



Facility Effluent Monitoring Plan for the 325 Radiochemical Processing Laboratory

April 2001



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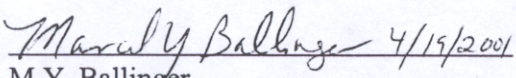


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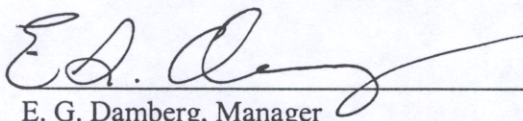
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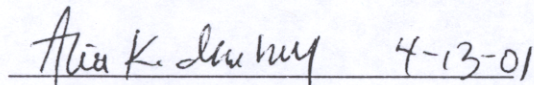
FACILITY EFFLUENT MONITORING PLAN FOR THE 325 RADIOCHEMICAL PROCESSING LABORATORY

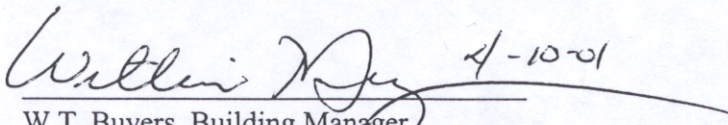
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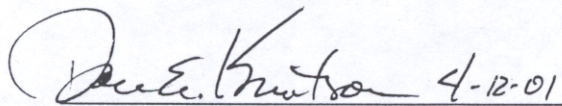

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Summary

This Facility Effluent Monitoring Plan (FEMP) has been prepared for the 325 Building Radiochemical Processing Laboratory (RPL) at the Pacific Northwest National Laboratory (PNNL) to meet the requirements in the U.S. Department of Energy (DOE) Order 5400.1, "General Environmental Protection Programs." This FEMP has been prepared for the RPL primarily because it has a "major" (potential to emit >0.1 mrem/yr) emission point for radionuclide air emissions according to the annual National Emission Standards for Hazardous Air Pollutants (NESHAP) assessment performed. This section summarizes the airborne and liquid effluents and the inventory based NESHAP assessment for the facility. The complete monitoring plan includes characterization of effluent streams, monitoring/sampling design criteria, a description of the monitoring systems and sample analysis, and quality assurance requirements.

The RPL consists of a central section containing general purpose laboratories modified for low-level radiochemical work; a south (front) wing containing office space, locker rooms, a lunch room, and maintenance shops; a high-level radiochemistry facility (325A) in the east wing; and a shielded analytical laboratory (325B) in the west wing providing shielded enclosures (hot cells) with remote manipulators for high-level radiochemical work.

Because the RPL is a research facility, the work conducted in the building is constantly changing according to programmatic needs. Current work at the facility includes analytical activities related to radioactive and hazardous waste, nuclear fuel, other areas associated with the Hanford Site characterization and remediation effort, tritium extraction and permeation tests, and medically usable radioisotopes. Work is typically divided among the two hot cell complexes, gloveboxes, fume hoods, and laboratory benches, depending on the radioactive or hazardous nature of the work.

Airborne Effluents

Potential radioactive airborne emissions in the RPL have been assessed, and all potential airborne release pathways have been identified. The primary stack at the RPL (EP-325-01-S) is currently registered with the Washington State Department of Health as required by Washington Administrative Code (WAC) 246-247 and is continuously sampled for alpha and beta emitting particulate matter as well as tritium using stack samplers that meet 40 CFR 61 criteria. Emissions of nonradioactive volatile organic compounds and toxic air pollutants have been characterized and determined to be within applicable permits and regulatory limits (PNNL-SA-32816).

Liquid Effluents

The RPL has three sewer systems: the Retention Process Sewer (RPS), the Radioactive Liquid Waste System (RLWS), and the Sanitary Sewer (SNS). All liquid effluent systems are either administratively or physically controlled. All laboratory sink and hood drains have been posted with

labels stating the type of drain and the controls for disposing of liquid effluents. All other connections, such as floor drains, in the laboratory spaces that have the potential for inadvertent release of chemicals or radioactive material to process sewers have been plugged. RPS liquid effluent lines from the facility enter into the 300 Area liquid effluent system operated by Fluor Hanford. The RPS stream is monitored by Fluor Hanford before being discharged to the 300 Area Treated Effluent Disposal Facility (TEDF) which treats the waste before ultimate release to the environment. The SNS stream is discharged into the 300 Area SNS, operated by DynCorp. The 300 Area SNS discharges to the City of Richland Publicly Owned Treatment Works (POTW) under a contract agreement between DOE and the City. Radioactive liquid waste disposed to the RLWS is collected in a tank in the basement of the building, then shipped to the 200 Area tank farms. RLWS waste is not released to the environment.

NESHAP Determination

An inventory-based method was used to estimate the maximum offsite dose from potential airborne releases in accordance with 40 CFR 61, Subpart H. The potential unmitigated dose exceeded 0.1 mrem/yr. A number of chemicals greater than Reportable Quantity in the building, as defined in 40 CFR 302, were identified. This meets both DOE-RL criteria for preparing a FEMP.

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Acronyms

ABPD	alpha-beta pseudocoincidence difference (method)
AED	aerodynamic equivalent diameter
ALARA	as low as reasonably achievable
AMAD	activity median aerodynamic diameters
ANSI	American National Standards Institute
AOP	air operating permit
BCAA	Benton Clean Air Authority
CFR	Code of Federal Regulations
CMC	Chemical Measurement Center
CMS	Chemical Management System
DEPO	Deposition computer code
DOE	U.S. Department of Energy
DOE/RL	U.S. Department of Energy/Richland Operations Office
EM	Effluent Management
EMP	environmental monitoring plan
EPA	U.S. Environmental Protection Agency
FEMP	Facility Effluent Monitoring Plan
HEPA	high-efficiency particulate air
HPGE	high purity germanium (detector)
HT	elemental tritium, diatomic hydrogen gas; (H_2 gas with 1 H as 3H)
HTO	tritiated water; (H_2O with 1 H as 3H)
HVAC	heating, ventilation, and air conditioning
MBA	material balance area
MDA	minimum detectable activity
MDL	minimum detection levels
MEI	maximally exposed individual
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NOC	notice of construction
OED	offsite emission dose
POTW	City of Richland Publicly Owned Treatment Works
PNL	Pacific Northwest Laboratory (previous name)
PNNL	Pacific Northwest National Laboratory
PS	process sewer
PTE	potential to emit
QA	quality assurance
QC	quality control
RLWS	radioactive liquid waste system
RQ	reportable quantity
RPL	Radiochemical Processing Laboratory

RPS	retention process sewer
SAR	Safety Analysis Report
SBMS	Standards Based Management System
SNM	special nuclear material
SNS	sanitary sewer system
SOP	safe (or standard) operating procedure
SOW	statement of work
TEDF	Treated Effluent Disposal Facility
TT	diatomic tritium ($^3\text{H}_2$)
WAC	Washington Administrative Code
WDOH	Washington Department of Health
WHC	Westinghouse Hanford Company

1.0 Introduction

It is the policy of the U.S. Department of Energy (DOE) to conduct its operations in an environmentally safe and sound manner and to ensure that programs are in place to ensure protection of the environment and the public. The Pacific Northwest National Laboratory (Pacific Northwest) is committed to providing a safe and healthy working environment for all staff; protecting the general public and the environment from unacceptable environmental, safety and health risks; and operating in a manner that protects and restores the environment. To implement these policies, effluent monitoring programs at Pacific Northwest must meet high standards of quality and credibility.

1.1 Purpose

DOE Order 5400.1 (DOE 1988), "General Environmental Protection Programs" states the following objective for environmental monitoring programs:

demonstrate compliance with legal and regulatory requirements imposed by applicable Federal, State, and local agencies; confirm adherence to DOE environmental protection policies; and support environmental management decisions (Section IV-1).

Plans must be prepared for each site, facility, or process that uses "significant pollutants or hazardous materials" (DOE 1988, Section, IV-2). These requirements are being met through the environmental monitoring program conducted for the Hanford Site and described by the DOE Richland Operations Office (DOE/RL) in the Hanford Site Environmental Monitoring Plan (EMP) (DOE 1997).

The EMP identifies and discusses two major activities as specified by DOE 5400.1: a) effluent monitoring, and b) environmental surveillance. Because the Hanford Site contains a number of facilities with effluent monitoring needs, individual facility effluent monitoring plans (Facility Effluent Monitoring Plans [FEMPs]) are prepared for those facilities to implement the effluent monitoring requirements. This report supplies information on effluent monitoring in the 325 Building Radiochemical Processing Laboratory (RPL). The information provided in this FEMP is current as of the time of FEMP issuance. DOE Order 5400.1 requires the EMP to be reviewed annually and updated every 3 years. Update of this FEMP will also occur on a 3 year schedule.

1.2 Scope

Characterizing the radioactive and nonradioactive constituents in inventory and in waste streams provides the underlying rationale for sampling and monitoring programs. Currently, routine sampling and monitoring compliance efforts at the RPL are confined to radioactive air emissions. Compliance assessments of the existing radioactive air sampling equipment are included in this FEMP. Compliance sampling for liquid streams from the RPL is incorporated into 300 Area compliance sampling activities

conducted by Fluor Hanford for process waste streams and DynCorp for sanitary discharges for the 300 Area, as required.

A major activity of the FEMP effort is to identify all the liquid and air release pathways (e.g., identify all access points to the various sewers and all radioactive emission release pathways) under normal operations and during process upset conditions. These are verified on as-built drawings that are maintained in PNNL's Essential Drawings System.

The method of characterization discussed in this plan identifies potential pollutants at the point of generation and potential upset conditions that are likely to occur, and evaluates the potential for those materials to enter an effluent stream.

1.3 Basis for Preparing FEMP

A FEMP was determined to be needed for the RPL because of the quantity of radionuclides and chemicals in the building. The RPL has a potential to emit (PTE) of >0.1 mrem/yr for radionuclides and has a number of chemicals in excess of their Reportable Quantity (RQ) value as defined in 40 CFR 302. This meets both DOE-RL criteria for the preparation of a FEMP. A list of radioactive material in the facility can be found in Appendix A and a list of chemicals in greater than the RQ is provided in Appendix B.

1.4 References

DOE 1988. General Environmental Protection Program, DOE 5400.1. U.S. Department of Energy Order. U.S. Department of Energy, Washington, D.C.

DOE 1997. Environmental Monitoring Plan, DOE/RL-91-50, Rev 2, United States Department of Energy, Richland Operations Office, Richland, Washington.

2.0 Facility Description

The 325 Building Radiochemical Processing Laboratory (RPL), Figure 2.1, consists of a central section containing general purpose laboratories modified for low-level radiochemical work; a south (front) wing containing office space, locker rooms, a lunch room, and maintenance shops; a high-level radiochemistry facility (325A) in the east wing; and a shielded analytical laboratory (325B) in the west wing providing shielded enclosures (hot cells) with remote manipulators for high-level radiochemical work.

Because the RPL is a research facility, the work conducted in the building is constantly changing according to programmatic needs. Current work at the facility includes analytical activities related to radioactive and hazardous waste, nuclear fuel, other areas associated with the Hanford Site characterization and remediation effort, tritium extraction and permeation tests, and medically usable radioisotopes. Work is typically divided between the two hot cell complexes, gloveboxes, fume hoods, and laboratory benches, depending on the radioactive or hazardous nature of the work

The RPL uses an Integrated Operations System (IOPS) approach for developing the Environment, Safety and Health (ES&H) program for the facility. IOPS is a web-based software tool that is used to establish and communicate safe laboratory practices, identify and control workspace hazards, and identify and obtain appropriate training to workspaces for an efficient and productive laboratory. Depending on the area and work being done, staff responsibilities are clearly defined and all users of an IOPS facility are responsible for knowing and implementing the requirements that apply to their own work. Software tools are used to identify the hazards associated with the equipment, facility, and activities in that work space. All FEMP activities are done in accordance with IOPS requirements.



Figure 2.1. Radiochemical Processing Laboratory

2.1 Physical Description

The RPL, Figure 2.1, is a rectangular-shaped, welded metal frame structure with insulated metal siding erected on reinforced concrete footings, walls, and slabs. Exterior walls are constructed of insulated 1-1/2 in. fiberglass sandwich metal panels. The flat roof is a metal deck with a built-up gravel surface insulated with 1-in. board. Windows are single pane. The facility dimensions are listed in Table 2.1.

Table 2.1. Dimensions and Space Assignments

Description	Dimensions
Perimeter	
Basement	220 ft 4 in. x 271 ft 9 in.
First Floor	235 ft 4 in. x 271 ft 9 in.
Second Floor	195 ft 10 in. x 116 ft 2 in.
Office Space	14,114 ft ²
Laboratories	46,415 ft ²
Common	70,593 ft ²
Storage	1,113 ft ²
Other	11,857 ft ²
Total Area	144,092 ft ²

The building consists of 1) a central portion containing general purpose laboratories designed for general chemical and low-level radiochemical work, 2) a south (front) wing containing office space, a machine and electrical shop, locker rooms, and a lunch room, 3) east and west wings provided with shielded enclosures with remote manipulators for high-level radiochemical work, 4) a filter addition area that provides a final testable high-efficiency particulate air (HEPA) filtration stage for ventilation exhaust air, and 5) outside radioactive-materials storage area and cargo containers, 6) a central basement area containing offices, ventilation equipment, support equipment, sumps, compressors, some laboratories and 7) a north (back) second floor areas containing offices, ventilation equipment, power operator station, switchgear, storage, and gaseous effluent monitoring equipment.

The first floor of the building contains approximately 100 laboratories and offices; the laboratories contain numerous hoods and gloveboxes for working safely with radioactive and hazardous materials. Offices are also located on the second floor and on a mezzanine area between the first floor and the basement (see Figures 2.2 and 2.3). The basement, Figure 2.4, contains several laboratories in addition to a portion of the ventilation and waste-handling systems. Instrument rooms, certain isolated laboratories, and the basement mezzanine office area have refrigerated air conditioning for temperature and humidity control.

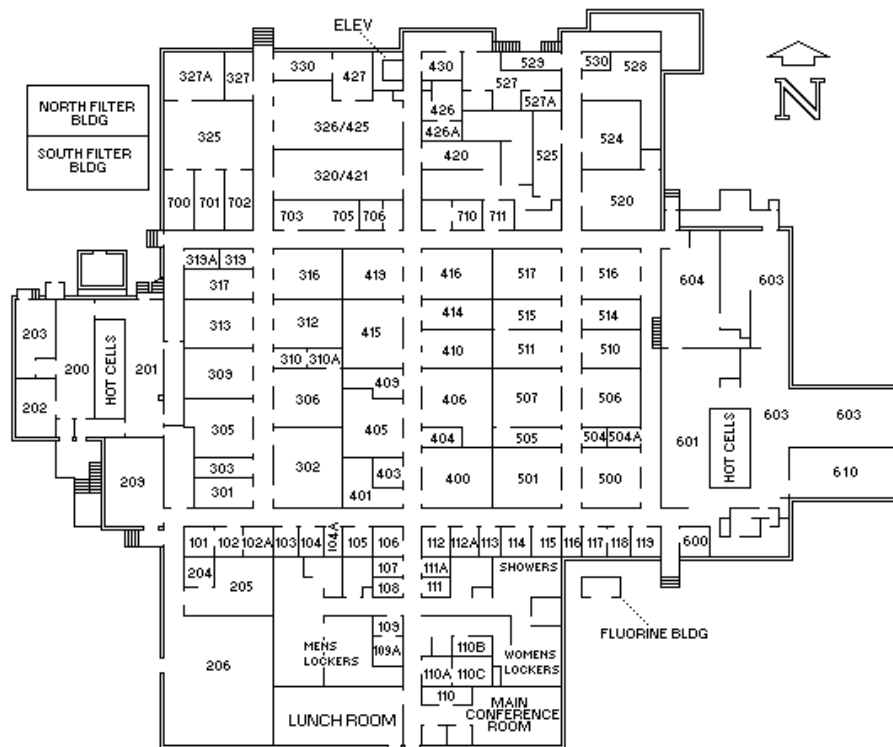


Figure 2.2. 325 First Floor Layout

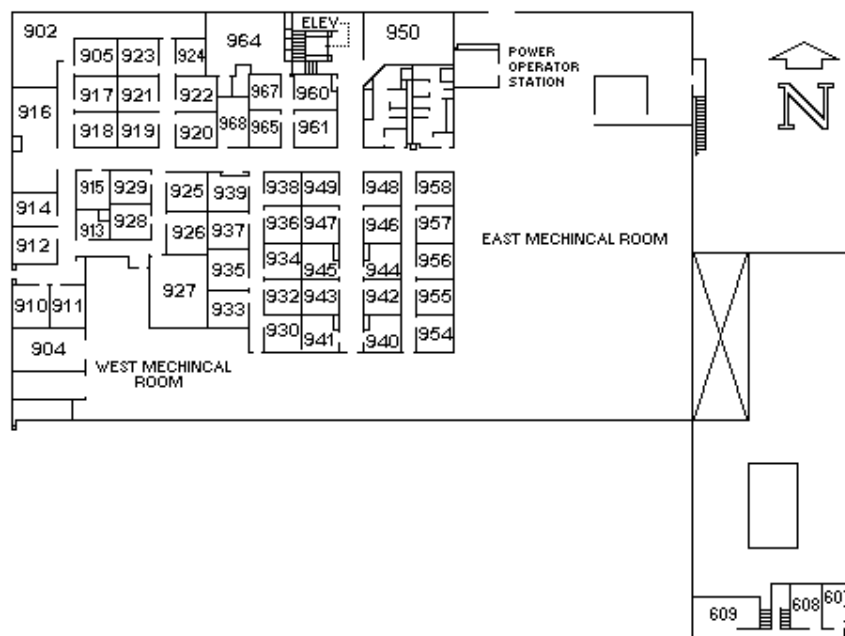


Figure 2.3. 325 Second Floor Layout

The building's main heating and ventilation system, located on the second floor, has four nominal 65,000 cfm supply fans with heating/cooling coils, spray chambers, and filters. Four 55,000 nominal cfm exhaust fans and a filter room are located in the filter addition annex northwest of the main building. Typically, three fans operate continuously with the remaining fan as a standby. Air is supplied to offices and corridors and exhausted from the laboratories through HEPA filters to a 90-ft (27-m)-high stack.

Small refrigerated air conditioning units serve other special purpose laboratories as well.

Utility services include steam; hot, cold, process, sanitary, deionized, and distilled water; compressed air; laboratory process vacuum; and three sewer systems. In addition to the laboratory vacuum provided by two pumps, a high-volume vacuum is furnished to air samplers by two additional pumps.

Electrical systems provide some isolated circuits for instruments, a 3000-lb electric elevator, and emergency power. Both the normal transformer and the emergency transformer are rated at 1000 kVA.

Safety/emergency equipment installed in the building includes safety showers, eyewash stations, decontamination shower, fire sprinklers, smoke alarms, heat detectors, storage cabinets for flammables, and emergency alarm systems: fire gongs, crash phones, and criticality horns.

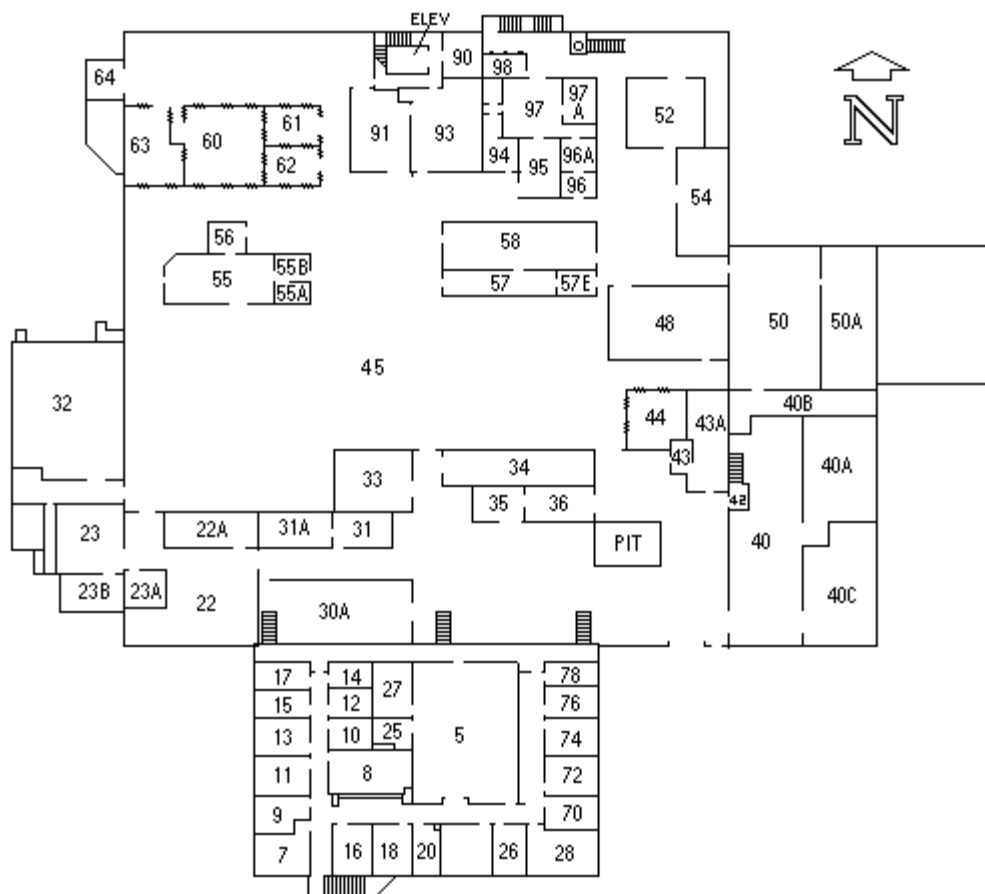


Figure 2.4. 325 Basement Layout

2.2 Process Description

The RPL work activities are divided among the two hot cell complexes, gloveboxes, fume hoods, and laboratory benches, depending on the radioactive or hazardous nature of the work. Projects frequently involve working in more than one of these locations, such as, sample preparation or dilution in a hot cell or glovebox, followed by analytical measurements in a fume hood. Analytical work is performed for the projects in the RPL, as well as for outside customers.

General chemical laboratories are typically equipped with laboratory benches, fume hoods, and/or gloveboxes, and other R&D equipment. Some laboratories are devoted exclusively to housing specialized instruments such as spectrometers. These laboratories may not contain any fume hoods and have few laboratory benches. Laboratories also may be devoted exclusively or almost exclusively to housing gloveboxes. The arrangement of laboratories and equipment in laboratories changes as some projects are completed and others are started, or as project needs change. Some typical work activities in the RPL are described below:

- Characterize chemical, radiochemical, and physical properties of samples such as tank wastes, spent fuel, contaminated soils and water, other solid, liquid, and gaseous materials, glass, ceramic, carbonaceous, or metallic waste forms
- Chemical process development and rheology tests and experiments such as:
 - bench scale testing of solid/liquid separation technologies including settle/decant, cross flow filtration, and dead end filtration
 - chemical process development for precipitation processes for waste treatment
 - evaluation of ion exchange material performance
 - evaluation and development of solvent extraction techniques
 - retrieval and transport testing (sluicing, pumping, and pipe flow)
 - gas generation testing
 - irradiation testing
 - development of methods for separation of radioisotopes
- Material disposition including immobilization and stabilization testing
- Perform evaluation and engineering testing of decontamination and decontamination technologies
- Electrochemical waste processing including salt splitting, nitrate destruction, organic destruction, and electroplating
- Development and testing of radioisotope generators
- Development and testing of plutonium technologies
- Actinide chemistry research and development
- Developing and testing waste treatment technologies such as evaporation/concentration of radioactive solutions, or vitrification and testing of glass waste forms
- Provide a treatment service for hazardous waste or mixed (hazardous and radioactive) waste, which includes grouting, neutralization, and distillation, and demonstrating new and emerging technologies for waste treatment and destruction.
- Perform Non-destructive analysis (NDA) evaluations of waste drums and other materials.
- Perform x-ray verification and compaction of low-level waste.
- Prepare and/or analyze samples for x-ray diffraction, electron microscope, optical microscopy, Auger analysis, and other surface techniques.
- Spent nuclear fuel characterization and performance testing.
- Mechanical properties testing on irradiated materials.
- Prepare standard solutions of radionuclides from stock batches for use in research and development of analytical procedures and for quality control.
- Perform reactor dosimetry and hydrogen and helium measurements to characterize radiation damage in materials.
- Analyze performance evaluation samples submitted by the EPA, the Environmental Monitoring Laboratory, and other organizations as a routine part of the laboratory quality control program.
- Separate and process medically usable radioisotopes. Develop and test equipment for nuclear medicine.
- Perform characterization and testing of tritium and tritium-bearing materials.

- Use radioisotopes in engineering applications such as radioactive/radioisotope heat sources or space and/or defense-related power and propulsion systems
- Perform analysis, characterization, and stabilization of sodium-bearing materials (Na and KaK)
- Perform analysis, fabricate, and characterize radioactive colloids.
- The research, development, and demonstration activities conducted within the RPL are continually changing. New activities using significant quantities of radioactive or hazardous materials are evaluated to determine potential permitting or monitoring conditions.

2.3 Source Term Definition and Description

The characteristics of releases that could contribute to each effluent stream during normal operating and upset conditions are described in this section. Unconfined contact with ventilation air or an unrestricted flowpath to a sewer are the only prerequisites for an inventory to present a potential source term to an effluent stream. For the purposes of this section, a source term is a description of the nature and location of potential sources of releases of radioactive and/or chemical materials within the building. Thus, all “passive” inventories stored in open containers, as well as those undergoing sparging, boiling, pouring, and other “active” processes can potentially produce air or liquid source terms. The following subsections discuss potential source terms under normal and upset conditions.

Normal Operations

Normal operations can be broken down into storage and handling, sample preparation, use of instrumentation, and process chemistry (at various scales). Storage and handling operations tend not to produce emissions, with the exceptions of: waste management activities including compaction; mixing the liquid waste tanks in the vault; and pouring large containers' contents (whether powder or liquid) into smaller containers. Sample preparation is likely to include small-scale wet chemistry (such as acid digestion, dissolution, and extraction), pouring liquids and powders, and perhaps, cutting or grinding solid samples. Some resuspension of aerosol from open sample cans, crucibles, and vials also probably exists. The releases from using instrumentation are less well-defined, but probably small compared to others. Process chemistry should be the largest contributor of releases.

The processes producing releases tend to be more similar in kind or location for hazardous chemicals than for radionuclides. Releases can be described in terms of four basic physical forms in which radioactive and other chemicals are found:

- nonvolatile liquids, dispersible powders, and crushable solids
- non-dispersible metals
- volatile liquids
- gases and vapors.

Powders are typically subjected to the physical processes of pouring, sieving, calcining, and resuspension of particulates from loose powders by airflow or wiping. Nonvolatile liquids may be sparged, heated, boiled to dryness, poured, or simply resuspended from open containers. Operations normally performed on friable solids (such as fuel pellets) are cutting and grinding, and tests such as heating or burning. However, the amounts of solid radionuclides that undergo such processes are already categorized as powders in the inventories. Releases from solids are much lower than for powders or liquids, and releases from metals are even lower than those from other solids. Volatile liquids and solids can evaporate from open vials, beakers, or trays. Heating may or may not be involved; some work is done at higher temperatures. Gases and vapors may also be released during normal operations.

The Appendix A source-term fractions, 1.0 for gases and volatiles, 0.001 for nonvolatile powders and liquids, and 1×10^{-6} for solids are believed to be conservative for the estimated annual building release fraction within the building. Sealed sources are exempted in the regulations and are given a release fraction of 0.0.

The radionuclide releases from the RPL, during normal operations, depend on the in-building source term, the effectiveness of effluent filtration, and the amount of inventory that undergoes normal operations during the year. The source term from normal operations varies over a wide range of isotopes, but the most significant contributors have historically been isotopes of americium, cesium, neptunium, plutonium, and strontium. Particles contaminated with these materials would be effectively removed by the HEPA filtration system with only a small fraction exhausted through the main facility stack, which is monitored for radiological releases. Additionally, work with tritium has produced airborne tritium that is also monitored and exhausted through the main stack.

A number of different chemicals are used in the building. Chemicals are tracked using the Chemical Management System (CMS). The amounts of chemicals in the facility are used to determine the level of chemical hazard in the building. The needs for monitoring airborne emissions of hazardous chemicals are established in the Hanford Site Air Operating Permit (to be issued under WAC 173-401). Emissions of nonradioactive volatile organic compounds and toxic air pollutants have been characterized and determined to be within applicable permits and regulatory limits (PNNL-SA-32816).

Under normal operating conditions, any release to airborne effluent pathways of regulated materials would undergo at least two stages of HEPA filtration before reaching the sampling and monitoring system prior to leaving the building through the stack.

Under normal operating conditions, the SNS only receives effluent from the restrooms, water fountains, lunchrooms, and change rooms. No radioactive or hazardous chemicals from processes or operations are normally released through this pathway. There are no indications that radioactive or hazardous materials would be present in the 325 SNS from past operations.

The retention process sewer (RPS) serves a number of laboratory areas with the potential for contamination; therefore, under upset operating conditions, this system may contain radioactive material.

Under normal operations, administrative controls (Standards Based Management System [SBMS], Managing Liquid Effluents, Managing Nonradioactive Chemical Wastes) are followed and liquid effluents are evaluated against sewer system acceptance criteria and approved prior to disposal. Liquid effluents in the RPS are actively monitored when exiting the RPL and again by Fluor Hanford at the 307 Facility for gross alpha activity before they are subsequently discharged to the 300 Area Process Sewer System.

The current normal operations do not call for routine monitoring or sampling the RPL SNS or RPS effluent. However, sampling is performed on an as-needed basis.

Upset Conditions

Upset conditions considered in this document are those that are likely to occur. These events may either cause an unusual source term that follows a normal effluent pathway (source-term upset), or a normal source term that follows an unusual pathway (flow-path upset). Both of these types of upset conditions are discussed in this section. Please note that because of the separation between the SNS and chemical and radioactive source terms, no upset conditions exist in which normal chemical or radioactive source terms can escape via the SNS.

- **Flow-Path Upsets.** Flow-path upsets occur when normal source terms (expected emissions during normal processing) follow unintended paths to be released at effluent exit points. This can result in an increased release owing to bypassed engineered controls such as HEPA filters. Possible flow-path upsets in the RPL include many types of events.
 - Glovebox confinement failures could develop from several kinds of damage or failure. The worst-case result is that of an unfiltered normal source term from one glovebox escaping to room air. Hot-cell confinement failure is considered beyond upset conditions.
 - A HEPA filter could fail mechanically (expelling part of its contents as well as permitting particles to flow through). This type of upset would likely result in increased emissions to the stack.
 - Possible supply system upsets include unanticipated shutdowns and excessive flow (resulting in pressurization). Source terms would be those from normal operations. The building would not be expected to remain at under-pressure or overpressure for more than a few minutes. A short period at overpressure might lead to effluent escape through and around outside doors, restroom vents, and other unmonitored, unfiltered pathways, including those in “clean” areas, such as the mezzanine, machine shop, or second floor. However, the loss of building air balance owing to oversupply would not cause a failure of the glovebox-to-room pressure gradient, but only some outflow of building air to the atmosphere through normal openings in the building skin. No unintended release path is expected from an oversupply air-balance upset.

- Possible exhaust-system upsets include unanticipated shutdowns and excessive flow (resulting in depressurization). The only parts of the main exhaust-fan control system that are common to all four exhaust fans are a controller on the second floor and the fan outlet pressure sensor. Failure of either of these devices would lead to maximum flow-rate operation of the exhaust fans. This event would cause a decrease in building pressure, but would not result in effluent leaving the building at unintended exit points.
- Releases to the liquid effluent pathways are those entering the RPS or radioactive liquid waste (RLWS) systems. Waste from the RLWS is collected in a tank in the basement of the building and is not released to the environment under normal conditions. The system is designed to prevent an environmental release under upset conditions.
- On exit from the RPL, control and monitoring responsibility for the RPS passes from Pacific Northwest to Fluor Hanford. Although Pacific Northwest does not have responsibility for compliance sampling of these 300 Area streams, but does have the responsibility for maintaining control and accountability for operational discharges from its facility. Releases are controlled via administrative restrictions on disposal of liquid to the sewer systems. Because of this, Pacific Northwest is not currently routinely sampling RPL liquid effluent streams. However, sampling may be performed on an as-needed basis.
- In summary, the flow-path upsets can lead to the release of a normal source term to the atmosphere through less filtration than normal (two stages of HEPA filtration), the release of hazardous chemicals, or a leak into the RPS system. In most cases, the source term at risk is the inventory at a single work station (glovebox or set of hot cells) for atmospheric releases or the contents of a maximum single-container amount for liquids.
- Source-Term Upsets. Source-term upsets occur when an upset creates an unusually large source term, which then follows normal release paths. Only the inventory in a single container or work-station would be affected, and damage to sealed sources would not be expected. Stack monitoring and sampling for radioactivity are already in place and are appropriate for potential upsets. (These would be expected to exhaust through the main stack.) Accidents that affect multiple areas (such as fires) are considered in the facility Safety Analysis Report (PNNL 2000) and are beyond the scope of upsets considered here. For these types of event, data in addition to effluent sampling would be needed to quantify releases, such as using alternative sampling methods described in Section 3.9.
- 40 CFR 68 Accidental Release Prevention Requirements: Risk Management Programs require facilities to do risk management planning to help prevent, detect and respond to accidental releases to the air of hazardous chemical. Chemical inventories were reviewed and determined to be well below the quantities requiring a risk management plan.
- Because the RPS serves areas of potential radioactive contamination, a source-term upset release of radioactive material could occur from spills or contamination of process water entering these systems. Such a release to the RPS could only be passed to the 307 basins where a redundant

screen is done if the radionuclide concentration were below the diversion set-point of 1×10^{-4} mCi/cc of ^{137}Cs or its gamma equivalent. If the radionuclides in the spill were alpha or beta emitters, concentrations higher than the value cited above for ^{137}Cs might pass through to the RPS without diversion as a result of the source-term upset.

2.3.1 Chemical

Chemical storage and usage are well dispersed throughout the facility and consist of bulk materials (solvents, acids/bases), small volume chemicals, and standards used in conducting laboratory experiments. All chemicals within the facility are inventoried and tracked via the CMS (SBMS, Working with Chemicals). A number of the chemicals in the facility exceed the reportable quantity (RQ) specified in 40 CFR 302.4. These chemicals are highlighted in Appendix B.

Many of the laboratories contain satellite accumulation areas for liquid and solid hazardous wastes. An active inventory of the waste contents is maintained. Liquid and solid wastes are disposed of in accordance with guidelines described in (SBMS, Managing Liquid Effluents and Managing Nonradioactive Chemical Waste).

2.3.2 Radionuclide

Radioactive material storage and usage are dispersed throughout the facility and include a large number of isotopes. These materials are found in several forms, including solid, liquid, particulate, and gas. Some of these materials are also heated during testing, producing vapors.

Some residual hold up is assumed from historical operation of mixed isotopes. This residual hold up could be found in the ventilation and filter system, the liquid waste system components, and fixed contamination in controlled areas.

Because the RPL is primarily intended for fissile material research, transuranics, uranium, and thorium compose the bulk of the radionuclides in the building. Fission products (usually derived from spent fuel) are also stored and handled. The radionuclides in the building may be in any physical form, although there are fewer gases than powders, liquids, and solids.

In general, plutonium and other transuranics are found inside gloveboxes or hot cells but are occasionally handled and stored in fumehoods. Uranium and thorium may be handled and stored in hoods as well as in gloveboxes and cells. Other radionuclides are handled as appropriate based on the potential dose to personnel and may be in hot cells, gloveboxes, hoods, or on the lab benches. The building also possesses low-level radioactive waste in a waste compactor and stores radioactive wastes in drums. Finally, an inventory of assorted radionuclides is present as "holdup" in HEPA filters and as plated deposits in ventilation ducts, gloveboxes, hoods, and liquid pipes (Haggard et al. 1996).

A detailed inventory for the building is provided in Appendix A. This inventory list is a combination of three material sources:

- Part 1 - Inventory Estimates provided by RPL staff, which is any radionuclide material that is not included in the Part 2 or Part 3 inventories. This part also accounts for building holdup not covered in Part 3.
- Part 2 - Composite Radioactive Material Inventory, which is the sealed sources that are assigned to custodians and accounted for by Pacific Northwest Health and Safety Department.
- Part 3 - Nuclear Materials Inventory, which is the inventory of special nuclear material (SNM) that is maintained in a material balance area (MBA) and assigned to an MBA custodian. This building holdup of SNM is within the boundaries of the MBA.

2.4 Identification of Effluent Pathways

Effluent pathways and their facility points-of-discharge of liquid and airborne effluents from the RPL are described in the following sections.

The term “point-of-discharge,” as used in this chapter, refers to the point at which the effluent leaves Pacific Northwest control. For airborne emissions, the discharge point coincides with the point of effluent entry into the uncontrolled environment. Thus, “discharges” of airborne emissions must comply with Pacific Northwest administrative controls (SBMS, Airborne Emissions), DOE, the United States Environmental Protection Agency (EPA), and the Washington Department of Health (WDOH) emission control and monitoring requirements.

Liquid effluents originating in the RPL, on the other hand, remain in a controlled system at the “point-of-discharge.” At these points, the responsibility for the effluent stream, including its ultimate disposition, passes from Pacific Northwest to the site waste management Hanford operations contractor, Fluor Hanford. As such, Fluor Hanford is responsible for monitoring and controlling environmental discharges of liquid effluents.

Fluor Hanford determines the need for and established separate FEMPs to cover liquid effluent discharge monitoring and control systems affecting operations of the 300 Area Treated Effluent Disposal Facility (TEDF). Although Pacific Northwest does not control the discharge of liquid effluent from all 300 Area facilities, it is responsible for characterizing effluents originating in its facilities and for exercising appropriate control over these effluent sources. Characterization information is documented annually and provided to TEDF. PNNL Effluent Management annually provides a certification plan. The annual documentation includes updates to building flow rates, a list of new connections to the sewer systems, list of new processes added or changed in the last year and any other pertinent changes to sewer discharges.

The RPL produces both liquid and gaseous effluent streams, most of which are generated in the building. The effluent streams during normal and shutdown operations include two sewers, one main ventilation stack, and a number of vents from support spaces (e.g., shops, restrooms, mechanical rooms).

2.4.1 Gaseous and Aerosol Emission Pathways

Figures 2.5 and 2.6 provide a simplified summary of the RPL main exhaust system. Greater detail can be found in the schematics presented in Appendix D. These drawings were prepared and field verified during the summer of 1991 and again in 1998. The drawings are updated whenever a building modification affects the systems shown on the drawings. Any facility modification that changes building flow paths must 1) receive prior concurrence of the building manager, and 2) requires updating of the appropriate drawing(s) before project close-out (SBMS, Creating or Modifying Engineering Calculations, Drawings, and Specifications).

Almost the entire RPL is in one ventilation zone, within which air balance causes flow from the outside atmosphere into the building and from lesser to greater areas of potential contamination. Confinement is also provided by conducting high-inventory operations in gloveboxes and hot cells. Off-gas from individual activities is typically handled by the building vacuum system or by the heating, ventilation, and air conditioning (HVAC) system. Potentially radioactively contaminated airflow passes through at least two stages of HEPA filtration before exiting the building through a single, monitored, and sampled stack. Supply and exhaust systems are discussed in the following subsections.

Supply

Three main supply fans (with a fourth on standby) using 100% outside air provide supply air to the majority of the RPL, as shown in Figure 2.5. In general, air is supplied first to the offices, from which it flows to the building hallways. The hallways serve as supply plenums for the laboratories that, in turn, may supply air to gloveboxes (at less than room pressure) and hoods. The “clean” second floor is also supplied with air (at a higher pressure than the first floor). The hot cells in the 325A and 325B annexes do not have a separate air supply, but draw air from the galleries through unfiltered inlet ducts and smaller leak paths.

Smaller supply systems serve other parts of the building: offices in the southern wing, rooms 202, 209, 23, 23A, and 23B (basement), and the machine shop, instrument shop, and associated office (rooms 204, 205, and 206). Some of these supply systems partially recirculate the air, others do not.

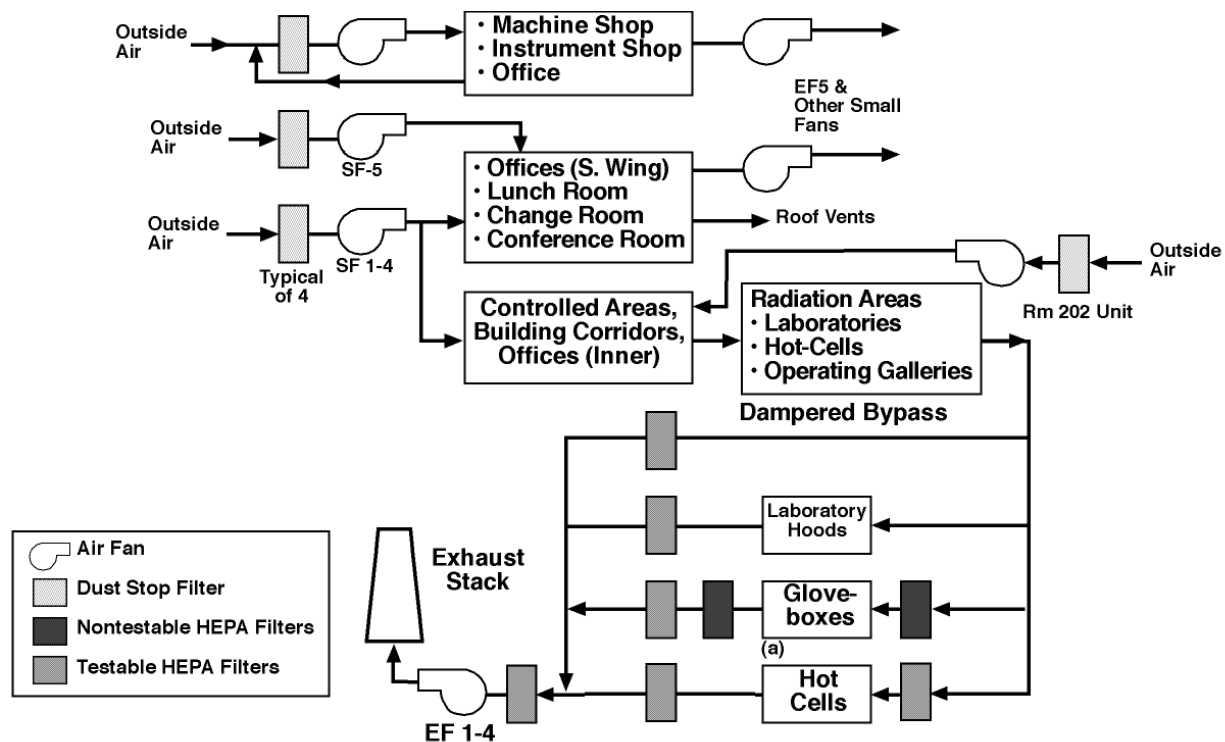
Exhaust

Three of the exhaust fans (with the fourth on standby) exhaust air from most of the RPL during normal operations. During normal operation, the exhaust system provides the only effluent path for in-building releases. The exhaust system consists of the air circulating first through the uncontrolled corridors, then to the controlled corridors, and finally to the laboratories. All rooms, gloveboxes, and hoods in potentially contaminated areas discharge through at least one stage of nearby testable HEPA filters to the main exhaust plenum, which leads to a second stage of HEPA filters just before the stack.

Thus, all potentially contaminated areas have at least two stages of HEPA filtration. The vacuum air sampling and building vacuum systems also exhausts (through a stage of HEPA filtration) to the main exhaust plenum. Some potentially contaminated locations have more than two stages of HEPA filtration. The exhaust downstream from the final bank of HEPA filters is sampled for radioactivity as determined by WAC 246-247 and 40 CFR 61, Subpart H, and the Hanford Site Air Operating Permit (AOP pending).

The following “clean” areas have their own unfiltered exhaust systems: the south wing area of the first floor (exhausted through a roof vent), the restrooms in the south wing area and on the second floor (vented by small fans), and the second floor offices and equipment rooms. The exhausts for the restrooms and change rooms (rooms 706 and 710) in the first floor laboratory area are exhausted to the sample receiving preparation and storage laboratory HEPA filter bank.

The main exhaust and supply fans are interlocked in pairs, so that no exhaust fan can shut down without shutting down the corresponding supply fan. In the event the normal power supply is lost, standby power is automatically provided for two of the main exhaust/supply fan pairs. The supply fans serving the south wing office area of the first floor and rooms 209, 23, 23A, and 23B are interlocked to shut down if building pressure becomes insufficiently negative (with respect to atmosphere). Finally, the supply fan for Room 202 is interlocked such that it will not run if neither main exhaust fan EF-1 or EF-2 is operating.



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Figure 2.5. Schematic of the General Vent System for RPL

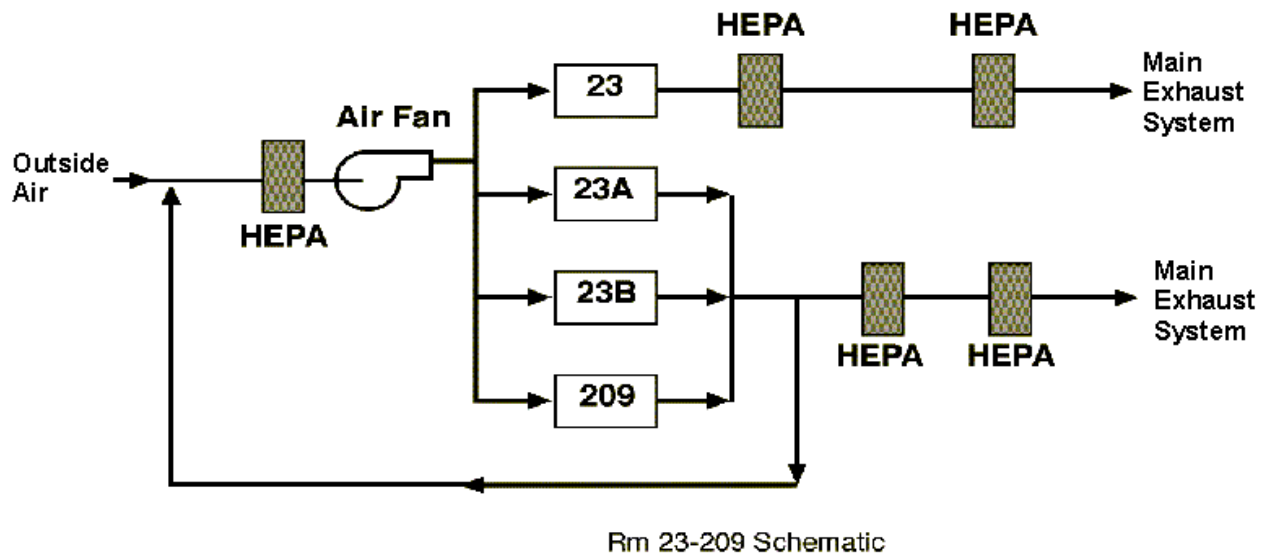


Figure 2.6. Ventilation Schematic for Room 23-209 System

Vents

Most of the air vents in the RPL can be considered part of the ventilation exhaust system and are discussed as such. The remaining vents, including the elevator shaft vent and the sewer system vents are not considered part of ventilation. Upset releases of regulated material are unlikely to be released through these vents because they are generally at a less negative pressure than the surrounding parts of the building.

Normal building leak paths may also act as vents. At average wind speeds, the normal air balance and pressure gradient ensure that all flow exits by the final exhaust plenum and stack, even if doors or the truck lock or smaller leak paths are open. The building pressure is maintained at between 0.05 and 0.08 in. water negative (or 12 to 20 Pa negative) with respect to the atmospheric pressure measured on the roof. This same range of lower-than-roof pressure may be found on the sides of a flat-roofed building at wind speeds of 20 mph or greater. Thus, flow might leave the building through normal leak paths on the sides of the building that are parallel to a high wind. Such hypothetical situations may occur during normal operations, but could only produce releases if an upset release occurred. Only a small part of the air flow in the building could escape in this manner.

2.4.2 Liquid Effluent Pathways

Liquid effluents are discharged from the RPL via two primary liquid waste systems: SNS and RPS. These systems come under Fluor Hanford and DynCorp control just after exit from the building. Table 2.2 summarizes the characteristics of these systems, and Figures 2.7 and 2.8 show the general layout of liquid effluent systems in the 300 Area.

Rainwater from the building roof and runoff from the loading dock drain to the soil at various locations around the building. No radioactive or chemical contamination is present on external building surfaces.

Table 2.2. Liquid Effluent Discharge Lines

Liquid Discharge System	Pipe Size	Building Exit Point
Sanitary sewer	8-in. dia.	East Service Tunnel
Retention Process Sewer	8-in. dia.	East Service Tunnel

Sanitary Sewer

The SNS receives effluent from only the restrooms, lunchroom, change rooms, some cooling processes, and other water uses in which no contamination is believed to be possible. Under normal operating conditions, no regulated materials are present in the SNS effluent. The sanitary waste is discharged into the 300 Area SNS system, operated by DynCorp under contract with DOE. The 300 Area SNS is discharged to the City of Richland wastewater handling system.

Retention Process Sewer

The RPS receives waste liquids, such as equipment cooling water, laboratory waste liquids, and floor drain liquids, that are normally free of radioactive contamination, but have a potential for such contamination in the event of a failure of an engineered barrier or administrative procedure. Floor drains are nonexistent or blocked in laboratories, and most hood drains are blocked. The RPS is a system of pipes to which all of the labs in the RPL are connected that routes waste to the 307 Basins and ultimately to TEDF. The RPS is monitored and equipped with alarms to alert Fluor of unusually high concentrations of radioactivity.

The monitor consists of a lead-shielded, gamma-radioactivity counting instrument which alarms if radioactivity in the waste exceeds a preset level. The monitor is operated and maintained by Fluor Hanford. After passing the monitor, if the RPL liquid wastes are free of radioactive contamination, they are discharged to the 307 basins operated by Fluor Hanford at the 340 Complex. If the monitor alarms, the stream is diverted to a dedicated basin at the 340 Complex; if not, the effluent is then screened at the 307 basins for alpha radioactivity before being discharged to the 300 Area process sewer (PS) system. A liquid effluent sampler for the RPL RPS system is in place and maintained. The system is sampled by Pacific Northwest on an as-needed basis.

Radioactive Liquid Waste System

The RLWS serves three liquid waste streams expected to be radioactive during normal operations. The sources for these streams are shown in Table 2.3. Wastes from this system go to a 3,000-gallon tank in the basement of the RPL. The tank contents will be transferred to a tanker for transportation to the 200 Area for disposal on an as-needed basis.

The first stream comes from one hood in Room 528 and from one floor drain (currently plugged) in Room 529. The second stream comes from the 325B hot cells and from two sinks in the 325B Addition. The third stream comes from the 325A Annex and Lab 603 including: cell drains, sink and floor drains, decontamination shower and sink, and process and tank cooling water. Prior approval is required to dispose of wastes via these streams.

Table 2.3. Sources for RLWS Waste Streams

- | | |
|-----------|---|
| Stream 1. | Lab 528 contains a sink drain in a hood for handling and disposing of radioactive liquid waste. |
| Stream 2. | The 325B analytical hot cells have a 330-gal holding tank where waste is held for less than 90 days. |
| Stream 3. | The 325A hot cells drain to waste holding tanks and Lab 603 containing three points of access: a sink drain in a hood, a drain from a liquid transfer hood, and a drain connected to the ultrasonic cleaner. A second source is the decontamination facilities. |

Administrative controls for each access point include appointing a cognizant space manager (CSM) who is trained in the requirements for disposal of radioactive and hazardous wastes. The CSM is to be responsible for the handling and disposition of material down the drain. Pacific Northwest has SBMS policy and procedures in place concerning disposal of material via the RLWS. All RLWS users must receive training on appropriate procedures and possess an approved RLWS disposal request (see SBMS Subject Area Managing Liquid Effluents) before using the system.

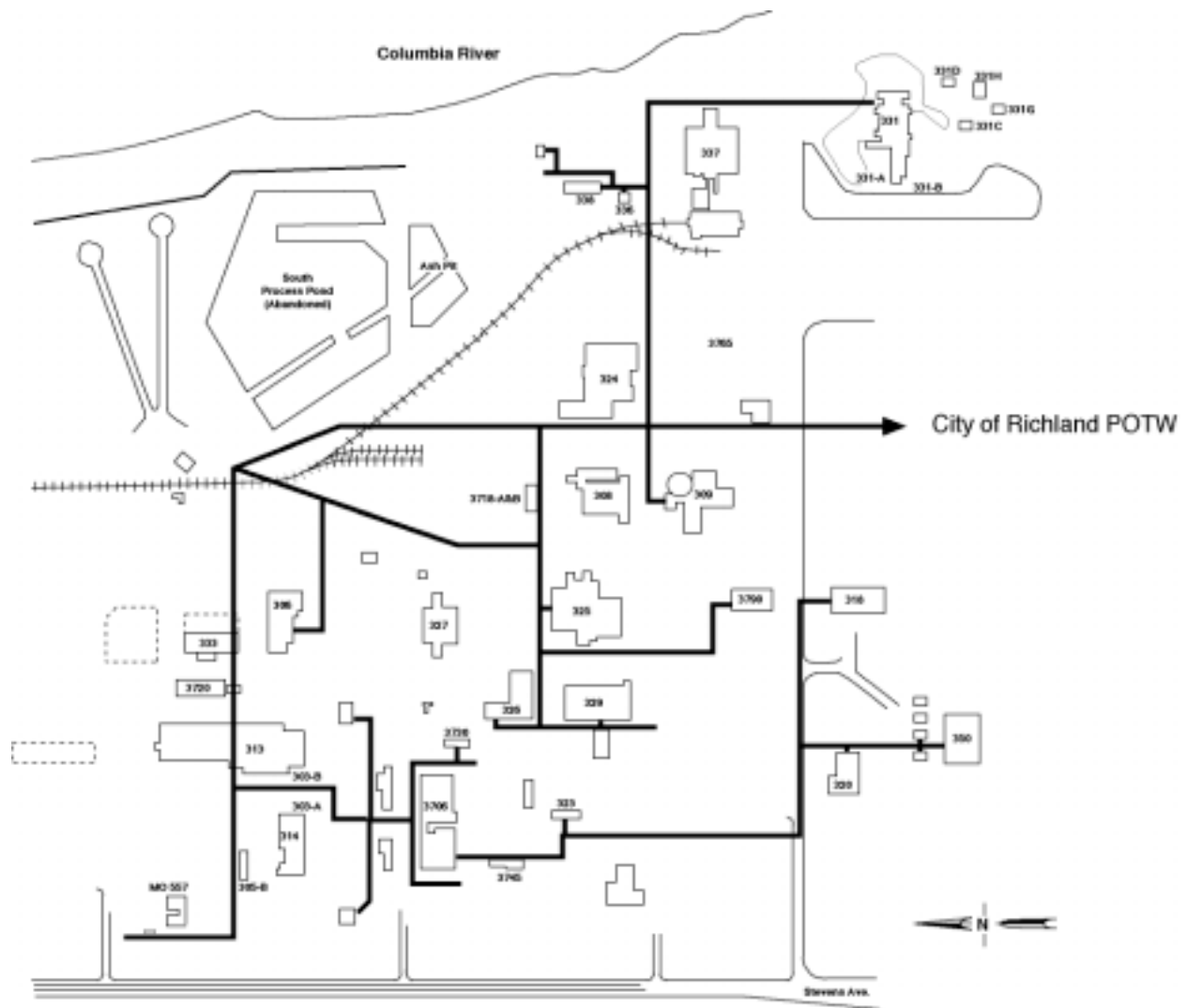


Figure 2.7. Schematic of Sanitary Sewer

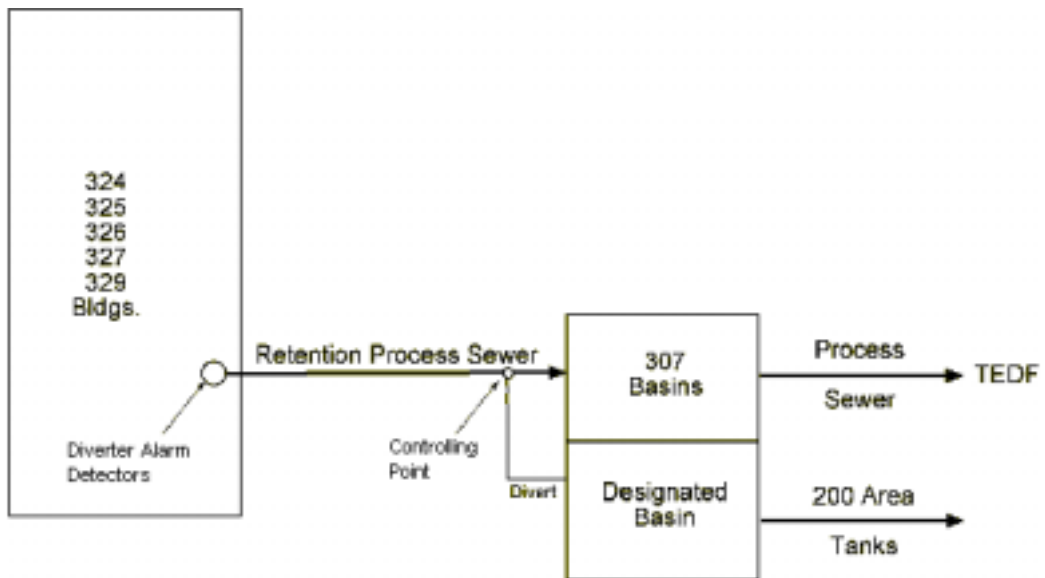


Figure 2.8. Schemaic of RPS

3.0 Rationale and Design Criteria for Monitoring

This section discusses design criteria for the measurement program for RPL airborne emissions and liquid effluents. Liquid effluent streams from the RPL are sent to two of the 300 Area liquid effluent systems (the RPS operated by Fluor Hanford and the sanitary sewer operated by DynCorp for DOE-RL). Thus, the RPL does not have any direct liquid discharge to the environment and this section will focus primarily on airborne emissions. Criteria are established to ensure that effluents are measured according to applicable regulations and guidance and are appropriate for existing facility operations.

In this section, the terms “sampling” and “monitoring” are used to distinguish between two types of measurement processes:

- “Sampling” refers to collecting a representative portion of the emission over a period of time, with subsequent analysis for constituents of interest. “Sampling” is an “after-the-fact” measurement.
- “Monitoring”, on the other hand, is measuring emission rates by means of a detector located in the sample stream. “Monitoring” is a “real-time” measurement.

Airborne emissions are sampled to demonstrate compliance with emission standards, to identify emission trends, and to provide evidence regarding the effectiveness of emission control systems (procedures and equipment). Effluents and emissions are monitored as a means to provide timely indication of a significant change in emission characteristics. Effluent sampling may also be performed to characterize waste streams or investigate discharges of concern.

Section 3.2 describes design and operation of the airborne-emission sampling/monitoring system at the RPL with specific reference to the criteria discussed in this section.

3.1 Basis for Design Criteria

The following regulations, DOE Orders, and guidance were considered for effluent sampling and monitoring system design and operation:

Regulations on Standards of Performance for New Stationary Sources, Appendix A: Reference Methods. Environmental Protection Agency, U.S. Code of Federal Regulations, 40 CFR 60. (EPA 1971)

National Emission Standards for Hazardous Air Pollutants. Environmental Protection Agency, U.S. Code of Federal Regulations, 40 CFR 61 (EPA 1990).

Hanford Site Air Operating Permit. Washington State Department of Ecology and Washington State Department of Health. HNF-AOP-97-1 (WDOE and WDOH 2000 – Not issued at time of publication).^(a)

Radiation Protection – Air Emissions. Washington Department of Health. Washington Administrative Code, WAC 246-247 (WAC 1994).

General Environmental Protection Program. U.S. Department of Energy. DOE 5400.1 (DOE 1988).

Radiation Protection of the Public and the Environment. U.S. Department of Energy. DOE 5400.5 (DOE 1990).

General Design Criteria. U.S. Department of Energy. DOE 6430.1A (DOE 1987).

Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance. U.S. Department of Energy. DOE/EH-0173T (DOE 1991).

Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities. American National Standards Institute ANSI N13.1-1969 (ANSI 1969).^(b)

Specifications and Performance of Onsite Instrumentation for Continuously Monitoring Radioactivity in Effluents. American National Standards Institute ANSI N42.18 1980b (ANSI 1980).

Administrative procedures from the operators of the 300 Area Treated Effluent Disposal Facility (TEDF).

The following additional requirements for sampling/monitoring at the RPL are prescribed in Pacific Northwest operational and programmatic documents:

SBMS, Airborne Emissions. 1999. *Airborne Emissions.* Standards-Based Management System Subject Area. (<http://sbms.pnl.gov/standard/0g/0g00t010.htm>) Pacific Northwest National Laboratory, Richland, Washington.

SBMS, Creating or Modifying Engineering Calculations, Drawings, and Specifications. 1997. *Creating or Modifying Engineering Calculations, Drawings, and Specifications.* Standards-Based Management System Subject Area. (<http://sbms.pnl.gov/standard/91/9100t010.htm>) Pacific Northwest National Laboratory, Richland, Washington.

(a) Individual radioactive emission permits are tracked by Effluent Management and will be rolled up into the air operating permit when issued.

(b) ANSI N13.1 was updated in 1999. However, applicability of the new standard to sampling systems already in place has yet to be determined.

SBMS, Managing Liquid Effluents. 1998. *Managing Liquid Effluents*. Standards-Based Management System Subject Area. (<http://sbms.pnl.gov/standard/0q/0q00t010.htm>) Pacific Northwest National Laboratory, Richland, Washington.

SBMS, Managing Nonradioactive Chemical Waste. 2000. *Managing Nonradioactive Chemical Waste*. Standards-Based Management System Subject Area. (<http://sbms.pnl.gov/standard/0f/0f00t010.htm>). Pacific Northwest National Laboratory, Richland, Washington.

SBMS, Working With Chemicals. 1999. *Working With Chemicals*. Standards-Based Management System Subject Area. Pacific Northwest National Laboratory, Richland, Washington. Criteria for Radionuclide Emission Sampling.

3.2 Criteria for Radionuclide Emission Sampling

Airborne radionuclide emission points at Pacific Northwest are classified as either “major” or “minor.” These two categories are defined as follows:

Major emission points	are those where radionuclide emissions could cause an offsite emission dose (OED) ^(a) of 0.1 mrem/year or more, if emission controls were not applied. Major emission points are sampled according to requirements in Subpart H of EPA (1990).
Minor emission points	are those that potentially could release radionuclides, but not at the levels of a “major” point.

The RPL main stack is considered a “major” emission point according to the criteria above and continuous sampling for radiological air emissions is required. There are no minor emission points at the RPL; radionuclides are only emitted out of the main stack.

(a) The annual OED is the maximum committed effective dose equivalent that could be expected to be received by an offsite individual from facility airborne radionuclide emissions if the facility were operated without any HEPA filtration or other emission controls. The method for calculating the OED consists of identifying the radionuclide inventory potentially available for release, multiplying this by a fractional release value, and multiplying this product times an emission dose factor calculated by the EPA Clean Air Act compliance code CAP-88 (Ballinger et al. 1999).

3.2.1 Sampling System Performance

Sampling at each major emission point should be capable of detecting an annual radionuclide release quantity resulting in an OED of 0.01 mrem/year (DOE 1991).

All radionuclides anticipated to contribute greater than 10% of the potential-to-emit (PTE) from the sampled emission point shall be accounted for, either by direct analysis or by inference from an indicator measurement (EPA 1990).

Biases in emission measurements, arising from the sample collection and analysis process, shall be minimized through the judicious application of design and operation practices according to American National Standards Institute (ANSI) (1969) and DOE (1991).

3.2.2 Sampling System Design Criteria

Samplers shall be located according to criteria in EPA (1971) Method 1, in Appendix A. Method 1 states that:

Sampling or velocity measurements are to be performed at a site located at least eight stack or duct diameters downstream and two diameters upstream from any flow disturbance such as a bend, expansion, or contraction in the stack, or from a visible flame.

However, the method also states that:

... if necessary, an alternative location may be selected, at a position at least two stack or duct diameters downstream and 0.5 diameters upstream from any flow disturbance.

Representative samples shall be withdrawn on a continuous basis at the sampling site following the guidance in ANSI (1969), Appendix A, Section A3.2, which recommends a minimum of six extraction points for the RPL stack (EP-325-01-S). Furthermore, ANSI (1969) recommends that each withdrawal point within a cylindrical stack be centered in an annular area of size equal to the cross sectional area divided by the number of probes. Withdrawal points may be on a single traverse or spaced to obtain samples from the total cross section. Additional design criteria for particulate and gaseous radionuclides are specified by ANSI (1969) and DOE (1991).

3.2.3 Sampling System Operation

Sampling system operating criteria are based on regulations and guidance documents listed in Section 3.1.

Sampling shall be performed to quantify emissions over a calendar year. Sample collection frequency shall be based on the need for unbiased samples while maximizing sensitivity and minimizing analytical costs. The period of sample collection, thus, should be as long as possible considering the

half-life of the radionuclide, the capacity of the collection media, and the need for timely return of sampling data.

Laboratory analysis of samples shall be according to procedures required by Appendix B, Method 114 “Test Methods for Measuring Radionuclide Emissions from Stationary Sources” in EPA (1990). Analyses are conducted by radioanalytical laboratories according to prescribed statements of work. Work statements specify analytical performance requirements, including minimum detectable activity (MDA), turnaround time, reporting requirements, quality control (QC) requirements, and sample handling.

Sampling program criteria in Section 3.2.1 specify an emission detection level of 0.01 mrem/year OED. The analytical MDA required to meet this criterion depends on a combination of factors, including sample size, stack flow rate, collection period, radionuclide half-life, and radionuclide emission dose factor. These factors shall be considered in sampling operations to ensure the required detection level is achieved.

When gross-activity measurements are used for assessing offsite dose, dose factors for the most restrictive radionuclide potentially contributing 10% or more to the annual emission dose shall be applied.^(a)

Radionuclide specific analyses shall be performed for all radionuclides potentially contributing >10% of the PTE for the building or that have a PTE >0.1 mrem.

Exhaust-stream flow rates at sampling locations shall be measured using EPA Method 2 (EPA 1971). (Beginning calendar year 1994, access to the vertical stack permitted the use of this method to measure flow in the RPL stack.) Flow rates should be measured on a periodic basis, as well as following modifications to the exhaust system that could be expected to cause the average exhaust rate to differ by $\pm 10\%$ from the previously measured rate.

Air-emission samplers should be designed to maximize the sensitivity of the sample, considering the capacity of the collection media, radioactive decay, and sample analysis costs.

Isokinetic sampling is required where particulate emissions are expected.^(b)

-
- (a) Before 1993, laboratory analysis of particulate emission samples consisted of total activity (total alpha, total beta) measurements. Total activity measurements were performed because emissions were historically very low, potentially significant constituents of the emission stream were known, and the gross activity measurement was nondestructive; radionuclide-specific measurement could be performed on the sample if gross activity measurements showed a potentially significant release quantity. Since 1993, airborne particulate samples have been analyzed for several specific radionuclides in addition to the gross activity measurements.
- (b) Emissions from the RPL stack are filtered using HEPA filters before discharge. Unless failure of a HEPA filter system occurs (an unlikely event), particle emissions are expected to be relatively small. Based on criteria in ANSI (1969), isokinetic sampling for systems emitting particles less than 5- μm aerodynamic diameter is not necessary. DOE (1991) recommends isokinetic sampling when particles are greater than 0.5- μm aerodynamic median diameter.

Under most operating conditions, isokinetic sampling shall be adequately accomplished by operating the sampler so that 1) sample probes are aligned axially with the stack and point into the direction of stack flow, and 2) sample nozzle inlet velocity is maintained within a factor of two of the mean stack exhaust velocity at the sample location.^(a)

At the “major” emission points, the sampler shall be operated continuously, except during planned sampler maintenance or testing outages. When continuous sampling is required, the loss of sampling capability shall be limited to 24 h/month. If this limit is exceeded, special interim sampling shall be provided, or pertinent facility operations shall be shut down.

3.3 Criteria for Radionuclide Emission Monitoring

3.3.1 General

Continuous emission monitoring is required for any emission system where:

- a potential of greater than once per year exists for exceeding 20% of the OED standard of 10 mrem/year (credit may be taken for emission control equipment such as HEPA filters) per DOE (1991).
- continuous emission monitoring is specified by a safety analysis report (SAR) or technical safety requirement (TSR).

3.3.2 Monitor Objectives

Continuous emission monitoring of building airborne radionuclide emissions shall detect significant increases in the stack emission rate. Rapid detection of such an increase may assist operational response actions.^(b)

The monitoring program should effectively provide notification of any transient or abnormal condition lasting more than 4 hours that would result in emissions of radioactive material in excess of applicable standards or license agreements if allowed to persist (WAC 1994). The emission monitor should be able to detect a sudden release that could (assuming 95th percentile atmospheric dispersion under 2-h meteorological conditions) result in an OED of 2 mrem/year (i.e., 20% of the emission standard) (DOE 1991). Notifications will be made in accordance with the requirements of the Air Operating Permit (WDOE and WDOH 2000)

(a) From Table C1 in ANSI (1969), a sampler operating at an inlet velocity of within a factor of two of the stack velocity will have a particle interception bias of 14% for a 4- μ m aerodynamic equivalent diameter (AED) particulate emission.

(b) The RPL stack-monitoring system is not used to activate engineered control systems, and is not relied on as a primary means for detecting an abnormal operating situation.

3.3.3 Monitor Design

General criteria for design of monitoring systems are provided in DOE (1991).

3.3.4 Monitor Operation

Monitors are operated continuously, except:

- When the monitored exhaust system is not operating, as approved by the Building Manager and Effluent Management (EM).
- During planned maintenance or testing of the monitoring system if scheduled through the building manager.

During periods when the exhaust system is operating and monitoring is required, loss of monitoring capability is not to exceed 4 hours at a time. If monitor outage exceeds this time, EM will specify requirements for interim monitoring of emissions or shut down of pertinent operations.

Continuous stack monitors must provide easily discernible alarms to responsible personnel in continuously or frequently occupied areas. A frequently occupied area is one that is occupied at least once every 4 hours.

Flow rates through monitors should, in combination with other operating parameters, be sufficient to enable the monitor to detect an emission meeting the above dose criteria.

3.4 Criteria for Air Chemical Emission Sampling

Air chemical emission sampling for the RPL is performed to comply with criteria established by the Hanford AOP or NOCs issued under WAC 173-400 and WAC 173-460. Criteria typically consists of EPA Standard Methods or alternate methods accepted by the agency. The following elements are in place to ensure that sampling for air chemical emissions meet required criteria:

- EM tracks requirements through an action/tracking plan and performs assessments of required sampling.
- Measurement equipment is procured, acceptance tested, calibrated, and maintained according to an EM Quality Assurance Plan (see Section 5) to ensure that sampling equipment has the capability to perform required measurements.
- Test plans and procedures are developed for measurements taken by the EM Group to ensure that measurements meet requirements.

3.5 Historical Monitoring/Sampling Data for Effluent Streams

The RPL was built in 1953 as a general purpose nuclear research and development laboratory. Some of the effluent streams from the building have been sampled and monitored over the history of operations. Information from historical sampling and monitoring is provided in this section to aid in providing a basis for future monitoring needs. A description of historic sampling and monitoring data under normal operating conditions for air and liquid effluent streams is given in Section 3.5.1. Estimates of the types of releases and release pathways experienced during plant operations under upset conditions are given in Section 3.5.2.

3.5.1 Normal Conditions

Sampling and monitoring of some of the air and liquid effluent streams has occurred since the RPL started operations. The types and locations of sampling and monitoring and analytical methods under normal operations are described in this section. Discussion is generally limited to the past 10 years (1989 to 1999) because this time period is the most relevant to future operations and monitoring needs. In 1987, control of the RPL was transferred from Westinghouse Hanford Company (WHC) to Pacific Northwest.

3.5.1.1 Air Effluent Monitoring/Sampling

Effluent air from the RPL main exhaust has been sampled and monitored downstream of the final HEPA filters for radioactive particles, ^{131}I , and tritium. Sampling for ^{131}I was performed when required by projects with potentially significant I-131 emissions. No I-131 sampling has been performed for the last decade. Monitoring and sampling for particulate gross alpha and beta has been provided by continuous air monitors and a record sampler for many years. In 1993 Pacific Northwest began compositing the record particulate samples on a quarterly basis and analyzing them for various radionuclides including isotopes of americium, antimony, cesium, europium, plutonium, and strontium. Compositing frequency was changed to semi-annual in 1996. The specific list of isotopes for which analyses are performed is evaluated annually.

The sampling and monitoring system was upgraded at the end of 1993 to meet the National Emission Standards for Hazardous Air Pollutants (NESHAP) (EPA 1990) requirements for continuous sampling. A multiple nozzle sampling array in the RPL stack was used for sampling before 1993, but little information was available on the actual configuration or design of the system. The new system is well documented and is described in Section 3.5. The sample collection system before the upgrades did not provide for an isokinetic sample, but the current sampler does.

Monitoring continues to be performed by passing a continuous stream of stack gas through continuous air monitors that detect particulate alpha and beta activity and tritium. Samples also continue to be collected by passing stack air through a particulate filter for gross alpha and beta, and silica gel for tritiated water vapor (HTO and HT).

Sample analyses are performed as described in Section 4.0. The MDL varies from sample to sample due to changes in background (which is highly variable) and counting time. Estimated emissions, calculated from the sampling data from 1994 to 1997, are shown in Table 3.1.

Table 3.1. RPL Annual Release Quantities 1994-1999 (Ci)

Nuclide	1994	1995	1996	1997	1998	1999
⁶⁰ Co	ND ⁽¹⁾	ND	NA ⁽²⁾	NA	NA	NA
⁶⁵ Zn	6.1E-7	NA	NA	NA	NA	NA
⁹⁰ Sr	ND	ND	2.4E-7	3.3E-8	4.3E-08	1.9E-07
⁹⁵ Zr	ND	NA	NA	NA	NA	NA
¹⁰⁶ Ru	2.4E-6	NA	NA	NA	NA	NA
¹²⁵ Sb	ND	NA	NA	NA	NA	NA
¹³⁴ Cs	ND	ND	NA	NA	NA	NA
¹³⁷ Cs	ND	ND	NA	4.4E-8	ND	3.4E-09
¹⁵⁴ Eu	ND	ND	NA	NA	NA	NA
¹⁵⁵ Eu	ND	ND	NA	NA	NA	NA
²⁴¹ Am	NA	1.2E-9	2.9E-8	4.6E-9	ND	9.7E-09
²³⁸ Pu	ND	ND	ND	ND	ND	ND
^{239/240} Pu	ND	3.6E-10	8.3E-9	ND	3.8E-08	1.1E-07
²⁴¹ Pu	NA	NA	NA	ND	ND	ND
Unspec. Alpha	2.3E-7	1.5E-7	NA	3.1E-8	6.0E-09	6.9E-08
Unspec. Beta	NA	NA	6.5E-7	7.3E-8	1.1E-07	1.2E-07
HT	2.3E+0	5.1E-1	1.4E+0	2.0E+1	9.3E+01	4.0E+01
HTO	1.4E+0	2.6E+0	1.6E+0	1.3E+0	6.4E+01	1.5E+02
⁽¹⁾ ND - Not Detected						
⁽²⁾ NA - Not Analyzed						

3.5.1.2 Liquid Effluent Monitoring

Liquid waste streams in the RPL have been served by three systems as described in Section 2.4.2. Table 3.2 lists the three systems and summarizes the type of historical monitoring/sampling each system has had. As noted in Table 3.2, no monitoring of the SNS or RPS occurred before 1994. The RPS was included in a characterization effort from March 1994 until September 1995 in support of the 300 Area Treated Effluent Disposal Facility startup (Thompson et al. 1997). As noted in the table, historically, 300 Area sanitary liquid waste was sampled at the SNS system just before the waste entered the SNS septic tanks. Before 1997, sanitary wastes were discharged to a 300 Area septic tank/trench system. In 1997 the 300 Area SNS was connected to the City of Richland POTW. A brief description of the sampling and analysis program before connection to the City of Richland POTW is given in the *Westinghouse Hanford Company Effluent Report for 300, 400, and 1100 Area Operations* (McCarthy 1990). Because this sampling program sampled combined effluent from all 300 Area facilities and not just from the RPL, its historical data are not reported here.

The RPS is routed to a diversion station in the RPL basement equipped with a radioactivity monitor that measures gamma activity. Prior to 1998 it automatically operated a three-way valve in the RPL basement that diverted flow to the RLWS and the 340 Complex if radioactivity above $5 \times 10^{-5} \mu\text{Ci/mL}$ of ^{137}Cs equivalent gamma activity was detected in the waste stream. Diverter alarms were annunciated in various locations in the RPL when diversions occurred and samples were taken automatically. However, data from the monitor was not recorded. In 1998 due to closure of the 340 Complex, the RLWS was deactivated. The RLWS was modified in the RPL to alarm in the 340 Complex to allow for diversion of the 300 Area RPS to a dedicated basin in the 340 Complex, see section 2.4.2. This modification removed diverter control of the three-way valve in the RPL basement. The RLWS is currently valved just outside RPL with future plans to physically disconnect the lines.

Normally, the RPL RPS passes through the diverter stations and into several large basins (307 basins) at the 340 Complex (see Section 2.4.2). The RPS is monitored for gross alpha activity before being discharged from the basins into the 300 Area PS lines. Before 1995, samples of the composite liquid waste from all the 300 Area PS lines were taken before the liquid was discharged to the 300 Area process trenches. A description of the sampling and analysis program is provided by McCarthy (1990). Sampling data from this program were obtained from combined effluent from all 300 Area facilities with PS service and thus, are not specific to RPL and are not included in this report. In 1995 a treatment facility, the Treated Effluent Disposal Facility (TEDF), was constructed and brought into operation.

In the past, the RLWS was connected to piping leading to tanks at the 340 Complex. The water in the RLWS holding tanks at the 340 Complex was sampled before being transferred to the 200 Area by rail car. Because the RLWS stream was not released to the environment, the sampling program is not pertinent to the FEMP.

The RLWS has been replaced by the Radioactive Liquid Waste Tank (RLWT) system, which serves liquid waste streams expected to contain radioactive liquids. This system is currently composed of pipes and holding tanks within the RPL. Waste from the pipes or holding tanks drain to a main collection tank in the RPL basement and are then pumped to a tanker truck for transfer to the 200 Area tank farms. The RLWT waste is sampled at the RPL before transfer to the tanker truck. However, one portion of the RLWS that includes a hood and floor drain (now plugged) in the central portion of the RPL is not connected to a holding tank. Waste through this portion flows directly through RLWS lines to the 3,000-gallon holding tank in the basement of the RPL.

Table 3.2. Summary of Historical Liquid Monitoring/Sampling

System	Notes
SNS	No sampling or monitoring at RPL. Sampled as composite with other 300 Area SNS before 1997 and sampled as required by contract with City of Richland POTW after 1997 hook-up.
RPS	Monitored at diverter station in RPL; grab samples taken in 1989; sampled as composite with other 300 Area PS, characterization study performed 1994-1995 (Thompson et al 1997). On demand samples taken as needed since 1996.
RLWS	Sampled at RPL prior to transfer and as needed

Historical sampling of nonradioactive constituents in the RPL liquid effluent included grab samples in 1989 and a series of field tests in 1994 and 1995. One location along the 300 Area PS line where contributions from both the RPL and the 3714 Building were received was sampled three times in May and June of 1989 (WHC 1989). The data was insufficient to provide a reasonable representation of effluent releases in this stream.

As part of support efforts for the start-up of TEDF, a study was performed on the physical, chemical, and radiological makeup of the waste streams in the PS and RPS. The study of Pacific Northwest facilities (Thompson et al. 1997) was performed from March 1994 until September 1995. This study covered the 306, 320, 324, RPL, 326, 327, 331, and 3720 Buildings as well as covering some background and influent locations. The average results of the constituents analyzed for RPL are provided in Table 3.3. Details regarding the number of samples, range, standard deviation, and other data quality discussions can be found in Thompson et al. (1997). Results showed that concentrations of pollutants in the RPL RPS were low (parts per billion) and met TEDF Waste Acceptance Criteria. However, only a limited number of samples were taken and a decision was made to discontinue routine sampling and to maintain the liquid effluent sampling and monitoring systems for sampling as needed.

Table 3.3. Average Results from RPS Characterization for RPL 1994-1995

From Thompson et al. (1997)

General Chemical Parameter (µg/L)				
Alkalinity	43,400		Total Carbon	22,250
Chemical Oxygen Demand	42,333		Total Dissolved Solids	82,000
Conductivity	155 (µmhos/sm)		Total Organic Carbon	4,850
pH	7.55 (pH units)			
Ammonia and Anions (µg/L)				
Ammonia	70		Nitrate	28,983
Chloride	3,937		Nitrite	300
Cyanide	2.0		Sulfate	15,383
Fluoride	432			
Metals (µg/L)				
Aluminum	78		Potassium	946
Barium	25		Selenium	1.02
Calcium	17,800		Silicon	2,650
Chromium	5.6		Sodium	3,473
Copper	17.2		Strontium	98
Iron	186		Thallium	1.00
Lead	3.8		Tin	33
Magnesium	4,220		Vanadium	2.6
Manganese	5.1		Zinc	72
Mercury	1.167			
Volatile Organic Compounds (µg/L)				
1,4-Dichlorobenzene	1.1		Ethanol	6.1
Acetone	45.07		Hexone	18.4
Chloroform	9.6			
Semi-volatile Organic Compounds (µg/L)				
1,4-Dichlorobenzene	1.1		Phenol	2.6
Bis(2-ethylhexyl)phthalate	15		Tributyl Phosphate	0.84
Radiological Parameters (pCi/L)				
Gross Alpha	4.922		Tritium	318

In May 1998, a single sampling event was conducted at each of the Pacific Northwest National Laboratories (Pacific Northwest) dedicated sampling stations to affirm that liquid effluents were not significantly different from previous characterization efforts. In this effort, a series of grab samples were taken at selected times over a 2-week period and then composited and analyzed. Samples were taken from sampling stations at the RPL at 11:00 a.m. and at 3:00 p.m. from May 11 to May 15 and from May 18 to May 22. The times were selected to maximize potential laboratory discharges over the 2-week period. Samples were composited and analyzed for total organic carbon, ammonia, cyanide, and metals. In addition, screening for radiological constituents (gross alpha and gross beta) was performed for

effluent samples from the Retention Process Sewer. The results confirm previous sampling performed in 1994 and 1995 from the Pacific Northwest 300 Area facilities (see Table 3.4). Concentrations for metals are low, in the micrograms per liter ($\mu\text{g/L}$) range and below the Treated Effluent Disposal Facility Waste Acceptance Criteria.

Table 3.4. Analytical Results for RPL 1998 Single Event Sampling

Constituent	Concentration, $\mu\text{g/L}$
Total Organic Carbon	5500
N-Ammonia, mg-N/L	70
Total Cyanide	<4 U
Aluminum	40
Antimony	<1 U
Arsenic	<1 U
Beryllium	<1 U
Cadmium	<0.2 U
Chromium	<5 U
Copper	27
Iron	310
Lead	2
Manganese	14
Mercury	1
Nickel	<10 U
Selenium	<1 U
Silver	0.4
Thallium	<1 U
Zinc	171
Gross Alpha, picocuries per liter (pCi/L)	<2
Gross Beta, pCi/L	4.63
U = Analyte undetected at given reporting limit.	

In February 2000, a single sampling event was conducted at each of the Pacific Northwest National Laboratories (Pacific Northwest) dedicated sampling stations in response to an occurrence declared by the Treated Effluent Disposal Facility (TEDF) for elevated alpha levels in the Process Sewer (PS) and RPS. Sampling took place on February 8 and 9, and samples were analyzed at the 325 Building analytical laboratory for gross alpha, gross beta, and tritium. Samples taken from the RPL did not have detectable concentrations of gross alpha, gross beta, and tritium (less than 2, 3, and 600 pCi/L for gross alpha, gross beta, and tritium respectively).

3.5.2 Upset Conditions

Upset conditions related to effluent releases that have occurred during the last ten years of operating history of the RPL are shown in Table 3.5. As seen by the table, these occurrences include unplanned radioactive air emissions and radioactive contamination found in sinks. The types of events shown in the table could be expected to occur during future operations and are considered in effluent monitoring planning (e.g., continuous sampling and monitoring for tritium, allowance for investigative liquid sampling when needed to determine effects and extent of inadvertent releases).

Other upset conditions have occurred that were not reportable. No formal records exist to summarize these incidents, which include punctures or tears of glovebox gloves, spills or drops of radioactive or toxic materials, loss of normal electrical power, and hot-cell fire. Airborne materials released from these events were transported out the normal ventilation pathways to the stack. Stack monitoring and sampling is described in Section 3.5.

Table 3.5. Unusual Occurrences in the RPL

Categorization of Event	
Environmental, Radionuclide Release (2A)	<ul style="list-style-type: none">Radioactive contamination discovered in lab sink that connects to RPS.Tritium released through stack from high level radiochemistry hot cells.Unplanned tritium emission from RPL.
Facility Condition, Safety Status Degradation (1C)	<ul style="list-style-type: none">HEPA filter failure during efficiency testing.Entry into Limiting Condition for Operation for loss of ventilation.
Facility Condition, Violation Inadequate Procedures (1F)	<ul style="list-style-type: none">Waste discharged to RLWS that violated waste acceptance criteria at 340 Building.Procedure to check pH before disposal not followed.
Facility Condition, Operations (1H)	<ul style="list-style-type: none">Building exhaust stack CAM alarmed; new replacement CAM did not show elevated readings.
Cross Category Item, Potential Concerns/Issues (10C)	<ul style="list-style-type: none">Tritium contamination found on surface of sink.Tritium contamination found in sink in lab 419 at RPL.Potential for exceeding administrative limits for chemicals.
Cancelled (NA)	<ul style="list-style-type: none">Divert of liquid effluent from the RPS to the RLWS.

3.6 Radionuclide Air Sampling/Monitoring System Description

Airborne radionuclide emissions are sampled and monitored at the RPL facility stack (EP-325-01-S), the only building exhaust point that could potentially contain radionuclides under normal operating conditions.

The building stack, located on the northwest side of the RPL, discharges ventilation exhaust from hot cells, and laboratory areas in the building at an exhaust rate of about 140,000 cfm. Because the stack flow is primarily building ventilation air, stack-gas specific gravity, humidity, and temperature are typical of the ventilation exhaust from an occupied building.

The types and quantities of radionuclides potentially present in the ventilation exhaust from the RPL must be understood to develop a program for measuring stack emissions. An index of emission potential is used by Pacific Northwest so that the relative significance of different radionuclides and different emission points can be compared. The index, expressed in terms of a projected potential dose equivalent to a maximum offsite receptor, is based on emission assessment methods in EPA (1971). It is assumed that no engineered emission controls (e.g., HEPA filters) are provided in the ventilation system, and that without such controls, the potential for radionuclide emissions is related to the quantity and physical form of radioactive material in the facility. This assessment method is described in Ballinger et al. (1999).

Radionuclides of primary importance in the RPL from an emission-sampling standpoint are determined on an annual basis, using the above methods. For example, based on the 2000 assessment of radionuclides inventory, radionuclides potentially contributing $\geq 10\%$ of the PTE are ^{241}Am , ^3H , ^{238}Pu , and $^{239/240}\text{Pu}$. Radionuclide inventories vary from year to year; therefore the nuclides of interest, those contributing $\geq 10\%$ of the total projected potential dose, are updated annually to account for these variations.

Continuous emission sampling for particulate radionuclides and tritium are performed using the isokinetic sampling system (ESP-325-01-S), which is compliant with NESHAP requirements in EPA (1990). Table 3.6 summarizes the types of emissions measurements performed by this system. A schematic diagram of the sampling/monitoring systems is provided in Figure 3.1. Detailed descriptions are provided below.

The radionuclide sampling system (ESP-325-01-S) was installed on the main building stack in late 1993. The system, which began operating in January 1994, complies with the sampler design criteria in Section 3.2.

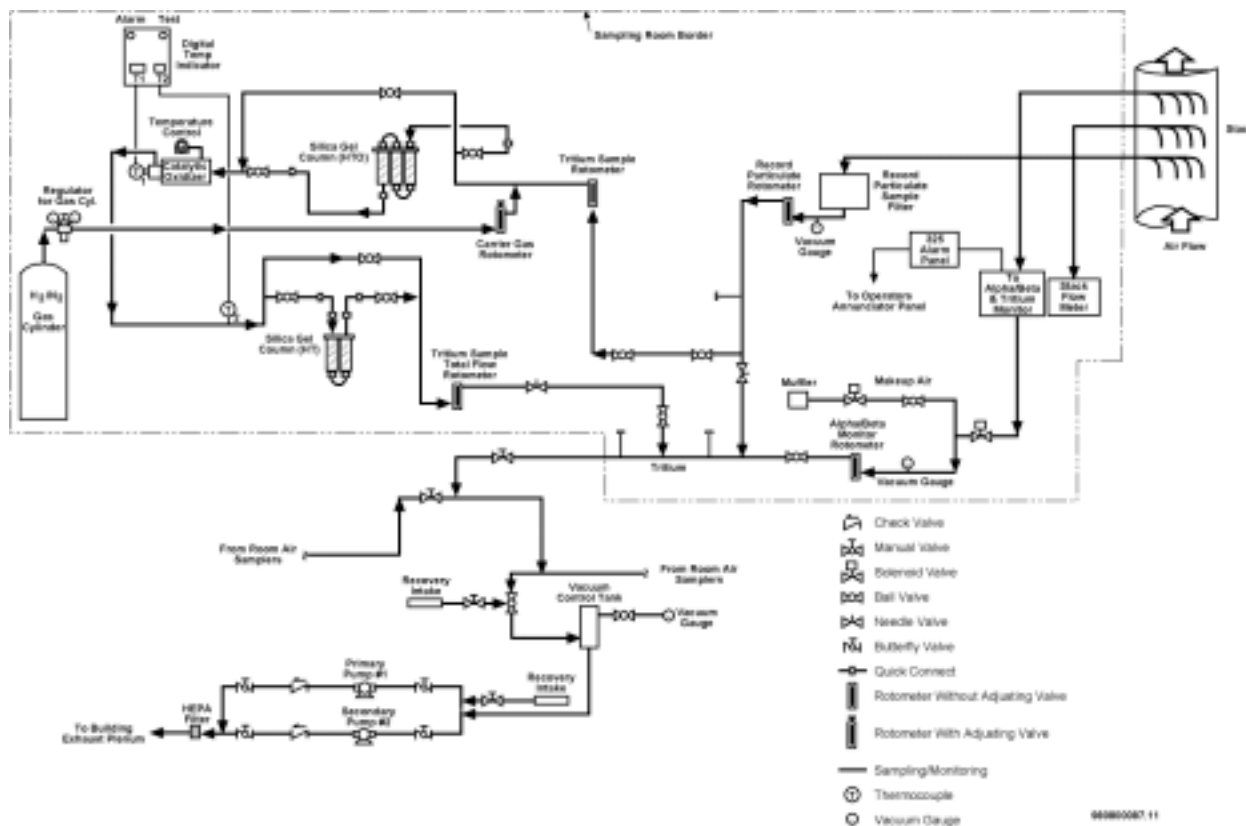


Figure 3.1. Schematic of RPL Main Stack Sampling System

Table 3.6. Airborne Emission Measurements - RPL

Continuous Sampling	Continuous Monitoring
Particulate Radioactivity	Particulate Alpha Activity
Tritium (HT and HTO)	Particulate Beta Activity
	Tritium Activity

The airborne radionuclide sampling system incorporates two co-located, six-nozzle, isokinetic sampling probe assemblies, (Figure 3.2), positioned in the approximately 90-ft-high^(a) stack (Figure 3.3). The probes are 7 equivalent diameters downstream of the stack entrance and 1 equivalent diameter upstream of the stack exit. Structural difficulties precluded meeting the 8:2 (downstream: upstream) duct-diameter placement recommendation from ANSI (1969). However, this design does comply with the alternative 2:0.5 criteria. The duct enters the stack at approximately 420-ft above sea level. Table 3.7 shows a comparison of the physical configurations of the probes. The sampling probe is used to sample for the record particulate sampler and tritium sampling system, while the monitoring probe is

(a) Height from ground. Stack height was increased as part of the sampling system upgrade in late 1993.

used for the continuous alpha/beta and tritium stack monitors. Probe nozzles for both probes are located at the centers of equal annular areas according to requirements in ANSI (1969).

Table 3.7. RPL Stack Probe Comparison

	Sampling	Monitoring
Nozzles	6	6
Nozzle Size	0.187"	0.494"
Header Size	1.25" (OD)	3" (OD)
Header Flow	3.1 scfm	21.2 scfm

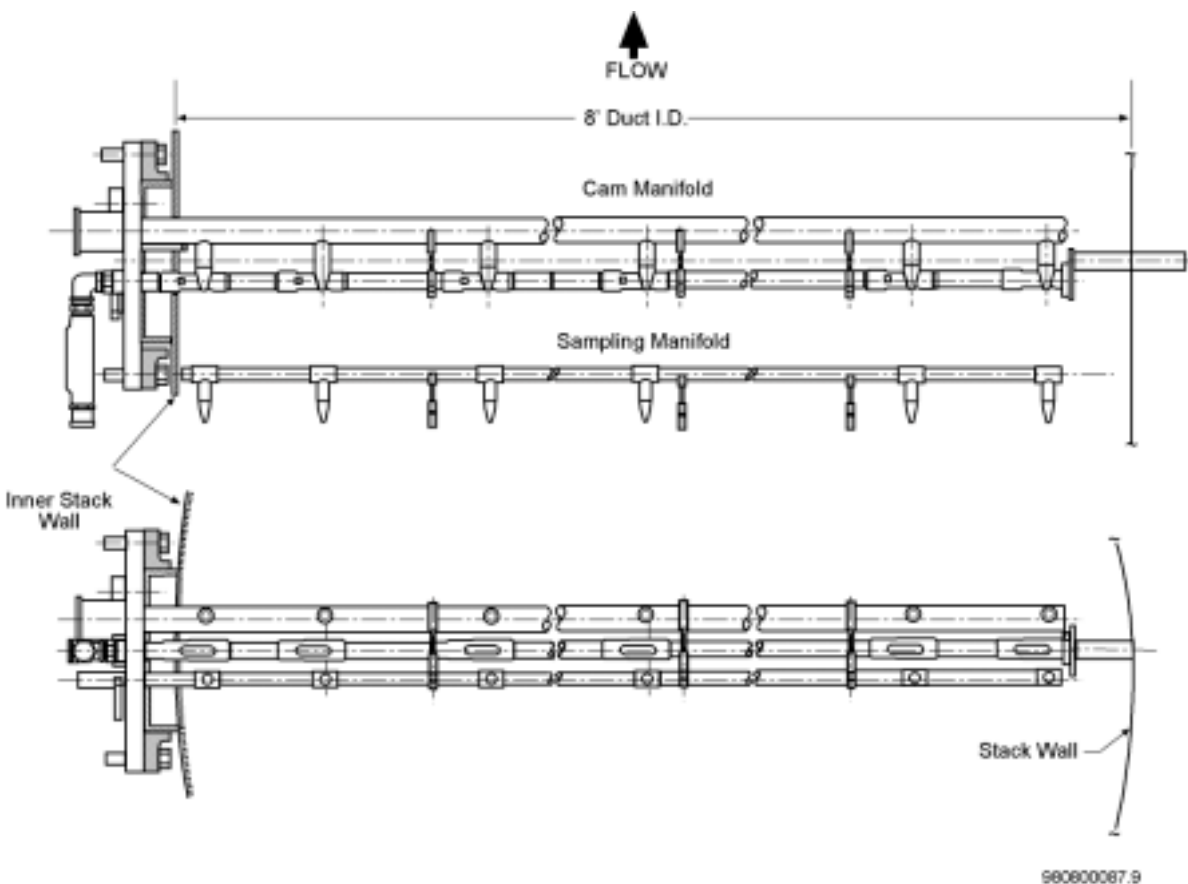


Figure 3.2. RPL Main Stack Sampling Probes

Near-isokinetic sampling conditions are maintained by adjusting the flow rate through both the sampler and the monitor so that the average airflow velocity of air entering the sampling nozzles corresponds to the average velocity of air in the stack at the nozzle locations. Stack emission samples are withdrawn from the stack and through the systems by means of the building vacuum air sampling system. Withdrawal rates are controlled by valves located downstream of the sampling and monitoring systems.

Flows are measured by rotameters that are placed upstream of the control valves. Stack velocities are measured on a quarterly frequency using EPA Method 2 (EPA 1971).

Both sample transport lines extend from the probe assembly to Room 916 where the sampling and monitoring equipment is located. The transport lines are constructed of stainless steel tubing and are heat traced, thermally insulated, and electrically grounded.

The sample transport efficiency of the collection systems has been calculated to be greater than 93% for an assumed 1-micron activity median aerodynamic diameters (AMAD) aerosol at nominal sampler and stack flow rates and greater than 95% for the monitoring system.^(a)

3.6.1 Main Stack Particulate Emission Sampling System

Airborne particles are collected on a 47-mm-diameter membrane filter (Gelman Sciences Versapor – Membrane, acrylic copolymer membrane filter). The membrane filter has an estimated retention efficiency for 0.3-micron particles of greater than 91% at face velocities of 180 fpm.

The record particulate collection filter is replaced every two weeks. The sample filter is stored for a minimum of 5 days after being removed from the sampler to permit decay of radon and thoron daughter radionuclides. The filter is then analyzed for gross alpha and gross beta radioactivity.

The two-week particulate samples are archived over a 6-month period (semi-annual). These are then combined (by emission point) and analyzed as a single sample for specific radionuclides as determined by the annual inventory assessment. Chemical Measurement Center (CMC) staff in the RPL analyze the samples using methods described in Chapter 4.0. Sample analysis results are evaluated as described in Section 3.7.

3.6.2 Main Stack Continuous Tritium Emission Sampling System

Tritium as water vapor (HTO) and tritium gas (HT and TT) is sampled continuously using a two-stage sampling system. The sub-sample flow rate to the tritium sampler is a nominal 200 mL/min.

The tritium sample stream is filtered by the record particulate sample collector that removes particles, and flow is measured using a rotameter. Initially, the sample stream is mixed with a nitrogen-hydrogen carrier gas (3% H₂ in N₂). It then enters the first tritium collection unit where silica gel is used to strip water vapor from the gas stream. On exit from the first stage, the dry sample stream is heated to >180°C in the presence of a palladium catalyst to convert free hydrogen (HT and TT) to water vapor. The sample stream is then cooled to under 40°C, condensing the water vapor, and then passed through the second silica gel collector to strip out the condensation.

(a) Loss calculations were performed using DEPO Version 4.0 (Riehl et al 1996). A 1-micron AMAD polydisperse aerosol was assumed for the calculations, based on the assumption that building operations and controls (HEPA filters) are “normal”.

The silica gel collection media are replaced with fresh media on a monthly basis; however, the exchange may be more frequent if premature collector loading occurs.^(a) Following the sampling period, the collection columns are exchanged with new columns and the used columns are sent to an analytical laboratory to determine the tritium content. Tritium emission quantities for the collection period are calculated assuming complete retention of sample in the collection column and multiplying the quantity of tritium collected in the column by the ratio of the stack flow rate to the sampler flow rate

3.6.3 Continuous Particulate Emission Monitoring System

Stack air is continuously monitored for radioactivity associated with particulate matter by an EG&G-Berthold LB-150D alpha-beta-pseudocoincident monitor (Figures 3.4 and 3.5).

The monitor uses an 8-in. diameter glass-fiber filter to collect airborne particles from the stack. The filter is mounted against a sandwich arrangement of gas-flow proportional radiation detectors to count the alpha, beta, and gamma emissions as particles accumulate on the filter.

(a) The collector unit is not allowed to exceed 2/3 of its maximum calculated capacity.



Figure 3.3. EG&G-Berthold Alpha-Beta and Tritium Monitor Detector Units



Figure 3.4. EG&G-Berthold Alpha-Beta and Tritium Monitor Display and Recorder Units

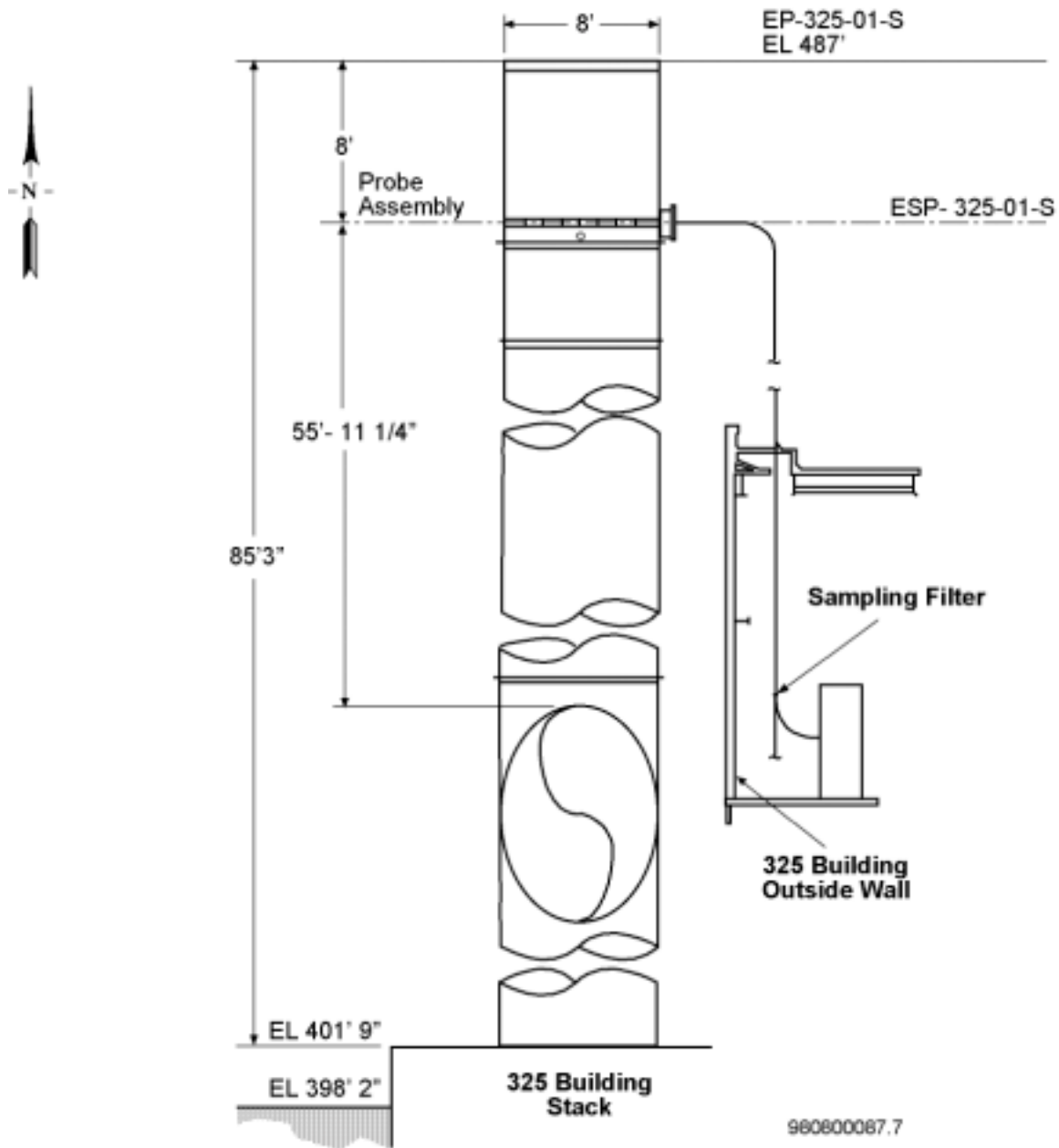


Figure 3.5. RPL Main Stack Sampling System Configuration

The monitoring system accounts for the presence of radioactive material associated with the decay products of naturally occurring radon isotopes by means of a timing gate to identify simultaneous alpha and beta emissions occurring on the filter. This method, referred to as the alpha-beta-pseudocoincidence-difference method (ABPD), uses the nearly simultaneous (pseudocoincident) alpha-beta decay transitions

in the ^{220}Rn and ^{222}Rn decay chains as a means of distinguishing naturally occurring radionuclides from artificial radionuclides deposited on the sample filter.^(a)

Local and remote annunciators provide indications of high particulate radionuclide emissions as well as monitor component failures.

3.6.4 Continuous Tritium Monitoring System

Stack air is continuously monitored for tritium by an EG&G-Berthold LB-110 tritium detector and an LB520/1001 tritium analyzer (Figures 3.4 and 3.5). The LB-110 is a windowless, flow-through proportional detector with pulse rise-time discrimination. The discriminator divides individual ionization events into short rise-time events and long rise-time events. Short rise-time events are counted as tritium, while long rise-time events are currently calibrated to ^{85}Kr .

The data from the discriminator are fed to the LB520/1001 analyzer. The analyzer is used to allow for subtracting background, accumulating pulse events, and converting those events to concentration. The analyzer also provides the output for the video display, chart recorder, and printer.

P-10 gas is mixed with the sample stream in a 4:1 ratio and passed through the detector. The P-10 gas is used to maximize sensitivity and minimize interference from other decays.

Local and remote annunciators provide indications of high tritium emissions, monitor component failures, and sample and P-10 flow transients lasting more than 60 seconds.

3.7 Radionuclide Air Sampling and Monitoring System Performance

This section describes the performance capability of the stack sampling and monitoring systems in terms of the offsite dose potentially resulting from a release. The determination of minimum sampler capability and the evaluation of monitor alarm levels is based on a series of assumptions of worst-case-exposure scenarios, resulting in calculations of upper bound doses. Thus, the methods used here to evaluate system capability are not appropriate for assessing actual releases. A realistic assessment of the significance of a monitor reading can be made only by considering the actual operational and environmental conditions at the time of the release.

(a) Three gas-flow proportional counters in a sandwich configuration independently count the number of alpha, beta, and gamma emissions on the sample collection filter. In addition, alpha and beta emissions that are detected pseudocoincidentally are also counted. The number of pseudocoincident events times a scaling factor is subtracted from the total alpha and beta counts to yield the net event detections attributed to sources other than radon isotopes.

3.7.1 Stack Radionuclide Sampling System Performance

Performance criteria for sampling are provided in Section 3.2. Two of the criteria concern measurement sensitivity, and the third concerns measurement bias. The criteria for bias is based on conformance of the system to design and operational guidance in ANSI (1969) and DOE (1991). The system description information in Section 3.5 is consistent with the design and operational guidance; thus, the bias criterion is met.

Sensitivity criteria (Section 3.2) for sampling are stated in terms of detectable offsite dose. According to the criteria, compliance sampling shall include measurement of radionuclides that could contribute greater than 10% of the PTE for the release point. Per performance criteria in Section 3.2.1, radionuclides should be detectable at emission levels resulting in an annual, committed effective dose equivalent of 0.01 mrem/year. Typically, measured radionuclides may include ^{137}Cs , ^{90}Sr , ^{238}Pu , $^{239/240}\text{Pu}$, ^{241}Pu , ^{241}Am , ^{243}Am , and tritium depending on the RPL radionuclide inventory. Total alpha activity and total beta activity are also measured to screen for other radionuclides in the stack exhaust.

Annual release quantities associated with an effective dose equivalent of 0.01 mrem/year were calculated from dose factors calculated using the EPA compliance code CAP-88 (Ballinger et al. 1999). These values are shown in Table 3.8.

The sensitivity of particulate radionuclide sampling is proportional to the collection efficiency of the sampler, the fraction of the emission quantity collected by the sampler (i.e., sampler efficiency), and the level at which the radionuclide can be detected in the collected sample. Under isokinetic sampling conditions, the RPL particulate sampler will intercept approximately 1/45,000 of the activity emitted via the stack (i.e., ratio of sampling rate to stack flow rate). Loss of particles in the sampling system due to deposition, plate-out, and filtering efficiency are estimated to be less than 7% for a 1-micron AMAD particulate aerosol.^(a) Using the contractual minimum detection level specified in the analytical laboratory statement of work (Table 3.8), the annual minimum detectable releases for specific radionuclides are as shown in Table 3.8. Detailed calculations are provided in Appendix C.

Annual release quantities associated with an effective dose equivalent of 0.01 mrem/year were calculated from dose factors calculated using the EPA compliance code CAP-88 (Ballinger et al. 1999). These values are shown in Table 3.8.

(a) Calculated using DEPO 4.0 (Riehl et al. 1996) assuming a particulate aerosol with an AMAD of 1.0 microns.

Table 3.8. Detection of Significant Radionuclides in RPL Stack Emission

Radionuclide	Analytical Limit (pCi/sample) ⁽¹⁾	Detectable Annual Release (Ci)	Emission Resulting in 0.01 mrem/year (Ci) ⁽⁶⁾
Beta Activity	38 ⁽²⁾	6.2E-5	2.0E-3 (as ¹³⁷ Cs)
Alpha Activity	1.0 ⁽²⁾	1.6E-6	5.6E-5 (as ²³⁸ Pu)
⁹⁰ Sr	38 ⁽³⁾	4.0E-6	2.0E-3
¹³⁷ Cs	38 ⁽³⁾	4.0E-6	2.0E-3
²⁴¹ Am	0.7 ⁽³⁾	7.4E-8	3.4E-5
²⁴³ Am	0.7 ⁽³⁾	7.4E-8	3.4E-5
²³⁸ Pu	1 ⁽³⁾	1.1E-7	5.6E-5
^{239/240} Pu	1 ⁽³⁾	1.1E-7	5.0E-5
²⁴¹ Pu	59 ⁽³⁾	1.1E-7	3.1E-3
Tritium (HTO)	63 ⁽⁴⁾	1.4E-2	24
Tritium (HT)	8 ⁽⁵⁾	1.9E-3	2400 ⁽⁷⁾
⁽¹⁾ From CMC Statement of Work ⁽²⁾ Includes correction for 15% reduction of the alpha and beta emissions originating from the sample that are absorbed by the sample media and surface dirt on the filter (Higby 1984). ⁽³⁾ Value for a 6-month composited group. ⁽⁴⁾ Based on submission of silica gel containing 160 mL of water loading and lab analysis minimum detection level of 1.9 pCi/aliquot for an aliquot size of 5 mL (i.e., 380 pCi/L). ⁽⁵⁾ Based on submission of silica gel containing 20 mL of water loading and lab analysis minimum detection level of 1.9 pCi/aliquot for an aliquot size of 5 mL (i.e., 380 pCi/L). ⁽⁶⁾ Based on dose per release factors to maximally exposed individual (MEI) calculated using CAP-88 (Ballinger et al. 1999). Dose factor for condensable (HTO) tritium is about 100 times that for noncondensable tritium (HT)			

The sensitivity of particulate radionuclide sampling is proportional to the collection efficiency of the sampler, the fraction of the emission quantity collected by the sampler (i.e., sampler efficiency), and the level at which the radionuclide can be detected in the collected sample. Under isokinetic sampling conditions, the RPL particulate sampler will intercept approximately 1/45,000 of the activity emitted via the stack (i.e., ratio of sampling rate to stack flow rate). Loss of particles in the sampling system due to deposition, plate-out, and filtering efficiency are estimated to be less than 7% for a 1-micron AMAD particulate aerosol.^(a) Using the contractual minimum detection level specified in the analytical laboratory statement of work (Table 3.8), the annual minimum detectable releases for specific radionuclides are as shown in Table 3.8. Detailed calculations are provided in Appendix C.

(a) Calculated using DEPO 4.0 (Riehl et al. 1996) assuming a particulate aerosol with an AMAD of 1.0 microns.

HTO sampling capability is related to total quantity of water vapor collected in the sample. For a given tritium release rate, the concentration of tritium in water vapor adsorbed on the collector will be inversely proportional to the quantity of water collected on the column (i.e., the water vapor containing tritium as HTO will be diluted by water vapor not containing HTO). The tritium collector is operated to a loading of 160 mL (operating procedures limit loading of collector to 2/3 of maximum rated capacity). Under worst-case sampling conditions (i.e., high humidity), 160 mL of water vapor will be collected in about 4 weeks. Analytical detection levels for tritium are 1.9 pCi for a 5-mL aliquot from the submitted sample. For a 160-mL sample size (i.e., maximum column loading), the worst-case minimum detectable tritium on the collector column would be 63 pCi. At a sampling rate of 200 mL/min (0.007 cfm), the stack to sample ratio is $1.99\text{E}7$ ($139,000 \text{ cfm}/0.007 \text{ cfm}$). Assuming the sampler is 100% efficient for collection of tritium vapor, the stack release for each sample period will be $1.98\text{E}7$ times the activity of tritium measured on the collector. For 12 sampling periods per year, the minimum annually detectable HTO emission is 0.014 Ci/year ($1.99\text{E}7$ times 12 samples/year times 60 pCi/sample).

The water vapor collected on the second (noncondensable forms of tritium) collection column is partially a function of the quantity of hydrogen in the atmosphere. However, because ambient air contains 0.5 ppm of hydrogen, at a 200 mL/min sample rate, the catalytic oxidizer will generate only about 1.5 mL of water over a 2-week period. Quantitative collection of this small amount of adsorbed water vapor is difficult, so additional hydrogen is injected into the sample stream to increase the quantity of collected water vapor to approximately 20 mL. The injection gas is nitrogen-hydrogen gas (3% H_2 in N_2). The addition of this gas mixture at 20 mL/min will generate an additional 20 mL of water loading over a 4-week sampling period. Because the sensitivity of tritium measurement is inversely proportional to the quantity of water loading on the collection column, the operation of the noncondensable tritium column at a water loading of 20 mL will achieve a detection level of $20/160 = 0.125$ times that of the condensable tritium column under full (160 mL) water loading.

From Table 3.8, it is apparent that the capability of the RPL stack sampling system exceeds the minimum criteria for detection of radionuclides in emissions.

3.7.2 Monitoring System Performance

This section describes the performance of the continuous stack monitoring systems for the RPL. The continuous stack monitoring systems notify operations personnel that a potentially “significant” radionuclide emission has occurred from the main building stack (EP-325-01-S).

As described in Section 3.3, emission monitoring systems should be able to detect a non-routine release that could result in an offsite effective dose equivalent of 2 mrem/year (i.e., 20% of the annual airborne radionuclide emission standard; DOE 1990). Alarm annunciation set points for the monitoring systems are maintained at or below the 2-mrem/year criteria level.^(a)

(a) Alarm setpoints below the minimum criteria level are developed in consideration of environmental “as low as reasonably achievable” (ALARA) objectives and existing facility conditions.

Monitor response to a radionuclide release is a function of the monitor sample collection and detection efficiency as well as the size of the sample. Under isokinetic sampling conditions, the RPL stack monitor will intercept approximately 1/6,200 of the release. Additionally, it is reasonable to assume that the failure of a filter system may have occurred as part of the accident and that emissions with a failed filter system could result in the presence of relatively large particles in the emission stream. Therefore, losses in the sample line assuming a 10-micron AED monodisperse aerosol are considered in alarm set points. In addition to these losses, it is assumed that 15% of the alpha and beta emissions originating in the sample are absorbed by the sample media and surface dirt on the filter (Higby 1984). Counting efficiencies based on monitor performance tests are also considered.

At this time, the actual minimum release that could be detected by the continuous particulate monitoring system has not been assessed. However, alarm set points based on an offsite effective dose equivalent of 2 mrem/year are calculated and documented by EM.

3.8 Handling of Radionuclide Air Sampling and Monitoring Data

Results obtained from the record sampling program are used to evaluate existing facility emission levels and to calculate annual emission quantities for compliance determination and reporting purposes.

Particulate samples are collected as described in Section 3.5. Analysis of samples by a laboratory is described in Chapter 4. Data are evaluated using documented and approved procedures. Data evaluation procedures are based on guidance in DOE (1991), *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* and EPA (1980).

Airborne-emission sampling data are reviewed for anomalies and trends. Provisional release estimates are updated throughout the sampling year (calendar year) as data are received. At the completion of the calendar year, data are reviewed, and the provisional release estimate is refined, as necessary, to account for anomalies or missing data as well as a significantly skewed data set. Anomalous data are investigated, and conclusions of the investigation are documented.

Final release quantities include corrections for isokinetic sampling efficiency, sample transport losses, sample self-absorption, decay, counting efficiency, background, and collection media efficiency.

3.9 Calibration and Maintenance of Radionuclide Air Sampling and Monitoring Equipment

Sampling and monitoring equipment, including rotameters, are maintained and calibrated according to predetermined schedules. Stack flow rates are measured using a standard-type pitot tube that is recognized by EPA as a primary calibration standard.

Radiation monitoring equipment is calibrated annually by the Instrumentation Services & Technology of Pacific Northwest. This group has responsibility for calibrating all portable radiation protection instrumentation at Hanford.

Continuous “major” sampling systems are inspected each workday by the Pacific Northwest Radiation Protection Section for proper flow rate setting and system operation. “Minor” sampling systems are inspected weekly during sampling periods. In addition, response and alarm tests are periodically conducted.

3.10 Alternative Sampling Methods for Radionuclide Air Emissions

All sampling and monitoring system components have replacement units available, so downtime is usually limited to a few hours, at most.

Alternative methods exist for assessing impacts of facility emissions. Workplace air monitoring systems provide evidence of the presence or absence of radionuclides in room air. Contamination surveys, routinely performed throughout the facility, provide additional evidence of contamination spreads. Air-emission control systems are checked annually for leaks.

An extensive environmental surveillance program is operated for the Hanford Site by Pacific Northwest. This program is described in detail in the Hanford Site Environmental Monitoring Plan (DOE 1997). The program performs ambient air sampling around the 300 Area perimeter as well as along the Hanford Site boundary and in adjacent communities. In addition to ambient air sampling, the environmental surveillance program samples groundwater, river water, drinking water, foodstuffs, soil, native vegetation, and aquatic and terrestrial animals. Annual reports issued by the Hanford Environmental Surveillance Program document the results of these samples.

3.11 Liquid Effluent Sampling and Monitoring

The liquid effluent sampling and monitoring system in the RPL is used to characterize facility effluents and to investigate potential discharges of concern. The primary criteria for this system is:

- Sampling capability sufficient to obtain grab and composite samples for effluent characterization data.
- Characterization sampling must ensure that a valid sample is obtained and that the sample can be analyzed for almost any chemical or parameter.
- Sampling and monitoring equipment to enable periodic verification of effluent characteristics as needed.
- Sampling and monitoring capabilities to investigate potential discharges of concern.

The liquid effluent sampling and monitoring system installed in the RPL is located downstream of the RPS sump which is located in the RPL basement (see Figure 3.6). At this point, all RPS liquid effluents from the building are combined (the RPL has no PS) and can be sampled and monitored as needed to meet the applicable requirement. The refrigerated sampling system has the ability to take grab or flow-composite samples and controls temperature of samples to ensure preservation requirements are met. In addition, EM has sampling procedures in place and a contract with an Ecology accredited analytical laboratory to ensure that sampling requirements are met.

A schematic of the system is provided in Figure 3.7. As shown, the system can provide pH, conductivity, and flow measurements of the RPS stream discharging from the RPL. Also, the system can obtain liquid effluent samples as needed to characterize waste or diagnose liquid effluent concerns to determine whether they are stemming from the RPL. As noted in Section 3.4.1.2, characterization sampling has been performed using this system and the system is maintained to perform sampling as needed.

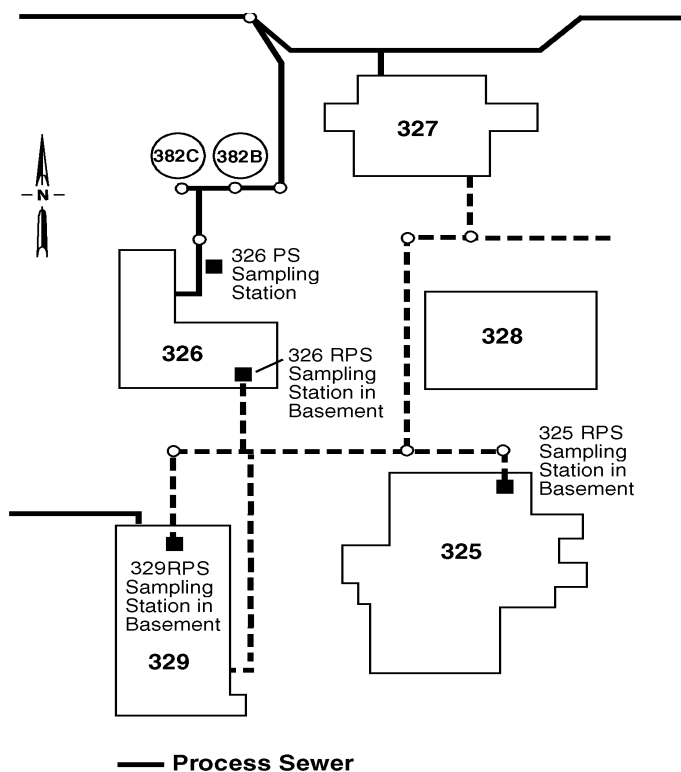


Figure 3.6. Location of Liquid Effluent Sampling and Monitoring System for RPL

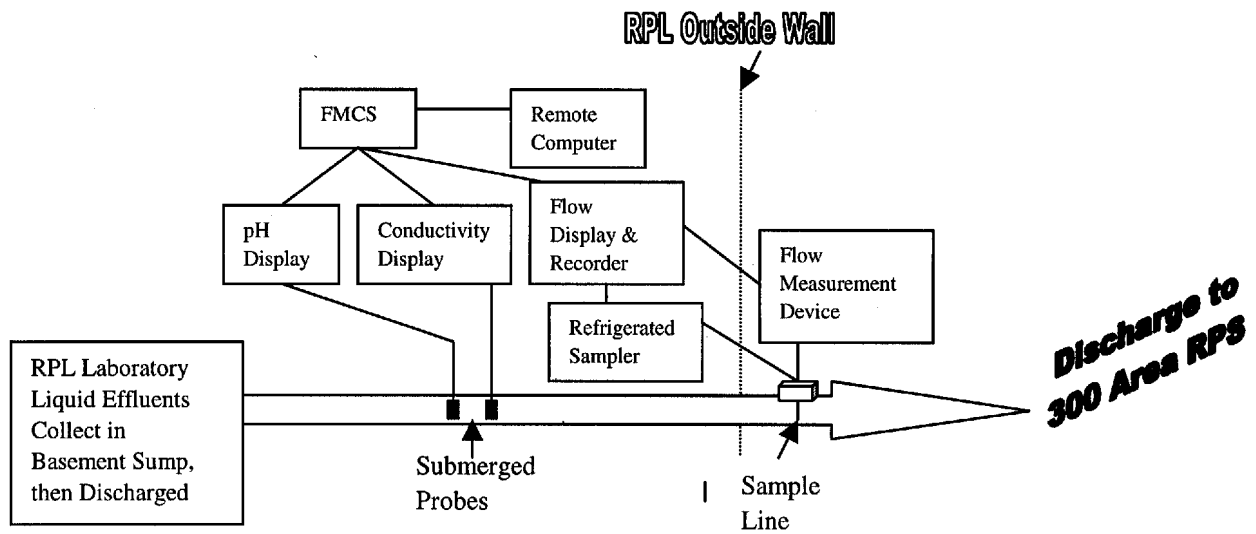


Figure 3.7. Schematic of Liquid Effluent Sampling and Monitoring System for RPL
(Note: Conductivity monitoring not currently in operation.)

4.0 Laboratory Analyses

This section provides information on the analytical laboratories and procedures used to analyze samples collected in support of the Pacific Northwest effluent monitoring program. Liquid discharges from the RPL are sampled by Fluor Hanford at the point of collection for final disposal and at the TEDF, and are therefore not addressed in this FEMP. RPL chemical air emissions, when sampled, are analyzed following EPA Compendium Method TO-15 (see Section 3.4) in the PNNL Field Hydrology and Chemistry Group analytical laboratory. This section therefore is limited to the laboratory analysis required for the determination of radioactivity in samples collected from the main building stack.

Section 3.5 describes the types of samples collected by the building sampling system for the main building stack. These samples are for particulate radionuclides on filter paper and tritium (tritiated water) on silica gel. The laboratories and procedures used to perform these analyses are described in Section 4.1. Section 4.2 provides a description of procedures employed by Pacific Northwest and its supporting analytical laboratories.

4.1 Analytical Procedures

Analytical procedures for alpha and beta particulate radioactivity and isotopic analysis are provided in this section. The principal radionuclides in RPL emissions are described in Section 3.0. These radionuclides are detectable using procedures described in this section. Analyses are performed by the Chemical Measurement Center (CMC) of the Pacific Northwest Radiochemical Processing Group. All analytical work associated with radionuclide sampling is performed according to required methods per Pacific Northwest contract and statement of work (SOW) with the analytical laboratory. The SOW is prepared to meet the QA requirements from 40 CFR 61 (EPA 1990).

4.1.1 Determination of Alpha and Beta Activity on Particulate Air Filters

Particulate air filter samples from the RPL Main Stack are collected every 2 weeks, as described in Section 3.5. The samples are initially delivered to a counting laboratory operated by Pacific Northwest's Radiation Protection Section. The samples are held a minimum of 4.5 days to allow for adequate decay of radon daughter radionuclides.

Following the hold time for radon daughter decay, each particulate filter is delivered to the CMC. Analytical services are performed according to documented requirements in a statement of work (SOW).

Samples are received, logged in, classified, and analyzed according to procedures documented as standard operating procedures (SOPs).

The CMC particulate alpha and beta analysis method is documented in CMC SOPs. Samples are counted on an alpha and beta proportional counter. The counters are operated with a full open-energy

window and are calibrated using ^{239}Pu and ^{90}Sr sources corrected for self-absorption. As specified in the SOW, required detection levels are 1-pCi/sample alpha and 38-pCi/sample beta activity on a single (2-week sample) filter for Type I and Type II errors of 0.05. For the RPL stack, this equates to a detectable concentration of $8\text{E-}16\text{ }\mu\text{Ci/cm}^3$ alpha and $3\text{E-}14\text{ }\mu\text{Ci/cm}^3$ beta (see Appendix C). Section 3.5 addresses the performance capability of the particulate emission sampling program in terms of detectable offsite dose.

4.1.2 Determination of Tritium in Silica Gel Column

Tritium in air is collected by trapping moisture in a column of silica gel. Following collection, the complete column is delivered to the lab for analysis.

As with the particulate alpha and beta analysis, the tritium analysis procedure is documented in CMC SOPs.

The procedure consists of quantitatively desorbing water collected in the silica gel column and counting for tritium using liquid scintillation spectrometry. The water is removed from the silica gel by distillation, and collected using a Gore-Tex membrane and Lachet tube. A 3-mL aliquot is removed from the collected water for liquid scintillation counting. The detection level for tritium in water, as specified in the SOW, is approximately 380 pCi/L of water, assuming a sample size of at least 3 mL. Pacific Northwest tritium samplers are designed and operated to provide the required sample size. Sensitivity of the measurement is highly dependent on the water loading of the sampler, with analytical sensitivity indirectly proportional to sampler loading. Assuming that a sampler is fully loaded with adsorbed water, after a 1-month sample period, a stack tritium concentration (HTO) of $7\text{E-}12\text{ }\mu\text{Ci/cm}^3$ is detectable. Supporting calculations are provided in Appendix C.

4.1.3 Isotopic Analysis

The record particulate filters analyzed by CMC for alpha and beta, as discussed in Section 4.1.1, are further analyzed for individual isotopes that contribute 10% or greater of the potential-to-emit. These analyses are performed by CMC on particulate samples composited on a semi-annual basis.

The CMC composite preparation and analysis methods used for the above isotopes are listed in Table 4.1. As specified in the SOW, required detection levels are also listed in Table 4.1.

Before digesting the particulate filters for isotopic analysis, the filters are grouped on a semi-annual basis in preparation for gamma scan analysis. The semi-annual groups of samples are transferred to a standard geometry container for counting on the gamma detectors. Intrinsic Germanium (high-purity germanium [HPGE]) detectors are used to detect isotopes with gamma ray energies between 60 and 2000 eV.

Table 4.1. Isotopic Separation and Analysis Methods

Method	MDA (pCi/sample)
Air Filter Preparation and Compositing	-NA-
Gamma Analysis Sample Preparation, All Matrices	38 ⁽¹⁾
Electrodeposition Procedure for the Actinides	-NA-
Strontium Determination for 6-month Filter Composites	38
Isotopic Plutonium Determination for 6-month Filter Composites	1
Isotopic Americium/Curium Determination for 6-month Filter Composites	0.7

Following the gamma scan, the semi-annual groups are digested, and the elements of interest are separated from other elements and the sample matrix by chemistry. The ^{90}Sr content is determined by the chemical separation and counting of a daughter element, ^{90}Y . The strontium is separated from other elements chemically, then ^{90}Y is permitted to grow into equilibrium with the ^{90}Sr . The ^{90}Y is then separated and processed to determine the chemical recovery and counted on a low background beta proportional counter. The quantity of ^{90}Sr is then determined based on the quantity of the daughter ^{90}Y produced.

Plutonium is separated from other elements and the sample matrix by adsorption on an anion exchange column. The plutonium is then processed chemically and electroplated or coprecipitated on rare earth fluorides. Isotopic concentrations of the deposited material is determined by alpha spectrometry. Following the removal of the plutonium, the sample matrix is further processed chemically and the americium and curium is removed by passing the sample through a cation exchange column. The americium and curium are eluted from the column and either electroplated or coprecipitated. As with the plutonium, isotopic concentrations of the deposited material are determined by alpha spectrometry.

4.2 Procedures

Pacific Northwest's Effluent Management Group (EM) maintains documented technical and operation procedures for all aspects of environmental monitoring. SBMS (Procedures, Permits, and Other Work Instructions) contains the requirements for preparation, review, and approval of these procedures. EM procedures incorporate all required elements of the SBMS (Procedures, Permits, and Other Work Instructions).

Sampling procedures include identification of applicable staff, identification of possible hazards encountered while collecting samples, emergency contacts, any applicable prerequisites for performing the work, and work instructions. The work instructions address areas such as equipment operation;

sample collection media to be used; amount of sample to be collected; and sample preservatives (as needed).

Effluent Management maintains documented chain-of-custody procedures for all samples. Procedures include provisions for transfer of samples between operational staff, to and from regulated storage areas, and to the analytical laboratory. Both Pacific Northwest and any offsite analytical services contractor implement chain-of-custody within the Laboratory.

The analytical laboratory maintained documented and approved chain-of-custody procedures for the preliminary analyses of particulate emission samples, for record analysis of particulate air filters, and silica gel collectors. Radiological particulate air samples are stored for 18 months before being discarded.

5.0 Quality Assurance Requirements

5.1 Quality Assurance Plan

A number of quality assurance (QA) plans were developed to address QA for the different types of effluent monitoring activities performed by Pacific Northwest, including: radiological air, chemical air, and water release sampling and monitoring. These plans were integrated into one Effluent Management QA Plan in 1997 and this plan has been updated on an annual basis. This plan addresses QA for all Pacific Northwest effluent management activities. The current QA program described by the plan is based on the following general requirements and guidance:

- DOE Order 414.1A, *Quality Assurance* (DOE 1999)
- 10 CFR 830.120 *Quality Assurance* (DOE 1994)
- Pacific Northwest Quality Homepage, *General Quality Assurance Planning* (<http://quality.pnl.gov/guidance/genqaplan/qaplan.htm>)
- DOE Order 5400.1, *General Environmental Protection Program* (DOE 1988)
- U.S. Environmental Protection Agency (EPA) QAMS-005/80, *Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans* (EPA 1980)
- American National Standards Institute/American Society for Quality Control (ANSI/ASQC) E4-1994, *American National Standard Specifications and Guidelines for Quality Systems for Environmental Data Collection and Environmental Technology Programs* (ANSI/ASQC 1994)
- DOE/EH-0173T, *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (DOE 1991b).

In addition, QA requirements specified in permits and regulations, including 40 CFR 61 (EPA 1990), for Pacific Northwest effluent sampling or monitoring activities are incorporated into the QA Plan.

5.2 Internal and External Plan Review

DOE 5400.1 (DOE 1988) states that the Environmental Monitoring Plan (EMP) will be reviewed annually and updated every 3 years. As a support document to the EMP, the FEMP will also be updated every 3 years. At a minimum, the FEMP assessment will be performed annually.

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6.0 Program Implementation Procedures

The Hanford Site Environmental Monitoring Plan (EMP) (DOE 1997) documents the effluent-monitoring and environmental surveillance programs for the Hanford Site.

6.1 Interface with the Near-facility Environmental Monitoring Program

The EMP divides the effluent-monitoring coverage into two areas, the FEMPs and the Near-Facility Environmental Monitoring Program. The FEMPs cover the monitoring of effluents within the facility. Pacific Northwest's Effluent Management Project maintains implementation procedures for all Pacific Northwest facility-monitoring activities. These procedures meet the Pacific Northwest requirements for technical and operating procedures (SBMS, Procedures, Permits, and Other Work Instructions) and ensure that facility effluent sampling and monitoring is conducted compliantly. The Near-Facility program monitors air, surface water, groundwater, soil, sediment, vegetation, and biota around site facilities to evaluate the adequacy of effluent control at various facilities at the Hanford Site. The program is conducted by Waste Management Federal Services, Inc. Northwest Operations.

6.2 Interface with the Operational Environmental Surveillance Program

Environmental surveillance of the 300 Area and the surrounding onsite and offsite areas is performed by the Pacific Northwest Hanford Site Surface Environmental Surveillance Project and the Pacific Northwest Site-Wide Groundwater Monitoring Project. These projects are notified in the event of actual or apparent new or off-normal discharges to the soil, surface waters, or air so they can assist in assessing their environmental and compliance significance. The data from these programs are also useful to verify the occurrence or nonoccurrence of facility releases. These surveillance projects are described in detail in DOE (1997).

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7.0 Reporting

This section describes the compliance reporting and notification requirements related to facility effluent monitoring activities for the RPL. It also identifies the requirements and provides an overview of the procedural steps for the notification, investigation, and reporting of all environmental off-normal events for Pacific Northwest operations.

7.1 Routine Effluent Monitoring Reports

On a periodic basis, effluent monitoring data are gathered by Pacific Northwest on specific DOE Richland Operations Office (DOE-RL) facilities for compilation and reporting to DOE and various regulatory agencies.

The following effluent monitoring reports are submitted to regulatory agencies:

Airborne Effluent

- An Annual NESHAP Air Emissions Report for the Hanford Site providing the required annual emissions measurements and climatological data is submitted to the U.S. Environmental Protection Agency (EPA) and the Washington State Department of Health (WDOH) for the Hanford Site radioactive airborne emissions.
- The Annual Radioactive Effluent and Onsite Discharge Data Report is submitted to DOE-Headquarters, the EPA, and WDOH through DOE-RL.
- Semiannual Reports will be required by the Hanford Site Air Operating Permit (issuance expected in 2001). These will require reporting deviations from monitoring and sampling requirements or emission limits, any required source test and monitoring reports, and the results of any air emission compliant investigations.
- An Annual Compliance Certification to WDOE, WDOH, BCCA, USEPA that certifies continuous or intermittent compliance with sampling and monitoring requirements, and emission limits under the AOP (First report due 12 months following the effective date of the AOP [anticipated 2001]).

Liquid Effluent

- WDOE is provided an annual report on significant discharges of hydrotest, maintenance, or construction wastewater discharged to ground as required by permit ST-4508 (WDOE 1997).

Other

- WDOE is provided with a monthly status report of all reportable spills from the previous month through DOE-RL.
- Annual Hanford Site Notification of Intent (NOI) for planned asbestos removal activities is submitted to Benton Clean Air Authority (BCAA) through Flour Hanford by December 15th each year. [BCAA Regulation 1, 40 CFR 61, Subpart M].

7.2 Non-Routine Notifications and Reports

There are a number of reports, including notification reports, that are required with respect to effluent monitoring activities. These include:

- A Notice of Construction (NOC) must be provided to WDOH and/or WDOE and/or the Benton Clean Air Authority (BCAA), depending on emissions type, whenever a new emission unit subject to regulation is to be created, or if there is to be significant modification to an existing emission unit.
- Prompt reporting of abnormal or upset conditions, or deviations from permit requirements to WDOH and/or WDOE will be required by the AOP when issued. A Notification Follow-up Report may also be requested in addition to the initial notification.
- Report of Closure shall be submitted to WDOH whenever an emission unit covered under WAC 246-247 (WAC 1994) ceases emission.
- Notification of Intent to Remove Asbestos Containing Material, or to Demolish must be submitted to the BCAA and if required, the U.S. EPA, 10 working days in advance of removal activity, should specific regulatory thresholds be exceeded [BCCA Regulation 1, 40 CFR 61, Subpart M].
- Prior to the construction and operation of Class V Underground Injection Control Wells (WAC 173-218), a registration form must be submitted to WDOE.

7.3 Event Notification and Reporting

“Events” or conditions may adversely affect DOE or contractor personnel, the public, property, the environment, or the DOE mission. Staff who discover an event that requires mitigation must notify the Battelle single-point-contact to begin the response and mitigation process. Managers who are notified of events within their domain participate in the recovery, evaluation, analysis, and corrective action of the event. These two processes, staff notification and management participation, are described in a Pacific Northwest Standards-Based Management System (SBMS) Subject Area (SBMS, Event Reporting). The Subject Area incorporates requirements from DOE 232.1A, “Occurrence Reporting and Processing of Operations Information” (DOE 1997) and associated DOE-RL Directives (RLIDS).

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Appendix A

Projection of Offsite Emission Dose

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Appendix A

Projection of Offsite Emission Dose

DOE Order 5400.1 states that Environmental Monitoring Plans (EMP) “shall be prepared for each site, facility, or process that uses, generates, releases, or manages significant pollutants or hazardous materials” (DOE Order 5400.1, IV-2). To support the EMP, Facility Effluent Monitoring Plans (FEMPs) are being prepared for those facilities that have the potential to release significant pollutants or hazardous materials. A methodology has been developed to determine whether potential releases of radioactive material are significant. This method is the same as that used to determine whether monitoring is required for the National Emission Standards for Hazardous Air Pollutants (NESHAPs - U.S. Code of Federal Regulations, Title 40 Part 161, Subparts H and I) and is described in *Assessment of Unabated Facility Emission Potentials for Evaluating Airborne Radionuclide Monitoring Requirements at Pacific Northwest National Laboratory – 1999*. (Ballinger et al. 1999, PNL-10855 Rev. 1).

The first step in the method (called the FEMP Determination when used to determine whether or not a FEMP is needed for a facility) is to obtain a listing of the facility inventory. The inventory includes the radionuclide, isotope, quantity, and form. Form can be gas, liquid or powder, solid (nondispersible), contained (in sealed sourced or DOT containers), or exempt (sealed sources meeting certain criteria). At Pacific Northwest, radioactive source and material information is maintained using three separate inventory systems: (1) facilities management radioactive materials inventory, (2) composite radioactive materials inventory, and (3) nuclear materials inventory. An identifier on the inventory listing indicates the inventory system that the information was obtained from. Additional detail on the FEMP Determination method is provided in PNL-10855 Rev. 1. A table is provided showing a listing by nuclide of the radioactive material inventory in the RPL. The table shows the total activity and the percent contribution to the total unabated Potential-to-Emit for the facility for the year 2000.

Year 2000 FEMP Dose Contribution by Nuclide for: 325

Total Dose: 1.50E+02 mrem

Nuclide	Inventory Ci	Dose (mrem)	% Total	Nuclide	Inventory Ci	Dose (mrem)	% Total
Ac-225	7.80E-13	2.71E-15	0.00%	Cm-243	5.83E+02	1.66E-04	0.00%
Ac-227	4.50E-03	1.64E-03	0.00%	Cm-244	2.50E+02	1.35E-01	0.09%
Ag-108	5.54E-12	3.44E-14	0.00%	Cm-245	1.30E-06	4.20E-07	0.00%
Ag-108m	6.23E-11	3.87E-13	0.00%	Cm-246	6.08E-07	1.94E-07	0.00%
Ag-109m	4.54E-11	1.24E-22	0.00%	Cm-247	3.16E-12	9.37E-13	0.00%
Ag-110	1.64E+03	1.10E-15	0.00%	Cm-248	1.50E-11	1.77E-11	0.00%
Ag-110m	9.48E-05	1.98E-09	0.00%	Co-57	8.46E+01	3.25E-08	0.00%
Am-241	1.94E+08	2.78E+00	1.85%	Co-58	1.97E+01	2.95E-06	0.00%
Am-242	2.60E-05	8.28E-10	0.00%	Co-60	2.22E+10	3.43E-03	0.00%
Am-242m	2.61E-05	7.85E-06	0.00%	Cr-51	5.38E-01	1.22E-09	0.00%
Am-243	3.42E+01	5.24E-01	0.35%	Cs-131	7.98E-10	4.96E-15	0.00%
Am-245	1.87E-15	1.16E-17	0.00%	Cs-134	7.96E+06	8.23E-05	0.00%
Ar-37	1.83E+03	6.94E-01	0.46%	Cs-135	6.62E-07	7.62E-11	0.00%
Ar-39	5.63E-02	3.50E-01	0.23%	Cs-137	3.87E+10	5.39E-01	0.36%
At-217	7.80E-13	2.44E-13	0.00%	Es-254	2.05E-15	6.41E-16	0.00%
Ba-131	1.44E-10	8.94E-16	0.00%	Eu-150	3.03E-11	1.88E-13	0.00%
Ba-133	2.48E+02	3.93E-07	0.00%	Eu-152	3.05E+03	3.11E-04	0.00%
Ba-137m	1.05E-01	2.30E-09	0.00%	Eu-154	1.42E+05	1.25E-03	0.00%
Be-10	4.16E-12	2.58E-14	0.00%	Eu-155	1.01E+05	3.22E-05	0.00%
Be-7	2.82E-09	1.42E-14	0.00%	Fe-55	2.47E+03	9.45E-03	0.01%
Bi-207	2.95E+01	3.27E-09	0.00%	Fe-59	3.43E-01	2.54E-07	0.00%
Bi-210	8.05E-01	8.94E-08	0.00%	Fr-221	7.80E-13	4.44E-19	0.00%
Bi-211	1.03E-11	5.32E-19	0.00%	Fr-223	1.43E-13	1.31E-19	0.00%
Bi-212	4.96E-08	7.60E-13	0.00%	Gd-148	1.02E+00	3.20E-07	0.00%
Bi-213	7.80E-13	4.42E-19	0.00%	Gd-153	1.00E+00	6.84E-08	0.00%
Bi-214	1.09E+00	4.91E-10	0.00%	H-3	9.40E+04	4.64E+01	30.94%
Bk-249	1.29E-10	7.99E-13	0.00%	Hf-175	4.75E-03	2.95E-08	0.00%
Bk-250	2.05E-15	6.42E-16	0.00%	Hf-181	9.76E-03	6.18E-10	0.00%
C-14	9.82E+02	7.84E-08	0.00%	Hg-203	1.00E-04	8.80E-09	0.00%
Ca-41	3.62E-04	9.56E-14	0.00%	Ho-166m	1.17E-08	2.43E-10	0.00%
Ca-45	3.12E-01	1.96E-06	0.00%	I-125	4.65E-05	1.91E-07	0.00%
Ca-47	1.14E-27	7.08E-33	0.00%	I-129	1.70E-01	5.83E-06	0.00%
Cd-109	2.57E+00	1.59E-08	0.00%	In-113m	6.76E-01	8.38E-11	0.00%
Cd-113m	7.41E-05	4.60E-07	0.00%	In-114m	2.86E-03	1.78E-08	0.00%
Ce-142	3.77E-11	2.34E-13	0.00%	In-114m	2.99E-03	1.86E-08	0.00%
Ce-144	4.40E+03	1.29E-03	0.00%	K-40	8.33E+06	2.66E-02	0.02%
Cf-249	2.18E-10	6.82E-11	0.00%	K-42	9.20E-12	5.71E-17	0.00%
Cf-250	8.33E-10	2.61E-10	0.00%	Kr-81	1.07E-12	6.66E-15	0.00%
Cf-251	8.47E-12	2.65E-12	0.00%	Kr-85	6.00E+01	6.42E-08	0.00%
Cf-252	1.64E+02	1.42E-05	0.00%	La-140	5.09E-15	5.34E-23	0.00%
Cl-36	2.45E-01	3.91E-02	0.03%	Lu-177	9.52E-07	5.91E-12	0.00%
Cm-242	2.26E+00	4.51E-07	0.00%	Mn-54	9.88E+02	1.13E-04	0.00%

Nuclide	Inventory Ci	Dose (mrem)	% Total	Nuclide	Inventory Ci	Dose (mrem)	% Total
Mo-93	6.50E-03	5.57E-08	0.00%	Pu-240	2.34E+05	2.49E-01	0.17%
Mo-99	5.33E-37	2.78E-45	0.00%	Pu-241	1.03E+04	7.79E-04	0.00%
Na-22	1.07E+01	1.72E-08	0.00%	Pu-242	3.42E-02	1.04E-04	0.00%
Nb-92	3.12E-11	1.94E-16	0.00%	Pu-243	3.16E-12	4.29E-19	0.00%
Nb-93m	2.65E+00	2.19E-08	0.00%	Pu-244	2.05E-12	3.94E-13	0.00%
Nb-94	4.87E+01	2.49E-06	0.00%	Ra-223	1.03E-11	6.18E-14	0.00%
Nb-95	1.42E+01	1.78E-06	0.00%	Ra-224	5.17E-08	1.11E-10	0.00%
Nb-95m	4.86E-02	3.95E-10	0.00%	Ra-225	7.80E-13	2.92E-15	0.00%
Nd-144	2.32E-15	7.28E-16	0.00%	Ra-226	1.95E+02	5.98E-04	0.00%
Ni-59	2.03E-01	7.75E-09	0.00%	Ra-228	9.03E+00	4.43E-08	0.00%
Ni-63	2.74E+03	4.17E-06	0.00%	Rb-87	2.71E-11	6.65E-15	0.00%
Np-235	3.59E-11	2.23E-13	0.00%	Re-186	7.29E-09	4.53E-11	0.00%
Np-236	7.55E-12	2.36E-12	0.00%	Re-188	1.52E-03	9.44E-09	0.00%
Np-237	1.64E+08	4.92E-02	0.03%	Rh-102	2.36E-07	1.47E-09	0.00%
Np-238	1.30E-07	2.62E-12	0.00%	Rh-106	1.50E-03	3.10E-14	0.00%
Np-239	5.81E-05	1.81E-10	0.00%	Rn-219	1.03E-11	6.77E-16	0.00%
Np-240m	2.05E-12	8.15E-20	0.00%	Rn-220	4.96E-08	6.35E-15	0.00%
P-32	1.27E-07	9.53E-15	0.00%	Rn-222	1.09E+00	1.48E-09	0.00%
Pa-231	5.30E-07	1.51E-07	0.00%	Ru-103	2.18E-05	1.04E-12	0.00%
Pa-233	4.37E-07	1.17E-11	0.00%	Ru-106	6.60E+03	1.13E-04	0.00%
Pa-234	4.89E-10	9.93E-16	0.00%	S-35	3.54E-03	3.75E-11	0.00%
Pa-234m	3.76E-07	4.44E-17	0.00%	Sb-124	1.18E-03	2.63E-10	0.00%
Pb-209	7.80E-13	4.03E-20	0.00%	Sb-125	1.54E+04	7.33E-05	0.00%
Pb-210	2.66E+00	2.95E-05	0.00%	Sb-126	1.72E-07	1.45E-11	0.00%
Pb-211	1.03E-11	3.94E-17	0.00%	Sb-126m	1.22E-06	4.01E-13	0.00%
Pb-212	2.12E-02	1.08E-10	0.00%	Sc-46	1.26E-03	1.51E-09	0.00%
Pb-214	3.20E+00	4.37E-10	0.00%	Sc-47	4.35E-27	2.70E-32	0.00%
Pd-107	2.09E-07	1.95E-12	0.00%	Se-75	4.80E+00	4.03E-06	0.00%
Pm-146	1.08E-06	6.69E-09	0.00%	Se-79	1.24E-06	7.68E-09	0.00%
Pm-147	1.00E+01	7.13E-07	0.00%	Sm-145	1.00E+00	6.21E-09	0.00%
Po-209	2.23E-03	6.98E-10	0.00%	Sm-146	6.00E-13	1.88E-13	0.00%
Po-210	6.33E-01	8.41E-06	0.00%	Sm-147	5.62E-12	2.33E-13	0.00%
Po-211	2.90E-14	9.06E-15	0.00%	Sm-151	1.00E+05	2.06E-06	0.00%
Po-212	3.18E-08	9.96E-09	0.00%	Sn-113	6.83E-01	3.86E-08	0.00%
Po-213	7.63E-13	2.39E-13	0.00%	Sn-119m	1.44E+01	8.99E-05	0.00%
Po-214	1.09E+00	3.41E-04	0.00%	Sn-121m	6.60E+03	4.70E-04	0.00%
Po-215	1.03E-11	3.24E-12	0.00%	Sn-123	3.26E-01	4.37E-10	0.00%
Po-216	4.96E-08	1.55E-08	0.00%	Sn-125	7.19E-11	4.41E-18	0.00%
Po-218	1.09E+00	4.57E-12	0.00%	Sn-126	6.06E+02	2.42E-08	0.00%
Pr-144	3.25E-04	1.00E-11	0.00%	Sr-85	4.78E+01	3.09E-07	0.00%
Pr-144m	3.90E-06	2.63E-14	0.00%	Sr-89	1.98E-03	8.77E-11	0.00%
Pu(12%)	4.16E+02	1.05E+01	7.00%	Sr-90	6.83E+08	4.92E-01	0.33%
Pu(24%)	3.76E+02	3.19E+01	21.29%	Ta-179	6.54E-08	4.06E-10	0.00%
Pu(6%)	5.82E+02	1.30E+01	8.69%	Ta-182	1.21E+01	8.18E-05	0.00%
Pu-236	2.63E-03	5.84E-09	0.00%	Ta-183	9.28E-20	5.76E-25	0.00%
Pu-238	2.10E+05	3.74E+01	25.00%	Tb-160	8.82E-16	1.46E-19	0.00%
Pu-239	2.82E+10	4.62E+00	3.08%	Tc-95m	2.80E-03	1.24E-08	0.00%

Nuclide	Inventory Ci	Dose (mrem)	% Total
Tc-97m	1.41E-01	8.74E-10	0.00%
Tc-98	1.08E-11	6.73E-14	0.00%
Tc-99	6.44E+04	1.40E-04	0.00%
Tc-99m	2.00E-02	1.24E-04	0.00%
Te-123m	1.18E-03	7.33E-09	0.00%
Te-125m	1.67E+00	5.43E-08	0.00%
Te-127	5.80E-11	1.35E-17	0.00%
Te-127m	5.92E-11	3.87E-15	0.00%
Th-227	1.02E-11	6.56E-14	0.00%
Th-228	3.25E+00	5.37E-07	0.00%
Th-229	1.60E-03	6.13E-04	0.00%
Th-230	4.72E+00	1.50E-04	0.00%
Th-231	6.23E-01	3.93E-13	0.00%
Th-232	1.17E+03	6.21E-04	0.00%
Th-234	3.76E-07	2.29E-11	0.00%
Tl-204	8.99E-02	5.59E-10	0.00%
Tl-207	1.03E-11	1.28E-20	0.00%
Tl-208	1.79E-08	3.26E-15	0.00%
Tl-209	1.68E-14	1.06E-21	0.00%
Tm-170	2.63E-14	1.63E-16	0.00%
Tm-171	2.33E-10	1.45E-12	0.00%
U(20%)	1.48E+05	4.46E-02	0.03%
U(90%)	1.41E+02	3.50E-04	0.00%
U(Dep)	5.17E+03	4.61E-04	0.00%
U(Han)	1.04E+03	4.31E-07	0.00%
U(Nat)	1.49E+04	1.13E-03	0.00%
U-232	4.86E+00	1.37E-06	0.00%
U-233	3.02E+03	3.26E-02	0.02%
U-234	4.89E+05	3.74E-04	0.00%
U-235	4.02E+07	7.27E-04	0.00%
U-236	4.17E+06	1.96E-05	0.00%
U-237	2.59E-06	2.04E-11	0.00%
U-238	5.27E+09	6.54E-03	0.00%
U-240	2.05E-12	2.81E-18	0.00%
V-49	7.30E-02	4.54E-04	0.00%
W-181	3.60E-03	9.28E-11	0.00%
W-185	3.00E-02	1.01E-08	0.00%
W-188	1.50E-03	9.31E-09	0.00%
Y-88	4.60E+00	2.86E-08	0.00%
Y-90	1.20E+02	2.96E-03	0.00%
Y-91	9.93E-03	6.38E-10	0.00%
Zn-65	3.25E-01	3.58E-07	0.00%
Zr-89	2.24E-36	1.39E-41	0.00%
Zr-93	1.17E-03	1.91E-10	0.00%
Zr-95	1.20E+01	6.92E-07	0.00%

Appendix B

Nonradioactive Hazardous Materials Characterization

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Appendix B

Nonradioactive Hazardous Materials Characterization

DOE Order 5400.1 states that Environmental Monitoring Plans (EMP) “shall be prepared for each site, facility, or process that uses, generates, releases, or manages significant pollutants or hazardous materials” (DOE Order 5400.1, IV-2). The Facility Effluent Monitoring Plans (FEMPs) being prepared to support the EMP include the consideration of nonradioactive hazardous materials.

A listing of the chemicals used in the building is obtained using the PNL Chemical Management System (CMS). The inventory information includes the location, chemical name, and quantity. In some cases the manufacturer and individual container quantities are also tracked. In addition, the CMS data includes the reportable quantity (RQ) of the chemical. RQs are obtained from 40 CFR 302 and are the amounts which, if released to the environment from a facility, require notification to the National Response Center. To characterize the relative hazard of the building, a summary table, Table B.1, is prepared showing those chemicals that are reported to be present in greater than RQ amounts. Table B.2 provides a list of all chemicals found in the RPL that have an RQ amount to give an indication of the many types of chemicals that could be present in the facility.

Table B.1. CMS Reportable Quantity Inventory Listing

For: 325-RADIOCHEMICAL PROCESSING LABORATORY
Above 100% of Reportable Quantity

For: 325-RADIOCHEMICAL PROCESSING LABORATORY
Above 100 % of Reportable Quantity

RQ Grp	Chemical Name	CAS No	State	Quantity	RQ	Value
QX	ARSENIC	7440-38-2	S	1.73	1	LB
QX	MERCURY	7439-97-6	L	2.98	1	LB
QX	SILVER CYANIDE	506-64-9	S	2	1	LB
QX	SILVER NITRATE	7761-88-8	S	23.91	1	LB
QX	SODIUM ARSENATE	7631-89-2	S	2	1	LB
QA	CARBON TETRACHLORIDE	56-23-5	L	18.21	10	LBS
QA	CUPRIC SULFATE	7758-98-7	S	19	10	LBS
QA	LEAD	7439-92-1	S	15.22	10	LBS
QB	SODIUM HYPOCHLORITE	7681-52-9	L	295.21	100	LBS
QB	SODIUM NITRITE	7632-00-0	S	139.14	100	LBS

Last updated 10/05/2000.

Send questions or comments to the CMS Support Team.

Table B.2. CMS Reportable Quantity Inventory Listing

For: 325-radiochemical processing laboratory

Above 0 % of reportable quantity

RQ Group	Chemical Name	CAS No	State	Quantity	RQ	Value
QX	ARSENENOUS ACID, SODIUM SALT (9CI)	7784-46-5	S	1	1	LB
QX	ARSENIC	7440-38-2	S	1.73	1	LB
QX	ARSENIC TRIOXIDE	1327-53-3	S	0.31	1	LB
QX	ETHYLENE DIBROMIDE	106-93-4	L	0.01	1	LB
QX	MERCURY	7439-97-6	L	2.98	1	LB
QX	SILVER CYANIDE	506-64-9	S	2	1	LB
QX	SILVER NITRATE	7761-88-8	S	23.91	1	LB
QX	SODIUM ARSENATE	7631-89-2	S	2	1	LB
QA	1,3-BUTADIENE	106-99-0	G	0.22	10	LBS
QA	2-NITROPROPANE	79-46-9	L	0.01	10	LBS
QA	AMMONIUM BICHROMATE	7788-98-5	S	2.5	10	LBS
QA	AMMONIUM CHROMATE	7788-98-9	S	1	10	LBS
QA	BENZENE	71-43-2	L	2.84	10	LBS
QA	BERYLLIUM	7440-41-7	S	1.32	10	LBS
QA	CADMIUM	7440-43-9	S	5.47	10	LBS
QA	CADMIUM CHLORIDE	10108-64-2	S	2	10	LBS
QA	CARBON TETRACHLORIDE	56-23-5	L	18.21	10	LBS
QA	CHLOROFORM	67-66-3	L	8.25	10	LBS
QA	CHROMIUM (VI) OXIDE	1333-82-0	S	3.04	10	LBS
QA	COPPER (I) CYANIDE	544-92-3	S	1	10	LBS
QA	COPPER(II) CHLORIDE	7447-39-4	S	1	10	LBS
QA	CUPRIC SULFATE	7758-98-7	S	19	10	LBS
QA	CYANIDES, AS CN	57-12-5	S	0.55	10	LBS
QA	DIMETHYLHYDRAZINE	57-14-7	L	0.01	10	LBS
QA	LEAD	7439-92-1	S	15.22	10	LBS
QA	LEAD ACETATE	301-04-2	S	1.43	10	LBS
QA	LEAD CHLORIDE	7758-95-4	S	4.7	10	LBS
QA	LEAD FLUORIDE	7783-46-2	S	1.66	10	LBS
QA	LEAD NITRATE	10099-74-8	S	6.11	10	LBS
QA	LEAD SULFIDE	1314-87-0	S	2.1	10	LBS
QA	MERCURIC SULFATE	7783-35-9	S	1	10	LBS
QA	MERCURY (I) NITRATE	10415-75-5	S	1.75	10	LBS
QA	METHYL HYDRAZINE	60-34-4	L	0.01	10	LBS
QA	N-METHYL-N'-NITRO-N-NITROSOGUANIDINE	70-25-7	S	0.02	10	LBS
QA	NITRIC OXIDE	10102-43-9	G	0.02	10	LBS
QA	POTASSIUM CHROMATE	7789-00-6	S	3	10	LBS

QA	POTASSIUM CYANIDE	151-50-8	S	0.25	10	LBS
QA	POTASSIUM DICHROMATE	7778-50-9	S	4.63	10	LBS
QA	PROPIONITRILE	107-12-0	L	0.01	10	LBS
QA	SELENIUM(IV) OXIDE	7446-08-4	S	0.22	10	LBS
QA	SODIUM	7440-23-5	S	6	10	LBS
QA	SODIUM CHROMATE	7775-11-3	S	1	10	LBS
QA	SODIUM CYANIDE	143-33-9	S	0.47	10	LBS
QA	SODIUM DICHROMATE	10588-01-9	S	5	10	LBS
QA	THIOACETAMIDE	62-55-5	S	0.44	10	LBS
QA	THIOUREA	62-56-6	S	3.2	10	LBS
QB	1,4-DIETHYLENE DIOXIDE	123-91-1	L	0.23	100	LBS
QB	3-METHYLPHENOL	108-39-4	L	0.01	100	LBS
QB	3-NITROPHENOL	554-84-7	S	0.06	100	LBS
QB	4-NITROPHENOL	100-02-7	S	0.06	100	LBS
QB	AMMONIA ANHYDROUS	7664-41-7	G	0.37	100	LBS
QB	AMMONIUM FLUORIDE	12125-01-8	S	6.2	100	LBS
QB	AMMONIUM HYDROGEN DIFLUORIDE	1341-49-7	S	3	100	LBS
QB	AMMONIUM SULFIDE	12135-76-1	S	3.3	100	LBS
QB	BROMOFORM	75-25-2	L	15.94	100	LBS
QB	BRUCINE	357-57-3	S	0.06	100	LBS
QB	CHLOROACETIC ACID	79-11-8	S	1.22	100	LBS
QB	CHLOROBENZENE	108-90-7	L	1.15	100	LBS
QB	CROTONALDEHYDE	4170-30-3	L	0.01	100	LBS
QB	CUPRIC ACETATE	142-71-2	S	1	100	LBS
QB	CUPRIC NITRATE	3251-23-8	S	0.53	100	LBS
QB	DIMETHYLFORMAMIDE	68-12-2	L	0.21	100	LBS
QB	ETHYL ETHER	60-29-7	L	2.64	100	LBS
QB	ETHYLENE DICHLORIDE	107-06-2	L	14.62	100	LBS
QB	FERROUS CHLORIDE	7758-94-3	S	1.05	100	LBS
QB	FORMALDEHYDE W/O METHANOL	50-00-0	L	1.51	100	LBS
QB	HYDROFLUORIC ACID		L	11.14	100	LBS
QB	IODOMETHANE	74-88-4	L	0.25	100	LBS
QB	METHYL CHLORIDE	74-87-3	G	0	100	LBS
QB	NICKEL	7440-02-0	S	2.46	100	LBS
QB	NICKEL (II) SULFATE	7786-81-4	S	1.25	100	LBS
QB	NICKEL NITRATE	14216-75-2	S	0.99	100	LBS
QB	NICKEL(II) CHLORIDE	7718-54-9	S	6.5	100	LBS
QB	NICKELOUS AMMONIUM SULFATE	15699-18-0	S	0.25	100	LBS
QB	PENTACHLORONITROBENZENE	82-68-8	S	0.01	100	LBS
QB	POTASSIUM PERMANGANTE	7722-64-7	S	31.34	100	LBS
QB	SELENIUM	7782-49-2	S	0.78	100	LBS
QB	SODIUM BIFLUORIDE	1333-83-1	S	2	100	LBS
QB	SODIUM HYPOCHLORITE	7681-52-9	L	295.21	100	LBS
QB	SODIUM NITRITE	7632-00-0	S	139.14	100	LBS
QB	THALLIUM CHLORIDE	7791-12-0	S	0.06	100	LBS

QB	URANYL NITRATE HEXAHYDRATE	13520-83-7	S	1.68	100	LBS
QB	XYLENE	1330-20-7	L	10.28	100	LBS
QC	1,1,1-TRICHLOROETHANE	71-55-6	L	13.19	1000	LBS
QC	2,2,4-TRIMETHYLPENTANE, HYDROCARBON KIT	540-84-1	L	31.57	1000	LBS
QC	ACETALDEHYDE	75-07-0	L	0.01	1000	LBS
QC	AMMONIUM HYDROXIDE	1336-21-6	L	31.96	1000	LBS
QC	AMMONIUM METAVANADATE	7803-55-6	S	0.06	1000	LBS
QC	ANTIMONY TRIOXIDE	1309-64-4	S	5.91	1000	LBS
QC	ANTIMONY(V) CHLORIDE	7647-18-9	L	0.25	1000	LBS
QC	CHROMIUM(II)CHLORIDE	10049-05-5	S	1.04	1000	LBS
QC	COBALT(II)BROMIDE	7789-43-7	S	0.22	1000	LBS
QC	CYCLOHEXANE	110-82-7	L	8.98	1000	LBS
QC	DIAMMONIUM HEXAFLUOROSILICATE	16919-19-0	S	0.56	1000	LBS
QC	ETHYLBENZENE	100-41-4	L	0.17	1000	LBS
QC	FERRIC NITRATE CRYSTALLINE AR GRADE	10421-48-4	S	2.22	1000	LBS
QC	FERRIC SULFATE	10028-22-5	S	8.2	1000	LBS
QC	FERROUS AMMONIUM SULFATE HEXAHYDRATE	10045-89-3	S	2.2	1000	LBS
QC	GLYCOL ETHER	110-80-5	L	1.54	1000	LBS
QC	HYDROGEN PEROXIDE	7722-84-1	L	10.84	1000	LBS
QC	IRON(II) SULFATE	7720-78-7	S	4	1000	LBS
QC	IRON(III) CHLORIDE	7705-08-0	S	10.2	1000	LBS
QC	M-XYLENE	108-38-3	L	0.19	1000	LBS
QC	METHACRYLONITRILE	126-98-7	S	0.01	1000	LBS
QC	METHYLENE CHLORIDE	75-09-2	L	105.5	1000	LBS
QC	N-BUTYLAMINE	109-73-9	L	0.11	1000	LBS
QC	NITRIC ACID	7697-37-2	L	300.53	1000	LBS
QC	NITROBENZENE	98-95-3	L	2.57	1000	LBS
QC	O-XYLENE	95-47-6	L	0.38	1000	LBS
QC	OSIUM TETROXIDE	20816-12-0	S	0	1000	LBS
QC	POTASSIUM HEXAFLUOROZIRCONATE	16923-95-8	S	0.11	1000	LBS
QC	POTASSIUM HYDROXIDE	1310-58-3	S	43.95	1000	LBS
QC	PROPIONALDEHYDE	123-38-6	L	0	1000	LBS
QC	PYRIDINE SILYLATION GRADE	110-86-1	L	9.42	1000	LBS
QC	SILVER	7440-22-4	S	0.51	1000	LBS
QC	SODIUM FLUORIDE	7681-49-4	S	20.96	1000	LBS
QC	SODIUM HYDROXIDE	1310-73-2	S	387.61	1000	LBS
QC	SULFURIC ACID	7664-93-9	L	86.04	1000	LBS
QC	TETRAHYDROFURAN	109-99-9	L	5.01	1000	LBS
QC	THALLIUM	7440-28-0	S	0.61	1000	LBS
QC	TITANIUM TETRACHLORIDE	7550-45-0	L	0.26	1000	LBS
QC	TOLUENE	108-88-3	L	12.78	1000	LBS
QC	VANADIUM PENTAOXIDE	1314-62-1	S	0.07	1000	LBS
QC	ZINC ACETATE	557-34-6	S	1	1000	LBS
QC	ZINC BROMIDE	7699-45-8	S	1	1000	LBS
QC	ZINC CARBONATE	3486-35-9	S	1.1	1000	LBS

QC	ZINC CHLORIDE	7646-85-7	S	4	1000	LBS
QC	ZINC NITRATE	7779-88-6	S	5	1000	LBS
QC	ZINC SULFATE	7733-02-0	S	2	1000	LBS
QD	ACETIC ACID	64-19-7	L	42.7	5000	LBS
QD	ACETIC ANHYDRIDE	108-24-7	L	1.22	5000	LBS
QD	ACETONE	67-64-1	L	79.87	5000	LBS
QD	ACETONITRILE	75-05-8	L	27.66	5000	LBS
QD	ACETOPHENONE	98-86-2	L	0.01	5000	LBS
QD	ALUMINUM SULPHATE	10043-01-3	S	3.54	5000	LBS
QD	AMMONIUM ACETATE	631-61-8	S	7.63	5000	LBS
QD	AMMONIUM BICARBONATE	1066-33-7	S	1	5000	LBS
QD	AMMONIUM CARBONATE	506-87-6	S	8.2	5000	LBS
QD	AMMONIUM CHLORIDE	12125-02-9	S	5	5000	LBS
QD	AMMONIUM CITRATE, DIBASIC	3012-65-5	S	2	5000	LBS
QD	AMMONIUM TARTRATE	14307-43-8	S	2	5000	LBS
QD	AMMONIUM THIOCYANATE	1762-95-4	S	3.1	5000	LBS
QD	ANTHRACENE	120-12-7	S	0.06	5000	LBS
QD	ANTIMONY	7440-36-0	S	2.3	5000	LBS
QD	BENZOIC ACID	65-85-0	S	2.19	5000	LBS
QD	BUTYL ACETATE	123-86-4	L	0.26	5000	LBS
QD	CHROMIUM	7440-47-3	S	0.68	5000	LBS
QD	COPPER	7440-50-8	S	25.58	5000	LBS
QD	CYCLOHEXANONE	108-94-1	L	6.66	5000	LBS
QD	DICHLORODIFLUOROMETHANE	75-71-8	G	0.04	5000	LBS
QD	ETHYL ACETATE	141-78-6	L	9.47	5000	LBS
QD	ETHYLENE GLYCOL	107-21-1	L	2.32	5000	LBS
QD	ETHYLENEDIAMINE	107-15-3	L	0.44	5000	LBS
QD	FORMIC ACID	64-18-6	L	28.14	5000	LBS
QD	HEXANE	110-54-3	L	65.16	5000	LBS
QD	HYDROCHLORIC ACID		L	121.51	5000	LBS
QD	ISOBUTYL ALCOHOL	78-83-1	L	1.03	5000	LBS
QD	ISOBUTYRIC ACID	79-31-2	L	0.22	5000	LBS
QD	METHYL ALCOHOL	67-56-1	L	108.94	5000	LBS
QD	METHYL ETHYL KETONE	78-93-3	L	1.69	5000	LBS
QD	METHYL ISOBUTYL KETONE	108-10-1	L	8.82	5000	LBS
QD	N-BUTYL ALCOHOL	71-36-3	L	4.59	5000	LBS
QD	PENTYL ACETATE	628-63-7	L	9.35	5000	LBS
QD	PHOSPHORIC ACID	7664-38-2	L	41.14	5000	LBS
QD	PROPYLAMINE	107-10-8	L	0.11	5000	LBS
QD	SODIUM PHOSPHATE DIBASIC	7558-79-4	S	8.2	5000	LBS
QD	SODIUM PHOSPHATE, TRIBASIC	7601-54-9	S	3	5000	LBS
QD	TRIETHYLAMINE	121-44-8	L	0.47	5000	LBS
QD	ZIRCONIUM NITRATE	13746-89-9	S	0.06	5000	LBS

Last updated 10/05/2000

Appendix C

Supporting Calculations

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Appendix C

Supporting Calculations

C.1 Minimum Detectable Activity (MDA)

The needed MDA for sample analysis is specific to each nuclide-sample combination and is calculated using the following formula assuming that release rates are relatively constant throughout the year.

$$\text{Required Analytical MDA} = \frac{\text{DOD} \times \text{SF} \times \text{FYS} \times \text{SEF} \times \text{RDS} \times 1\text{E}12}{\text{DF} \times \text{MEF}} \quad (\text{pCi / sample})$$

where: DOD = Offsite dose (mrem/y) to be detected via sampling
SF = Sampling fraction (ratio of sample volume to exhaust volume during sample collection)
FYS = Fraction of year represented by sample (y/sample)
SEF = Sampler efficiency factor
RDF = Radionuclide decay factor
1E12 = Convert Ci to pCi
DF = Unit release dose factor (mrem/Ci) for source-receptor combination
MEF = Margin of Error Factor

To simplify the establishment of MDA requirements for analytical laboratories, the MDA for the worst case scenario (i.e., worst case combination of SF, FYS, SEF, RDF, and DF) is calculated. The following table summarizes the MDA for the worst case sampling situation for several types of analysis. The above MDA formula may also be used to calculate needed MDAs for other nuclide/sampling scenarios.

Table C.1. Minimum Detectable Activity Results

Analysis Type	Nominal Sample Period	Maximum Sample Size	Minimum Sample Fraction (SF)	Fraction of Year Sampled (FYS)	Minimum Sampler Efficiency Factor (SEF)	Dose Factor (mrem/Ci) (DF)	Minimum Required Analytical MDA
Tritium	1 month	160 mL water*	5E-8	0.083 (1 month, 160 mL water collected)	1.0	4.1E-4	10,000 pCi/160 mL water (or 63 pCi/mL water)*
Gross Beta	2 weeks	(1) 47-mm filter	2E-5	0.019 (1 week)	0.5	4.9**	38 pCi/single filter
Gross Alpha	2 weeks	(1) 47-mm filter	2E-5	0.019 (1 week)	0.5	180***	1 pCi/single filter
Cs-137	6 months	(15) 47-mm filters	2E-5	0.019 (1 week)	0.5	4.9	38 pCi/multiple filters
Sr-90	6 months	(15) 47-mm filters	2E-5	0.019 (1 week)	0.5	4.9	38 pCi/multiple filters
Pu-238	6 months	(15) 47-mm filters	2E-5	0.019 (1 week)	0.5	180	1 pCi/multiple filters
Pu-239/240	6 months	(15) 47-mm filters	2E-5	0.019 (1 week)	0.5	200	1 pCi/multiple filters
Pu-241	6 months	(15) 47-mm filters	2E-5	0.019 (1 week)	0.5	3.20	159 pCi/multiple filters
Am-241	6 months	(15) 47-mm filters	2E-5	0.019 (1 week)	0.5	290	0.7 pCi/multiple filters
Am-243	6 months	(15) 47-mm filters	2E-5	0.019 (1 week)	0.5	290	0.7 pCi/multiple filters
<p>* It is assumed that the collected sample will contain the maximum quantity of adsorbed water, which is 160 mL based on maximum allowed collector loading capacity before collector changeout.</p> <p>** Assuming that all activity due to Sr-90 (predominant beta radionuclide)</p> <p>*** Assuming that all activity due to Pu-238 (predominant alpha radionuclide)</p>							

Appendix D

Facility Effluent Pathway Drawings

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Appendix D

Facility Effluent Pathway Drawings

Current copies of the Essential Drawings related to effluent pathways are included in this appendix. These drawings are current as of the publishing of this document. The official up-to-date version can be obtained from Battelle Engineering Files.