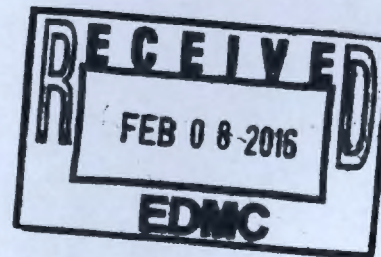


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## AIR MONITORING PLAN FOR THE REMEDIATION OF THE 618-10 BURIAL GROUND

### 1.0 INTRODUCTION

The remediation of the 618-10 Burial Ground has the potential-to-emit (PTE) radionuclides. This activity is being conducted under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* document *Hanford Site 300 Area Record of Decision for 300-FF-2 and 300-FF-5, and Record of Decision Amendment for 300-FF-1* (EPA 2013), in accordance with the *Remedial Design Report/Remedial Action Work Plan for 300-FF-2 Soils* (300-FF-2 RDR/RAWP) (DOE/RL-2014-13-ADD1). This air monitoring plan is an addendum to the 300-FF-2 RDR/RAWP. Quantification of radioactive emissions, implementing best available radionuclide control technology (BARCT), and air monitoring have been identified as substantive requirements (i.e., applicable or relevant and appropriate requirements) for this remedial action. A BARCT compliance demonstration is determined by the regulatory agency on a case-by-case basis. These substantive requirements are according to *Washington Administrative Code* (WAC) 246-247-040, "Radiation Protection – Air Emissions." This air monitoring plan presents compliance with WAC-246-247-040 requirements.

The 618-10 Burial Ground consists of 12 trenches and 94 vertical pipe units (VPUs). The trenches range in size from 15 to 97 m (50 to 320 ft) long by 12 to 21 m (40 to 70 ft) wide. The following three types of VPUs were used at the 618-10 waste site:

- Carbon steel pipes 25 to 61 cm (10 to 24 in.) in diameter and up to 4.6 m (15 ft) in length
- Corrugated steel pipes 36 cm (14 in.) in diameter and up to 4.6 m (15 ft) in length
- Drums 56 cm (22 in.) in diameter and 4.4 m (14.4 ft) in length; these VPUs were constructed by welding five 208-L (55-gal) bottomless drums together end-to-end and burying them vertically.

The 618-10 Burial Ground was covered in soil when it was closed. The work scope includes remediation of the 618-10 Burial Ground disposal trenches and VPUs.

### 2.0 PLANNED ACTIVITIES – TRENCH REMEDIATION

General remedial action operations include excavating, sampling, sorting, size reducing, stockpiling, treating (if necessary), containerizing, loading, backfilling, and transporting of materials from the trenches. Materials may include a wide range of chemically- and/or radiologically-contaminated soil, miscellaneous debris, buried equipment, and structural materials. In addition, this work scope includes performance of all operations and incidentals for the handling, processing, and staging of buried drums or other anomalous materials that may be encountered. Also included are test pitting, trenching, and other activities that may be performed during remediation to further characterize the buried waste and/or determine the limits of the

waste sites. Specific treatment activities include stabilization of uranium oxide, crushing/stabilization of liquids in bottles, and processing concreted drums. HEPA-filtered vacuum activities will be used throughout trench remediation.

Excavated material will be sent primarily to the Environmental Restoration Disposal Facility (ERDF) for disposal. On a case-by-case basis, other U.S. Environmental Protection Agency (EPA)-approved disposal facilities may be used based on the specific waste stream designation.

## **2.1 SOIL AND MISCELLANEOUS DEBRIS EXCAVATION**

Standard construction equipment will be used for excavation, sorting, loading, and hauling. The loading of contaminated material into waste containers may result in soil spilled on the waste containers and/or haul trucks. Haul trucks with loaded containers will enter a survey area where they will be screened to detect exterior contamination. A decontamination station will be established to decontaminate containers and haul trucks, as required. Waste containers and/or haul trucks will be decontaminated by conventional means such as brushing or wiping. Decontaminated trucks and containers will then proceed to the container transfer area where the transportation subcontractor will pick up the containers for transport to the ERDF.

## **2.2 ANOMALY PROCESSING**

Most anomalies (including drums and containers) will be overpacked at the excavation site, characterized for disposal, and then processed under grout. Containers are opened in a high-efficiency particulate air (HEPA)-filtered enclosure. Some of these containers may contain significant quantities of plutonium or other radionuclides that present an airborne risk and thus the HEPA filtered enclosure.

Several VPU-like anomalies were discovered during intrusive characterization activities at the 618-10 Burial Ground in August 2010. An approximately 3-m (10-ft) long, 30-cm (12-in.)-diameter schedule-40 steel pipe was unearthed while excavating the last investigative trench east of the VPU field. No dose rate was detected from the pipe; upon examination, it was found to be empty. Another similar pipe was uncovered approximately 3 m (10 ft) farther up the trench (heading into the general direction of the VPU field). It was also empty. A corrugated pipe with a dose rate of 15 to 20 mrem/hr was discovered approximately 3 to 5 m (10 to 15 ft) farther up the trench, in the direction of the VPU field. The corrugated pipe separated at a band-clamped joint (typical to the assembly of this type of pipe to hold pipe sections together) during the intrusive characterization. A concrete plug was observed at the top of the remaining section of corrugated pipe. A vertically-oriented corrugated pipe was discovered in October 2012 during trench remediation operations in the same area. It was also reburied shortly after discovery and its location noted.

Short lengths of the VPU-like anomalies will be exposed, forms (e.g., existing soil excavation sidewall, placing a mix box with some or all of the bottom removed to allow placement of the box over the exposed anomaly or constructing a standard form) will be constructed around the exposed portion of the anomaly, and it will be covered in grout for processing. Excavator implements, such as a shear and bucket, will be used to process and mix the contents to ensure

all sealed containers are breached and any reactive material is stabilized. The material will then be transferred to a container or placed into the excavation for curing. Radiological characterization of each grouted batch will be performed to determine its radiological status and disposal path in accordance with the *300 Area Remedial Action Sampling and Analysis Plan* (DOE/RL-2001-48). Treatment of the VPU-like anomalies will be performed in accordance with the requirements of the *618-10 Burial Ground VPU Treatment Plan* (WCH-550).

### 2.3 DRUM HANDLING

Drummed waste will be encountered in the 618-10 Burial Ground trenches. The exact quantity of drums and the types of waste material contained in the drums is not known at this time. Extensive records searches indicate that low-activity wastes were primarily disposed of in the trenches, but some of the moderate- to high-activity wastes were also disposed of in the trenches inside concrete/lead-shielded drums. Wastes included radiological contaminated laboratory instruments, bottles, boxes, filters, aluminum cuttings, metal cuttings, irradiated fuel element samples, metallurgical samples, electrical equipment, lighting fixtures, barrels, laboratory equipment and hoods/gloveboxes, and low- and high-activity liquid waste sealed in containers. To address the potential emission contributions from drummed waste handling, a database was created based upon information gathered from a review of historical documentation related to the 618-10 Burial Ground. This database was queried to develop a worksheet that identified the population of waste drums and associated inventory that was used for the emission calculation.

Drums will be placed in a salvage container (e.g., salvage drum, B-12 box) at the dig face and then moved through nondestructive assay stations. To support physical characterization and sampling of the contents, waste drum lids may be pierced. The piercing of lids will be conducted in either of two drum penetration facilities (DPFs). Each DPF is a fully-enclosed, remotely-operated structure designed to safely handle unvented drums. Each DPF enclosure is maintained under negative differential pressure and the active ventilation exhaust is filtered by a HEPA filter. Sampling of the drum contents is conducted in a separate area with only passive ventilation. The drummed waste will subsequently be moved to a control area within the burial ground area of contamination or other regulatory-approved locations, loaded onto flatbed trailers, and transported to the ERDF or other regulatory-approved locations for interim staging or disposal. Retrieved drums containing Zircaloy-2 chips and oil or water will have clean mineral oil or water added to, as needed, to ensure chips are immersed.

During the overpacking, a Nucfil<sup>®</sup> vent or equivalent may be inserted into the salvage container. The potential emissions from this activity are negligible compared with potential emissions from sampling and containerizing drums. This activity (venting drums) assumes a release fraction of 2E-09 (Letter AIR 99-1006), resulting in a calculated PTE several orders of magnitude below that associated with sampling and containerizing the drums. Therefore, potential to emit during the sampling and containerizing of drums accounts for the activity of venting of drums.

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<sup>®</sup> Nucfil is a registered trademark of Nuclear Filter Technology Incorporated, 5161 Ward Rd., Wheat Ridge, Colorado.

If any of the drums are corroded to the point that they cannot be overpacked, the potential emissions will be part of soil excavation and will result in lower emissions from the drum handling activities.

## **2.4 URANIUM OXIDE TREATMENT**

Approximately 600 containers of uranium oxide powder are suspected of being disposed at the 618-10 Burial Ground. The waste is intended for disposal at the ERDF. The waste consists of uranium oxide potentially contaminated with barium, cadmium, or lead, and possibly other toxicity characteristic leaching procedure metals. The waste requires stabilization of the toxicity characteristic leaching procedure metals prior to disposal in the ERDF. Additionally, uranium that may have been incompletely oxidized may form uranium hydrides in the waste matrix, which could cause the powder to be pyrophoric. The stabilization technique will also stabilize the potential pyrophoricity of the material and render it safe to handle, transport, and dispose. Drums of uranium oxide will be placed in a mixing box, covered with a Portland cement-based flowable grout; the drums will be opened under the grout with an appropriate end effector and mixed with the grout. After curing, if the stabilized waste meets the ERDF waste acceptance criteria it will be loaded into ERDF containers and transported for disposal. Treatment will be performed in accordance with the requirements of the *Treatment Plan for Containerized Granular Material at the 618-10 Burial Ground (WCH-585)*.

## **2.5 BOTTLE PROCESSING AND TREATMENT**

Treatment of liquid waste in bottles, up to one gallon per bottle, will occur in a tray or box within the excavation. Bottles and soil will be placed into the mix box containing slurry within the box. Crushed rock will be added to aid in bottle shearing if not already present in burial ground soil. The bottles will be crushed and mixed to ensure all bottles are broken. Post-treatment verification sampling will be performed to demonstrate compliance with land disposal restrictions and disposal facility acceptance criteria. Treatment will be performed in accordance with the requirements of the *Acceptance and Treatment Plan for Liquid Anomalies in Bottles and Processing Concrete Drums at the 618-10 Burial Ground (WCH-532)*.

Liquid waste treated in this manner will be subsequently handled as bulk waste or may be transported for disposal as a monolith within an acceptable container. Waste will be disposed in the ERDF.

## **2.6 CONCRETED DRUM PROCESSING AND TREATMENT**

Approximately 948 concreted/lead-shielded drums are suspected of being disposed at the 618-10 Burial Ground. The waste is intended for disposal at ERDF (for low-level waste [LLW] portion) or storage at the Central Waste Complex (CWC) and ultimate disposal at the Waste Isolation Pilot Plant if suspect transuranic (TRU) waste. The waste consists of moderate- to high-activity waste that could include radiologically-contaminated laboratory instruments, bottles, boxes, filters, aluminum cuttings, metal cuttings, irradiated fuel element sample residue, metallurgical samples, electrical equipment, lighting fixtures, barrels, laboratory equipment and hoods/gloveboxes, and low- and high-activity liquid waste sealed in containers. The waste

requires stabilization to ensure the acceptance criteria for the receiving facility (ERDF for LLW fraction and CWC/Waste Isolation Pilot Plant for the suspect TRU fraction) is met. The drums will be processed in a grout mixture to stabilize and neutralize free liquids, if encountered, and fix radiological contamination. In addition, processing in grout will allow for removal of prohibited items (e.g., radioactive lead solids from LLW streams) and monitoring for organics that may be encountered. If bottles and/or liquids are observed during processing the waste will be managed consistent with the bottle processing and treatment operations discussed above in Section 2.5. Treatment will be performed in accordance with the requirements of WCH-532.

### **3.0 PLANNED ACTIVITIES – VERTICAL PIPE UNIT OVER-CASING AND AUGERING**

The activities summarized in Sections 3.1 through 3.3 are for drum VPUs (rows 3 and 4) and corrugated-pipe VPUs (rows 2, 5, and 6) at the 618-10 Burial Ground. The high-gauge steel pipe construction of the VPUs in row 1 will require a different approach that will be discussed in a future revision to this plan. HEPA-filtered vacuum activities will be used throughout VPU remediation.

#### **3.1 OVER-CASING**

A steel over-casing has been driven into the ground around the outside of each corrugated-pipe VPU and drum VPU with a vibratory hammer suspended from a crane. (The remediation of the steel pipe VPUs will not include the use of an over-casing.)

#### **3.2 AUGERING**

Augering will be performed after installation of the auger tool enclosure (ATE). The ATE's main function is to control contamination during the augering operation. The ATE will be connected to an active HEPA-filtered negative pressure ventilation system to reduce emissions to acceptable levels and minimize the risk of a radionuclide airborne discharge to the environment during augering. The active ventilation system includes an inlet filter, two HEPA exhaust filters (1<sup>st</sup> and 2<sup>nd</sup> stage), a carbon filter, ducting, and an exhaust fan. Drawings of the ventilation system are depicted in Figure 1. Two ATEs and HEPA-filtered negative pressure ventilation systems could be used simultaneously. The ATE attaches to a VPU over-casing (Figure 2). An auger provides size reduction and mixing functions to stabilize the contents of the over-casing. This auger can also be used for grouting if required. Figure 3 provides an example schematic of the proposed stabilization and size reduction process.

Access ports are provided on the ATE for sampling of the auger prior to removal of the enclosure. High-pressure, low-volume water nozzles are located near the top, middle, and bottom of the ATE for controlling dust within the enclosure and to provide a high-pressure rinse of the auger and stem as it is retracted from the over-casing depths.

During the augering process, one or more passes may be made with the auger to inject water (with or without dust control agents such as calcium chloride) into the soil/waste mixture prior to

waste retrieval. Wetting the mixture will greatly reduce the potential for dust generation during its extraction from the over-casing.

### **3.3 RADIOLOGICAL DETERMINATION**

Characterization of the VPUs will take place to determine if the contents of the VPUs can be disposed of at the ERDF or sent to the CWC as suspect TRU. All characterization of the VPU waste will be performed in accordance the *Sampling and Analysis Plan for the Radiological Determination of the 618-10 Vertical Pipe Units (WCH-534)*.

### **3.4 LOW-LEVEL WASTE REMOVAL WITH A RETRIEVAL TOOL**

The augered soil/waste mixture (ungROUTED) will be removed from the over-casing with a retrieval tool (e.g., bucket auger or clamshell) deployed by an excavator or a drill rig. Other equipment such as a waste container, excavator with a grout mixing attachment, and/or a grout plant will also be moved to the site as needed.

The retrieval tool will transfer soil/waste mixture to an interim location (e.g., a waste container pre-staged in an ERDF container) where it will be mixed with grout. All low-level VPU soil/waste mixtures will be grouted prior to disposal at the ERDF. The grout will be supplied by a cement truck or grout plant. An excavator may then be used to mix the grout and VPU soil/waste mixture. Multiple passes may be made with the retrieval tool until the interim waste location is sufficiently full or a sufficient quantity of material has been retrieved (as judged by field personnel). Samples of the soil/waste mixture may be retrieved, if needed. The grouted mixture will be allowed to cure, and will then be transported to the ERDF for disposal.

This remediation process will continue until the over-casing has been emptied. The over-casing and affected soil surrounding the over-casing will then be remediated using conventional methods. The over-casing will be size reduced using a shear to meet ERDF disposal requirements.

## **4.0 AIRBORNE SOURCE INFORMATION**

There is a potential for radioactive airborne emissions resulting from the 618-10 Burial Ground and remediation activities. The primary radiological constituents of concern at the waste sites include plutonium, americium, uranium, strontium/yttrium, and cesium/barium. Other isotopes will be encountered, however, it is expected that dose estimates provided below are conservative and represent the upper bound of what will actually be found.

## **5.0 INVENTORY**

The radionuclide annual possession quantities and subsequent potential emission calculations for the 618-10 Burial Ground are summarized in Attachments 1 through 5. The record review described in Section 2.3 resulted in creation of a database of radiological information for the

burial ground. This database was queried to develop a worksheet that identified the population of waste drums and associated inventory that was used for the emission calculation. Since trench remediation and VPU remediation will occur sequentially rather than simultaneously (although completion of trench remediation and concrete drum processing will overlap with VPU augering), their respective inventory and dose estimates are described separately.

## 5.1 TRENCH REMEDIATION

For trench remediation, the burial ground inventory is divided into two categories: (1) emitted as a point source through a DPF and (2) emitted as a fugitive emission during remediation of the burial ground trenches. The point source emission category was formed by assembling all unshielded drums in the 618-10 trenches. The fugitive emissions category encompasses all remaining waste items including shielded drums, VPU-like anomalies, and 10% of the unshielded drums that will be processed through a DPF (to account for degraded drums). Waste items in the 618-10 VPUs are excluded. The item count associated with each category and container size is shown in Table 1.

**Table 1. 618-10 Burial Ground Item Type and Count.**

Category				Total
Point Source (Drum Penetration Facility)	Unshielded Drums			1,297
Fugitive Emissions	Remaining Waste Items (2,184)	Shielded Drums (948)	Degraded Unshielded Drums (130 estimated)	3,262
<b>Total</b>				<b>4,559</b>

An additional source of inventory must also be considered. Well water is planned to be used as a dust suppressant to control potentially airborne contaminants during the remediation activities. Two water supply wells (200-PO-1 Operable Unit Groundwater) have been constructed approximately 304.8 m (1,000 ft) northwest of the 618-10 Burial Ground boundary for this purpose. Groundwater samples have been collected from monitoring wells at the Hanford Site for nearly 40 years and analytical results compiled into the Hanford Environmental Information System database. A search of the Hanford Environmental Information System database for all analytical data from existing wells in the vicinity of the 618-10 Burial Ground provided over 14,000 entries for non-radiological and radiological hazardous materials. The information provided from the database search will serve as the basis for determining an inventory of isotopes for the dust suppression water. This inventory will be counted in the fugitive emission inventory.

Drums may fall into the following four categories:

- Drums filled with loose debris (e.g., vermiculite, construction debris)
- Drums filled with uranium or zircaloy metal shavings/chips/fines or thorium oxide powders

- Concrete/lead-shielded drums containing high-activity (predominantly fission product) liquid and dry waste.
- Drums filled with other miscellaneous materials (e.g., powders, granular materials, aqueous liquids, oils, resins).

When a drum is discovered in the excavation, it is monitored remotely for gamma radiation, chemical vapors (including detection of lower explosive limit vapor concentrations), combustibility, and temperature with the intent of determining if it is safe to remove the drum from the excavation. If it is determined that the drum can be moved safely, it is placed into an overpack at the excavation face and then removed for transport to the nondestructive assay (NDA)/characterization area. There the drum is weighed, screened for radionuclide content (using gamma spectrometry), and a neutron count is taken. The drum (depending on screening results) may then be moved to a DPF for visual observation and further radiological dose and chemical vapor monitoring.

Concrete drums, debris drums, and drums identified as potentially containing TRU waste receive additional quantitative radionuclide analysis. Drums awaiting NDA/characterization and drums with completed NDA/characterization are temporarily stored in the Interim Storage Area.

Characterized/stabilized drums requiring sampling are moved to the sampling area. Sampling and characterization activities are conducted in accordance with the data quality objective process, operational controls, and in accordance with the requirements of a sampling and analysis plan (e.g., WCH-532, WCH-585, WCH-602) that are specific to the remediation effort, as well as the requirements found in *618-10 Burial Ground Drum Sampling and Analysis Instruction* (WCH-449).

The installation of lids on drums in preparation for transport offsite (if required) is performed in the sampling area. The drums are then moved to the Material Release Area for external dose measurements and Industrial Hygiene chemical vapor monitoring prior to moving the drums out of the Material Release Area and into the Long-Term Storage Area. Drums are stored in the Long-Term Storage Area until they are loaded on trucks for transport offsite to an approved waste treatment or disposal facility (e.g., chips in oil drums may be sent to the PermaFix facility for processing).

### **5.1.1 Drum Penetration Facilities**

The DPF enclosures are commercially-available hazardous material storage units that have been modified for the specific purpose of housing the drum penetration equipment. Operation of the DPFs allow for remote breaching, inspection, and stabilization of drums. The DPFs provide for remote monitoring of radiation and presence of volatile organic compounds (including detection of lower explosive limit vapor concentrations), temperature measurement, video monitoring and recording capability, remote operation of the drum penetrating equipment, and the ability to add stabilizing fluids (water or mineral oil) to the drum contents to render the contents safe for personnel to approach and sample. The DPFs are also equipped with a hopper filled with sand

that can be released remotely in the event of a fire during drum penetration. Each enclosure is ventilated by HEPA-filtered exhaust systems.

Consistent with WAC 246-247, a release fraction 1E-03 was applied to the inventory assuming all of the material disposed of is in the form of particulate. An exception is for gaseous radionuclides (i.e., H-3, Rn-219, Rn-220, Rn-222, and Kr-85), which have a release fraction of 1. The use of these release fractions is considered conservative because it will be used on waste forms including bulk soil, neutron irradiated items, fixed contamination, and volumetrically-contaminated items. It is assumed that all trench remediation activities will occur over 4 years.

The CAP88-PC model was used to determine the total effective dose equivalent, or annual unabated offsite dose for trench remediation. The PTE (curies per year) were the input for the computer model, and the model generated the annual unabated dose. The CAP88-PC model summary and synopsis are presented in *Total Effective Dose Equivalent Calculation for Remediation of the 618-10 Burial Ground* (0600X-CA-V0087). The total effective dose equivalent (TEDE) to the hypothetical maximally-exposed offsite individual (MEI) for trench remediation is 1.87 mrem/yr. The unmitigated TEDE to the MEI for drum characterization total through both DPFs is 8.44E-03 mrem/yr. The MEI for both activities was located 2,360 m (7,743 ft) to the south southeast.

### 5.1.2 Special Considerations for Uranium Oxide and Bottle Treatment

Potential emissions and TEDE for burial ground activities are detailed in 0600X-CA-V0087. The TEDE calculation estimated that 1,297 drums, which included uranium oxide drums, would be processed through a DPF. The result of the TEDE calculation showed that the DPFs are classified as a "minor stack" (TEDE less than 0.1 mrem/yr to the maximally exposed offsite individual). For the planned onsite treatment of uranium oxide, these emissions would actually be in the diffuse/fugitive category rather than the point source (drum penetration). Moving the site of potential emission from uranium oxide drums from the DPFs to being part of the fugitive emissions from the trenches (which were already categorized as a major unit) does not change the total PTE for the project or the major/minor unit status of the two areas.

## 5.2 VPU REMEDIATION

The radionuclide inventory for the 618-10 Burial Ground VPUs was obtained from the in *Total Effective Dose Equivalent Calculation for Remediation of the 618-10 Burial Ground Vertical Pipe Units* (0600X-CA-V0131). The 618-10 VPUs primarily received waste from the 327 facility, along with small amounts from 325, 325-A, and other facilities (0600X-CA-N0100). An overview of the results of the review of records that were kept of the disposal practices are presented in 0600X-CA-N0083. The waste disposed in the 618-10 VPUs consisted primarily of debris, but abrasive cutting fines, solidified liquid waste and soil, gravel, and concrete were added to reduce exposure. Waste items included activated graphite, activated metal, residue from weapons grade fuel, high-exposure fuel, neptunium targets, weapons-grade plutonium and high-exposure plutonium, fission and activation products removed during the plutonium uranium reduction and extraction chemical separation method, strontium, thorium, depleted uranium, and natural uranium.

The 618-10 Burial Ground operated between 1954 and 1963. During this period, information associated with shipment of waste to the 618-10 Burial Ground was primarily documented in Hanford technical documents, as well as radiation survey records, onsite radioactive shipment documents, and routine and repetitive survey forms.

Consistent with WAC 246-247, a release fraction of 1E-03 was applied to the inventory assuming all of the material disposed of is in the form of particulate. An exception is for gaseous radionuclides (i.e., H-3, Rn-219, Rn-220, Rn-222, and Kr-85), which have a release fraction of 1.

Point source emissions could include those from the dual stage HEPA filters of the active ventilation system when they are moved VPU to VPU within the 618-10 Burial Ground. Fugitive emissions could occur during the retrieval of the VPUs (for each VPU determined to have ERDF acceptable waste and steel VPUs). Consequently, the entire VPU PTE are considered to be fugitive emissions.

The CAP88-PC model was used to determine the total effective dose equivalent, or annual unabated offsite dose to the hypothetical MEI for VPU remediation. The PTE (curies per year) were the input for the computer model, and the model generated the annual unabated dose. The CAP88-PC model summary and synopsis are presented in *Total Effective Dose Equivalent Calculation for Remediation of the 618-10 Burial Ground Vertical Pipe Units* (0600X-CA-V0131). The TEDE to the MEI for VPU remediation is 5.37E-01 mrem/yr, located 2,309 m (7,575 ft) to the south southeast. Although Section 3.0 stated that some of the VPU remediation design has still yet to be defined, 0600X-CA-V0131 addresses the entire VPU inventory.

## **6.0 BEST AVAILABLE RADIONUCLIDE CONTROL TECHNOLOGY**

The following is the BARCT, to be implemented during the 618-10 remedial action.

### **6.1 DRUM VENTING FILTERS**

The venting filters inserted in drums, if used, will be Nucfil<sup>®</sup> filters, or equivalent, that are considered BARCT for radioactive emissions at the Hanford Site.

### **6.2 DRUM SAMPLING AND OVERPACKING – HEPA FILTRATION**

During trench remediation, drum sampling activities will be conducted utilizing as low as reasonably achievable practices during the sampling/containerization campaign. These practices include isolating each drum prior to sampling, ensuring each drum is stabilized as appropriate, and utilizing safety precautions such as grounding equipment and nonsparking tools. If physical characterization is needed, the lids of intact waste drums will be pierced in either of two DPFs that are each maintained under negative differential pressure and are actively ventilated by HEPA-filtered exhaust systems. The drum contents will be sampled in a separate unventilated area.

The use of HEPA filters has been generally accepted as BARCT and their use is encouraged whenever practical during remediation activities. HEPA filters shall have efficiency testing performed upon installation and on an annual basis thereafter, and must be demonstrated to 99.95% removal efficiency.

### 6.3 VPU REMEDIATION – HEPA FILTRATION

The ATE and future retrieval system will be vented through an active ventilation system of the same design, approved as BARCT by Letter AIR 11-1006, "Pursuant to Chapter 246-247 of the Washington Administrative Code (WAC), Your Application was Hereby Approved on October 19, 2011, According to the Enclosed License for: Operation of the Transuranic Waste Retrieval Project." This abatement technology will consist of two banks of HEPA filters with an in-place testable efficiency of 99.95% for removal of test aerosol particulate with a median diameter of 0.7 micron. In addition, negative pressure ensures no outleakage during routine operations.

The annual average volumetric flow rate through the intermittently-operated ventilation system exhauster is 0.47 m<sup>3</sup>/sec (1,000 cfm) providing up to 27.8 air exchanges per hour within the structures. Ventilation for this system will include an inlet filter, two exhaust HEPA filters (1<sup>st</sup> and 2<sup>nd</sup> stage), a carbon filter, ducting, and an exhaust fan. Each HEPA filter stage will provide an in-place testable efficiency of at least 99.95% for removal of test aerosol particulate with a median diameter of 0.7 micron. The exhaust duct is 20.3 cm (8 in.) in diameter and will exhaust at least 0.9 m (3 ft) above grade. The active ventilation system will be in operation during initial augering and during suspect TRU material retrieval. The HEPA filters will be monitored daily (when the system is used) for saturation by measuring the pressure change over the filter during operation. The filter housing for each of the two inline HEPA filters is equipped with a magnehelic gauge to measure the pressure at the inlet and outlet of the filter housing. As the filter becomes saturated with moisture and/or dust, the resistance to airflow in the filter increases and the pressure drops across the filter. The filter will be replaced when the pressure drop across the filter is 10 cm (4 in.) of water, as measured by the magnehelic gauge.

Control technology standard applicability and compliance for the VPU-active ventilation system is discussed in Section 18.3 of *Radioactive Air Emissions Notice of Construction for the Transuranic Waste Retrieval Project* (DOE/RL-2001-57).

### 6.4 APPLICATION OF DUST SUPPRESSANTS

The following describes the controls to be implemented during the excavation, sorting, size reduction, stockpiling, and bulk material loading:

- Water will be applied during excavation, sorting, size reduction, container loading, stockpiling, and backfilling processes to minimize airborne releases. Only the amount necessary to control airborne releases will be used so as to minimize the potential for downward migration of mobile contaminants.

- Soil fixatives will be applied to any exposed contaminated soils and debris that will be inactive for more than 24 hours.
- Fixatives will be applied to exposed contaminated soils and debris (including stockpiles) that will be inactive less than 24 hours at the end of work operations, if the sustained windspeed is predicted overnight to be greater than 32.2 kph (20 mph) based on the Hanford Meteorological Station morning forecast. This will allow the project enough time, if necessary, to prepare for the application of dust control measures. For overnight periods with wind speeds predicted less than 32.2 kph (20 mph), project operations may determine fixative application to be prudent. If a soil fixative has already been applied and the soil will remain undisturbed, further use of fixatives will not be needed. The fixatives or other controls will not be applied when the contaminated soils are frozen, or if it is raining, snowing, or other freezing precipitation is falling at the end of work operations.
- An entry will be made in the project logbook or equivalent when the forecast predicts sustained wind speeds of greater than 32.2 kph (20 mph) and dust control is to be applied at the end of the work shift.
- Additional measures for controlling small debris in waste piles may be prudent based on waste site conditions as determined by project personnel. Some additional measures that may be used include the following:
  - Apply a thin layer of other contaminated soil from the same waste site that is free of debris on the surface and follow normal fixative application
  - Apply a thin layer of uncontaminated soil that is free of debris on the surface and follow normal fixative application
  - Apply a bonded fiber fixative
  - Cover the area containing small debris that is easily re-suspended with a tarp or other appropriate material.
- Other dust suppression methods, such as processing water, augmented water, calcium or magnesium chloride, or flowable grout into the soil matrix and active ventilation systems may be utilized.
- For uranium oxide, bottled liquid treatment, and concreted drum processing, the practice of opening containers under a layer of grout will be employed.

## 7.0 MONITORING – GENERAL

During remediation of the 618-10 Burial Ground, monitoring activities will consist of four previously established air monitoring stations (Figure 4). These air monitors will be located upwind and downwind of the burial ground. In addition, four thermoluminescent

dosimeters (TLDs) will be used to supplement the air monitoring data. The TLDs will be co-located with the air monitors.

These air monitors/TLDs are the means/methods to measure emissions. The operation of these monitors/TLDs will follow the protocol established for these programs. The data from these monitors/TLDs will be included in the annual reports prepared for the Hanford Site. Air samples are collected every 2 weeks and analyzed for total alpha and total beta. These samples are composited semi-annually and analyzed for isotopic uranium, isotopic plutonium, Am-241, Sr-90, and gamma-emitting radionuclides (gamma energy analysis). Soil deposition samples will also be collected before, during, and after remediation. The samples will be obtained near the air monitor locations and will be analyzed for isotopic uranium, isotopic plutonium, Am-241, Sr-90, and gamma-emitting radionuclides (gamma energy analysis). The TLDs are collected and read quarterly.

Air monitors are run continuously during remediation activities and air monitor downtime will be minimized. If any one of the near facility air monitor stations is out of operation for more than 48 hours during normal work operations (excluding weekends and holidays), the regulatory agency will be notified. At least three air monitors must be operating for normal work operations, excavation, and sampling activities to continue at the site.

Exhaust points from HEPA filters (and any ductwork, seams, or other potential release locations from enclosures) will be monitored on a routine basis for potential radionuclide releases and results recorded (e.g., post survey results negative). Any positive survey results will require appropriate maintenance on the facility to ensure that continued releases do not occur. In the event of positive survey results, work will stop and the cause investigated. The results of this investigation will be discussed with EPA before operations continue. Records of routine monitoring and necessary maintenance will be provided to regulatory staff upon request.

As part of the site-wide evaluation of near-facility monitoring data, the electronic release summary database compares near-facility monitoring composite air sample results to 10% of the Table 2 values in 40 *Code of Federal Regulations* (CFR) 61, "National Emission Standards for Hazardous Air Pollutants," Appendix E. The database identifies results that exceed these values. Results from the air monitors identified in this plan that are above these values will be investigated and the adequacy of the controls evaluated as appropriate.

During uranium oxide treatment, bottle processing and concreted drum processing at the 618-10 Burial Ground, a minimum of one portable air sampler will be deployed as close to the work area boundary as practicable in the predominant downwind direction. In addition, a portable air sampler will be deployed near the exhaust outlet during operation of the HEPA filtration units supporting VPU auguring and suspect TRU retrieval activities. The air samplers that will be used are those that are employed daily by radiological control to assess the airborne radiological conditions present during operations. The resulting air samples will be processed in accordance with Washington Closure Hanford procedures including RC-200, *Radiological Control Field Procedures*, RC-200-4.1, "Field Air Sampling," and RC-100, *Radiological Control Support Procedures*, RC-100-4.1, "Monitoring and Evaluating Airborne Radioactive Material." The air sample(s) will be collected and analyzed according to these procedures.

The air samples will be counted as soon as possible but no later than the next working morning. If the sample result is greater than or equal to 0.1 Total Derived Air Concentration (TDAC), the sample will be retained for further counting. If the sample result is less than 0.1 TDAC, no further counting is required. If 72 calendar hours have elapsed since the sample was collected and the sample result is greater than or equal to 0.3 TDAC, the sample will be sent to the Radiological Counting Facility for further analysis. All results are documented on the Air Sample Evaluation Record.

## 8.0 ALTERNATIVE MONITORING FOR VPU REMEDIATION POINT SOURCES

In lieu of installation of a continuous flow measurement and sample extraction system, destructive examination of the final stage HEPA filter for the active ventilation system described in Section 6.3 will occur. This destructive examination will be performed annually (no later than a year after operations commence).

## 9.0 REFERENCES

- 40 CFR 61, "National Emission Standards for Hazardous Air Pollutants," *Code of Federal Regulations*, as amended.
- 0600X-CA-N0083, 2012, *Radiological Inventory in the 618-10 Vertical Pipe Units*, Rev. 0, Washington Closure Hanford, Richland, Washington.
- 0600X-CA-N0100, 2013, *618-10 and 618-11 Burial Ground Radiological Source Terms*, Rev. 0, Washington Closure Hanford, Richland, Washington.
- 0600X-CA-V0087, 2015, *Total Effective Dose Equivalent Calculation for Remediation of the 618-10 Burial Ground*, Rev. 5, Washington Closure Hanford, Richland, Washington.
- 0600X-CA-V0131, 2015, *Total Effective Dose Equivalent Calculation for Remediation of the 618-10 Burial Ground Vertical Pipe Units*, Rev. 1, Washington Closure Hanford, Richland, Washington.
- Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, 42 U.S.C. 9601, et seq.
- DOE/RL-2001-48, 2015, *300 Area Remedial Action Sampling and Analysis Plan*, Rev. 4, U.S. Department of Energy, Richland Operations Office, Richland, Washington.
- DOE/RL-2001-57, 2001, *Radioactive Air Emissions Notice of Construction for the Transuranic Waste Retrieval Project*, Rev. 6, U.S. Department of Energy, Richland Operation Office, Richland, Washington.

DOE/RL-2014-13-ADD1, pending, *Remedial Design Report/Remedial Action Work Plan for 300-FF-2 Soils*, Rev. 0, U.S. Department of Energy, Richland Operation Office, Richland, Washington.

EPA, 2013, *Hanford Site 300 Area Record of Decision for 300-FF-2 and 300-FF-5, and Record of Decision Amendment for 300-FF-1*, U.S. Environmental Protection Agency, Region 10, Seattle, Washington, and U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Letter AIR 11-1006, 2011, "Pursuant to Chapter 246-247 of the Washington Administrative Code (WAC), Your Application was Hereby Approved on October 19, 2011, According to the Enclosed License for: Operation of the Transuranic Waste Retrieval Project," external letter to R. J. Corey, U.S. Department of Energy, Richland Operations Office, from J. Martell, Washington State Department of Health, Richland, Washington, October 28.

Letter AIR 99-1006, 1999, "Department of Health Staff has Completed the Review of the Request for Approval Vented Container Annual Release Fraction, DOE/RL-99-60, Rev. 0, September 1999," external letter to J. E. Rasmussen, U.S. Department of Energy, Richland Operations Office, from A. W. Conklin, Washington State Department of Health, Richland, Washington, October 18.

RC-100, *Radiological Control Support Procedures*, Washington Closure Hanford, Richland, Washington.

RC-200, *Radiological Control Field Procedures*, Washington Closure Hanford, Richland, Washington.

WAC 246-247, "Radiation Protection – Air Emissions," *Washington Administrative Code*, as amended.

WCH-449, 2013, *618-10 Burial Ground Drum Sampling and Analysis Instruction*, Rev. 0, Washington Closure Hanford, Richland, Washington.

WCH-532, TBD, *Acceptance and Treatment Plan for Liquid Anomalies in Bottles and Processing Concrete Drums at the 618-10 Burial Ground*, Rev. 4, Washington Closure Hanford, Richland, Washington.

WCH-534, 2015, *Sampling and Analysis Plan for the Radiological Determination of the 618-10 Vertical Pipe Units*, Draft A, Washington Closure Hanford, Richland, Washington.

WCH-550, 2015, *618-10 Burial Ground VPU Treatment Plan*, Rev. 2, Washington Closure Hanford, Richland, Washington.

WCH-585, 2014, *Treatment Plan for Containerized Granular Material at the 618-10 Burial Ground, Rev. 3*, Washington Closure Hanford, Richland, Washington.

WCH-602, 2014, *Treatment Plan for 618-10 Hazardous Debris, Rev. 0*, Washington Closure Hanford, Richland, Washington.

Figure 1. Ventilation System Drawing.

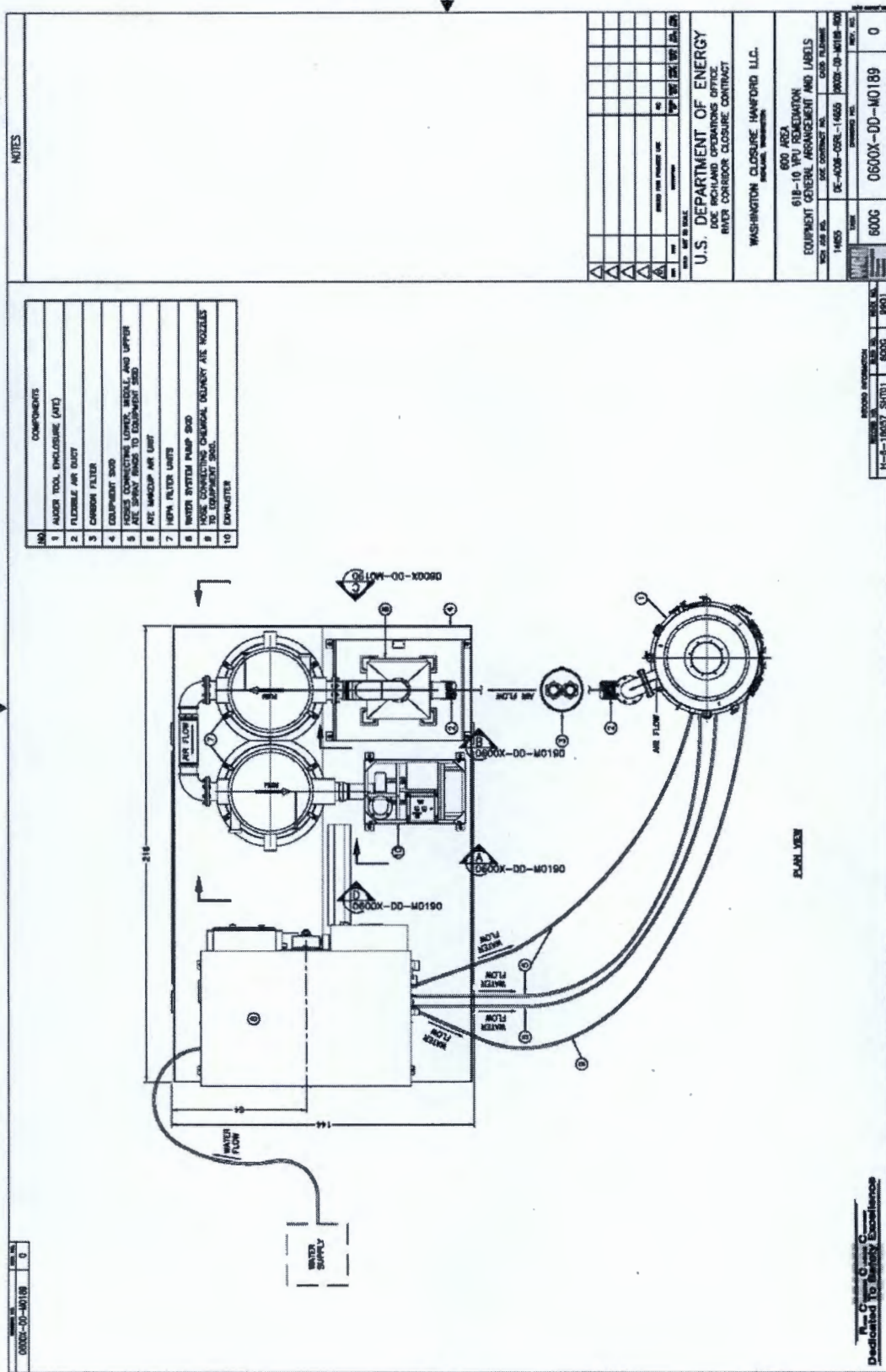


Figure 2. ATE with Auger Attached to Over-Casing.

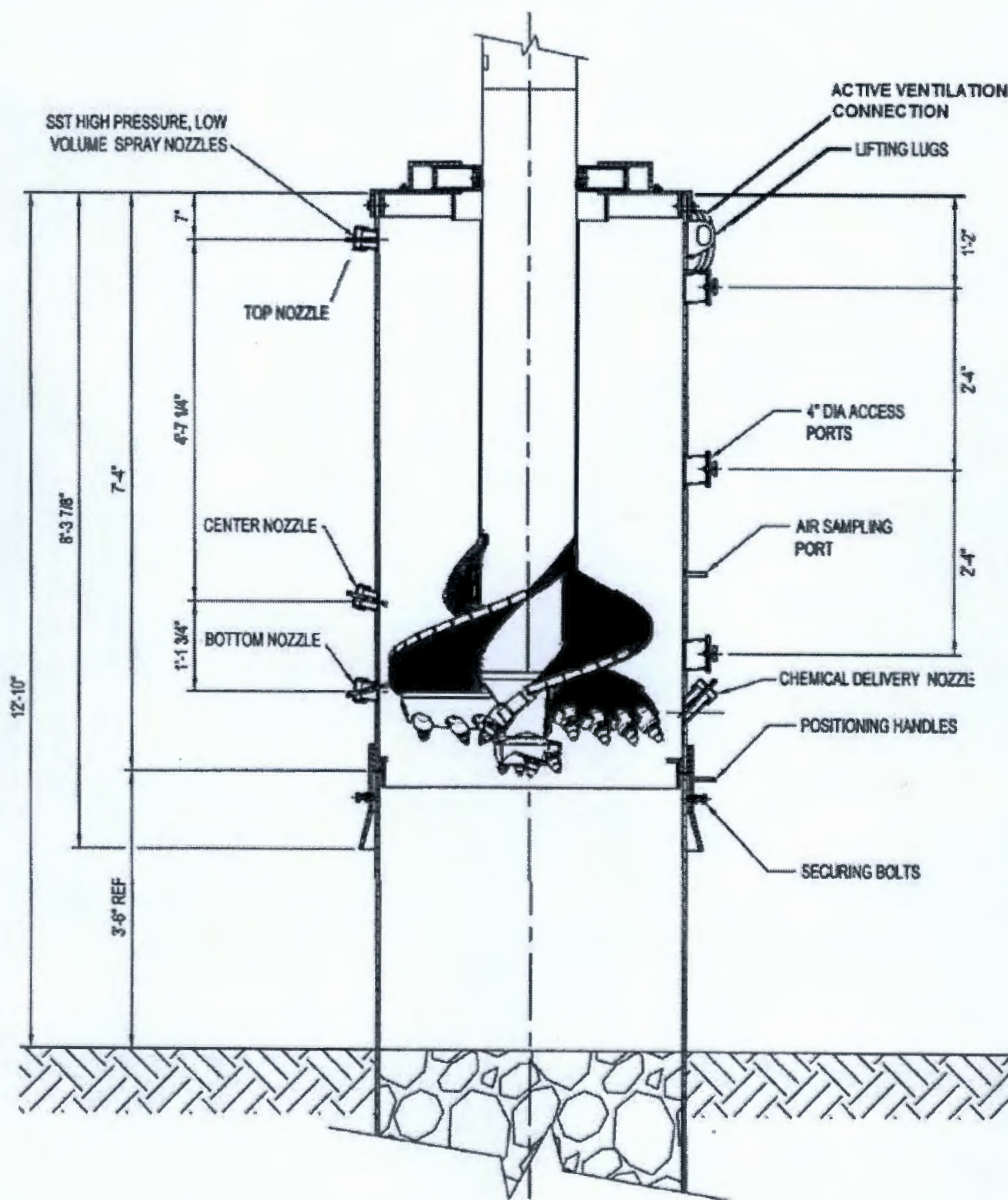
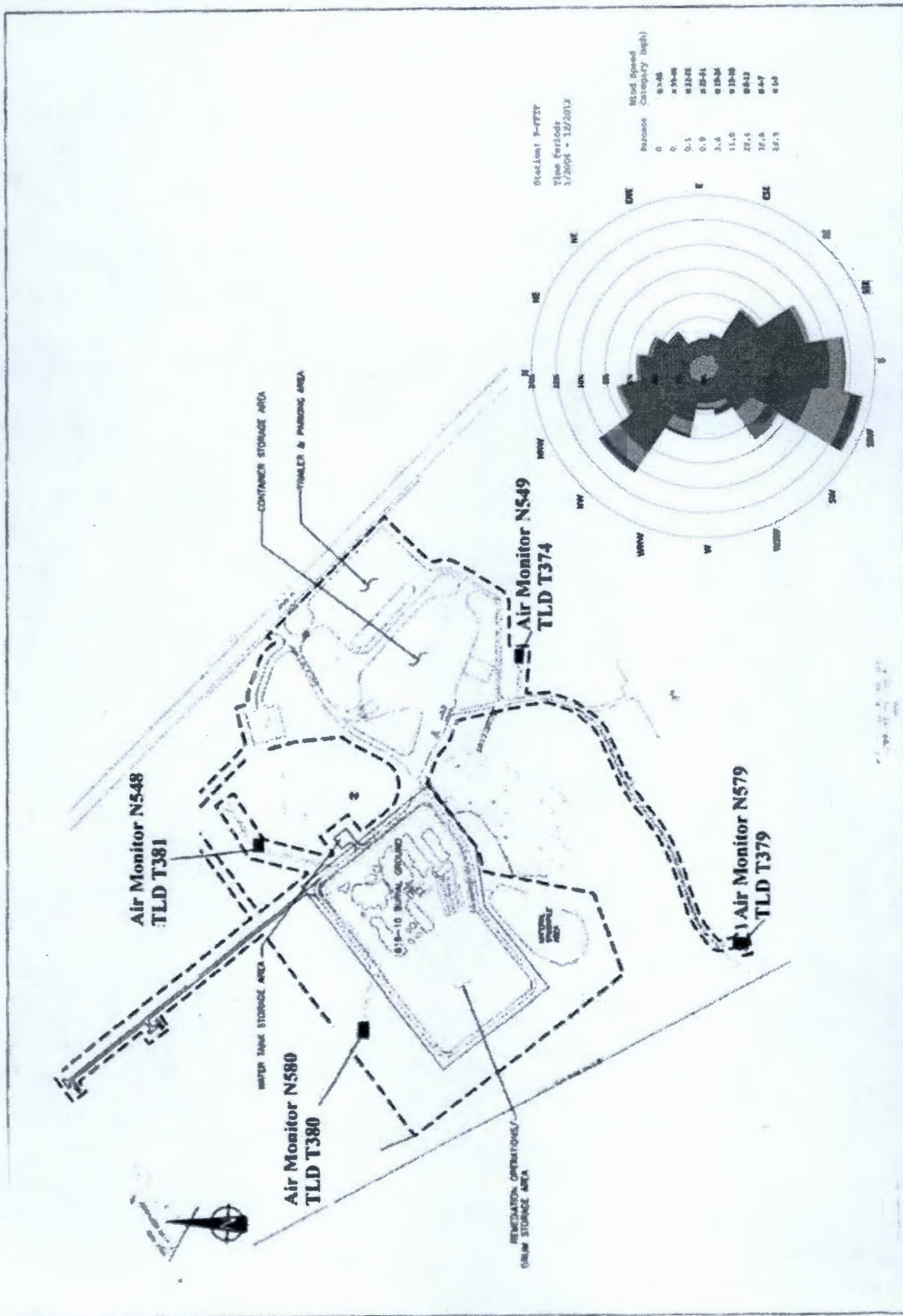




Figure 4. 618-10 Near Facility Air Monitor and TLD Locations.



**ATTACHMENT 1**

**TOTAL FUGITIVE CATEGORY PTE**

<b>Isotope</b>	<b>Trench PTE (Ci/yr)</b>	<b>Well Water PTE (Ci/yr)</b>	<b>Total Fugitive Emission PTE (Ci/yr)</b>
H-3	5.11E-01	5.30E+00	5.81E+00
Be-7		8.79E-06	8.79E-06
Be-10	4.23E-10		4.23E-10
C-14	2.39E-04	3.92E-07	2.39E-04
Cl-36	1.21E-06		1.21E-06
K-40		1.30E-05	1.30E-05
Ca-41	5.48E-06		5.48E-06
Fe-59		7.73E-07	7.73E-07
Co-58		2.52E-07	2.52E-07
Co-60	7.94E-06	1.50E-06	9.44E-06
Ni-59	6.65E-06		6.65E-06
Ni-63	5.71E-04		5.71E-04
Zn-65		6.18E-07	6.18E-07
Se-79	5.48E-06		5.48E-06
Kr-85	5.06E+00		5.06E+00
Sr-90	4.65E-01	4.13E-08	4.65E-01
Y-90	4.65E-01	4.13E-08	4.65E-01
Zr-93	2.73E-05		2.73E-05
Zr-95		1.85E-05	1.85E-05
Nb-93m	2.41E-05		2.41E-05
Nb-94	2.12E-08		2.12E-08
Mo-93	1.35E-08		1.35E-08
Tc-99	1.83E-04	9.25E-06	1.92E-04
Ru-106		1.20E-05	1.20E-05
Pd-107	7.87E-07		7.87E-07
Sn-121m	6.27E-06		6.27E-06
Sn-126	9.17E-06		9.17E-06
Sb-125		2.13E-06	2.13E-06
Sb-126	1.28E-06		1.28E-06
Sb-126m	9.17E-06		9.17E-06
I-129	3.79E-07	3.99E-08	4.19E-07
Cs-134	9.59E-09	4.79E-07	4.89E-07
Cs-135	4.89E-06		4.89E-06
Cs-137	4.01E-01	1.42E-06	4.01E-01
Ba-137m	3.79E-01	1.35E-06	3.79E-01
Ce-144		2.47E-06	2.47E-06
Sm-151	1.24E-02		1.24E-02
Eu-152	8.00E-06	5.53E-07	8.56E-06
Eu-154	2.90E-04	7.56E-07	2.91E-04
Eu-155		1.30E-06	1.30E-06
Re-187	8.43E-13		8.43E-13
Tl-207	1.04E-08		1.04E-08
Tl-208	6.44E-06		6.44E-06
Pb-209	1.29E-14		1.29E-14
Pb-210	6.43E-10		6.43E-10
Pb-211	1.05E-08		1.05E-08

Isotope	Trench PTE (Ci/yr)	Well Water PTE (Ci/yr)	Total Fugitive Emission PTE (Ci/yr)
Pb-212	1.79E-05		1.79E-05
Pb-214	1.71E-09		1.71E-09
Bi-210	6.43E-10		6.43E-10
Bi-211	1.05E-08		1.05E-08
Bi-212	1.79E-05		1.79E-05
Bi-213	1.29E-14		1.29E-14
Bi-214	1.71E-09		1.71E-09
Po-210	6.43E-10		6.43E-10
Po-211	2.75E-11		2.75E-11
Po-212	1.15E-05		1.15E-05
Po-213	1.27E-14		1.27E-14
Po-214	1.71E-09		1.71E-09
Po-215	1.05E-08		1.05E-08
Po-216	1.79E-05		1.79E-05
Po-218	1.71E-09		1.71E-09
At-217	1.29E-14		1.29E-14
Rn-219	1.05E-05		1.05E-05
Rn-220	1.79E-02		1.79E-02
Rn-222	1.71E-06		1.71E-06
Fr-221	1.29E-14		1.29E-14
Fr-223	1.44E-10		1.44E-10
Ra-223	1.05E-08		1.05E-08
Ra-224	1.79E-05		1.79E-05
Ra-225	1.29E-14		1.29E-14
Ra-226	1.71E-09		1.71E-09
Ra-228	1.79E-05		1.79E-05
Ac-225	1.29E-14		1.29E-14
Ac-227	1.05E-08		1.05E-08
Ac-228	1.79E-05		1.79E-05
Th-227	1.03E-08		1.03E-08
Th-228	1.79E-05		1.79E-05
Th-229	1.29E-14		1.29E-14
Th-230	1.53E-07		1.53E-07
Th-231	1.86E-05		1.86E-05
Th-232	1.80E-05		1.80E-05
Th-234	8.15E-04		8.15E-04
Pa-231	2.04E-08		2.04E-08
Pa-233	2.77E-06		2.77E-06
Pa-234	1.06E-06		1.06E-06
Pa-234m	8.15E-04		8.15E-04
U-232	3.22E-08		3.22E-08
U-233	7.38E-10	7.05E-07	7.06E-07
U-234	3.27E-04	3.51E-06	3.30E-04
U-235	1.86E-05	1.88E-07	1.87E-05
U-236	7.88E-06		7.88E-06
U-237	1.17E-06		1.17E-06
U-238	8.15E-04	5.40E-06	8.21E-04
U-240	1.63E-18		1.63E-18
Np-237	2.77E-06		2.77E-06
Np-238	1.59E-08		1.59E-08
Np-239	1.84E-06		1.84E-06

<b>Isotope</b>	<b>Trench PTE (Ci/yr)</b>	<b>Well Water PTE (Ci/yr)</b>	<b>Total Fugitive Emission PTE (Ci/yr)</b>
Np-240m	1.63E-18		1.63E-18
Pu-238	2.97E-03	7.04E-09	2.97E-03
Pu-239	1.50E-02	1.11E-09	1.50E-02
Pu-240	5.75E-03		5.75E-03
Pu-241	4.77E-02		4.77E-02
Pu-242	1.23E-06		1.23E-06
Am-241	1.68E-02		1.68E-02
Am-242	3.17E-06		3.17E-06
Am-242m	3.19E-06		3.19E-06
Am-243	1.84E-06		1.84E-06
Cm-242	2.62E-06		2.62E-06
Cm-243	3.14E-07		3.14E-07
Cm-244	4.73E-06		4.73E-06
Cm-245	6.46E-10		6.46E-10
Cm-246	1.80E-11		1.80E-11

**Notes:**

Radionuclide potential to emit values are presented in Calculation 0600X-CA-V0087, 2015, *Total Effective Dose Emissions Calculation for Remediation of the 618-10 Burial Ground*, Rev. 5, Washington Closure Hanford, Richland, Washington.

ATTACHMENT 2

WELL WATER INVENTORY AND POTENTIAL TO EMIT (FUGITIVE)

A	B	C	D	E	F
Well Name	Nuclide	Concentration (pCi/L)	Concentration (Ci/L)	Activity (Ci)	PTE (Ci/year)
699-S6-E4D	Be-7	6.98E+01	6.98E-11	8.79E-03	8.79E-06
699-S6-E4A	C-14	3.11E+00	3.11E-12	3.92E-04	3.92E-07
699-S6-E4D	Ce/Pr-144 <sup>(1)</sup>	1.96E+01	1.96E-11	2.47E-03	2.47E-06
699-S6-E4A	Co-58	2.00E+00	2.00E-12	2.52E-04	2.52E-07
699-S6-E4B	Co-60	1.19E+01	1.19E-11	1.50E-03	1.50E-06
699-S6-E4A	Cs-134	3.80E+00	3.80E-12	4.79E-04	4.79E-07
699-S6-E4D	Cs-137	1.13E+01	1.13E-11	1.42E-03	1.42E-06
	Ba-137m <sup>(6)</sup>			1.35E-03	1.35E-06
699-S6-E4K	Eu-152	4.39E+00	4.39E-12	5.53E-04	5.53E-07
699-S6-E4D	Eu-154	6.00E+00	6.00E-12	7.56E-04	7.56E-07
699-S6-E4A	Eu-155	1.03E+01	1.03E-11	1.30E-03	1.30E-06
699-S6-E4A	Fe-59	6.14E+00	6.14E-12	7.73E-04	7.73E-07
699-S6-E4D	H-3 <sup>(5)</sup>	4.21E+04	4.21E-08	5.30E+00	5.30E+00
699-S6-E4D	I-129	3.17E-01	3.17E-13	3.99E-05	3.99E-08
699-S6-E4D	K-40	1.03E+02	1.03E-10	1.30E-02	1.30E-05
699-S6-E4A	Pu-238	5.59E-02	5.59E-14	7.04E-06	7.04E-09
699-S6-E4B	Pu-239/240 <sup>(2)</sup>	8.83E-03	8.83E-15	1.11E-06	1.11E-09
699-S6-E4D	Ru-106	9.54E+01	9.54E-11	1.20E-02	1.20E-05
699-S6-E4D	Sb-125	1.69E+01	1.69E-11	2.13E-03	2.13E-06
699-S6-E4A	Sr-90	3.28E-01	3.28E-13	4.13E-05	4.13E-08
	Y-90 <sup>(7)</sup>			4.13E-05	4.13E-08
699-S6-E4D	Tc-99	7.34E+01	7.34E-11	9.25E-03	9.25E-06
699-S6-E4L	U-233/234 <sup>(3)</sup>	5.60E+00	5.60E-12	7.05E-04	7.05E-07
699-S6-E4A	U-234	2.79E+01	2.79E-11	3.51E-03	3.51E-06
699-S6-E4A	U-235	1.49E+00	1.49E-12	1.88E-04	1.88E-07
699-S6-E4A	U-238	4.29E+01	4.29E-11	5.40E-03	5.40E-06
699-S6-E4D	Zn-65	4.91E+00	4.91E-12	6.18E-04	6.18E-07
699-S6-E4D	Zr/Nb-95 <sup>(4)</sup>	1.47E+02	1.47E-10	1.85E-02	1.85E-05

Notes:

- (1) Assumed to be all Ce-144
- (2) Assumed to be all Pu-239
- (3) Assumed to be all U-233
- (4) Assumed to be all Zr-95
- (5) Release Fraction of 1 consistent with gaseous material form.
- (6) Ba-137m, a daughter product of Cs-137, is assumed to be 0.946 of Cs-137 activity.
- (7) Y-90, a daughter product of Sr-90, is assumed to be in equal proportion to Sr-90.
- (8) Radionuclide potential to emit values are presented in Calculation 0600X-CA-V0087, 2015, *Total Effective Dose Emissions Calculation for Remediation of the 618-10 Burial Ground*, Rev. 5, Washington Closure Hanford, Richland, Washington.

ATTACHMENT 3

TOTAL FUGITIVE CATEGORY PTE AND TOTAL EFFECTIVE DOSE EQUIVALENT

Isotope	Trench PTE (Ci/yr)	Well Water PTE (Ci/yr)	Total Fugitive Emission PTE (Ci/yr)
H-3	5.11E-01	5.30E+00	5.81E+00
Be-7		8.79E-06	8.79E-06
Be-10	4.23E-10		4.23E-10
C-14	2.39E-04	3.92E-07	2.39E-04
Cl-36	1.21E-06		1.21E-06
K-40		1.30E-05	1.30E-05
Ca-41	5.48E-06		5.48E-06
Fe-59		7.73E-07	7.73E-07
Co-58		2.52E-07	2.52E-07
Co-60	7.94E-06	1.50E-06	9.44E-06
Ni-59	6.65E-06		6.65E-06
Ni-63	5.71E-04		5.71E-04
Zn-65		6.18E-07	6.18E-07
Se-79	5.48E-06		5.48E-06
Kr-85	5.06E+00		5.06E+00
Sr-90	4.65E-01	4.13E-08	4.65E-01
Y-90	4.65E-01	4.13E-08	4.65E-01
Zr-93	2.73E-05		2.73E-05
Zr-95		1.85E-05	1.85E-05
Nb-93m	2.41E-05		2.41E-05
Nb-94	2.12E-08		2.12E-08
Mo-93	1.35E-08		1.35E-08
Tc-99	1.83E-04	9.25E-06	1.92E-04
Ru-106		1.20E-05	1.20E-05
Pd-107	7.87E-07		7.87E-07
Sn-121m	6.27E-06		6.27E-06
Sn-126	9.17E-06		9.17E-06
Sb-125		2.13E-06	2.13E-06
Sb-126	1.28E-06		1.28E-06
Sb-126m	9.17E-06		9.17E-06
I-129	3.79E-07	3.99E-08	4.19E-07
Cs-134	9.59E-09	4.79E-07	4.89E-07
Cs-135	4.89E-06		4.89E-06
Cs-137	4.01E-01	1.42E-06	4.01E-01
Ba-137m	3.79E-01	1.35E-06	3.79E-01
Ce-144		2.47E-06	2.47E-06
Sm-151	1.24E-02		1.24E-02
Eu-152	8.00E-06	5.53E-07	8.56E-06
Eu-154	2.90E-04	7.56E-07	2.91E-04
Eu-155		1.30E-06	1.30E-06
Re-187	8.43E-13		8.43E-13
Tl-207	1.04E-08		1.04E-08
Tl-208	6.44E-06		6.44E-06
Pb-209	1.29E-14		1.29E-14
Pb-210	6.43E-10		6.43E-10

<b>Isotope</b>	<b>Trench PTE (Ci/yr)</b>	<b>Well Water PTE (Ci/yr)</b>	<b>Total Fugitive Emission PTE (Ci/yr)</b>
Pb-211	1.05E-08		1.05E-08
Pb-212	1.79E-05		1.79E-05
Pb-214	1.71E-09		1.71E-09
Bi-210	6.43E-10		6.43E-10
Bi-211	1.05E-08		1.05E-08
Bi-212	1.79E-05		1.79E-05
Bi-213	1.29E-14		1.29E-14
Bi-214	1.71E-09		1.71E-09
Po-210	6.43E-10		6.43E-10
Po-211	2.75E-11		2.75E-11
Po-212	1.15E-05		1.15E-05
Po-213	1.27E-14		1.27E-14
Po-214	1.71E-09		1.71E-09
Po-215	1.05E-08		1.05E-08
Po-216	1.79E-05		1.79E-05
Po-218	1.71E-09		1.71E-09
At-217	1.29E-14		1.29E-14
Rn-219	1.05E-05		1.05E-05
Rn-220	1.79E-02		1.79E-02
Rn-222	1.71E-06		1.71E-06
Fr-221	1.29E-14		1.29E-14
Fr-223	1.44E-10		1.44E-10
Ra-223	1.05E-08		1.05E-08
Ra-224	1.79E-05		1.79E-05
Ra-225	1.29E-14		1.29E-14
Ra-226	1.71E-09		1.71E-09
Ra-228	1.79E-05		1.79E-05
Ac-225	1.29E-14		1.29E-14
Ac-227	1.05E-08		1.05E-08
Ac-228	1.79E-05		1.79E-05
Th-227	1.03E-08		1.03E-08
Th-228	1.79E-05		1.79E-05
Th-229	1.29E-14		1.29E-14
Th-230	1.53E-07		1.53E-07
Th-231	1.86E-05		1.86E-05
Th-232	1.80E-05		1.80E-05
Th-234	8.15E-04		8.15E-04
Pa-231	2.04E-08		2.04E-08
Pa-233	2.77E-06		2.77E-06
Pa-234	1.06E-06		1.06E-06
Pa-234m	8.15E-04		8.15E-04
U-232	3.22E-08		3.22E-08
U-233	7.38E-10	7.05E-07	7.06E-07
U-234	3.27E-04	3.51E-06	3.30E-04
U-235	1.86E-05	1.88E-07	1.87E-05
U-236	7.88E-06		7.88E-06
U-237	1.17E-06		1.17E-06
U-238	8.15E-04	5.40E-06	8.21E-04
U-240	1.63E-18		1.63E-18
Np-237	2.77E-06		2.77E-06
Np-238	1.59E-08		1.59E-08

<b>Isotope</b>	<b>Trench PTE (Ci/yr)</b>	<b>Well Water PTE (Ci/yr)</b>	<b>Total Fugitive Emission PTE (Ci/yr)</b>
Np-239	1.84E-06		1.84E-06
Np-240m	1.63E-18		1.63E-18
Pu-238	2.97E-03	7.04E-09	2.97E-03
Pu-239	1.50E-02	1.11E-09	1.50E-02
Pu-240	5.75E-03		5.75E-03
Pu-241	4.77E-02		4.77E-02
Pu-242	1.23E-06		1.23E-06
Am-241	1.68E-02		1.68E-02
Am-242	3.17E-06		3.17E-06
Am-242m	3.19E-06		3.19E-06
Am-243	1.84E-06		1.84E-06
Cm-242	2.62E-06		2.62E-06
Cm-243	3.14E-07		3.14E-07
Cm-244	4.73E-06		4.73E-06
Cm-245	6.46E-10		6.46E-10
Cm-246	1.80E-11		1.80E-11

**NUCLIDE EFFECTIVE DOSE EQUIVALENT SUMMARY FOR POINT  
SOURCE EMISSIONS**

Nuclide	Selected Individual (mrem)
Ac-227	8.73E-07
Th-227	1.06E-07
Fr-223	1.04E-10
Ra-223	8.02E-08
Rn-219	2.13E-09
Ac-228	5.09E-05
Th-228	3.66E-04
Ra-224	2.38E-05
Rn-220	1.07E-08
Po-216	7.26E-11
Am-241	2.07E-04
Np-237	2.20E-08
Pa-233	1.13E-09
U-233	2.40E-16
Th-229	5.55E-17
Am-242	8.69E-11
Cm-242	3.16E-09
Pu-242	1.67E-08
Pu-238	3.76E-05
U-238	4.37E-03
Am-242m	3.44E-08
Np-238	1.18E-11
Am-243	2.16E-08
Np-239	4.74E-10
Pu-239	2.43E-04
U-235m	0.00E+00
U-235	7.77E-05
Ba-137m	2.02E-04
Bi-210	7.80E-11
Po-210	1.87E-09
Tl-206	1.11E-16
Bi-211	4.72E-12
Tl-207	1.02E-13
Po-211	6.11E-17
Bi-212	3.01E-07
Po-212	0.00E+00
Tl-208	7.74E-09
Bi-214	8.12E-10
Po-214	2.51E-17
Tl-210	1.80E-16
Pb-210	2.37E-09
C-14	2.42E-10
U-234	6.72E-04
Th-230	1.48E-06
Ra-226	7.78E-09
Cm-243	2.78E-09
Cm-244	3.47E-08
Pu-240	8.82E-05
U-236	8.63E-09

Th-232	2.81E-04
Ra-228	9.64E-05
Co-60	2.45E-09
Cs-134	5.34E-12
Cs-135	5.31E-10
Cs-137	2.24E-04
Eu-152	5.49E-09
Gd-152	9.87E-28
Sm-148	0.00E+00
Nd-144	0.00E+00
Eu-154	1.63E-07
At-219	0.00E+00
Bi-215	4.67E-19
H-3	2.06E-08
I-129	9.79E-10
Kr-85	2.30E-09
Mo-93	1.39E-13
Nb-93m	3.05E-11
Ni-59	3.22E-12
Ni-63	6.04E-10
Ra-225	7.70E-18
Th-231	1.86E-06
Pa-231	2.27E-06
Ac-225	6.40E-20
Pa-234	2.11E-05
Rn-222	4.98E-12
Pa-234m	1.07E-03
Hg-206	3.84E-18
Pb-211	2.91E-10
Pb-212	3.85E-06
Pb-214	5.91E-09
Pd-107	1.65E-13
Po-215	4.32E-14
Po-218	1.04E-16
At-218	1.59E-16
Rn-218	1.19E-24
Pu-241	1.30E-05
U-237	1.07E-10
Th-234	1.04E-04
Sb-126	4.88E-09
Sb-126m	2.04E-08
Se-79	9.86E-10
Sm-151	1.44E-08
Sn-121m	3.51E-11
Sn-121	2.37E-13
Sn-126	1.60E-09
Sr-90	2.41E-04
Y-90	3.22E-05
Tc-99	2.30E-08
U-232	8.97E-11
Zr-93	1.05E-10
TOTAL	8.44E-03

Notes:

The annual unabated dose was determined using the CAP88-PC, Version 4 Model. The PTE was the input for the model, and the model generated the annual unabated dose. The CAP88-PC model summary and synopsis is presented in 0600X-CA-V0087, 2015, *Total Effective Dose Emissions Calculation for Remediation of the 618-10 Burial Ground*, Rev.5, Washington Closure Hanford, Richland, Washington.

**ATTACHMENT 4**

**DRUM PUNCH FACILITY INVENTORY AND POINT SOURCE PTE**

<b>Isotope</b>	<b>Puncturable Drum Inventory (Ci)</b>	<b>PTE (Ci/yr)</b>
H-3	1.07E-03	2.67E-04
Be-10	5.07E-10	1.27E-13
C-14	1.31E-04	3.28E-08
Co-60	9.29E-06	2.32E-09
Ni-59	7.86E-06	1.97E-09
Ni-63	6.74E-04	1.69E-07
Se-79	1.55E-05	3.87E-09
Kr-85	1.42E-02	3.56E-03
Sr-90	9.02E-01	2.26E-04
Y-90	9.02E-01	2.26E-04
Zr-93	7.36E-05	1.84E-08
Nb-93m	6.50E-05	1.63E-08
Nb-94	3.11E-09	7.77E-13
Mo-93	1.61E-08	4.04E-12
Tc-99	5.16E-04	1.29E-07
Pd-107	2.27E-06	5.67E-10
Sn-121m	9.04E-06	2.26E-09
Sn-126	2.60E-05	6.51E-09
Sb-126	3.65E-06	9.11E-10
Sb-126m	2.60E-05	6.51E-09
I-129	1.08E-06	2.69E-10
Cs-134	2.83E-08	7.07E-12
Cs-135	1.38E-05	3.45E-09
Cs-137	1.13E+00	2.83E-04
Ba-137m	1.07E+00	2.68E-04
Sm-151	3.43E-02	8.56E-06
Eu-152	2.27E-05	5.67E-09
Eu-154	8.57E-04	2.14E-07
Re-187	1.00E-12	2.50E-16
Tl-207	1.35E-04	3.37E-08
Tl-208	4.29E-02	1.07E-05
Pb-209	1.55E-15	3.87E-19
Pb-210	4.74E-06	1.18E-09
Pb-211	1.35E-04	3.38E-08
Pb-212	1.19E-01	2.98E-05
Pb-214	1.26E-05	3.16E-09
Bi-210	4.74E-06	1.18E-09
Bi-211	1.35E-04	3.38E-08
Bi-212	1.19E-01	2.98E-05
Bi-213	1.55E-15	3.87E-19
Bi-214	1.26E-05	3.16E-09
Po-210	4.74E-06	1.18E-09
Po-211	3.78E-07	9.46E-11
Po-212	7.64E-02	1.91E-05
Po-213	1.52E-15	3.79E-19
Po-214	1.26E-05	3.16E-09
Po-215	1.35E-04	3.38E-08

Isotope	Puncturable Drum Inventory (Ci)	PTE (Ci/yr)
Po-216	1.19E-01	2.98E-05
Po-218	1.26E-05	3.16E-09
At-217	1.55E-15	3.87E-19
Rn-219	1.35E-04	3.38E-05
Rn-220	1.19E-01	2.98E-02
Rn-222	1.26E-05	3.16E-06
Fr-221	1.55E-15	3.87E-19
Fr-223	1.86E-06	4.66E-10
Ra-223	1.35E-04	3.38E-08
Ra-224	1.19E-01	2.98E-05
Ra-225	1.55E-15	3.87E-19
Ra-226	1.26E-05	3.16E-09
Ra-228	1.20E-01	2.99E-05
Ac-225	1.55E-15	3.87E-19
Ac-227	1.35E-04	3.38E-08
Ac-228	1.20E-01	2.99E-05
Th-227	1.33E-04	3.33E-08
Th-228	1.19E-01	2.98E-05
Th-229	1.55E-15	3.87E-19
Th-230	1.13E-03	2.83E-07
Th-231	2.41E-01	6.03E-05
Th-232	1.20E-01	3.00E-05
Th-234	1.90E+01	4.74E-03
Pa-231	2.64E-04	6.61E-08
Pa-233	1.07E-05	2.67E-09
Pa-234	2.47E-02	6.16E-06
Pa-234m	1.90E+01	4.74E-03
U-232	1.10E-07	2.75E-11
U-233	2.87E-09	7.19E-13
U-234	2.43E+00	6.08E-04
U-235	2.41E-01	6.03E-05
U-236	3.38E-05	8.44E-09
U-237	3.84E-06	9.59E-10
U-238	1.90E+01	4.74E-03
U-240	5.10E-18	1.28E-21
Np-237	1.07E-05	2.67E-09
Np-238	5.08E-08	1.27E-11
Np-239	5.80E-06	1.45E-09
Np-240m	5.10E-18	1.28E-21
Pu-238	9.03E-03	2.26E-06
Pu-239	5.37E-02	1.34E-05
Pu-240	1.95E-02	4.87E-06
Pu-241	1.56E-01	3.91E-05
Pu-242	3.89E-06	9.73E-10
Am-241	5.51E-02	1.38E-05
Am-242	1.01E-05	2.53E-09
Am-242m	1.02E-05	2.54E-09
Am-243	5.80E-06	1.45E-09
Cm-242	8.35E-06	2.09E-09
Cm-243	9.84E-07	2.46E-10
Cm-244	1.48E-05	3.70E-09
Cm-245	2.01E-09	5.03E-13

<b>Isotope</b>	<b>Puncturable Drum Inventory (Ci)</b>	<b>PTE (Ci/yr)</b>
Cm-246	5.59E-11	1.40E-14

Notes:

Radionuclide potential to emit and total effective dose equivalent values are presented in Calculation 0600X-CA-V0087, 2015, *Total Effective Dose Emissions Calculation for Remediation of the 618-10 Burial Ground*, Rev. 5, Washington Closure Hanford, Richland, Washington.

## NUCLIDE EFFECTIVE DOSE EQUIVALENT SUMMARY FOR FUGITIVE EMISSIONS

Nuclide	Selected Individual (mrem/y)
Ac-227	2.72E-07
Th-227	3.29E-08
Fr-223	3.24E-11
Ra-223	2.50E-08
Rn-219	6.63E-10
Ac-228	3.06E-05
Th-228	2.20E-04
Ra-224	1.44E-05
Rn-220	6.48E-09
Po-216	4.44E-11
Am-241	2.53E-01
Np-237	2.29E-05
Pa-233	1.18E-06
U-233	8.00E-07
Th-229	2.18E-10
Am-242	1.09E-07
Cm-242	3.98E-06
Pu-242	2.12E-05
Pu-238	4.95E-02
U-238	7.60E-04
Am-242m	4.33E-05
Np-238	1.48E-08
Am-243	2.75E-05
Np-239	6.03E-07
Pu-239	2.73E-01
U-235m	0.00E+00
U-235	2.42E-05
Ba-137m	2.88E-01
Be-10	6.36E-12
Be-7	6.25E-09
Bi-210	4.26E-11
Po-210	1.02E-09
Tl-206	6.08E-17
Bi-211	1.47E-12
Tl-207	3.18E-14
Po-211	1.90E-17
Bi-212	1.81E-07
Po-212	0.00E+00
Tl-208	4.66E-09
Bi-214	4.40E-10
Po-214	1.36E-17
Tl-210	9.03E-17
Pb-210	1.30E-09
C-14	1.77E-06
Ca-41	4.64E-08

Ce-144	5.66E-08
Pr-144m	1.83E-11
Pr-144	2.78E-08
Nd-144	0.00E+00
Cl-36	5.82E-06
U-234	3.66E-04
Th-230	8.02E-07
Ra-226	4.22E-09
Cm-243	3.56E-06
Cm-244	4.44E-05
Pu-240	1.04E-01
U-236	8.08E-06
Th-232	1.69E-04
Ra-228	5.79E-05
Cm-245	9.99E-09
Pu-241	1.58E-02
U-237	1.31E-07
Co-58	5.46E-09
Co-60	9.97E-06
Cs-134	3.71E-07
Cs-135	7.55E-07
Cs-137	3.18E-01
Eu-152	8.31E-06
Gd-152	1.50E-24
Sm-148	0.00E+00
Eu-154	2.22E-04
Eu-155	3.12E-08
Fe-59	1.59E-08
At-219	0.00E+00
Bi-215	1.40E-19
I-129	1.52E-06
K-40	1.21E-05
Kr-85	3.28E-06
Mo-93	4.66E-10
Nb-93m	4.53E-08
Nb-94	6.36E-08
Ni-59	1.09E-08
Ni-63	2.05E-06
Ra-225	3.09E-11
Th-231	5.77E-07
Pa-231	7.03E-07
Ac-225	3.70E-11
Pa-234	3.67E-06
Rn-222	2.70E-12
Pa-234m	1.86E-04
Hg-206	2.10E-18
Pb-211	9.06E-11
Pb-212	2.32E-06
Pb-214	3.20E-09
Pd-107	2.30E-10
Po-215	1.34E-14
Po-218	5.64E-17
At-218	8.64E-17
Rn-218	6.96E-25
Th-234	1.81E-05

Ru-106	3.26E-07
Rh-106	3.81E-07
Sb-125	2.17E-07
Te-125m	3.10E-09
Sb-126	6.89E-06
Sb-126m	2.88E-05
Se-79	1.40E-06
Sm-151	2.09E-05
Sn-121m	9.77E-08
Sn-121	6.58E-10
Sn-126	2.26E-06
Sr-90	4.97E-01
Y-90	6.63E-02
Tc-99	3.43E-05
U-232	1.05E-07
Fr-221	7.54E-11
Zn-65	1.03E-07
Zr-93	1.57E-07
Zr-95	2.61E-07
Nb-95m	2.01E-10
Nb-95	2.16E-07
H-3	4.50E-04
Cm-246	2.74E-10
TOTAL	1.87E+00

ATTACHMENT 5

VERTICAL PIPE UNIT, INVENTORY AND POTENTIAL TO EMIT

Nuclide	Total VPU Inventory (Ci)	Total Adjusted VPU Inventory (Ci)	PTE (Ci/year)
H-3	1.066E+01	6.392E+00	1.278E+00
Be-10	5.625E-04	3.373E-04	6.746E-08
C-14	1.456E+02	8.731E+01	1.746E-02
Cl-36	5.218E-04	3.129E-04	6.258E-08
Ca-41	2.360E-03	1.415E-03	2.830E-07
Co-60	1.050E+01	6.296E+00	1.259E-03
Ni-59	8.799E+00	5.276E+00	1.055E-03
Ni-63	7.511E+02	4.504E+02	9.008E-02
Se-79	1.193E-02	7.154E-03	1.431E-06
Kr-85	1.068E+01	6.404E+00	1.281E+00
Sr-90	6.758E+02	4.052E+02	8.105E-02
Y-90	6.761E+02	4.054E+02	8.108E-02
Zr-93	2.806E+00	1.683E+00	3.365E-04
Nb-93m	2.477E+00	1.485E+00	2.971E-04
Nb-94	4.071E-05	2.441E-05	4.882E-09
Mo-93	1.790E-02	1.073E-02	2.147E-06
Tc-99	3.994E-01	2.395E-01	4.790E-05
Pd-107	2.039E-03	1.223E-03	2.445E-07
Sn-121m	7.124E+00	4.272E+00	8.544E-04
Sn-126	2.096E-02	1.257E-02	2.514E-06
Sb-126	2.934E-03	1.759E-03	3.519E-07
Sb-126m	2.096E-02	1.257E-02	2.514E-06
I-129	8.604E-04	5.159E-04	1.032E-07
Cs-134	2.970E-05	1.781E-05	3.562E-09
Cs-135	1.069E-02	6.410E-03	1.282E-06
Cs-137	8.782E+02	5.266E+02	1.053E-01
Ba-137m	8.307E+02	4.981E+02	9.962E-02
Sm-151	2.181E+01	1.308E+01	2.616E-03
Eu-152	2.374E-02	1.424E-02	2.847E-06
Eu-154	9.043E-01	5.423E-01	1.085E-04
Re-187	1.128E-06	6.764E-07	1.353E-10
Tl-207	3.331E-06	1.997E-06	3.995E-10
Tl-208	4.143E-05	2.484E-05	4.969E-09
Pb-209	8.423E-17	5.051E-17	1.010E-20
Pb-210	2.948E-07	1.768E-07	3.535E-11
Pb-211	3.340E-06	2.003E-06	4.006E-10
Pb-212	1.153E-04	6.914E-05	1.383E-08
Pb-214	7.784E-07	4.668E-07	9.335E-11
Bi-210	2.949E-07	1.768E-07	3.537E-11
Bi-211	3.340E-06	2.003E-06	4.006E-10
Bi-212	1.153E-04	6.914E-05	1.383E-08
Bi-213	8.423E-17	5.051E-17	1.010E-20
Bi-214	7.784E-07	4.668E-07	9.335E-11
Po-210	2.949E-07	1.768E-07	3.537E-11
Po-211	1.583E-09	9.492E-10	1.898E-13
Po-212	7.390E-05	4.431E-05	8.863E-09
Po-213	8.240E-17	4.941E-17	9.882E-21

Nuclide	Total VPU Inventory (Ci)	Total Adjusted VPU Inventory (Ci)	PTE (Ci/year)
Po-214	7.784E-07	4.668E-07	9.335E-11
Po-215	3.340E-06	2.003E-06	4.006E-10
Po-216	1.153E-04	6.914E-05	1.383E-08
Po-218	7.787E-07	4.669E-07	9.339E-11
At-217	8.423E-17	5.051E-17	1.010E-20
Rn-219	3.340E-06	2.003E-06	4.006E-07
Rn-220	1.153E-04	6.914E-05	1.383E-05
Rn-222	7.787E-07	4.669E-07	9.339E-08
Fr-221	8.423E-17	5.051E-17	1.010E-20
Fr-223	4.604E-08	2.761E-08	5.521E-12
Ra-223	3.340E-06	2.003E-06	4.006E-10
Ra-224	1.153E-04	6.914E-05	1.383E-08
Ra-225	8.423E-17	5.051E-17	1.010E-20
Ra-226	7.787E-07	4.669E-07	9.339E-11
Ac-225	8.423E-17	5.051E-17	1.010E-20
Ac-227	3.336E-06	2.000E-06	4.001E-10
Th-227	3.294E-06	1.975E-06	3.950E-10
Th-228	1.153E-04	6.914E-05	1.383E-08
Th-229	8.423E-17	5.051E-17	1.010E-20
Th-230	6.911E-05	4.144E-05	8.288E-09
Th-231	5.705E-03	3.421E-03	6.842E-07
Th-234	1.156E-01	6.932E-02	1.386E-05
Pa-231	6.431E-06	3.856E-06	7.713E-10
Pa-233	8.640E-03	5.181E-03	1.036E-06
Pa-234	1.503E-04	9.013E-05	1.803E-08
Pa-234m	1.156E-01	6.932E-02	1.386E-05
U-232	1.123E-04	6.734E-05	1.347E-08
U-233	2.270E-06	1.361E-06	2.722E-10
U-234	1.470E-01	8.815E-02	1.763E-05
U-235	5.705E-03	3.421E-03	6.842E-07
U-236	1.983E-02	1.189E-02	2.378E-06
U-237	4.222E-03	2.532E-03	5.063E-07
U-238	1.156E-01	6.932E-02	1.386E-05
U-240	6.760E-15	4.054E-15	8.107E-19
Np-237	8.640E-03	5.181E-03	1.036E-06
Np-238	6.611E-05	3.964E-05	7.928E-09
Np-239	7.683E-03	4.607E-03	9.214E-07
Np-240m	6.760E-15	4.054E-15	8.107E-19
Pu-238	9.603E+00	5.758E+00	1.152E-03
Pu-239	3.799E+01	2.278E+01	4.556E-03
Pu-240	1.824E+01	1.094E+01	2.187E-03
Pu-241	1.720E+02	1.031E+02	2.063E-02
Pu-242	4.863E-03	2.916E-03	5.832E-07
Am-241	6.073E+01	3.642E+01	7.283E-03
Am-242	1.315E-02	7.885E-03	1.577E-06
Am-242m	1.322E-02	7.927E-03	1.585E-06
Am-243	7.683E-03	4.607E-03	9.214E-07
Cm-242	1.088E-02	6.524E-03	1.305E-06
Cm-243	1.330E-03	7.975E-04	1.595E-07
Cm-244	2.002E-02	1.200E-02	2.401E-06
Cm-245	2.746E-06	1.647E-06	3.293E-10
Cm-246	7.656E-08	4.591E-08	9.182E-12

Notes:

Radionuclide potential to emit and total effective dose equivalent values are presented in Calculation 0600X-CA-V0131, 2015, *Total Effective Dose Equivalent Calculation for Remediation of the 618-10 Burial Ground Vertical Pipe Units*, Rev. 1, Washington Closure Hanford, Richland, Washington.

**VERTICAL PIPE UNIT NUCLIDE EFFECTIVE DOSE EQUIVALENT  
SUMMARY**

Nuclide	Selected Individual (mrem)
Ac-227	1.08E-08
Th-227	1.31E-09
Fr-223	1.27E-12
Ra-223	9.87E-10
Rn-219	2.62E-11
Am-241	1.14E-01
Np-237	8.90E-06
Pa-233	4.62E-07
U-233	3.20E-10
Th-229	1.10E-13
Am-242	5.64E-08
Cm-242	2.06E-06
Pu-242	1.04E-05
Pu-238	1.99E-02
U-238	1.33E-05
Am-242m	2.23E-05
Np-238	7.63E-09
Am-243	1.43E-05
Np-239	3.13E-07
Pu-239	8.59E-02
U-235m	0.00E+00
U-235	9.17E-07
Ba-137m	7.83E-02
Be-10	1.05E-09
Bi-210	2.43E-12
Po-210	5.82E-11
Tl-206	3.46E-18
Bi-211	5.82E-14
Tl-207	1.26E-15
Po-211	7.61E-19
Bi-212	1.45E-10
Po-212	0.00E+00
Tl-208	3.74E-12
Bi-214	2.39E-11
Po-214	7.82E-19
Tl-210	6.42E-18
Pb-210	7.39E-11
C-14	1.34E-04
Ca-41	2.48E-09
Cl-36	3.12E-07
U-234	2.03E-05
Th-230	4.51E-08
Ra-226	2.39E-10
Cm-243	1.88E-06
Cm-244	2.34E-05
Pu-240	4.12E-02

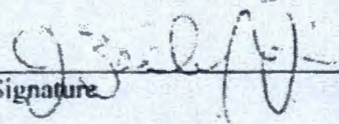
U-236	2.53E-06
Th-232	2.37E-18
Ra-228	2.62E-18
Cm-245	5.28E-09
Pu-241	7.11E-03
U-237	5.89E-08
Co-60	1.38E-03
Cs-134	2.80E-09
Cs-135	2.05E-07
Cs-137	8.65E-02
Eu-152	2.87E-06
Gd-152	5.05E-25
Sm-148	0.00E+00
Nd-144	0.00E+00
Eu-154	8.60E-05
At-219	0.00E+00
Bi-215	3.93E-21
I-129	3.94E-07
Kr-85	8.60E-07
Mo-93	7.68E-08
Nb-93m	5.80E-07
Nb-94	1.52E-08
Ni-59	1.79E-06
Ni-63	3.35E-04
Ra-225	1.55E-14
Th-231	2.19E-08
Pa-231	2.76E-08
Ac-225	1.48E-14
Pa-234	6.43E-08
Rn-222	1.52E-13
Pa-234m	3.26E-06
Hg-206	1.20E-19
Pb-211	3.60E-12
Pb-212	1.86E-09
Pb-214	1.79E-10
Pd-107	7.42E-11
Po-215	5.33E-16
Po-216	3.45E-13
Po-218	3.18E-18
At-218	4.90E-18
Rn-218	9.44E-26
Ac-228	2.99E-15
Th-234	3.17E-07
Ra-224	1.15E-08
Rn-220	1.43E-11
Sb-126	1.96E-06
Sb-126m	8.18E-06
Se-79	3.79E-07
Sm-151	4.57E-06
Sn-121m	1.38E-05
Sn-121	9.31E-08
Sn-126	6.43E-07
Sr-90	8.98E-02
Y-90	1.20E-02
Tc-99	8.87E-06

Th-228	1.77E-07
U-232	4.57E-08
Fr-221	3.01E-14
Zr-93	2.01E-06
H-3	1.03E-04
Cm-246	1.45E-10
Re-187	1.82E-14
TOTAL	5.37E-01

**APPROVAL PAGE**


**Title:** Air Monitoring Plan for the Remediation of the 618-10 Burial Ground

**Approval:** J. Zeisloft, U.S. Department of Energy, Richland Operations Office

  
Signature

1/28/16  
Date

B. Simes, U.S. Environmental Protection Agency

  
Signature

1/29/16  
Date