10^{-3}	3×10^{-8}	2×10^{-4}
Hafnium (72)	Hf 181	S	4×10^{-8}	2×10^{-3}	1×10^{-9}	7×10^{-5}
		I	7×10^{-8}	2×10^{-3}	3×10^{-9}	7×10^{-5}
Holmium (67)	Ho 166	S	2×10^{-7}	9×10^{-4}	7×10^{-9}	3×10^{-5}
		I	2×10^{-7}	9×10^{-4}	6×10^{-9}	3×10^{-5}
Hydrogen (1)	H3	S	5×10^{-6}	1×10^{-1}	2×10^{-7}	3×10^{-3}
		I	5×10^{-6}	1×10^{-1}	2×10^{-7}	3×10^{-3}
		Sub	2×10^{-3}		4×10^{-5}	
Indium (49)	In 113m	S	8×10^{-6}	4×10^{-2}	3×10^{-7}	1×10^{-3}
		I	7×10^{-6}	4×10^{-2}	2×10^{-7}	1×10^{-3}
	In 114m	S	1×10^{-7}	5×10^{-4}	4×10^{-9}	2×10^{-5}
		I	2×10^{-8}	5×10^{-4}	7×10^{-10}	2×10^{-5}
	In 115m	S	2×10^{-6}	1×10^{-2}	8×10^{-8}	4×10^{-4}
		I	2×10^{-6}	1×10^{-2}	6×10^{-8}	4×10^{-4}
	In 115	S	2×10^{-7}	3×10^{-3}	9×10^{-9}	9×10^{-5}
		I	3×10^{-8}	3×10^{-3}	1×10^{-9}	9×10^{-5}
Iodine (53)	I 125	S	5×10^{-9}	4×10^{-5}	8×10^{-11}	2×10^{-7}
		I	2×10^{-7}	6×10^{-3}	6×10^{-9}	2×10^{-4}
	I 126	S	8×10^{-9}	5×10^{-5}	9×10^{-11}	3×10^{-7}
		I	3×10^{-7}	3×10^{-3}	1×10^{-8}	9×10^{-5}
	I 129	S	2×10^{-9}	1×10^{-5}	2×10^{-11}	6×10^{-8}
		I	7×10^{-8}	6×10^{-3}	2×10^{-9}	2×10^{-4}
	I 131	S	9×10^{-9}	6×10^{-5}	1×10^{-10}	3×10^{-7}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
	I 132	S	2×10^{-7}	2×10^{-3}	3×10^{-9}	8×10^{-6}
		I	9×10^{-7}	5×10^{-3}	3×10^{-8}	2×10^{-4}
	I 133	S	3×10^{-8}	2×10^{-4}	4×10^{-10}	1×10^{-6}
		I	2×10^{-7}	1×10^{-3}	7×10^{-9}	4×10^{-5}
	I 134	S	5×10^{-7}	4×10^{-3}	6×10^{-9}	2×10^{-5}

APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

[See notes at end of appendix.]

Element (atomic number)	Isotope [1]	†	Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Iodine (53)	I 134	I	3 × 10[illegible]	2 × 10[illegible]	1 × 10[illegible]	6 × 10[illegible]
	I 135	S	1 × 10[illegible]	7 × 10[illegible]	1 × 10[illegible]	4 × 10[illegible]
		I	4 × 10[illegible]	2 × 10[illegible]	1 × 10[illegible]	7 × 10[illegible]
Iridium (77)	Ir [illegible]	S	1 × 10[illegible]	6 × 10[illegible]	4 × 10[illegible]	2 × 10[illegible]
		I	4 × 10[illegible]	5 × 10[illegible]	[illegible]	2 × 10[illegible]
	Ir 192	S	1 × 10[illegible]	1 × 10[illegible]	4 × 10[illegible]	4 × 10[illegible]
		I	2 × 10[illegible]	1 × 10[illegible]	9×10^{-10}	4 × 10[illegible]
	Ir 194	S	2 × 10[illegible]	1 × 10[illegible]	8 × 10[illegible]	3 × 10[illegible]
		I	5 × 10[illegible]	9 × 10[illegible]	5 × 10[illegible]	3 × 10[illegible]
Iron (26)	Fe 55	S	9 × 10[illegible]	2 × 10[illegible]	3 × 10[illegible]	8 × 10[illegible]
		I	1 × 10[illegible]	7 × 10[illegible]	3 × 10[illegible]	2 × 10[illegible]
	Fe 59	S	1 × 10[illegible]	2 × 10[illegible]	5 × 10[illegible]	6 × 10[illegible]
		I	5 × 10[illegible]	2 × 10[illegible]	2 × 10[illegible]	5 × 10[illegible]
Krypton (36)	Kr 85m	Sub	6 × 10[illegible]		1 × 10[illegible]	
	Kr 85	Sub	1 × 10[illegible]	......	3 × 10[illegible]	
	Kr 87	Sub	1 × 10[illegible]		2 × 10[illegible]	
	Kr 88	Sub	1 × 10[illegible]		2 × 10[illegible]	
Lanthanum (57)	La 140	S	2 × 10[illegible]	7 × 10[illegible]	5 × 10[illegible]	2 × 10[illegible]
		I	1 × 10[illegible]	7 × 10[illegible]	4 × 10[illegible]	2 × 10[illegible]
Lead (82)	Pb 203	S	3 × 10[illegible]	1 × 10[illegible]	9 × 10[illegible]	4 × 10[illegible]
		I	2 × 10[illegible]	1 × 10[illegible]	6 × 10[illegible]	4 × 10[illegible]
	Pb 210	S	1×10^{-10}	4 × 10[illegible]	4×10^{-12}	1 × 10[illegible]
		I	2×10^{-10}	5 × 10[illegible]	8×10^{-12}	3 × 10[illegible]
	Pb 212	S	2 × 10[illegible]	6 × 10[illegible]	6×10^{-10}	2 × 10[illegible]
		I	2 × 10[illegible]	5 × 10[illegible]	7×10^{-10}	2 × 10[illegible]
Lutetium (71)	Lu 177	S	6 × 10[illegible]	3 × 10[illegible]	2 × 10[illegible]	1 × 10[illegible]
		I	5 × 10[illegible]	3 × 10[illegible]	2 × 10[illegible]	1 × 10[illegible]
Manganese (25)	Mn 52	S	2 × 10[illegible]	1 × 10[illegible]	7 × 10[illegible]	3 × 10[illegible]
		I	1 × 10[illegible]	9 × 10[illegible]	5 × 10[illegible]	3 × 10[illegible]
	Mn 54	S	4 × 10[illegible]	4 × 10[illegible]	1 × 10[illegible]	1 × 10[illegible]
		I	4 × 10[illegible]	3 × 10[illegible]	1 × 10[illegible]	1 × 10[illegible]
	Mn 56	S	8 × 10[illegible]	4 × 10[illegible]	3 × 10[illegible]	1 × 10[illegible]
		I	5 × 10[illegible]	[illegible]	2 × 10[illegible]	1 × 10[illegible]
Mercury (80)	Hg 197m	S	7 × 10[illegible]	6 × 10[illegible]	2 × 10[illegible]	2 × 10[illegible]
		I	[illegible]	5 × 10[illegible]	3 × 10[illegible]	2 × 10[illegible]
	Hg 197	S	[illegible]	9 × 10[illegible]	4 × 10[illegible]	3 × 10[illegible]
		I	[illegible]	1 × 10[illegible]	9 × 10[illegible]	5 × 10[illegible]
	Hg 203	S	7 × [illegible]	5 × 10[illegible]	2 × 10[illegible]	2 × 10[illegible]
		I	1 × 10[illegible]	3 × 10[illegible]	4 × 10[illegible]	1 × 10[illegible]
Molybdenum (42)	Mo 99	S	7 × 10[illegible]	5 × 10[illegible]	3 × 10[illegible]	2 × 10[illegible]
		I	2 × 10[illegible]	1 × 10[illegible]	7 × 10[illegible]	4 × 10[illegible]
Neodymium (60)	Nd 144	S	8×10^{-11}	2 × 10[illegible]	3×10^{-12}	7 × 10[illegible]
		I	3×10^{-10}	2 × 10[illegible]	1×10^{-11}	8 × 10[illegible]
	Nd 147	S	4 × 10[illegible]	2 × 10[illegible]	1 × 10[illegible]	6 × 10[illegible]
		I	2 × 10[illegible]	2 × 10[illegible]	8 × 10[illegible]	6 × 10[illegible]
	Nd 149	S	2 × 10[illegible]	8 × 10[illegible]	6 × 10[illegible]	3 × 10[illegible]
		I	1 × 10[illegible]	8 × 10[illegible]	5 × 10[illegible]	3 × 10[illegible]

APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

[See notes at end of appendix]

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Element (atomic number)	Isotope [1]		Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Neptunium (93)	Np 237	S	4 × 10 [illegible]	9 × 10 [illegible]	1 × 10 [illegible]	3 × 10 [illegible]
		I	1 × 10 [illegible]	9 × 10 [illegible]	4 × 10 [illegible]	3 × 10 [illegible]
	Np 239	S	8 × 10 [illegible]	4 × 10 [illegible]	3 × 10 [illegible]	1 × 10 [illegible]
		I	7 × 10 [illegible]	4 × 10 [illegible]	2 × 10 [illegible]	1 × 10 [illegible]
Nickel (28)	Ni 59	S	5 × 10 [illegible]	6 × 10 [illegible]	2 × 10 [illegible]	2 × 10 [illegible]
		I	8 × 10 [illegible]	6 × 10 [illegible]	3 × 10 [illegible]	2 × 10 [illegible]
	Ni 63	S	6 × 10 [illegible]	8 × 10 [illegible]	2 × 10 [illegible]	3 × 10 [illegible]
		I	3 × 10 [illegible]	2 × 10 [illegible]	1 × 10 [illegible]	7 × 10 [illegible]
	Ni 65	S	9 × 10 [illegible]	4 × 10 [illegible]	3 × 10 [illegible]	1 × 10 [illegible]
		I	5 × 10 [illegible]	3 × 10 [illegible]	2 × 10 [illegible]	1 × 10 [illegible]
Niobium (Columbium) (41).	Nb 93m	S	1 × 10 [illegible]	1 × 10 [illegible]	4 × 10 [illegible]	4 × 10 [illegible]
		I	2 × 10 [illegible]	1 × 10 [illegible]	5 × 10 [illegible]	4 × 10 [illegible]
	Nb 95	S	5 × 10 [illegible]	3 × 10 [illegible]	2 × 10 [illegible]	1 × 10 [illegible]
		I	1 × 10 [illegible]	3 × 10 [illegible]	3 × 10 [illegible]	1 × 10 [illegible]
	Nb 97	S	6 × 10 [illegible]	3 × 10 [illegible]	2 × 10 [illegible]	9 × 10 [illegible]
		I	5 × 10 [illegible]	3 × 10 [illegible]	2 × 10 [illegible]	9 × 10 [illegible]
Osmium (76)	Os 185	S	5 × 10 [illegible]	2 × 10 [illegible]	2 × 10 [illegible]	7 × 10 [illegible]
		I	5 × 10 [illegible]	2 × 10 [illegible]	2 × 10 [illegible]	7 × 10 [illegible]
	Os 191m	S	2 × 10 [illegible]	7 × 10 [illegible]	6 × 10 [illegible]	3 × 10 [illegible]
		I	9 × 10 [illegible]	7 × 10 [illegible]	3 × 10 [illegible]	2 × 10 [illegible]
	Os 191	S	1 × 10 [illegible]	5 × 10 [illegible]	4 × 10 [illegible]	2 × 10 [illegible]
		I	4 × 10 [illegible]	5 × 10 [illegible]	1 × 10 [illegible]	2 × 10 [illegible]
	Os 193	S	4 × 10 [illegible]	2 × 10 [illegible]	1 × 10 [illegible]	6 × 10 [illegible]
		I	3 × 10 [illegible]	2 × 10 [illegible]	9 × 10 [illegible]	5 × 10 [illegible]
Palladium (46)	Pd 103	S	1 × 10 [illegible]	1 × 10 [illegible]	5 × 10 [illegible]	3 × 10 [illegible]
		I	7 × 10 [illegible]	8 × 10 [illegible]	3 × 10 [illegible]	3 × 10 [illegible]
	Pd 109	S	6 × 10 [illegible]	3 × 10 [illegible]	2 × 10 [illegible]	9 × 10 [illegible]
		I	4 × 10 [illegible]	2 × 10 [illegible]	1 × 10 [illegible]	7 × 10 [illegible]
Phosphorus (15)	P 32	S	7 × 10 [illegible]	5 × 10 [illegible]	2 × 10 [illegible]	2 × 10 [illegible]
		I	8 × 10 [illegible]	7 × 10 [illegible]	3 × 10 [illegible]	2 × 10 [illegible]
Platinum (78)	Pt 191	S	8 × 10 [illegible]	4 × 10 [illegible]	3 × 10 [illegible]	1 × 10 [illegible]
		I	6 × 10 [illegible]	3 × 10 [illegible]	2 × 10 [illegible]	1 × 10 [illegible]
	Pt 193m	S	7 × 10 [illegible]	3 × 10 [illegible]	2 × 10 [illegible]	1 × 10 [illegible]
		I	5 × 10 [illegible]	3 × 10 [illegible]	2 × 10 [illegible]	1 × 10 [illegible]
*	Pt 193	S	1 × 10 [illegible]	2 × 10 [illegible]	4 × 10 [illegible]	9 × 10 [illegible]
		I	3 × 10 [illegible]	5 × 10 [illegible]	1 × 10 [illegible]	2 × 10 [illegible]
	Pt 197m	S	6 × 10 [illegible]	3 × 10 [illegible]	2 × 10 [illegible]	1 × 10 [illegible]
		I	5 × 10 [illegible]	3 × 10 [illegible]	2 × 10 [illegible]	9 × 10 [illegible]
	Pt 197	S	8 × 10 [illegible]	4 × 10 [illegible]	3 × 10 [illegible]	1 × 10 [illegible]
		I	6 × 10 [illegible]	3 × 10 [illegible]	2 × 10 [illegible]	1 × 10 [illegible]
Plutonium (94)	Pu 238	S	2 × 10 [illegible]	1 × 10 [illegible]	7 × 10 [illegible]	5 × 10 [illegible]
		I	3 × 10 [illegible]	8 × 10 [illegible]	1 × 10 [illegible]	3 × 10 [illegible]
	Pu 239	S	2 × 10 [illegible]	1 × 10 [illegible]	6 × 10 [illegible]	5 × 10 [illegible]
		I	4 × 10 [illegible]	8 × 10 [illegible]	1 × 10 [illegible]	3 × 10 [illegible]
	Pu 240	S	2 × 10 [illegible]	1 × 10 [illegible]	6 × 10 [illegible]	5 × 10 [illegible]
		I	4 × 10 [illegible]	8 × 10 [illegible]	1 × 10 [illegible]	3 × 10 [illegible]
	Pu 241	S	9 × 10 [illegible]	7 × 10 [illegible]	3 × 10 [illegible]	2 × 10 [illegible]
		I	4 × 10 [illegible]	4 × 10 [illegible]	1 × 10 [illegible]	1 × 10 [illegible]

APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

[See notes at end of appendix]

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Element (atomic number)	Isotope [1]	†	Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Plutonium (94)	Pu 242	S	2×10^{-12}	1×10^{-4}	6×10^{-14}	5×10^{-6}
		I	4×10^{-11}	9×10^{-4}	1×10^{-12}	3×10^{-5}
	Pu 243	S	2×10^{-6}	1×10^{-2}	6×10^{-8}	3×10^{-4}
		I	2×10^{-6}	1×10^{-2}	8×10^{-8}	3×10^{-4}
	Pu 244	S	2×10^{-12}	1×10^{-4}	6×10^{-14}	4×10^{-6}
		I	3×10^{-11}	3×10^{-4}	1×10^{-12}	1×10^{-5}
Polonium (84)	Po 210	S	5×10^{-10}	2×10^{-5}	2×10^{-11}	7×10^{-7}
		I	2×10^{-10}	8×10^{-4}	7×10^{-12}	3×10^{-5}
Potassium (19)	K 42	S	2×10^{-6}	9×10^{-3}	7×10^{-8}	3×10^{-4}
		I	1×10^{-7}	6×10^{-4}	4×10^{-9}	2×10^{-5}
Praseodymium (59)	Pr 142	S	2×10^{-7}	9×10^{-4}	7×10^{-9}	3×10^{-5}
		I	2×10^{-7}	9×10^{-4}	5×10^{-9}	3×10^{-5}
	Pr 143	S	3×10^{-7}	1×10^{-3}	1×10^{-8}	5×10^{-5}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	5×10^{-5}
Promethium (61)	Pm 147	S	6×10^{-8}	6×10^{-3}	2×10^{-9}	2×10^{-4}
		I	1×10^{-7}	6×10^{-3}	3×10^{-9}	2×10^{-4}
	Pm 149	S	3×10^{-7}	1×10^{-3}	1×10^{-8}	4×10^{-5}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-5}
Protoactinium (91)	Pa 230	S	2×10^{-9}	7×10^{-3}	6×10^{-11}	2×10^{-4}
		I	8×10^{-10}	7×10^{-3}	3×10^{-11}	2×10^{-4}
	Pa 231	S	1×10^{-12}	3×10^{-5}	4×10^{-14}	9×10^{-7}
		I	1×10^{-10}	8×10^{-4}	4×10^{-12}	2×10^{-5}
	Pa 233	S	6×10^{-7}	4×10^{-3}	2×10^{-8}	1×10^{-4}
		I	2×10^{-7}	3×10^{-3}	6×10^{-9}	1×10^{-4}
Radium (88)	Ra 223	S	2×10^{-9}	2×10^{-5}	6×10^{-11}	7×10^{-7}
		I	2×10^{-10}	1×10^{-4}	8×10^{-12}	4×10^{-6}
	Ra 224	S	5×10^{-9}	7×10^{-5}	2×10^{-10}	2×10^{-6}
		I	7×10^{-10}	2×10^{-4}	2×10^{-11}	5×10^{-6}
	Ra 226	S	3×10^{-11}	4×10^{-7}	3×10^{-12}	3×10^{-8}
		I	5×10^{-11}	9×10^{-4}	2×10^{-12}	3×10^{-5}
	Ra 228	S	7×10^{-11}	8×10^{-7}	2×10^{-12}	3×10^{-8}
		I	4×10^{-11}	7×10^{-4}	1×10^{-12}	3×10^{-5}
Radon (86)	Rn 220	S	3×10^{-7}		1×10^{-8}	
	Rn 222 [3] ***		*** 3×10^{-8}		3×10^{-9}	
Rhenium (75)	Re 183	S	3×10^{-6}	2×10^{-2}	9×10^{-8}	6×10^{-4}
		I	2×10^{-7}	8×10^{-3}	5×10^{-9}	3×10^{-4}
	Re 186	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-5}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	5×10^{-5}
	Re 187	S	9×10^{-6}	7×10^{-2}	3×10^{-7}	3×10^{-3}
		I	5×10^{-7}	4×10^{-2}	2×10^{-8}	2×10^{-3}
	Re 188	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
		I	2×10^{-7}	9×10^{-4}	6×10^{-9}	3×10^{-5}
Rhodium (45)	Rh 103m	S	8×10^{-5}	4×10^{-1}	3×10^{-6}	1×10^{-2}
		I	6×10^{-5}	3×10^{-1}	2×10^{-6}	1×10^{-2}
	Rh 105	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Rubidium (37)	Rb 86	S	3×10^{-7}	2×10^{-3}	1×10^{-8}	7×10^{-5}
		I	7×10^{-8}	7×10^{-4}	2×10^{-9}	2×10^{-5}
	Rb 87	S	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	7×10^{-8}	5×10^{-3}	2×10^{-9}	2×10^{-4}

APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

[See notes at end of appendix]

Element (atomic number)	Isotope [1]		Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Ruthenium (44)	Ru 97	S	2×10^{-6}	1×10^{-2}	8×10^{-8}	4×10^{-4}
		I	2×10^{-6}	1×10^{-2}	6×10^{-8}	3×10^{-4}
	Ru 103	S	5×10^{-7}	2×10^{-3}	2×10^{-8}	8×10^{-5}
		I	8×10^{-8}	2×10^{-3}	3×10^{-9}	8×10^{-5}
	Ru 105	S	7×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
	Ru 106	S	8×10^{-8}	4×10^{-4}	3×10^{-9}	1×10^{-5}
		I	6×10^{-9}	3×10^{-4}	2×10^{-10}	1×10^{-5}
Samarium (62)	Sm 147	S	7×10^{-11}	2×10^{-3}	2×10^{-12}	6×10^{-5}
		I	3×10^{-11}	2×10^{-3}	9×10^{-13}	7×10^{-5}
	Sm 151	S	6×10^{-8}	1×10^{-2}	2×10^{-9}	4×10^{-4}
		I	1×10^{-7}	1×10^{-2}	5×10^{-9}	4×10^{-4}
	Sm 153	S	5×10^{-7}	2×10^{-3}	2×10^{-8}	8×10^{-5}
		I	4×10^{-7}	2×10^{-3}	1×10^{-8}	8×10^{-5}
Scandium (21)	Sc 46	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-5}
		I	2×10^{-8}	1×10^{-3}	8×10^{-10}	4×10^{-5}
	Sc 47	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-5}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-5}
	Sc 48	S	2×10^{-7}	8×10^{-4}	6×10^{-9}	3×10^{-5}
		I	1×10^{-7}	8×10^{-4}	5×10^{-9}	3×10^{-5}
Selenium (34)	Se 75	S	1×10^{-6}	9×10^{-3}	4×10^{-8}	3×10^{-4}
		I	1×10^{-7}	8×10^{-3}	4×10^{-9}	3×10^{-4}
Silicon (14)	Si 31	S	6×10^{-6}	3×10^{-2}	2×10^{-7}	9×10^{-4}
		I	1×10^{-6}	6×10^{-3}	3×10^{-8}	2×10^{-4}
Silver (47)	Ag 105	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	8×10^{-8}	3×10^{-3}	3×10^{-9}	1×10^{-4}
	Ag 110m	S	2×10^{-7}	9×10^{-4}	7×10^{-9}	3×10^{-5}
		I	1×10^{-8}	9×10^{-4}	3×10^{-10}	3×10^{-5}
	Ag 111	S	3×10^{-7}	1×10^{-3}	1×10^{-8}	4×10^{-5}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-5}
Sodium (11)	Na 22	S	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
		I	9×10^{-9}	9×10^{-4}	3×10^{-10}	3×10^{-5}
	Na 24	S	1×10^{-6}	6×10^{-3}	4×10^{-8}	2×10^{-4}
		I	1×10^{-7}	8×10^{-4}	5×10^{-9}	3×10^{-5}
Strontium (38)	Sr 85m	S	4×10^{-5}	2×10^{-1}	1×10^{-6}	7×10^{-3}
		I	3×10^{-5}	2×10^{-1}	1×10^{-6}	7×10^{-3}
	Sr 85	S	2×10^{-7}	3×10^{-3}	8×10^{-9}	1×10^{-4}
		I	1×10^{-7}	5×10^{-3}	4×10^{-9}	2×10^{-4}
	Sr 89	S	3×10^{-8}	3×10^{-4}	3×10^{-10}	3×10^{-6}
		I	4×10^{-8}	8×10^{-4}	1×10^{-9}	3×10^{-5}
	Sr 90	S	1×10^{-9}	1×10^{-5}	3×10^{-11}	3×10^{-7}
		I	5×10^{-9}	1×10^{-3}	2×10^{-10}	4×10^{-5}
	Sr 91	S	4×10^{-7}	2×10^{-3}	2×10^{-8}	7×10^{-5}
		I	3×10^{-7}	1×10^{-3}	9×10^{-9}	5×10^{-5}
	Sr 92	S	4×10^{-7}	2×10^{-3}	2×10^{-8}	7×10^{-5}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
Sulfur (16)	S 35	S	3×10^{-7}	2×10^{-3}	9×10^{-9}	6×10^{-5}
		I	3×10^{-7}	8×10^{-3}	9×10^{-9}	3×10^{-4}
Tantalum (73)	Ta 182	S	4×10^{-8}	1×10^{-3}	1×10^{-9}	4×10^{-5}
		I	2×10^{-8}	1×10^{-3}	7×10^{-10}	4×10^{-5}

25 FR 10914

APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

(See notes at end of appendix.)

25 FR 10914

Element (atomic number)	Isotope[1]	†	Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Technetium (43)	Tc 96m	S	8×10^{-5}	4×10^{-1}	3×10^{-6}	1×10^{-2}
		I	3×10^{-6}	3×10^{-1}	1×10^{-7}	1×10^{-2}
	Tc 96	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	5×10^{-5}
	Tc 97m	S	2×10^{-6}	1×10^{-2}	8×10^{-8}	4×10^{-4}
		I	2×10^{-7}	5×10^{-3}	5×10^{-9}	2×10^{-4}
	Tc 97	S	1×10^{-5}	5×10^{-2}	4×10^{-7}	2×10^{-3}
		I	3×10^{-7}	2×10^{-2}	1×10^{-8}	8×10^{-4}
	Tc 99m	S	4×10^{-4}	2×10^{-1}	1×10^{-5}	6×10^{-3}
		I	1×10^{-4}	8×10^{-1}	5×10^{-6}	3×10^{-2}
	Tc 99	S	2×10^{-6}	1×10^{-2}	7×10^{-8}	3×10^{-4}
		I	6×10^{-8}	5×10^{-3}	2×10^{-9}	2×10^{-4}
Tellurium (52)	Te 125m	S	4×10^{-7}	5×10^{-3}	1×10^{-8}	2×10^{-4}
		I	1×10^{-7}	3×10^{-3}	4×10^{-9}	1×10^{-4}
	Te 127m	S	1×10^{-7}	2×10^{-3}	5×10^{-9}	6×10^{-5}
		I	4×10^{-8}	2×10^{-3}	1×10^{-9}	5×10^{-5}
	Te 127	S	2×10^{-6}	8×10^{-3}	6×10^{-8}	3×10^{-4}
		I	9×10^{-7}	5×10^{-3}	3×10^{-8}	2×10^{-4}
	Te 129m	S	8×10^{-8}	1×10^{-3}	3×10^{-9}	3×10^{-5}
		I	3×10^{-8}	6×10^{-4}	1×10^{-9}	2×10^{-5}
	Te 129	S	5×10^{-6}	2×10^{-2}	2×10^{-7}	8×10^{-4}
		I	4×10^{-6}	2×10^{-2}	1×10^{-7}	8×10^{-4}
	Te 131m	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
	Te 132	S	2×10^{-7}	9×10^{-4}	7×10^{-9}	3×10^{-5}
		I	1×10^{-7}	6×10^{-4}	4×10^{-9}	2×10^{-5}
Terbium (65)	Tb 160	S	1×10^{-7}	1×10^{-3}	3×10^{-9}	4×10^{-5}
		I	3×10^{-8}	1×10^{-3}	1×10^{-9}	4×10^{-5}
Thallium (81)	Tl 200	S	3×10^{-6}	1×10^{-2}	9×10^{-8}	4×10^{-4}
		I	1×10^{-6}	7×10^{-3}	4×10^{-8}	2×10^{-4}
	Tl 201	S	2×10^{-6}	9×10^{-3}	7×10^{-8}	3×10^{-4}
		I	9×10^{-7}	5×10^{-3}	3×10^{-8}	2×10^{-4}
	Tl 202	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	2×10^{-7}	2×10^{-3}	8×10^{-9}	7×10^{-5}
	Tl 204	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	3×10^{-8}	2×10^{-3}	9×10^{-10}	6×10^{-5}
Thorium (90)	* Th 227	S	3×10^{-10}	5×10^{-4}	1×10^{-11}	2×10^{-5}
		I	2×10^{-10}	5×10^{-4}	6×10^{-12}	2×10^{-5}
	Th 228	S	9×10^{-12}	2×10^{-4}	3×10^{-13}	7×10^{-6}
		I	6×10^{-12}	4×10^{-4}	2×10^{-13}	1×10^{-5}
	Th 230	S	2×10^{-12}	5×10^{-5}	8×10^{-14}	2×10^{-6}
		I	1×10^{-11}	9×10^{-4}	3×10^{-13}	3×10^{-5}
	* Th 231	S	1×10^{-6}	7×10^{-3}	5×10^{-8}	2×10^{-4}
		I	1×10^{-6}	7×10^{-3}	4×10^{-8}	2×10^{-4}
	Th 232	S	3×10^{-11}	5×10^{-5}	1×10^{-12}	2×10^{-6}
		I	3×10^{-11}	1×10^{-3}	1×10^{-12}	4×10^{-5}
	** Th natural	S	6×10^{-11}	6×10^{-5}	2×10^{-12}	2×10^{-6}
		I	6×10^{-11}	6×10^{-4}	2×10^{-12}	2×10^{-5}

APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

(See notes at end of appendix)

Element (atomic number)		Isotope[1]	†	Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Thorium (90)		Th 234	S	6×10^{-8}	5×10^{-4}	2×10^{-9}	2×10^{-5}
			I	3×10^{-8}	5×10^{-4}	1×10^{-9}	2×10^{-5}
Thulium (69)		Tm 170	S	4×10^{-8}	1×10^{-3}	1×10^{-9}	5×10^{-5}
			I	3×10^{-8}	1×10^{-3}	1×10^{-9}	5×10^{-5}
		Tm 171	S	1×10^{-7}	1×10^{-2}	4×10^{-9}	5×10^{-4}
			I	2×10^{-7}	1×10^{-2}	8×10^{-9}	5×10^{-4}
Tin (50)		Sn 113	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	9×10^{-5}
			I	5×10^{-8}	2×10^{-3}	2×10^{-9}	8×10^{-5}
		Sn 125	S	1×10^{-7}	5×10^{-4}	4×10^{-9}	2×10^{-5}
			I	8×10^{-8}	5×10^{-4}	3×10^{-9}	2×10^{-5}
Tungsten (Wolfram) (74)		W 181	S	2×10^{-6}	1×10^{-2}	8×10^{-8}	4×10^{-4}
			I	1×10^{-7}	1×10^{-2}	4×10^{-9}	3×10^{-4}
		W 185	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
			I	1×10^{-7}	3×10^{-3}	4×10^{-9}	1×10^{-4}
		W 187	S	4×10^{-7}	2×10^{-3}	2×10^{-8}	7×10^{-5}
			I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
Uranium (92)		U 230	S	3×10^{-10}	1×10^{-4}	1×10^{-11}	5×10^{-6}
			I	1×10^{-10}	1×10^{-4}	4×10^{-12}	5×10^{-6}
		U 232	S	1×10^{-10}	8×10^{-4}	3×10^{-12}	3×10^{-5}
			I	3×10^{-11}	8×10^{-4}	9×10^{-13}	3×10^{-5}
		U 233	S	5×10^{-10}	9×10^{-4}	2×10^{-11}	3×10^{-5}
			I	1×10^{-10}	9×10^{-4}	4×10^{-12}	3×10^{-5}
	••	U 234	S[4]	6×10^{-10}	9×10^{-4}	2×10^{-11}	3×10^{-5}
			I	1×10^{-10}	9×10^{-4}	4×10^{-12}	3×10^{-5}
	••	U 235	S[4]	5×10^{-10}	8×10^{-4}	2×10^{-11}	3×10^{-5}
			I	1×10^{-10}	8×10^{-4}	4×10^{-12}	3×10^{-5}
		U 236	S	6×10^{-10}	1×10^{-3}	2×10^{-11}	3×10^{-5}
			I	1×10^{-10}	1×10^{-3}	4×10^{-12}	3×10^{-5}
	••	U 238	S[4]	7×10^{-11}	1×10^{-3}	3×10^{-12}	4×10^{-5}
			I	1×10^{-10}	1×10^{-3}	5×10^{-12}	4×10^{-5}
		U 240	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	3×10^{-5}
			I	2×10^{-7}	1×10^{-3}	6×10^{-9}	3×10^{-5}
	••	U-natural	S[4]	1×10^{-10}	1×10^{-3}	5×10^{-12}	3×10^{-5}
			I	1×10^{-10}	1×10^{-3}	5×10^{-12}	3×10^{-5}
Vanadium (23)		V 48	S	2×10^{-7}	9×10^{-4}	6×10^{-9}	3×10^{-5}
			I	6×10^{-8}	8×10^{-4}	2×10^{-9}	3×10^{-5}
Xenon (54)		Xe 131m	Sub	2×10^{-5}		4×10^{-7}	
		Xe 133	Sub	1×10^{-5}		3×10^{-7}	
		Xe 133m	Sub	1×10^{-5}		3×10^{-7}	
		Xe 135	Sub	4×10^{-6}		1×10^{-7}	
Ytterbium (70)		Yb 175	S	7×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
			I	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Yttrium (39)		Y 90	S	1×10^{-7}	6×10^{-4}	4×10^{-9}	2×10^{-5}
			I	1×10^{-7}	6×10^{-4}	3×10^{-9}	2×10^{-5}
		Y 91m	S	2×10^{-5}	1×10^{-1}	8×10^{-7}	3×10^{-3}
			I	2×10^{-5}	1×10^{-1}	6×10^{-7}	3×10^{-3}
		Y 91	S	4×10^{-8}	8×10^{-4}	1×10^{-9}	3×10^{-5}
			I	3×10^{-8}	8×10^{-4}	1×10^{-9}	3×10^{-5}
		Y 92	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
			I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
		Y 93	S	2×10^{-7}	8×10^{-4}	6×10^{-9}	3×10^{-5}
			I	1×10^{-7}	8×10^{-4}	5×10^{-9}	3×10^{-5}

25 FR 10914

APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

Element (atomic number)	Isotope[1]		Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Zinc (30)	Zn 65	S	1×10⁻⁷	3×10⁻³	4×10⁻⁹	1×10⁻⁴
		I	6×10⁻⁸	5×10⁻³	2×10⁻⁹	2×10⁻⁴
	Zn 69m	S	4×10⁻⁷	2×10⁻³	1×10⁻⁸	7×10⁻⁵
		I	3×10⁻⁷	2×10⁻³	1×10⁻⁸	6×10⁻⁵
	Zn 69	S	7×10⁻⁶	5×10⁻²	2×10⁻⁷	2×10⁻³
		I	9×10⁻⁶	5×10⁻²	3×10⁻⁷	2×10⁻³
Zirconium (40)	Zr 93	S	1×10⁻⁷	2×10⁻²	4×10⁻⁹	8×10⁻⁴
		I	3×10⁻⁷	2×10⁻²	1×10⁻⁸	8×10⁻⁴
	Zr 95	S	1×10⁻⁷	2×10⁻³	4×10⁻⁹	6×10⁻⁵
		I	3×10⁻⁸	2×10⁻³	1×10⁻⁹	6×10⁻⁵
	Zr 97	S	1×10⁻⁷	5×10⁻⁴	4×10⁻⁹	2×10⁻⁵
		I	9×10⁻⁸	5×10⁻⁴	3×10⁻⁹	2×10⁻⁵
Any single radionuclide not listed above with decay mode other than alpha emission or spontaneous fission and with radioactive half-life less than 2 hours.		Sub	1×10⁻⁶		3×10⁻⁸	
Any single radionuclide not listed above with decay mode other than alpha emission or spontaneous fission and with radioactive half-life greater than 2 hours.			3×10⁻⁹	9×10⁻⁵	1×10⁻¹⁰	3×10⁻⁶
Any single radionuclide not listed above, which decays by alpha emission or spontaneous fission.			6×10⁻¹³	4×10⁻⁷	2×10⁻¹⁴	3×10⁻⁸

35 FR 19218

[1] Soluble (S); Insoluble (I).

[2] "Sub" means that values given are for submersion in a semispherical infinite cloud of airborne material.

40 FR 50704

[e] These radon concentrations are appropriate for protection from radon-222 combined with its short-lived daughters. Alternatively, the value in Table I may be replaced by one-third (1/3) "working level." (A "working level" is defined as any combination of short-lived radon-222 daughters, polonium-218, lead-214, bismuth-214 and polonium-214, in one liter of air, without regard to the degree of equilibrium, that will result in the ultimate emission of 1.3×10^5 MeV of alpha particle energy.) The Table II value may be replaced by one-thirtieth (1/30) of a "working level." The limit on radon-222 concentrations in restricted areas may be based on an annual average.

39 FR 23990

‡4. For soluble mixtures of U-238, U-234 and U-235 in air chemical toxicity may be the limiting factor. If the percent by weight (enrichment) of U-235 is less than 5, the concentration value for a 40-hour workweek, Table I, is 0.2 milligrams uranium per cubic meter of air average. For any enrichment, the product of the average concentration and time of exposure during a 40-hour workweek shall not exceed 8×10^{-3} SA μCi-hr/ml, where SA is the specific activity of the uranium inhaled. The concentration value for Table II is 0.007 milligrams uranium per cubic meter of air. The specific activity for natural uranium is 6.77×10^{-7} curies per gram U. The specific activity for other mixtures of U-238, U-235 and U-234, if not known, shall be:

$SA = 3.6 \times 10^{-7}$ curies/gram U U-depleted

$SA = (0.4 + 0.38E + 0.0034E^2) 10^{-6}$ $E \geq 0.72$

where E is the percentage by weight of U-235 expressed as percent.

* Amended 37 FR 23319.

** Amended 39 FR 23990; footnote redesignated 40 FR 50704.

*** Amended 40 FR 50704.

† Amended 38 FR 29314.

‡ Amended 39 FR 25463; redesignated 40 FR 50704.

NOTE TO APPENDIX B

26 FR 11046

NOTE: In any case where there is a mixture in air or water of more than one radionuclide, the limiting values for purposes of this Appendix should be determined as follows:

1. If the identity and concentration of each radionuclide in the mixture are known, the limiting values should be derived as follows: Determine, for each radionuclide in the mixture, the ratio between the quantity present in the mixture and the limit otherwise established in Appendix B for the specific radionuclide when not in a mixture. The sum of such ratios for all the radionuclides in the mixture may not exceed "1" (i.e., "unity").

EXAMPLE: If radionuclides A, B, and C are present in concentrations C_A, C_B, and C_C, and if the applicable MPC's, are MPC_A, and MPC_B, and MPC_C respectively, then the concentrations shall be limited so that the following relationship exists:

$$\frac{C_A}{MPC_A}+\frac{C_B}{MPC_B}+\frac{C_C}{MPC_C}\leq 1$$

30 FR 15801

2. If either the identity or the concentration of any radionuclide in the mixture is not known, the limiting values for purposes of Appendix B shall be:

a. For purposes of Table I, Col. 1—6×10^{-13}
b. For purposes of Table I, Col. 2—4×10^{-7}
c. For purposes of Table II, Col. 1—2×10^{-14}
d. For purposes of Table II, Col. 2—3×10^{-8}

26 FR 11046

3. If any of the conditions specified below are met, the corresponding values specified below may be used in lieu of those specified in paragraph 2 above.

a. If the identity of each radionuclide in the mixture is known but the concentration of one or more of the radionuclides in the mixture is not known, the concentration limit for the mixture is the limit specified in Appendix "B" for the radionuclide in the mixture having the lowest concentration limit; or

b. If the identity of each radionuclide in the mixture is not known, but it is known that certain radionuclides specified in Appendix "B" are not present in the mixture, the concentration limit for the mixture is the lowest concentration limit specified in Appendix "B" for any radionuclide which is not known to be absent from the mixture; or

30 FR 15801

c. Element (atomic number) and isotope	Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
If it is known that Sr 90, I 125, I 126, I 129, I 131, (I 133, table II only), Pb 210, Po 210, At 211, Ra 223, Ra 224, Ra 226, Ac 227, Ra 228, Th 230, Pa 231, Th 232, Th-nat, Cm 248, Cf 254, and Fm 256 are not present		9×10^{-5}		3×10^{-6}
If it is known that Sr 90, I 125, I 126, I 129, (I 131, I 133, table II only), Pb 210, Po 210, Ra 223, Ra 226, Ra 228, Pa 231, Th-nat, Cm 248, Cf 254, and Fm 256 are not present		6×10^{-5}		2×10^{-6}
If it is known that Sr 90, I 129, (I 125, I 126, I 131, table II only), Pb 210, Ra 226, Ra 228, Cm 248, and Cf 254 are not present		2×10^{-5}		6×10^{-7}
If it is known that (I 129, table II only), Ra 226, and Ra 228 are not present		3×10^{-6}		1×10^{-7}
If it is known that alpha-emitters and Sr 90, I 129, Pb 210, Ac 227, Ra 228, Pa 230, Pu 241, and Bk 249 are not present	3×10^{-9}		1×10^{-10}	
If it is known that alpha-emitters and Pb 210, Ac 227, Ra 228, and Pu 241 are not present	3×10^{-10}		1×10^{-11}	
If it is known that alpha-emitters and Ac 227 are not present	3×10^{-11}		1×10^{-12}	
If it is known that Ac 227, Th 230, Pa 231, Pu 238, Pu 239, Pu 240, Pu 242, Pu 244, Cm 248, Cf 249 and Cf 251 are not present	3×10^{-12}		1×10^{-13}	

40 FR 50704

4. If a mixture of radionuclides consists of uranium and its daughters in ore dust prior to chemical separation of the uranium from the ore, the values specified below may be used for uranium and its daughters through radium-226, instead of those from paragraphs 1, 2, or 3 above.

39 FR 23990

a. For purposes of Table I, Col. 1—1×10^{-10} μCi/ml gross alpha activity; or 5×10^{-11} μCi/ml natural uranium; or 75 micrograms per cubic meter of air natural uranium.

b. For purposes of Table II, Col. 1—3×10^{-12} μCi/ml gross alpha activity; or 2×10^{-12} μCi/ml natural uranium; or 3 micrograms per cubic meter of air natural uranium.

26 FR 11046

5. For purposes of this note, a radionuclide may be considered as not present in a mixture if (a) the ratio of the concentration of that radionuclide in the mixture (C_A) to the concentration limit for that radionuclide specified in Table II of Appendix B (MPC_A) does not exceed 1/10

(i.e. $\frac{C_A}{MPC_A}\leq\frac{1}{10}$) and (b) the sum of such ratios for all the radionuclides considered as not present in the mixture does not exceed 1/4

(i.e. $\frac{C_A}{MPC_A}+\frac{C_B}{MPC_B}+\cdots\cdots\leq\frac{1}{4}$).

APPENDIX F

TELEDYNE ISOTOPES

PACKAGING PROCEDURES FOR RADIOACTIVE WASTE

I.0 GENERAL

I.1 Categories of Radioactive Waste:

There are three disposal facilities being used and the categories for each are listed below:

I.1.1 BURIAL AT RICHLAND, WASHINGTON

1. (DMR) Dry Material destined for Richland
2. (DCR) Dry Compactibles destined for Richland
3. (SVR) Small Volume liquids destined for Richland
4. (LVR) Large Volume liquids destined for Richland
5. (ACR) Animal Carcasses or biological waste destined for Richland

I.1.2 PROCESSING AT QUADREX HPS, GAINESVILLE, FLORIDA

1. (VXN) Scintillation Vials - NRC exempt - Non RCRA regulated
2. (VRN) Scintillation Vials - NRC regulated - Non RCRA regulated
3. (VXR) Scintillation Vials - NRC exempt and RCRA regulated
4. (VRR) Scintillation Vials - NRC regulated and RCRA regulated

I.1.3 PROCESSING AT SCIENTIFIC ECOLOGY GROUP, OAK RIDGE, TENNESSEE

1. (DMS) Dry solid Material destined for S.E.G.
2. (DCS) Dry solid Compactible destined for S.E.G.
3. (SVS) Small Volume liquid destined for S.E.G.

I.2 Items in different categories cannot be mixed in any one container unless specifically authorized.

I.3 The packaging procedure that is used is to be marked on the drum (e.g. DMR-8/87).

I.4 Transuranic and radium waste in excess of 10 nanocuries per gram is not acceptable unless specifically authorized.

I.5 Gaseous waste must meet certain provisions. Please see the burial site's license for details or call the Radiological Services Department Office.

I.6 Special Nuclear Material requires specific approval and will be accepted only upon special request to the Radiological Services Department Office.

I.7 DO NOT EXCEED THE FOLLOWING WEIGHTS UNLESS SPECIFICALLY AUTHORIZED:

5 gallon container - 80 lbs.
30 gallon container - 300 lbs.
55 gallon container - 480 lbs.

I.8 CHEMICAL TOXICITY:

The chemical composition of the materials disposed must be compatible with the procedures which follow. Any additional hazards of the material must be evaluated to determine if additional packaging is required. If materials are listed in N. Irving Sax's "Dangerous Properties of Industrial Materials", Fifth Edition, Van Nostrand Reinhold, as having a THR=HIGH via any route, except IP or IV, specific approval must be obtained from the State of Washington Radiation Control Program. Contact the Radiological Services Department for details.

I.9 PROHIBITIONS

I.9.1 Burial Prohibitions:

Lead and other U.S. EPA hazardous wastes are prohibited from land burial at the current radioactive waste disposal sites. Please ensure there are no Resource Conservation and Recovery Act (RCRA) wastes in your radioactive waste streams.

I.9.2 Scintillation Vial Processing:

Only those isotopes listed in the Quadrex license are allowed for processing. In addition, strict control must be held over the packaging of scintillation vials. No other wastes of any kind are allowed in these containers.

I.10 Special Notes

Two 2 ml liners may be used in place of a single 4 ml liner.

Instead of lining the whole drum, individual 4 ml (or double 2-ml) bags may be substituted, provided each bag is layered as below.

For a list of approved absorbants for use with waste destined for Richland, please see the US Ecology license.

When layering, the absorbant must be the first layer on the bottom and the last layer on the top. Proper volume ratios must be determined by the generator to be used for the different absorbants.

The amount of absorbant must be capable of absorbing twice the amount of liquid present.

I.11 VOIDS - All voids in the containers must be filled to the extent practicable.

TELEDYNE ISOTOPES

II.0 WASTE FOR BURIAL AT US ECOLOGY, RICHLAND, WASHINGTON

II.1 DRY SOLID MATERIAL FOR BURIAL AT RICHLAND, WASHINGTON (DMR-8/87)

II.1.1 Select a 5, 30 or 55-gallon drum.

II.1.2 Fill to capacity with only dry solid materials.

II.1.3 Fill in any voids to the extent practical.

II.1.4 Secure drum cover.

II.1.5 Label drum DMR-8/87, to designate that the drum has been packaged according to these directions.

II.2 DRY SOLID COMPACTIBLES FOR BURIAL AT RICHLAND, WASHINGTON (DCR-8/87)

II.2.1 Select a 30 or 55 gallon container.

II.2.2 Place waste into double 4 mil plastic liners. (Note: For 55 gallon drums, use two sets of double 4 mil bags, each set approximately 27 gallons. If heavy materials are used, please use additional double 4 mil liners and decrease the quantity put into each.)

II.2.3 Twist and seal liners.

II.2.4 Place double 4 mil bags into the selected container.

II.2.5 Replace lid and ring.

II.2.6 Secure ring. DO NOT BOLT.

II.2.7 Label drum DCR-8/87 to indicate it was packaged in accordance with these instructions.

NOTE: DO NOT DISPOSE OF UNPROTECTED SHARP OBJECTS.

NOTE: DO NOT DISPOSE OF NON-COMPACTIBLE ITEMS IN THESE TYPES OF CONTAINERS.

NOTE: ONLY LOW SPECIFIC ACTIVITY MATERIAL IS ACCEPTABLE IN COMPACTIBLE DRUMS. UNDER NO CIRCUMSTANCES SHOULD SOURCES BE PLACED INTO THESE CONTAINERS.

TELEDYNE ISOTOPES

II.3 SMALL VOLUME LIQUID WASTE DESTINED FOR RICHLAND (SVR-8/87)

These drums can contain vials which contain liquids which are acceptable for burial, and each vial must contain less than 50 ml of liquid.

Liquid should not be absorbed directly onto the absorption media (e.i. do not open vials). Any tool or device which contains free standing liquid must be considered small volume liquid waste. Please reference the definition of free standing liquid as found in US Ecology's lisense.

II.3.1 Select only a 30 or 55-gallon drum; 5-gallon pails are not allowed.

II.3.2 Line the drum with 4 ml thick poly liner.

II.3.3 Using an approved absorbant, alternate layers of absorbant with layers of waste.

II.3.4 Twist and seal liner.

II.3.5 Secure drum cover.

II.3.6 Label drum SVR-8/87, to designate that the drum has been packaged according to these instructions.

II.3.7 Special Note: Toluene, Xylene and other flammable liquids in scintillation vials will not be accepted for burial. [illegible] must be packaged for reprocessing and meet the reprocessor's license criteria.

I.4 LARGE VOLUME LIQUID WASTE DESTINED FOR RICHLAND (LVR-8/87)

All items containing 50 ml or more of an aqueous liquid may not be disposed in SVR or SVS drums. The liquid must be packaged as follows while the container itself must be either (1) dried and placed in a DMR, DCR, DMS or DCS drum or (2) placed in an SVR or SVS drum once the bulk of the liquid is removed.

II.4.1 Select only the 55-gallon double-walled container for liquid waste.

II.4.2 Remove the 55-gallon drum cover.

II.4.3 Loosen and remove the bung from the 30-gallon drum which has been filled with an approved absorbant.

II.4.4 Pour up to 10 gallons of liquid (pH-6.0 - 9.0) into the absorbant in the 30-gallon drum through the 2-1/2" opening.

II.4.5 Replace bung and tighten.

II.4.6 Twist and seal poly liner.

II.4.7 Secure cover of 55-gallon drum.

II.4.8 Label drum LVR-(8/87) to designate that the drum has been packaged according to these instuctions.

II.4.9 SPECIAL NOTE:

Toluene or Xylene and other liquids unacceptable at the burial site cannot be absorbed.

II.5 ANIMAL CARCASSES OR BIOLOGICAL WASTE (ACR-8/87)

Animal carcasses or biological waste must be disposed using a double-walled container. Be sure when ordering to specify a 55-gallon double-walled container for animal carcasses.

II.5.1 Select only a 55-gallon double-walled drum.

II.5.2 Remove inner 30-gallon container and absorbant.

II.5.3 Line 30-gallon drum with 4 ml poly liner. See Section I.10.

II.5.4 Package waste into liner using at least one part slaked lime for every 10 parts of an approved absorbant. Fill completely.

II.5.5 Twist and seal liner.

II.5.6 Seal 30-gallon drum.

II.5.7 Place 30-gallon drum into 55-gallon drum.

II.5.8 Place absorbant around and covering 30-gallon drum.

II.5.9 Secure 55-gallon drum cover.

II.5.10 Label drum ACR-8/87 to designate that drum has been packaged according to these instructions.

III.0 RADIOACTIVE WASTE FOR PROCESSING AT S.E.G., OAK RIDGE, TENNESSEE

III.1 DRY SOLID MATERIAL DESTINED FOR S.E.G. (DMS-8/87)

III.1.1 See the procedure for DMR and follow exactly, except for labelling the container DMS-8/87, however, only Class A unstable materials are acceptable. Please see the S.E.G. license for further details on acceptable materials.

III.2 DRY SOLID COMPACTIBLE DESTINED FOR S.E.G. (DCS-8/87)

III.2.1 See the procedure for DCR and follow exactly, except for labelling the container DCS-8/87, however, only Class A unstable materials are acceptable. Please see the S.E.G. license for further details on acceptable materials.

III.3 SMALL VOLUME LIQUIDS DESTINED FOR S.E.G. (SVS-8/87)

III.3.1 See the procedure for SVR and follow exactly, except for labelling the container SVS-8/87.

III.3.2 The liquids present must be strictly incidental. A couple of examples of incidental liquids are:
a) A drop in the end of a pipette
b) A couple of milliliters in the bottom of a vial
c) Moisture on the sides of a beaker.

III.3.3 Use the absorbant sparingly.

SPECIAL NOTE: In the SVS drum you may mix other dry waste which would be suitable for either the DMS or DCS container. You do not have to segregate these three types as long as the drum is classified as an SVS-8/87.

IV.0 SCINTILLATION VIAL WASTE FOR REPROCESSING AT QUADREX, GAINESVILLE, FLORIDA, (VXN, VRN, VXR, VRR)

These drums may contain scintillation vials which contain Toluene or Xylene or any other flammable scintillation media acceptable according to Quadrex's License No. 1354-1 (State of Florida, Department of Health & Rehabilitative Services).

All drums to Quadrex are packaged identically using the procedure below, however, the labelling and manifesting are specific to the classification selected. The generator is responsible for identifying the isotopes, concentrations and chemical forms of the waste material.

IV.1 Select only a 30 or 55-gallon drum.

IV.2 Line the drum with 4 ml thick poly liner.

IV.3 Add 12 inches of an approved absorbant.

IV.4 Line drum again with another 4 ml thick poly liner.

IV.5 Fill with vials or other containers of less than one pint capacity. NOTE: With one pint containers, add absorbant to suitably cushion these to prevent breakage.

IV.6 Twist and seal liners.

IV.7 Top off the drum with additional absorbant.

IV.8 Secure drum cover.

IV.9 Label drum with the appropriate designation for the descriptions below.

V.10 Classification of Scintillation Vial Drums

As you know, there are many different types of scintillation fluids being used by the industry. The major difference between these fluids is their flashpoint. The state your facility is in may, or may not, regulate these fluids as hazardous waste. Although we have been and will continue to help identify when and where the RCRA regulations apply, it is the generator's responsibility under RCRA regulations to determine if his waste stream is a Hazardous Waste.

"V" - For marking purposes, all scintillation vial drums will have a first charcter of "V".

"X" or "R" - The second character will be either an "X" or an "R". If the drum contains only H-3/C-14 in less than 0.05 uCi/gram concentrations it is an "X". If the drum contains H-3/C-14 as above plus other isotopes listed in Quadrex's license, then it is an NRC "R"egulated material and would be an "R".

"N" or "R" - The third character indicates whether the drum is US EPA RCRA "R"egulated or "N"ot regulated. This classification is simple for those who use a high (greater than 140°F) flashpoint cocktail as these fluids are "N"ot RCRA regulated. If you have a cocktail with a lower flashpoint, the material may, or may not be, "R"egulated. This depends on each state. As the states are currently changing their positions rapidly, we have not included a listing from these procedures. Please call for further information.

APPENDIX: G.1

ENVIROGEN RADIATION SAFETY TRAINING PACKET

August, 1990

RUTGERS RADIATION SAFETY LECTURE

OUTLINE

August, 1990

OUTLINE

RADIATION SAFETY ORIENTATION LECTURE

1. Why are we here?
   a. Regulations
   b. Orientation to Rutgers Radiation Safety Program

2. All uses of radiation require License (in New Jersey).

3. Describe Rutgers Licenses (and sources of radiation).

4. Licenses require University to assure safe use through:
   a. Organization
   b. Facilities and equipment
   c. Evaluation
   d. Control
   e. Services

5. Radioactivity and radioactive decay: alpha, beta, gamma (X-ray), heavy particles.

6. Interaction of radiation with matter (and penetration).

7. Dosimetry (Roentgen - Rad - Rem)

8. Bioeffects:
   a. Somatic
   b. Genetic
   c. Teratogenic

9. Regulations - based on ICRP and NCRP recommendations.

10. Rutgers Radiation Safety Program.
    a. Committee responsibility and composition
    b. Radiation and Environmental Health and Safety Department
    c. Control program
    d. Evaluation
    e. Compliance
    f. Services

11. Laboratory practices.
    a. External hazards, including X-rays
    b. Internal hazards
    c. Surveys
    d. Instrumentation - which instrument to use?
    e. Records
    f. Waste disposal
    g. Labelling and marking
    h. Storage
    i. Restriction of access
    j. As low as readily achievable
    k. Emergency procedures (posted)

12. Specific Problems.

    a. ^{3}H
    b. ^{14}C
    c. ^{32}P
    d. ^{125}I
    e. Concept of MPC and regulatory requirements
    f. Radiation exposure artifacts
    g. TLD - return of badges
    h. Marking of waste containers
    i. Ordering radioisotopes
    j. Changes in experimental design and hardware
    k. Hesitancy to ask for help and where to get it
    l. Rules for use of radioisotopes

13. Rights of Workers

    a. 10 CFR 19
    b. Privacy Act
    c. Pregnant Workers

ENV:ROGEN SUPPLEMENTAL TOPICS

August, 1990

CAUTION RADIOACTIVE MATERIAL

Posting and Labelling Requirements for Commonly Used Isotopes

<u>CAUTION</u> <u>RADIOACTIVE</u> <u>MATERIALS</u> signs are required to be conspicuously posted in each area or room where the quantity of radioactive material exceeds the following quantities.

MOST COMMONLY USED RADIOISOTOPES

C-14	1,000 μCi	(= 1 mCi)
H-3	10,000 μCi	(= 10 mCi)
I-125	10 μCi	
P-32	100 μCi	
S-35	1,000 μCi	(= 1 mCi)

SOME OTHER ISOTOPES

Ca-45	100 μCi
Hg-203	100 μCi
Se-75	100 μCi
Zn-65	100 μCi

<u>CAUTION</u> <u>RADIOACTIVE</u> <u>MATERIAL</u> labels including additional information such as activity and date are required on containers of radioactive material where the quantity of radioactive material exceeds the following:

C-14	100 μCi	
H-3	1,000 μCi	(= 1 mCi)
I-125	1 μCi	
P-32	10 μCi	
S-35	100 μCi	

REQUIREMENTS FOR AREAS CONTAINING RADIOACTIVE MATERIALS AND/OR RADIATION LEVELS

RESTRICTED AREAS

"Any area access to which is controlled ...for the purpose of protection of individuals from exposure to radiation or radioactive materials."

An area where an individual <u>could</u> receive a dose of 2 milliRem in one hour or 100 milliRem in seven consecutive days must be restricted.

RADIATION AREAS

Any area accessible to personnel such that a major portion of the body could receive 5 milliRem in one hour or 100 milliRem in five consecutive days.

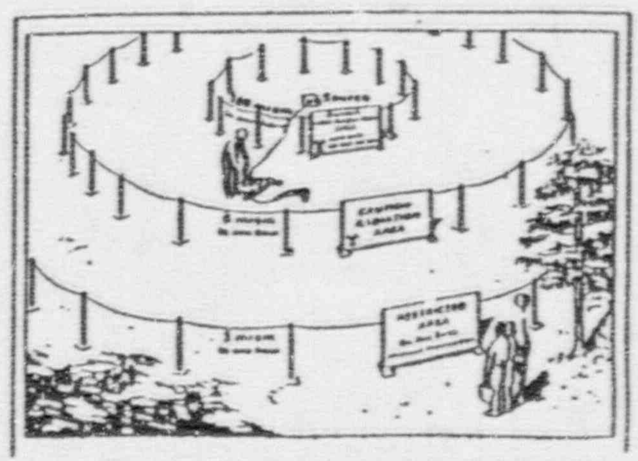
All radiation areas must be conspicuously posted with CAUTION--RADIATION AREA signs

HIGH RADIATION AREAS

Any area accessible to personnel such that a major portion of the body could receive 100 milliRem in one hour.

A combination of warning signs, access control devices, alarms, etc., are required.

Exposure Control



DECONTAMINATION PROCEDURES

A. Contamination of the Skin

Thorough washing with soap and water is the best general method for decontamination of the hands and other parts of the body, regardless of the contaminant. If the contamination is localized, it is often more practical to mask off the affected area and cleanse with swabs, before risking the danger of spreading the contaminant by general washing.

Do not use decontamination methods which will spread localized material or increase penetration of the contaminant into the body. Therefore avoid abrasion of the skin or organic solvents, which may increase skin penetration. Do not use highly alkaline soaps which may result in fixation of the contaminant.

The recommended procedures for intact skin are as follows:

1. Wet hands and apply mild soap or detergent.
2. Work up a good lather; keep lather wet.
3. Work lather into contaminated skin by rubbing gently for at least three minutes. Apply water frequently.
4. Rinse thoroughly with lukewarm water, limiting water to contaminanted areas.
5. Repeat several times, gently scrubbing residual contaminated areas with a soft brush, if necessary.
6. If the hands have been contaminated, give special attention to the areas between the fingers and around the fingernails.
7. If contamination still exists after the above procedures, the RSO will recommend more powerful decontamination procedures.

B. Contamination of Laboratory Surfaces

Personnel should wear protective clothing, footwear, goggles, and respirators, as appropriate. Normal cleaning agents are usually adequate. One procedure for decontamination suggests that the cleaning personnel start from the outermost edges of the contaminated area and work inwards, reducing systematically the contaminated area. All contaminated cleaning supplies and waste water should be disposed of as radioactive waste immediately to prevent the spread of contamination. A person equipped with a survey meter should follow the cleaning work and watch for the accidental spread of contamination.

DO'S AND DONT'S FOR FILM BADGE WEARERS

DO'S

1. Wear film badge when working.
2. Wear film badge only during the month indicated on the film badge.
3. Change film badge insert every month.
4. Report the loss or damage of a film badge to RSO.
5. Keep film badge dry.

DONT'S

1. Don't wear film badge while being exposed to x-rays for personal medical purposes (chest films, dental x-ray examination, etc.).
2. Don't leave film badge at home when you come to work. There is no reason to take your film badge home. Leave film badge in wall board when not working or in a radiation and heat free area.
3. Don't tear paper covering of film badge insert or mark on film badge with any implement. Do not tack badge to any boards.
4. Don't lose your film badge. There is a fine charged to your department.
5. Don't let your film badge go through the laundry.
6. Don't leave film badge in radiographic room when it is not being worn.
7. Don't wear film badge in such a manner that radiation striking it does not strike you or vice versa, e.g., do not wear badge on outside of lead apron. Wear under lead apron to record radiation striking body at waist level during fluoroscopy.
8. Don't write on parts on your film badge.
9. Don't let others use your film badge.

PART 19 NOTICES, INSTRUCTIONS, AND REPORTS TO WORKERS; INSPECTIONS

[53 FR 31651]

Authority: Secs. 53, 63, 81, 103, 104, 161, 186, 68 Stat. 930, 933, 935, 936, 937, 948, 955, as amended, sec. 234, 83 Stat. 444, as amended (42 U.S.C. 2073, 2093, 2111, 2133, 2134, 2201, 2236, 2282); sec. 201, 88 Stat. 1242, as amended (42 U.S.C. 5841), Pub. L. 95-601, sec. 10, 92 Stat. 2951 (42 U.S.C. 5851).

For the purposes of sec. 223, 68 Stat. 958, as amended (42 U.S.C. 2273); §§ 19.11(a), (c), (d), and (e) and 19.12 are issued under sec. 161b, 68 Stat. 948, as amended (42 U.S.C. 2201(b)); and §§ 1 nd 19.14(a) are issued under sec. 161o tat. 950, as amended (42 U.S.C. 2201(o)).

[40 FR 8774]

§ 19.1 Purpose.

The regulations in this part establish requirements for notices, instructions, and reports by licensees to individuals participating in licensed activities, and options available to such individuals in connection with Commission inspections of licensees to ascertain compliance with the provisions of the Atomic Energy Act of 1954, as amended, Title II of the Energy Reorganization Act of 1974, and regulations, orders, and licenses thereunder regarding radiological working conditions.

[53 FR 31651]

§ 19.2 Scope.

The regulations in this part apply to all persons who receive, possess, use, or transfer material licensed by the Nuclear Regulatory Commission pursuant to the regulations in Parts 30 through 35, 39, 40, 60, 61, 70, or 72 of this chapter, including persons licensed to operate a production or utilization facility pursuant to Part 50 of this chapter.

[38 FR 22217]

§ 19.3 Definitions.

As used in this part:

(a) "Act" means the Atomic Energy Act of 1954, (68 Stat. 919) including any amendments thereto;

(b) "Commission" means the United States Nuclear Regulatory Commission;

(c) "Worker" means an individual engaged in activities licensed by the Commission and controlled by a licensee, but does not include the licensee.

[53 FR 31651]

(d) "License" means a license issued under the regulations in Parts 30 through 35, 39, 40, 60, 61, 70, or 72 of this chapter, including licenses to operate a production or utilization facility pursuant to Part 50 of this chapter. "Licensee" means the holder of such a license.

[38 FR 22217]

(e) "Restricted area" means any area access to which is controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials. "Restricted area" shall not include any areas used as residential quarters, although a separate room or rooms in a residential building may be set apart as a restricted area.

§ 19.4 Interpretations.

Except as specifically authorized by the Commission in writing, no interpretation of the meaning of the regulations in this part by any officer or employee of the Commission other than a written interpretation by the General Counsel will be recognized to be binding upon the Commission.

[53 FR 43419]

§ 19.5 Communications.

Except where otherwise specified in this part, all communications and reports concerning the regulations in this part should be addressed to the Regional Administrator of the appropriate U.S. Nuclear Regulatory Commission Regional Office listed in Appendix D of Part 2 this chapter. Communications, repo s, and applications may be delivered in person at the Commission's offices at 2120 L Street NW., Washington, DC, or at 11555 Rockville Pike, Rockville, Maryland.

[49 FR 19623]

§ 19.8 Information collection requirements: OMB approval.

(a) The Nuclear Regulatory Commission has submitted the information collection requirements contained in this part to the ffice of Management and Budg B) for approval as required Paperwork Reduction Act of 1980 (44 U.S.C. 3501 et seq.). OMB has approved the information collection requirements contained in this part under control number 3150–0044.

(b) The approved information collection requirements contained in this part appear in § 19.13.

[38 FR 22217]

§ 19.11 Posting of notices to workers.

(a) Each licensee shall post current copies of the following documents: (1) The regulations in this part and in Part 20 of this chapter; (2) the license, license conditions, or documents incorporated into a license by reference, and amendments thereto; (3) the operating procedures applicable to licensed activities; (4) any notice of violation involving radiological working conditions, proposed imposition of civil penalty, or order issued pursuant to Subpart B of Part 2 of this chapter, and any response from the licensee.

(b) If posting of a document specified in paragraph (a) (1), (2) or (3) of this section is not practicable, the licensee may post a notice which describes the document and states where it may be examined.

[47 FR 30452]

(c) Each licensee and applicant shall post Form NRC–3, (Revision 6–82 or later) "Notice to Employees," as required by Parts 30, 40, 50, 60, 70, 72, and 150 of this chapter.

Note: Copies of Form NRC–3 may be obtained by writing to the Regional Administrator of the appropriate U.S. Nuclear Regulatory Commission Regional Office listed in Appendix D of Part 20 of this chapter.

[38 FR 22217]

(d) Documents, notices, or forms posted pursuant to this section shall appear in a sufficient number of places to permit individuals engaged in licensed activities to observe them on the way to or from any particular licensed activity location to which the document applies, shall be conspicuous, and shall be replaced if defaced or altered.

(e) Commission documents posted pursuant to paragraph (a)(4) of this section shall be posted within 2 working days after receipt of the documents from the Commission; the licensee's response, if any, shall be posted within 2 working days after dispatch by the licensee. Such documents shall remain posted for a minimum of 5 working days or until action correcting the violation has been completed, whichever is later.

§ 19.12 Instructions to workers.

All individuals working in or frequenting any portion of a restricted area shall be kept informed of the storage, transfer, or use of radioactive materials or of radiation in such portions of the restricted area; shall be instructed in the health protection problems associated with exposure to such radioactive materials or radiation, in precautions or procedures to minimize exposure, and in the purposes and functions of protective devices employed; shall be instructed in, and instructed to observe, to the extent within the worker's control, the applicable provisions of Commission regulations and licenses for the protection of personnel from exposures to radiation or radioactive materials occurring in such areas; shall be instructed of their responsibility to report promptly to the licensee any condition which may lead to or cause a violation of Commission regulations and licenses or unnecessary exposure to radiation or to radioactive material; shall be instructed in the appropriate response to warnings made in the event of any unusual occurrence or malfunction that may involve exposure to radiation or radioactive material; and shall be advised as to the radiation exposure reports which workers may request pursuant to § 19.13. The extent of these instructions shall be commensurate with potential radiological health protection problems in the restricted area.

§ 19.13 Notifications and reports to individuals.

(a) Radiation exposure data for an individual, and the results of any measurements, analyses, and calculations of radioactive material deposited or retained in the body of an individual, shall be reported to the individual as specified in this section. The information reported shall include data and results obtained pursuant to Commission regulations, orders or license conditions, as shown in records maintained by the licensee pursuant to Commission regulations. Each notification and report shall: be in writing; include appropriate identifying data such as the name of the licensee, the name of the individual, the individual's social security number; include the individual's exposure information; and contain the following statement:

This report is furnished to you under the provisions of the Nuclear Regulatory Commission regulation 10 CFR Part 19. You should preserve this report for further reference.

[38 FR 22217]

(b) At the request of any worker, each licensee shall advise such worker annually of the worker's exposure to radiation or radioactive material as shown in records maintained by the licensee pursuant to § 20.401(a) and (c).

(c) At the request of a worker formerly engaged in licensed activities controlled by the licensee, each licensee shall furnish to the worker a report of the worker's exposure to radiation or radioactive material. Such report shall be furnished within 30 days from the time the request is made, or within 30 days after the exposure of the individual has been determined by the licensee, whichever is later; shall cover, within the period of time specified in the request, each calendar quarter in which the worker's activities involved exposure to radiation from radioactive materials licensed by the Commission; and shall include the dates and locations of licensed activities in which the worker participated during this period.

(d) When a licensee is required pursuant to § 20.405 or § 20.408 of this chapter to report to the Commission any exposure of an individual to radiation or radioactive material the licensee shall also provide the individual a report on his exposure data included therein. Such report shall be transmitted at a time not later than the transmittal to the Commission.

[38 FR 22217]

(e) At the request of a worker who is terminating employment in a given calendar quarter with the licensee in work involving radiation dose, or of a worker who, while employed by another person, is terminating assignment to work involving radiation dose in the licensee's facility in that calendar quarter, each licensee shall provide to each such worker, or to the worker's designee, at termination, a written report regarding the radiation dose received by that worker from operations of the licensee during that specifically identified calendar quarter or fraction thereof, or provide a written estimate of that dose if the finally determined personnel monitoring results are not available at that time. Estimated doses shall be clearly indicated as such.

[44 FR 32352]

§ 19.14 Presence of representatives of licensees and workers during inspections.

(a) Each licensee shall afford to the Commission at all reasonable times opportunity to inspect materials, activities, facilities, premises, and records pursuant to the regulations in this chapter.

(b) During an inspection, Commission inspectors may consult privately with workers as specified in § 19.15. The licensee or licensee's representative may accompany Commission inspectors during other phases of an inspection.

(c) If, at the time of inspection, an individual has been authorized by the workers to represent them during Commission inspections, the licensee shall notify the inspectors of such authorization and shall give the workers' representative an opportunity to accompany the inspectors during the inspection of physical working conditions.

[38 FR 22217]

(d) Each workers' representative shall be routinely engaged in licensed activities under control of the licensee and shall have received instructions as specified in § 19.12.

(e) Different representatives of licensees and workers may accompany the inspectors during different phases of an inspection if there is no resulting interference with the conduct of the inspection. However, only one workers' representative at a time may accompany the inspectors.

(f) With the approval of the licensee and the workers' representative an individual who is not routinely engaged in licensed activities under control of the license, for example, a consultant to the licensee or to the workers' representative, shall be afforded the opportunity to accompany Commission inspectors during the inspection of physical working conditions.

(g) Notwithstanding the other provisions of this section, Commission inspectors are authorized to refuse to permit accompaniment by any individual who deliberately interferes with a fair and orderly inspection. With regard to areas containing information classified by an agency of the U.S. Government in the interest of national security, an individual who accompanies an inspector may have access to such information only if authorized to do so. With regard to any area containing proprietary information, the workers' representative for that area shall be an individual previously authorized by the licensee to enter that area.

§ 19.15 Consultation with workers during inspections.

(a) Commission inspectors may consult privately with workers concerning matters of occupational radiation protection and other matters related to applicable provisions of Commission regulations and licenses to the extent the inspectors deem necessary for the conduct of an effective and thorough inspection.

(b) During the course of an inspection any worker may bring privately to the attention of the inspectors, either orally or in writing, any past or present condition which he has reason to believe may have contributed to or caused any violation of the act, the regulations in this chapter, or license condition, or any unnecessary exposure of an individual to radiation from licensed radioactive material under the licensee's control. Any such notice in writing shall comply with the requirements of § 19.16(a).

[38 FR 22217]

(c) The provisions of paragraph (b) of this section shall not be interpreted as authorization to disregard instructions pursuant to § 19.12.

§ 19.16 Requests by workers for inspections.

(a) Any worker or representative of workers who believes that a violation of the Act, the regulations in this chapter, or license conditions exists or has occurred in license activities with regard to radiological working conditions in which the worker is engaged, may request an inspection by giving notice of the alleged violation to the Director of the appropriate Commission Regional Office, or to Commission inspectors. Any such notice shall be in writing, shall set forth the specific grounds for the notice, and shall be signed by the worker or representative of workers. A copy shall be provided the licensee by the Regional Office Director, or the inspector no later than at the time of inspection except that, upon the request of the worker giving such notice, his name and the name of individuals referred to therein shall not appear in such copy or on any record published, released, or made available by the Commission, except for good cause shown.

(b) If, upon receipt of such notice, the Regional Office Director determines that the complaint meets the requirements set forth in paragraph (a) of this section, and that there are reasonable grounds to believe that the alleged violation exists or has occurred, he shall cause an inspection to be made as soon as practicable, to determine if such alleged violation exists or has occurred. Inspections pursuant to this section need not be limited to matters referred to in the complaint.

[52 FR 31601]

§ 19.17 Inspections not warranted; informal review.

(a) If the appropriate Regional Office determines, with respect to a complaint under § 19.16, that an inspection is not warranted because there are no reasonable grounds to believe that a violation exists or has occurred, he shall notify the complainant in writing of such determination. The complainant may obtain review of such determination by submitting a written statement of position with the Executive Director for Operations, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, who will provide the licensee with a copy of such statement by certified mail, excluding, at the request of the complainant, the name of the complainant. The licensee may submit an opposing written statement of position with the Executive Director for Operations who will provide the complainant with a copy of such statement by certified mail. Upon the request of the complainant, the Executive Director for Operations or his designee may hold an informal conference in which the complainant and the licensee may orally present their views. An informal conference may also be held at the request of the licensee, but disclosure of the identity of the complainant will be made only following receipt of written authorization from the complainant. After considering all written and oral views presented, the Executive Director for Operations shall affirm, modify, or reverse the determination of the appropriate Regional Office and furnish the complainant and the licensee a written notification of his decision and the reason therefor.

(b) If the appropriate Regional Office determines that an inspection is not warranted because the requirements of § 19.16(a) have not been met, he shall notify the complainant in writing of such determination. Such determination shall be without prejudice to the filing of a new complaint meeting the requirements of § 19.16(a).

52 FR 31601

§ 19.20 Employee protection.

Employment discrimination by a licensee or a contractor or subcontractor of a licensee against an employee for engaging in protected activities under this part or Parts 30, 40, 50, 60, 70, 72, or 150 of this chapter is prohibited.

47 FR 30452

§ 19.30 Violations.

An injunction or other court order may be obtained prohibiting any violation of any provision of the Act or Title II of the Energy Reorganization Act of 1974, or any regulation or order issued thereunder.

40 FR 8774

A court order may be obtained for the payment of a civil penalty imposed pursuant to section 234 of the Act for violation of section 53, 57, 62, 63, 81, 82, 101, 103, 104, 107, or 109 of the Act or any rule, regulation, or order issued thereunder, or any term, condition or limitation of any license issued thereunder, or for any violation for which a license may be revoked under section 186 of the Act. Any person who willfully violates any provision of the Act or any regulation or order issued thereunder may be guilty of a crime and, upon conviction, may be punished by fine or imprisonment or both, as provided by law.

§ 19.31 Application for exemptions.

The Commission may, upon application by any licensee or upon its own initiative, grant such exemptions from the requirements of the regulations in this part as it determines are authorized by law and will not result in undue hazard to life or property.

38 FR 22217

§ 19.32 Discrimination prohibited.

No person shall on the ground of sex be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity licensed by the Nuclear Regulatory Commission. This provision will be enforced through agency provisions and rules similar to those already established, with respect to racial and other discrimination, under title VI of the Civil Rights Act of 1964. This remedy is not exclusive, however, and will not prejudice or cut off any other legal remedies available to a discriminatee.

40 FR 8774

PACKAGING PROCEDURES FOR RADIOACTIVE WASTE

I.0 GENERAL

I.1 Categories of Radioactive Waste:

There are three disposal facilities being used and the categories for each are listed below:

I.1.1 BURIAL AT RICHLAND, WASHINGTON

1. (DMR) Dry Material destined for Richland
2. (DCR) Dry Compactibles destined for Richland
3. (SVR) Small Volume liquids destined for Richland
4. (LVR) Large Volume liquids destined for Richland
5. (ACR) Animal Carcasses or biological waste destined for Richland

I.1.2 PROCESSING AT QUADREX HPS, GAINESVILLE, FLORIDA

1. (VXN) Scintillation Vials - NRC exempt - Non RCRA regulated
2. (VRN) Scintillation Vials - NRC regulated - Non RCRA regulated
3. (VXR) Scintillation Vials - NRC exempt and RCRA regulated
4. (VRR) Scintillation Vials - NRC regulated and RCRA regulated

I.1.3 PROCESSING AT SCIENTIFIC ECOLOGY GROUP, OAK RIDGE, TENNESSEE

1. (DMS) Dry solid Material destined for S.E.G.
2. (DCS) Dry solid Compactible destined for S.E.G.
3. (SVS) Small Volume liquid destined for S.E.G.

I.2 Items in different categories cannot be mixed in any one container unless specifically authorized.

1.3 The packaging procedure that is used is to be marked on the drum (e.g. DMR-8/87).

I.4 Transuranic and radium waste in excess of 10 nanocuries per gram is not acceptable unless specifically authorized.

I.5 Gaseous waste must meet certain provisions. Please see the burial site's license for details or call the Radiological Services Department Office.

I.6 Special Nuclear Material requires specific approval and will be accepted only upon special request to the Radiological Services Department Office.

I.7 DO NOT EXCEED THE FOLLOWING WEIGHTS UNLESS SPECIFICALLY AUTHORIZED:

5 gallon container - 80 lbs.
30 gallon container - 300 lbs.
55 gallon container - 480 lbs.

TELEDYNE ISOTOPES

I.8 CHEMICAL TOXICITY:

The chemical composition of the materials disposed must be compatible with the procedures which follow. Any additional hazards of the material must be evaluated to determine if additional packaging is required. If materials are listed in N. Irving Sax's "Dangerous Properties of Industrial Materials", Fifth Edition, Van Nostrand Reinhold, as having a THR=HIGH via any route, except IP or IV, specific approval must be obtained from the State of Washington Radiation Control Program. Contact the Radiological Services Department for details.

I.9 PROHIBITIONS

I.9.1 Burial Prohibitions:

Lead and other U.S. EPA hazardous wastes are prohibited from land burial at the current radioactive waste disposal sites. Please ensure there are no Resource Conservation and Recovery Act (RCRA) wastes in your radioactive waste streams.

I.9.2 Scintillation Vial Processing:

Only those isotopes listed in the Quadrex license are allowed for processing. In addition, strict control must be held over the packaging of scintillation vials. No other wastes of any kind are allowed in these containers.

I.10 Special Notes

Two 2 ml liners may be used in place of a single 4 ml liner.

Instead of lining the whole drum, individual 4 ml (or double 2-ml) bags may be substituted, provided each bag is layered as below.

For a list of approved absorbants for use with waste destined for Richland, please see the US Ecology license.

When layering, the absorbant must be the first layer on the bottom and the last layer on the top. Proper volume ratios must be determined by the generator to be used for the different absorbants.

The amount of absorbant must be capable of absorbing twice the amount of liquid present.

I.11 VOIDS - All voids in the containers must be filled to the extent practicable.

II.0 WASTE FOR BURIAL AT US ECOLOGY, RICHLAND, WASHINGTON

II.1 DRY SOLID MATERIAL FOR BURIAL AT RICHLAND, WASHINGTON (DMR-8/87)

II.1.1 Select a 5, 30 or 55-gallon drum.

II.1.2 Fill to capacity with only dry solid materials.

II.1.3 Fill in any voids to the extent practical.

II.1.4 Secure drum cover.

II.1.5 Label drum DMR-8/87, to designate that the drum has been packaged according to these directions.

II.2 DRY SOLID COMPACTIBLES FOR BURIAL AT RICHLAND, WASHINGTON (DCR-8/87)

II.2.1 Select a 30 or 55 gallon container.

II.2.2 Place waste into double 4 mil plastic liners. (Note: For 55 gallon drums, use two sets of double 4 mil bags, each set approximately 27 gallons. If heavy materials are used, please use additional double 4 mil liners and decrease the quantity put into each.)

II.2.3 Twist and seal liners.

II.2.4 Place double 4 mil bags into the selected container.

II.2.5 Replace lid and ring.

II.2.6 Secure ring. DO NOT BOLT.

II.2.7 Label drum DCR-8/87 to indicate it was packaged in accordance with these instructions.

NOTE: DO NOT DISPOSE OF UNPROTECTED SHARP OBJECTS.

NOTE: DO NOT DISPOSE OF NON-COMPACTIBLE ITEMS IN THESE TYPES OF CONTAINERS.

NOTE: ONLY LOW SPECIFIC ACTIVITY MATERIAL IS ACCEPTABLE IN COMPACTIBLE DRUMS. UNDER NO CIRCUMSTANCES SHOULD SOURCES BE PLACED INTO THESE CONTAINERS.

II.3 SMALL VOLUME LIQUID WASTE DESTINED FOR RICHLAND (SVR-8/87)

These drums can contain vials which contain liquids which are acceptable for burial, and each vial must contain less than 50 ml of liquid.

Liquid should not be absorbed directly onto the absorption media (e.i. do not open vials). Any tool or device which contains free standing liquid must be considered small volume liquid waste. Please reference the definition of free standing liquid as found in US Ecology's lisense.

II.3.1 Select only a 30 or 55-gallon drum; 5-gallon pails are not allowed.

II.3.2 Line the drum with 4 ml thick poly liner.

II.3.3 Using an approved absorbant, alternate layers of absorbant with layers of waste.

II.3.4 Twist and seal liner.

II.3.5 Secure drum cover.

II.3.6 Label drum SVR-8/87, to designate that the drum has been packaged according to these instructions.

II.3.7 Special Note: Toluene, Xylene and other flammable liquids in scintillation vials will not be accepted for burial. They must be packaged for reprocessing and meet the reprocessor's license criteria.

I.4 LARGE VOLUME LIQUID WASTE DESTINED FOR RICHLAND (LVR-8/87)

All items containing 50 ml or more of an aqueous liquid may not be disposed in SVR or SVS drums. The liquid must be packaged as follows while the container itself must be either (1) dried and placed in a DMR, DCR, DMS or DCS drum or (2) placed in an SVR or SVS drum once the bulk of the liquid is removed.

II.4.1 Select only the 55-gallon double-walled container for liquid waste.

II.4.2 Remove the 55-gallon drum cover.

II.4.3 Loosen and remove the bung from the 30-gallon drum which has been filled with an approved absorbant.

II.4.4 Pour up to 10 gallons of liquid (pH-6.0 - 9.0) into the absorbant in the 30-gallon drum through the 2-1/2" opening.

II.4.5 Replace bung and tighten.

II.4.6 Twist and seal poly liner.

II.4.7 Secure cover of 55-gallon drum.

II.4.8 Label drum LVR-(8/87) to designate that the drum has been packaged according to these instructions.

II.4.9 SPECIAL NOTE:

Toluene or Xylene and other liquids unacceptable at the burial site cannot be absorbed.

II.5 ANIMAL CARCASSES OR BIOLOGICAL WASTE (ACR-8/87)

Animal carcasses or biological waste must be disposed using a double-walled container. Be sure when ordering to specify a 55-gallon double-walled container for animal carcasses.

II.5.1 Select only a 55-gallon double-walled drum.

II.5.2 Remove inner 30-gallon container and absorbant.

II.5.3 Line 30-gallon drum with 4 ml poly liner. See Section I.10.

II.5.4 Package waste into liner using at least one part slaked lime for every 10 parts of an approved absorbant. Fill completely.

II.5.5 Twist and seal liner.

II.5.6 Seal 30-gallon drum.

II.5.7 Place 30-gallon drum into 55-gallon drum.

II.5.8 Place absorbant around and covering 30-gallon drum.

II.5.9 Secure 55-gallon drum cover.

II.5.10 Label drum ACR-8/87 to designate that drum has been packaged according to these instructions.

III.0 RADIOACTIVE WASTE FOR PROCESSING AT S.E.G., OAK RIDGE, TENNESSEE

III.1 DRY SOLID MATERIAL DESTINED FOR S.E.G. (DMS-8/87)

III.1.1 See the procedure for DMR and follow exactly, except for labelling the container DMS-8/87, however, only Class A unstable materials are acceptable. Please see the S.E.G. license for further details on acceptable materials.

III.2 DRY SOLID COMPACTIBLE DESTINED FOR S.E.G. (DCS-8/87)

III.2.1 See the procedure for DCR and follow exactly, except for labelling the container DCS-8/87, however, only Class A unstable materials are acceptable. Please see the S.E.G. license for further details on acceptable materials.

III.3 SMALL VOLUME LIQUIDS DESTINED FOR S.E.G. (SVS-8/87)

III.3.1 See the procedure for SVR and follow exactly, except for labelling the container SVS-8/87.

III.3.2 The liquids present must be strictly incidental. A couple of examples of incidental liquids are:
a) A drop in the end of a pipette
b) A couple of milliliters in the bottom of a vial
c) Moisture on the sides of a beaker.

III.3.3 Use the absorbant sparingly.

SPECIAL NOTE: In the SVS drum you may mix other dry waste which would be suitable for either the DMS or DCS container. You do not have to segregate these three types as long as the drum is classified as an SVS-8/87.

IV.0 SCINTILLATION VIAL WASTE FOR REPROCESSING AT QUADREX, GAINESVILLE, FLORIDA, (VXN, VRN, VXR, VRR)

These drums may contain scintillation vials which contain Toluene or Xylene or any other flammable scintillation media acceptable according to Quadrex's License No. 1354-1 (State of Florida, Department of Health & Rehabilitative Services).

All drums to Quadrex are packaged identically using the procedure below, however, the labelling and manifesting are specific to the classification selected. The generator is responsible for identifying the isotopes, concentrations and chemical forms of the waste material.

IV.1 Select only a 30 or 55-gallon drum.

IV.2 Line the drum with 4 ml thick poly liner.

IV.3 Add 12 inches of an approved absorbant.

IV.4 Line drum again with another 4 ml thick poly liner.

IV.5 Fill with vials or other containers of less than one pint capacity. NOTE: With one pint containers, add absorbant to suitably cushion these to prevent breakage.

IV.6 Twist and seal liners.

IV.7 Top off the drum with additional absorbant.

IV.8 Secure drum cover.

IV.9 Label drum with the appropriate designation for the descriptions below.

V.10 Classification of Scintillation Vial Drums

As you know, there are many different types of scintillation fluids being used by the industry. The major difference between these fluids is their flashpoint. The state your facility is in may, or may not, regulate these fluids as hazardous waste. Although we have been and will continue to help identify when and where the RCRA regulations apply, it is the generator's responsibility under RCRA regulations to determine if his waste stream is a Hazardous Waste.

"<u>V</u>" - For marking purposes, all scintillation vial drums will have a first charcter of "V".

"<u>X</u>" or "<u>R</u>" - The second character will be either an "X" or an "R". If the drum contains only H-3/C-14 in less than 0.05 uCi/gram concentrations it is an "X". If the drum contains H-3/C-14 as above <u>plus</u> other isotopes listed in Quadrex's license, then it is an NRC "R"egulated material and would be an "R".

"<u>N</u>" or "<u>R</u>" - The third character indicates whether the drum is US EPA RCRA "R"egulated or "N"ot regulated. This classification is simple for those who use a high (greater than 140°F) flashpoint cocktail as these fluids are "N"ot RCRA regulated. If you have a cocktail with a lower flashpoint, the material may, or may not be, "R"egulated. This depends on each state. As the states are currently changing their positions rapidly, we have not included a listing from these procedures. Please call for further information.

For Further Reference

1. Shapiro, Jacob. Radiation Protection: A Guide for Scientists and Physicians, Cambridge, Ma: Harvard University Press, 1990.

2. Casarett, Alison P. Radiation Biology. Englewood Cliffs, NJ: Prentice Hall, Inc., 1968

3. Wang, C.H. and Willis, D.L. Radiotracer Methodology in Biological Science. Englewood Cliffs, NJ: Prentice Hall, Inc., 1965.

4. Cember, Herman. Introduction to Health Physics. Oxford: Pergamon Press. 2nd Edition, 1983.

5. Knoll, Glenn F. Radiation Detection and Measurement. New York: John Wiley & Sons, Inc., 1989.

6. Radiological Health Handbook. edited by the Bureau of Radiological Health of the Department of Health, Education and Welfare. Washington, DC: Government Printing Office. 1970.

7. Wang, Y. (ed). CRC Handbook of Radioactive Nuclides. Cleveland: The Chemical Rubber Co., 1969.

8. National Council on Radiation Protection (NCRP) reports. NCRP Publications, P.O. Box 30175, Washington, DC 20014.

APPENDIX G.2

The following forms are examples of the Radiation Safety Forms which Envirogen will employ as part of its Radiation Safety Program.

EMERGENCY NOTIFICATION

In the case of emergency, please notify the Lawrenceville police and fire departments at 609-896-1111.

In the case of after hours emergency, please contact one of the following Envirogen personnel:

Janet Klass	609-520-1410
Dr. R. Unterman	609-737-6727
Dr. B. Ensley	215-321-3292

If none of the above Envirogen personnel are available please contact Dr. E. Christman at 609-937-5274.

Instructions for Completing Forms #1, #1a

1. Form #1 (Personnel Data and Exposure History)

   (a) Print legibly or type

   (b) Fill out completely and sign.

   (c) Special name instructions:

      (1) If you have no middle name or initial, indicate by "(NMI)."

      (2) If you "go by" or "use" your middle name instead of your given first name, circle your middle name.

2. Form #1a (Source of Radiation Exposure)

   (a) Complete as indicated and sign.

August, 1990

Form #1 PERSONNEL DATA AND EXPOSURE HISTORY

PLEASE PRINT DATE ________________

FULL NAME ________________________________ BIRTH DATE ___/___/___
(last,first,middle)

SOCIAL SECURITY NO. __________________________ SEX _______

POSITION _________________________________ DATE EMPLOYED _______________.

MAILING ADDRESS ____

IF YOU ARE EMPLOYED BY ANOTHER ORGANIZATION, PLEASE INDICATE:

---

1. Have you previously had regular film badge service at Envirogen?

No_____ Yes_____ Approximate Dates ___________________

2. Have you ever worn an Envirogen visitor badge?

No _____ Yes ______ Approximate Dates ___________________________

3. Have you ever received any high or unusual radiation exposure?

No _____ Yes ______

4. Have you ever inhaled, ingested, or been injected with any radioactive material?

No _____ Yes _____

5. Have you ever been tested for internally deposited radioisotopes by urine or fecal analysis or by whole body counting?

No _____ Yes _____

If "Yes" to questions #3, #4, and/or #5, please explain:

6. Have you received any occupational radiation dose during the current calendar quarter* from sources not under Envirogen control?

No _____ Yes _____

If "Yes", please indicate amount and nature of any dose received during period:

*Calendar quarters are: 1/1-3/31, 4/1-6/30, 7/1-9/30, or 10/1-12/31.

Form #1A

7. Have you previously worked with radioisotopes?

No ____ Yes _____

If "Yes", please indicate when, where, and identify the isotopes and typical amounts used:

8. Have you ever been monitored for an occupational radiation exposure?

No ____ Yes _____

If "Yes", to questions #6, #7, and/or #8, please provide the following additional information:

Previous employer's name and address	Department/ Supervisor	Dates of Employment	Periods of Exposure

If exposure was received in the military, please provide the requested additional information:

Discharge Date	Rank at time of Discharge	Service Number	Reserve Status

Certification: I certify that the exposure history given above is correct and complete to the best of my knowledge and belief.

_______________________________________ DATE ______________
(signature)

ENVIROGEN

New Solutions to Hazardous Waste Problems

3371 Route 1
Suite 203
Lawrenceville, New Jersey 08648

Tel. 609-452-1038
Fax: 609-452-1632

ISOTOPE SHIPMENT FORM

Vial Inventory #:

Purchase Order #:

Reference Date:

Isotope:

Form:

Qty (uCi):

Received by:

Date Received:

Survey meter and #:

Counts per minute:

Comments:

ISOTOPE INVENTORY FORM

Isotope
Form
Qty (uCi)

Vial Inv #
Ref Date

		Usage (uCi)		Disposal (uCi)					
User	Date	Amount Used	Amount Left	Dry	Small Vol Liq	Liquid	Scint. Vials	Drain	Total Disp.

RADIONUCLIDE LABORATORY SURVEY LOG

DATE	TIME	SURVEYOR'S NAME	ISOTOPE USED	SURVEY TYPE		SURVEY RESULTS IN CPM & COMMENTS DO NOT USE "OK" OR "BACKGROUND"	SURVEY METER USED: MFG., MOD & S/N AND PROBE TYPE
				PERSONAL	WORK AREA		

This survey record must be kept for two years from the date of the last survey entered on the page.

SURVEY FORM

CONTAMINATION REPORT: WIPE METHOD

Date: ____________________

Surveyor: ________________________________

Location Designation	Level of Spill- dpm	Decontamination Method	Initials	After Spill- dpm

This record MUST be completed when adding radioactive waste to this container.

Department ______________________________

Principal Investigator ______________________________

This container may be used ONLY for:

DRY, SOLID WASTE - COMPACTIBLE
(No unprotected, sharp objects.)

Date	Isotope	Amount		Initials
			Circle unit of activity: mCi	
	TOTAL:			

This record MUST be completed when adding radioactive waste to this container.

Department ________________________________

Principal Investigator ________________________

This container may be used ONLY for:

SOLID WASTE WITH INCIDENTAL LIQUID*
(Absorbent materials, pipette tips, etc.)

Date	Isotope	Amount	Circle unit of activity: mCi	Initials
	TOTAL:			

*No vials of standing liquid.

This record MUST be completed when adding radioactive waste to this container

Department ______________________________

Principal Investigator ______________________________

This container may be used ONLY for:

LARGE VOLUME LIQUIDS*

Date	Isotope	Amount	Circle unit of activity: μCi mCi	Volume (ml)	Initials
TOTAL:					

*One liter may be added to four liters of absorbent.

This record MUST be completed when adding radioactive waste to this container

Department ________________________________

Principal Investigator ________________________________

This container may be used ONLY for:

LIQUID SCINTILLATION VIALS*

Date	Isotope	Activity (µCi)	Initials	L.S. Solution (Toluene, etc.)

TOTAL: ________ NRC Reg. yes [] no []
RCRA Reg. yes [] no []

*C-14 and H-3 may not exceed 0.05 µCi/gm.

APPENDIX H

GLOSSARY

Authoree - one who is authorized by Rutgers to use specific sources of radiation, and who has primary responsibility for the radiation safety associated with the use of sources of radiation.

Ionizing Radiation - Electromagnetic or corpuscular radiation capable of producing ions directly or indirectly in its passage through matter (e.g., alpha particles, beta particles, gamma or X-rays, neutrons).

rad - the traditional unit of absorbed dose.
1 rad = 100 erg/gm
The quantity of radiation absorbed per unit mass of any material.
The S.I. unit is the Gray (Gy) = 1 Joule/kg = 100 rads.

Radiation - any ionizing or non-ionizing electromagnetic or particulate radiation.

Radiation Emergency - an unforeseen combination of circumstances involving use of sources of radiation which calls for immediate action. This includes contamination of people or property, unnecessary exposure to radiation, and release of radioactive material into the air.

Radioactivity (activity) - the spontaneous disintegration of unstable nuclei with the resulting emission of nuclear radiation.

Curie (Ci) - the traditional unit for measuring radioactivity
= 3.7×10^{10} disintegrations per second (dps)

Becquerel (Bq) - the S.I. unit for radioactivity
= 1 disintegration per second ($1\ S^{-1}$)

Prefixes:

Pico (p)	= 1/1,000,000,000,000	or 10^{-12}	X ___.
Nano (n)	= 1/1,000,000,000	or 10^{-9}	X ___.
Micro (m)	= 1/1,000,000	or 10^{-6}	X ___.
Milli (m)	= 1/1,000	or 10^{-3}	X ___.
Kilo (k)	= 1,000	or 10^{3}	X ___.
Mega (M)	= 1,000,000	or 10^{6}	X ___.
Giga (G)	= 1,000,000,000	or 10^{9}	X ___.

Radioactivity (activity) - (continued)

Conversions:

1 Becquerel = 27 picocuries
1 microcurie = 37 kiloBecquerels

Radioisotope - used in this Guide to mean radionuclide.

rem - the traditional unit of dose equivalent.
A measure of the absorbed dose of any ionizing radiation by body tissue in terms of its estimated biological effect relative to an absorbed dose of X-rays.
The S.I. unit for the dose equivalent is the Sievert (Sv)
1 Sievert = 1 Joule/kg = 100 rem

The following are considered to be equivalent to a dose of 1 Sievert:

. An exposure of one hundred Roentgens due to X- or gamma radiation.
. A dose of one Gray due to X-, gamma, or beta radiation.
. A dose of 0.1 Gray due to neutrons or high-energy protons.
. A dose of 0.05 Gray due to particles heavier than protons and with sufficient energy to reach the lens of the eye.
. A dose of 0.05 Gray due to alpha particles deposited in body tissue.

Roentgen - the traditional unit of radiation exposure.
1 Roentgen = 2.58×10^{-4} Coulombs/kg
Exposure is defined as the quotient Q/ m where Q is the charge either sign created in a mass of air, m, by photons (gamma or X-rays) of moderate energy.

Source of Radiation - any radioisotope, X-ray producing machine, accelerator, electron microscope, or other device which emits ionizing radiation.

X-Ray Producing Machine - For the purpose of this guide, the term "X-ray producing machine" refers to X-ray machines of both the standard diagnostic and therapeutic types, X-ray diffraction units, electron microscopes, high voltage rectifiers with voltages exceeding 20 KeV and in some cases high voltage vacuum switches.