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Scoping Summary for the F-Area Material Storage Building (235-F)

(Removal Site Evaluation Report/Engineering Evaluation/Cost Analysis – Removal Alternative Comparative Analysis Scoping)

SRNS-RP-2020-00444

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1.0 PROJECT PHASE/STATUS OF SCOPING SUMMARY

The F-Area Material Storage (FAMS) Building (aka Metallurgical Building) (235-F), herein referred to as Building 235-F, is undergoing deactivation as directed by the U.S. Department of Energy (USDOE) in preparation for decommissioning. Building 235-F is listed in the Savannah River Site (SRS) Federal Facility Agreement on Appendix K.1: *D&D Facilities to be Decommissioned*. Deactivation activities are currently underway in Building 235-F to establish a "Cold and Dark Transition Surveillance and Maintenance Facility." An opportunity currently exists for the USDOE Office of Environmental Management (EM) to reprioritize the decommissioning of Building 235-F to its end state as a major risk-reduction achievement in the near term. On March 6, 2019, the USDOE presented an acceleration strategy for decommissioning Building 235-F to the U.S. Environmental Protection Agency (USEPA) Region 4 and the South Carolina Department of Health and Environmental Control (SCDHEC). The Core Team (i.e., representatives from the USDOE, USEPA, and SCDHEC) agreed that a non-time critical (NTC) removal action under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) was the appropriate regulatory mechanism to support decommissioning of Building 235-F. On May 14, 2019, the SRS Citizens Advisory Board published Recommendation #364 to accelerate the timeline for decommissioning Building 235-F and preparation of the required regulatory documents in parallel with the deactivation process. A follow-up information meeting was held with the Core Team on October 30, 2019, and agreement was reached to proceed with development of a Removal Site Evaluation Report/Engineering Evaluation/Cost Analysis (RSER/EE/CA). A scoping meeting with the Core Team was held on September 15, 2020, and agreement was reached on the problem(s) warranting a response action and the NTC removal action alternatives for evaluation in the RSER/EE/CA.

This scoping summary supported and reflects the outcome of the April 12, 2021 scoping meeting to evaluate the comparative analysis of the NTC removal action alternatives agreed to at the September 15, 2020 scoping meeting. The objectives of the April 12, 2021 scoping meeting were to reach Core Team agreement on the comparative analysis, identify any uncertainties, and discuss the preferred

NTC removal alternative for Building 235-F. A record of Core Team agreements is maintained throughout the project lifecycle and is provided in Table 1a. A record of Key Changes has been added to the Scoping Summary in Table 1b to identify significant changes to the scoping summary since the September 15, 2020 Core Team meeting.

2.0 BUILDING 235-F UNIT HISTORY AND BACKGROUND

Building 235-F is a windowless, two-story, reinforced-concrete structure located in F Area near the center of SRS (Figure 1). Building 235-F is designated a Hazard Category 2 nonreactor facility according to DOE STD-1027-92. Other facilities in the vicinity of Building 235-F include nuclear facilities and standard industrial buildings. F-Canyon (Building 221-F) is located approximately 270 meters (m) (886 feet [ft]) west of Building 235-F, and the F-Area Tank Farm (241-F) is located approximately 500 m (1640 ft) southwest of Building 235-F. The former Mixed Oxide Fuel Facility Project administrative building is located approximately 200 m (656 ft) north of Building 235-F (Figure 2). The surface elevation across Building 235-F is approximately 93.4 m (306 ft) above mean sea level (MSL). The Upper Three Runs Aquifer (UTRA) is the shallow-most aquifer beneath Building 235-F. The water table elevation is approximately 67.4 m (221 ft) above MSL (i.e., 26 m [85 ft] below ground surface), and groundwater flow is north/northeast towards the UTR Creek and its tributaries.

Building 235-F is approximately 68 m (222 ft) long, 33 m (109 ft) wide, and 8.5 m (28 ft) high. Excluding ancillary structures, the building has a footprint of approximately 2230 square meters (m^2) (24,000 square ft [ft^2]). A historical photo (date unknown) of the building is shown in Figure 3. The two-story structure has double-reinforced 36-centimeter (cm) (14-inch [in]) thick exterior walls supported by a 1.5-m (5-ft) wide perimeter grade beam. The first building level consists of a 20-cm (8-in) reinforced concrete slab on grade. Pier footings and columns support the second building level. The roof is supported by reinforced concrete beam and girder systems and includes a 23-cm (9-in) high perimeter curb or parapet. Drainage off the roofs is directed through roof drains. Some interior walls are reinforced concrete load bearing walls. In addition to Building 235-F, the NTC removal action will address the Metallurgical

Building Stack (293-F), also referred to as the "abandoned capped stack" located on the east side of the building, and an underground storage tank connected by a pipe trench on the north side of the building.

Within the Building 235-F perimeter fence, there are three buildings in addition to Building 235-F which have the potential for residual radiological contamination, primarily in the form of plutonium-238 (Pu-238) and neptunium-237 (Np-237). The three buildings include the Sand Filter Fan House (292-2F), Sand Filter (294-2F), and the Exhaust Stack (291-2F) (Figure 4). These three buildings are not part of the NTC removal action but are important because they support the ventilation systems that will remain operational during decommissioning of Building 235-F. The below-grade Sand Filter (294-2F), primarily of concrete construction, receives exhaust air from Building 235-F and is linked to the building through a 213-cm (84-inch) diameter underground duct/tunnel constructed of 1.8 m (6 ft) and 2.4 m (8 ft) segments of reinforced concrete pipe. The underground duct/tunnel is considered part of the Sand Filter (294-2F). The Sand Filter Fan House (292-2F) is a separate structure that contains a fan room, diesel generator room, and electrical control room which serves the exhaust fans and other building loads. Currently, the exhaust fans draw air from radiologically contaminated process areas/enclosures within Building 235-F through double HEPA filtration to the below-grade Sand Filter (294-2F) before discharge to the metal constructed Exhaust Stack (291-2F). The Sand Filter Fan House (292-2F), Sand Filter (294-2F), and the Exhaust Stack (291-2F) have not been assayed. However, the Sand Filter (294-2F) has been surveyed per the SRS Radiological Controls Program. Based on historical operations, the radiological inventories in all three buildings are significantly less than the estimate of holdup (i.e., residual radioactive contamination) within Building 235-F.

2.1 Process History

Building 235-F was constructed in the 1950s as part of the original SRS project and used for a variety of missions. The original mission slated for Building 235-F was "C-Line" designed to manufacture nuclear triggers from Pu-239 metal. The mission was cancelled before any equipment was installed, and the building unused until the mid-1960s. During the mid- to late 1960s, Building 235-F was used to house the Special Products Fabrication Facility (SPFF) that supported facilities processing uranium-238 (U-238), Np-237, and Pu-239 oxide. These facilities were known as the "Slug Facility" and the "Alloy Line." The Slug Facility extended almost the entire length of the building (east to west), occupying space later taken over by the Actinide Billet Line (ABL) and the Plutonium Fuel Form (PuFF) Facility. The Slug Facility processed uranium, plutonium, and other actinide-bearing materials into irradiation target components. The Alloy Line was a set of gloveboxes running north and south on the first level of the building at the east end and had blending, welding, machining, and decontamination capabilities. The Alloy Line included an induction furnace that was used to cast uranium alloy pieces for targets/slugs. The Alloy Line cabinets were removed in 1984, and the New Metallography Lab was built in its place in 1986. The New Metallography Lab was never placed into operation.

In the mid-1970s, the SPFF was decontaminated and decommissioned, and the building reconfigured to support the ABL mission and make room for the PuFF Facility (Figures 5 and 6). As part of these modifications, the Slug Facility cabinets were truncated to the current ABL configuration. The ABL consisted of a glovebox line and associated equipment, and initially fabricated plutonium billets for special reactor applications. ABL was later modified to produce special billets from Np-237 oxide powder for extrusion into reactor targets. The ABL continued operations until 1991.

The next mission of Building 235-F was the PuFF Facility and Plutonium Experimental Facility (PEF) including a Metallography Laboratory (commonly known as the Old Metallurgical Lab [OML]) (Figures 5 through 7). These facilities produced heat sources from Pu-238 oxide powder for the National Aeronautics and Space Administration program. The radioactive pellets (i.e., encapsulated Pu-238 heat source) were shipped to the USDOE Mound Facility for final assembly into a system referred to as a Radioisotope Thermoelectric Generator (RTG). The RTG acts as a power source to convert heat from the radioactive decay of the Pu-238 pellets into electricity.

The PuFF Facility was installed on the first building level and consisted of Process Cells 1-5 (east line) and their attached gloveboxes, Process Cells 6-9 (west line), and the auxiliary systems located on the second building level (Figures 6 through 7). The PuFF Facility produced Pu-238 heat source pellets from 1977 until 1983. The PuFF Facility cells and gloveboxes contain significant residual amounts of Pu-238 oxide contamination. The cells and associated gloveboxes are maintained at negative pressure by the process exhaust ventilation system for confinement of the residual material.

The PEF contains a line of 12 gloveboxes and 2 hoods (Figure 6). PEF activities included research and development on processes that manufactured Pu-238 heat sources. Pu-238 was processed in the PEF from 1979 to 1981 to develop the fuel pellet fabrication process performed in the PuFF Facility. The Pu-238 inventory was removed when the facility was shut down, but residual Pu-238 dust/particulates remain throughout the glovebox line. The glovebox line is maintained at negative pressure by the process exhaust ventilation system for confinement of residual plutonium oxide. The layout of the first building level is shown in Figure 6.

The OML facility, located on the second building level, contains a glovebox line that was used to test Pu-238 heat source pellets for compliance to design specifications (Figure 7). OML was used to examine the iridium welds and was also used to cut iridium from failed welding runs so the Pu-238 oxide could be recycled back to the SRS HB-Line. The glovebox line is maintained at negative pressure by the process exhaust ventilation system for confinement of the residual material. The layout of the second level is shown in Figure 7 and depicts areas where the ductwork supports the ABL, PuFF Facility, and PEF.

All metallurgical processes within Building 235-F (including PEF, PuFF Facility, OML, and ABL) were shut down by 1991. The last mission of the Building 235-F provided for the receipt, storage (within vaults), and repackaging of containerized plutonium and uranium bearing materials (i.e., specialized nuclear materials) to support both the SRS and the USDOE complex. The original vault areas and other rooms within Building 235-F were equipped to provide storage space for nuclear materials as well as designated material repacking areas. The storage and repackaging mission ended in 2006 and all special nuclear materials, except for radiological holdup, were removed from the building (i.e., the vaults were de-inventoried, and all stored plutonium and shipping containers were removed). During upcoming deactivation, Building 235-F will be prepared for Long Term Safe Storage, which involves minimal surveillance and maintenance (S&M) for containing and monitoring the remaining radiological holdup within the process areas.

In addition to Building 235-F, the NTC removal action will include the abandoned capped stack (293-F) located on the east side of the building, and an underground storage tank connected to the north side of the building by a pipe trench (Figure 5). The original 22.9 m (75 ft) high stack (293-F) was part of the 1950s ventilation system and is located approximately 9 m (30 ft) east of Building 235-F and connected by a concrete tunnel. The stack was abandoned in place in the 1970s after a change in facility mission. It was recognized that the abandoned capped stack was vulnerable to natural phenomena hazard events which could cause it to fall on the ventilation exhaust duct on the Building 235-F roof. In 2010, the stack height was reduced to 8.6 m (28 ft), and an aluminum cap was installed to prevent rainwater infiltration and ecological habitat (Figure 8). The height reduction was accomplished by chipping away the stack walls and dropping the debris inside the remaining stack. The interior volume of the remaining stack, 19 m^3 (680 ft^3), is filled with approximately 10 m^3 (357 ft^3) of debris. Void space resulting from possible large pieces of debris is unevenly distributed and this condition was taken into consideration in the structural evaluation of the reduced height stack. The 8.6 m (28 ft) debris filled stack was found to be structurally adequate to resist design basis tornado and seismic loads. Prior to the stack height reduction, cores from the stack were collected at approximately 13.7 m (45 ft) and were sampled for radioactivity and polychlorinated biphenyl (PCB) contamination. The radioactivity of the waste material was less than 400 picocuries/gram (pCi/g) and no PCBs were detected.

The underground storage tank is a 560-gallon (nominal) tank housed in a 2.13 m (7 ft) by 2.13 m (7 ft) by 3.96 m (13 ft) deep concrete pit. A 0.457-m (1.5-ft) wide underground pipe trench connects the concrete pit to Building 235-F, and a single 5 cm (2 in) diameter pipe connects the underground storage tank to the building. The underground tank initially supported the ABL by receiving liquid waste solutions in the 1960s and 1970s. The underground storage tank was repurposed in the late 1970s to receive liquids from decontamination activities in the PuFF Facility cells (i.e., condensate from radiological monitors). In 1990, the underground tank was identified during an SRS Hazardous Waste Survey as potentially containing hazardous waste. The bottom of the underground tank was sampled in December 1990 as part of a Settlement Agreement with SCDHEC[1]. Sampling confirmed the presence of radionuclides (plutonium and tritium) and hazardous waste constituents (cadmium and chromium). In May 1991, the tank was emptied and cleaned of liquid and sludge and the inlet pipe capped. The final characterization of the sludge materials from the tank were identified as low-level waste. The liquid was sent to the SRS H-Area Tank Farm, and the sludge collected in drums and sent to the SRS Mixed Waste Storage Facility. The tank walls and bottom were scraped and mopped, and the tank flushed with approximately 1893 liters (L) (500 gallons [gal]) of water and caustic. The tank was inspected to verify all material was removed in accordance with the SCDHEC Settlement Agreement.

2.2 Current Status of Building 235-F

In 2006, Building 235-F was de-inventoried of all special nuclear material with the exception of legacy radiological holdup. Extensive deactivation activities to remove as much Material At Risk (MAR)[2] as possible from each of the PuFF Facility process cells and gloveboxes associated with the PuFF Facility Cells 1 through 9 were completed in June 2019. The majority of MAR in PuFF Facility Cells 1 and 2, which included the gloveboxes with the highest concentration of radiological holdup, was removed to the greatest extent practical. As removal activities progressed, it became apparent that further MAR removal did not justify the risk of exposure to deactivation workers. On July 10, 2019, the USDOE instructed Savannah River Nuclear Solutions (SRNS) to stop removal of MAR from Building 235-F and proceed with the activities necessary to establish a deactivation end state for a "Cold and Dark Transition Surveillance and Maintenance Facility."[3] As discussed at the October 30, 2019 information meeting, the USEPA and SCDHEC recognized the increased risk from additional MAR removal to the deactivation worker and agreed that the potential for contaminant release to groundwater within 10,000 years could be mitigated by in-situ (ISD) decommissioning of the building.

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[1] SCDHEC Settlement Agreement 90-64-SW, September 5, 1990, pgs. 103 and 130.
[2] MAR = material at risk (curies or grams) is the amount of hazardous material used to calculate the source term for a release due to an accident or event.
[3] NMPD-19-0024, *Savannah River Management and Operating Contract DE-AC09-08R22470, Direction Regarding Building 235-F Activity, July 10, 2019.*

No additional MAR removal from any of the enclosures is planned, and all remaining activities associated with final deactivation and S&M are non-intrusive to the process areas (i.e., no internal penetration of the exhaust ventilation confinement boundary of a cell, glovebox, hood, cabinet, or enclosure). Building 235-F is designated a Hazard Category 2 nonreactor facility according to DOE STD-1027-92 (i.e., residual holdup exceeds the 3.6 curies [Ci] threshold for Pu-238). Building 235-F is expected to be downgraded to less than a Hazard Category 3 radiological facility once a documented safety analysis confirms that the radiological inventory is unreleasable following decommissioning.

Building 235-F and support facilities are in a reduced S&M state awaiting final deactivation activities and preparations for decommissioning. Residual radiological holdup remains in the PuFF Facility process area (Pu-238), PEF (Pu-238 oxide), OML (Pu-238 oxide), and ABL (Pu-238 oxide and Np-237 oxide). S&M activities include support for the electrical system, diesel generator, ventilation, instrument air, alarm monitoring, steam supply, and chilled water systems used for containment, and for monitoring of residual radiological holdup. Building 235-F structure and process ventilation systems currently function to provide confinement for the remaining radiological holdup. Rooms within the building are maintained at slight vacuum as compared to the atmosphere outside the building. Also, the air atmospheres within the process enclosures (cells and gloveboxes) are maintained at a slight vacuum as compared to the rooms. Deactivation will de-energize supply and exhaust fans within the building, but not the exhaust fans external to the building. During and after deactivation, these external fans will maintain vacuum inside Building 235-F and inside the process enclosures. A ventilation strategy will be developed during the design of the selected NTC removal action to determine the appropriate ventilation to prevent contaminant release to the environment and to protect workers. Building 235-F is not occupied and is monitored remotely.

3.0 LAND USE

According to the SRS Future Use Project Report, residential use of SRS land should be prohibited. The SRS Land Use Control Assurance Plan for the SRS designates Building 235-F as being within an industrial area with the future land use expected to remain industrial. No current or projected future development of the Building 235-F complex is planned. An industrial land use scenario is selected as the baseline risk assessment exposure scenario for the protection of human health and the environment.

Groundwater is not part of the NTC removal action scope for Building 235-F. There is no current or projected future use of the groundwater as a drinking water source. The groundwater in F-Area is currently monitored by the General Separations Area Western Groundwater Operable Unit monitoring network.

4.0 BUILDING 235-F HAZARDOUS MATERIALS AND RADIONUCLIDE INVENTORY AND ANALYSIS

4.1 Building 235-F Hazardous and Radionuclide Contamination Inventory

Extensive characterization of Building 235-F has been performed to identify hazardous and radiological contamination that is expected to remain in the building following deactivation activities. The current radiological inventory is based on the most recent material removal campaign in 2019 and supplemented with data following the shutdown of the final mission of the building in 2006. Characterization methods included non-destructive analysis of radiological holdup, smear data for radiological contamination, dose measurements, hazardous material sampling results, and engineering/process knowledge. Hazardous material data is predominately from reports following the shutdown of the final mission of the building in 2006.[4] The radiological inventory identified that 85% of the Pu-238 remaining in the building is located in the PuFF Facility cells and 87% of Np-237 is in ABL. The complete radiological inventory for the building is provided in Table 2. The location of radiological holdup on the first and second building levels is depicted in Figures 9 and 10, respectively.

[4] *Characterization Report for Building 235-F, F-Area Material Storage Building (FAMS)*, G-ESR-F-00097, Revision 0, May 2020.

Building 235-F was thoroughly inspected for asbestos in 2006 using facility knowledge, visual inspection completed by certified asbestos inspectors, document review, and the collection of bulk samples. This inspection identified 9643 m^2 (103,791 ft^2) of asbestos transite-containing material (ACM) in the building. There is no intent to remove ACM during deactivation unless it is determined to be friable or is disturbed by deactivation activities.

Lead is present in the building in PuFF Facility gloveboxes, leaded glass on glovebox windows, lead washers, brass valves, lead-acid batteries such as in emergency lights, lead shielding, lead solder in sewer line joints, and lead counterweights. During deactivation, the accessible lead counterweights and lead-acid batteries will be removed. The largest contributor of lead is shielding in the walls of gloveboxes and shield doors of the process areas, which will not be removed during deactivation. A total of 17,208 kilograms (kg) (37,937 pounds [lbs]) of lead is estimated to remain in processing areas following deactivation. In addition, lead-based paint is likely present throughout both the process areas and non-process areas. The mass of lead due to lead-based paint was conservatively estimated to be 1.68 kg (3.7 lbs). Paint that remains intact on the wall will be abandoned-in-place, while any lead disturbed by deactivation activities will be removed. Paint removal during deactivation is not expected to result in a significant change in the overall lead inventory remaining in the building.

Other hazardous materials in the building may include the following:

- Mercury in lamps, switches, batteries, thermostats, etc. These features will be removed if accessible during deactivation.

- Used oil in locations throughout Building 235-F. During inventory assessments it has been determined that all transformers are dry and void of dielectric fluid. Hydraulic oil in the main reservoirs for the hot and cold presses have been drained aside from the small lines to the presses and the hydraulic cylinders. The accessible used oil will be drained from the chillers (Room 209) and air compressors (Room 152) during deactivation.

- Chiller/cooling water containing chemicals that inhibit biological activity (i.e. sodium nitrate), prevent freezing (i.e. ethylene glycol) and/or inhibit corrosion within the piping and equipment. The cooling water will be drained and recovered as wastewater.

- PCBs may be present in paint, joint compounds, insulation, capacitors, hydraulic oil, and light ballasts. Accessible PCB ballasts will be removed during deactivation. PCBs in paint on the first and second levels, assuming two surface coats of paint applied, was conservatively estimated at 2.38 kg (7.44 lbs). PCBs in building components, paint, etc., will remain in place and be addressed by the NTC removal action alternative.

- Other hazards include refrigerant that will be removed from the HVAC units and chiller units during deactivation. Lead and chromium may be present in items throughout the facility such as circuit boards and smoke detectors that will not be removed during deactivation. Photographic equipment in a former dark room has been removed, but a sewer connection remains. Residual silver or other photographic chemicals may be present in the sewer line or associated trap.

- Historical storage and handling of beryllium components were conducted on the first level. Beryllium-containing items were removed from containers for visual inspection and then placed back into storage. No cutting, grinding, or other activities were performed on the components that would have generated beryllium dust. All beryllium-containing items have been removed from Building 235-F.

4.2 Basis for Action - Human Health Risk Assessment

A streamlined human health risk assessment (HHRA) was conducted on the inventory presented in Table 2 for Pu-238 and Np-237. It is recognized that other contaminants are present within the facility due to process impurities and radioactive decay (i.e., daughter products). In addition, hazardous materials such as asbestos, lead, and PCBs will remain in the building following deactivation as discussed in Section 4.1. Because any risk from exposure to the radioactive decay products and hazardous materials is well bounded by the risk from exposure to Pu-238 and Np-237 in the process areas, the streamlined risk evaluation focuses on Pu-238 and Np-237 as the primary risk drivers.

The HHRA was performed on PuFF Facility Process Cells 1-5 where the majority of Pu-238 (85%) is located, and the ABL since it contains the majority of Np-237 (87%). The HHRA was also performed for an Entire Building 235-F scenario which includes the Pu-238 and Np-237 inventory from PuFF Facility Process Cells 1-5, PuFF Facility Process Cells 6-9, ABL, PEF, OML, and various exhaust and ductwork components. The contribution of the other process areas and building components (excluding PuFF Facility Process Cells 1-5 and ABL) was 14% of Pu-238 and 13% of Np-237.

The default indoor worker receptor scenario, herein referred to as the default industrial worker, is a standard USEPA scenario which addresses long-term risks to workers who are exposed to building contaminants within an industrial setting. The exposure assumptions for this default scenario are 25 years, 250 days per year, and 8 hours per day. The default industrial worker is exposed to contaminated air in the building via two exposure routes, i.e., inhalation and external exposure (submersion). The HHRA conservatively assumes that no personal protective equipment is used, and that all of the contamination remains within the building. Source material at SRS is considered principal threat source material (PTSM) when the cumulative risk exceeds 1E-03 for carcinogens or a hazard index greater than 10 for noncarcinogens. As shown in Table 3a, the risk to the default industrial worker (i.e., Entire Building Risk = 2.3E+09, PuFF Facility Cells 1-5 risk = 5.9E+10, ABL risk = 6.9E+08) is significantly higher than the USEPA acceptable risk range of 1E-04 to1E-06, and the contamination is considered PTSM (>1E-03).

Although a viable route of human exposure to hazardous materials present in building components is unlikely, exposure to PCBs and lead in paint is a recognized health hazard. A risk evaluation of PCBs and lead, based on estimated concentrations in building paint, is provided in Table 3b to demonstrate the negligible risk contribution from these hazardous inventories when compared to the primary risk drivers. Although ACM is present in the building, there is no intent to remove ACM during deactivation unless it is determined to be friable or is disturbed by deactivation activities. The USEPA does not provide a screening level for asbestos for the purpose of estimating risk. A risk evaluation for non-radiological constituents will be discussed qualitatively and quantified to the extent practicable in the RSER/EE/CA.

4.3 Basis for Action - Contaminant Migration Analysis

Fate and transport (F&T) modeling of the migration of the radionuclide inventory (Table 2), elemental lead inventory, and PCB inventory through the vadose zone to groundwater was performed. The inventories and F&T modeling results are representative of the deactivated end state for Building 235-F with the assumption that the building is decommissioned in year 2025.

Future exceedances of groundwater protection standards (maximum contaminant level [MCLs]) are discussed in greater detail below. Based on the radionuclide inventories in Table 2, the following parent radionuclides and their full-chain progeny were considered:

Np-237 – key parent nuclide in the ABL $^{237}Np \rightarrow {}^{233}U \rightarrow {}^{229}Th$

Pu-238 – key parent nuclide in the PuFF Facility $^{238}Pu \rightarrow {}^{234}U \rightarrow {}^{230}Th \rightarrow {}^{226}Ra \rightarrow {}^{210}Pb$

The dashed line in each abbreviated decay chain indicates the radionuclide that contributes the most dose and concentration in the ABL and PuFF Facility.

For the F&T modeling, the total estimated total elemental lead inventory of 17,208 kg (37,937 lbs) was conservatively placed in PuFF Facility Cell 3. PCBs were assumed to be contained within the surface paint throughout Building 235-F. The estimated total PCB inventory of 2.38 kg (7.44 lbs) in paint was equally distributed in PuFF Facility Cells 1-5.

The following scenarios were evaluated using a one-dimensional GoldSim model to support the proposed NTC removal action alternatives. Each subsequent modeling scenario assumes the addition of cementitious barriers to further reduce and/or delay the release of radioactive constituents from Building 235-F to the environment. Due to the one-dimension nature of the Goldsim model, only the grouted areas are modeled for the ISD scenarios. Grouting the non-process areas provides no additional level of protectiveness.

- **No Action Scenario**. Represents Building 235-F deactivated state. The F&T model assumes the existing roof collapses at 150 years with no modifications to prevent ponding of rainwater.
- **Grout First and Second Levels with Engineered Roof Scenario.** First and second building level process areas are grouted. An engineered roof is placed over Building 235-F. The engineered roof is assumed to last over 1,000 years.

In addition, the F&T model evaluated a scenario to relocate the second level contaminated process equipment and ventilation ducts to the first level and grout the first level only with no modifications to the roof. The F&T model assumed the existing roof collapses at 150 years, and the second level floor slab is assumed to be intact for an additional 600 years following roof collapse. This modeling scenario was not carried forward as a NTC removal action alternative due to the high risk to the remedial worker. The F&T model also evaluated a scenario to grout the first and second building levels with the assumption that the existing roof collapses at 750 years with no modifications to prevent ponding of rainwater. This modeling scenario was not proposed as an NTC removal action alternative for evaluation in the RSER/EE/CA because the existing roof could not serve as a robust barrier for 750 years without the installation of an engineered roof.

The F&T evaluation simulated the migration of contaminants from the building through the vadose zone, the Upper Three Runs (UTR) aquifer, and an unnamed UTR tributary at five different points of assessment (POA) as follows: 1-m (3-ft) beyond the outside perimeter of Building 235-F; 100-m (328-ft) beyond the outside perimeter of Building 235-F; 360-m (1,181-ft) (F-Area industrial area boundary fence along the plume path); 683-m (2,241-ft) (closest groundwater-fed seepline to Building 235-F along the plume path); and the surface water in an unnamed UTR tributary. The POAs and groundwater flow paths are depicted in Figure 11. The compliance periods evaluated in the model include 0-1,000 years (0-1K years), 0-10,000 years (0-10K years), and 0-100,000 years (0-100K years). The results of the F&T analysis are provided in Tables 4 and 5.

For the No Action scenario at the 1-m (3-ft) POA and 0-10K years compliance period, Np-237 exceeds the MCL threshold for gross alpha with the short lived daughter protacinium-233 (Pa-233) driving exceedances in beta-gamma dose (Table 4), and Pu-238 exceeds the MCL for beta-gamma, gross-alpha, and radium (Table 5). Based on Core Team discussion from the October 19, 2019 information meeting, the compliance period of 0-10K years at the 360-m (1,181-ft) POA (F-Area industrial area boundary fence) was considered the baseline condition for the identification of contaminant migration problems warranting action. For the No Action scenario at the 360-m (1,181-ft) POA and 0-10K years compliance period (i.e., baseline deactivated building state), Np-237 exceeds the MCL threshold for gross alpha.

For the No Action scenario at the 1-m (3-ft) POA, elemental lead is not predicted to exceed its MCL for over 100,000 years. The only exceedance for PCBs (maximum concentration of 0.8 ug/L) was predicted at the 1-m (3-ft) POA for the 100,000-year compliance period under the No Action scenario.

4.4 Non-Time Critical Removal Action Alternatives

The RSER/EE/CA will include an evaluation of four NTC removal action alternatives including a No Action alternative as required by the National Contingency Plan, two ISD removal action alternatives, and a complete Building 235-F removal alternative. The following NTC removal action alternatives for Building 235-F also address the abandoned capped stack (293-F) and the underground storage tank (NBN).

- **Alternative A-1. No Action**. Building 235-F, underground storage tank, and abandoned capped stack (293-F) remain as currently exists. The roof is assumed to collapse at 150 years at which time additional response action will likely be necessary to mitigate exposure/spread of contaminants. No Action is representative of the Building 235-F deactivated state.

- **Alternative A-2. ISD of First and Second Level Process Areas/Engineered Roof**. First and second level process areas are grouted. An engineered roof (sloped concrete reinforced roof slab with integral crystalline waterproofing) designed to last 1,000 years is installed. The underground storage tank is grouted/capped, and the abandoned capped stack (293-F) is permanently sealed

- **Alternative A-3. ISD of Entire Building/Engineered Roof**. First and second levels are grouted. An engineered roof (sloped concrete reinforced roof slab with integral crystalline waterproofing) designed to last 1,000 years is installed. The underground storage tank is grouted/capped, and the abandoned capped stack (293-F) is permanently sealed.

- **Alternative A-4. Complete Building 235-F Removal/Soil Cover.** Building 235-F is demolished to the building slab. The abandoned capped stack (293-F) is removed. The underground storage tank is grouted/capped. A soil cover is applied over both the building slab and grouted underground storage tank.

The F&T modeling scenarios discussed in Section 4.3 support the proposed NTC removal action alternatives. As shown in Tables 4 and 5, Alternatives A-2 and A-3 meet the contaminant migration removal action objective (RAO) to prevent the migration of radionuclide contamination from Building 235-F to groundwater at concentrations that exceed MCLs at the 360-m (1,181-ft) POA at 0-10K years. In addition, Alternative A-4 Complete Building 235-F Removal/Soil Cover removes all contamination and meets the RAO.

Table 6 provides a detailed description of each NTC removal action alternative. A complete building removal alternative was needed to provide a bounding case, but the Core Team agreed that the CERCLA criteria evaluation for this alternative does not need to be as detailed as the evaluation for the more likely ISD alternatives. The Core Team agreed that a “scoping level” evaluation with a rough order of magnitude cost estimate in the RSER/EE/CA is acceptable for Alternative A-4 Complete Building 235-F Removal/Soil Cover. Building 235-F is divided into grout/encasement zones (i.e., Zones 1 through 13) such that these areas can be grouted/encased in phases as funding becomes available (Figures 12 and 13). The NTC removal action zone strategy for ISD removal Alternatives A-2 and A-3 are shown in Figures 14 - 17.

5.0 BUILDING 235-F PROBLEMS WARRANTING ACTION

The following table identifies the problems warranting action for Building 235-F and the NTC removal actions that will be evaluated in the RSER/EE/CA.

Problem Warranting Action	Removal Action Objectives	Scope of Problem(s)	Likely Removal Actions
• Radiological contamination (primarily Pu-238 and Np-237) are present in Building 235-F at levels that exceed the 1E-06 default industrial worker risk and PTSM risk threshold (1E-03). Entire Building: 2.3E+09 risk PuFF Facility Cells 1-5: 5.9E+10 risk ABL: 6.9E+8 risk • Np-237 has the potential to migrate to groundwater at the 360-m POA at concentrations that exceed the gross alpha MCL (15 pCi/L) prior to 10,000 years.	• Prevent exposure of the default industrial worker to radiological contaminants present in Building 235-F that exceed 1E-06 risk thresholds (including PTSM). • Prevent the migration of radionuclide contamination from Building 235-F to groundwater at concentrations that exceed MCL at the 360-m (1,181-ft) POA to the extent practicable.	• Building 235-F is a two-story reinforced concrete structure 68 m (222 ft) long, 33 m (109 ft) wide and 8.5 m (28 ft) high with double reinforced 36-cm (14-in) thick exterior walls. Radiological contamination remains in process areas • Underground storage tank is a 560-gallon housed in a 2.1 m (7 ft) by 2.1 m (7 ft) by 4 m (13 ft) deep concrete pit. A 0.46 m (1.5 ft) wide underground pipe trench connects the concrete pit to Building 235-F. • Abandoned capped stack (293-F) is 8.6 m (28 ft) high with an aluminum cap.	• Alternative A-1. No Action • Alternative A-2. ISD of First and Second Level Process Areas/Engineered Roof • Alternative A-3. ISD of Entire Building 235-F/Engineered Roof • Alternative A-4: Complete Building 235-F Removal/Soil Cover
Uncertainties			
• It is uncertain if residual silver remains in the sewer line from the former photographic dark room. This uncertainty impacts the problems warranting action and will be resolved by sampling of the sewer line during deactivation and the results reported in the RSER/EE/CA.			

6.0 COMPARISON OF REMOVAL ACTION ALTERNATIVES

Guidance on conducting NTC removal actions under CERCLA recommends that each alternative be reviewed against three broad criteria: effectiveness, implementability, and cost. Long-term effectiveness is evaluated for each alternative on the basis of the magnitude of residual risk and the adequacy and reliability of controls used to manage contaminated media that remain after response objectives have been achieved. Evaluation of alternatives for short-term effectiveness considers protection of decommissioning workers, members of the community, and the environment during implementation of the removal action and the time required to achieve RAOs. Implementability of each alternative is assessed against technical feasibility and administrative feasibility. Cost estimates for each alternative are based on a generic description and preconceptual design of activities for each alternative with limited engineering data. The cost estimates were developed for comparative evaluation only with an expected level of accuracy of -30% to +50%

A comparative analysis of the removal action alternatives is provided in Table 7. Based on the results of the comparative analysis, the Core Team agrees that Alternative A-2 provides the best balance of tradeoffs among the other alternatives with respect to the evaluation criteria.

7.0 OPERABLE UNIT STRATEGY

The Core Team agreed in October 2019 to the development of a RSER/EE/CA that could support a phased approach (if necessary) for implementation of the selected NTC removal action alternative as funding becomes available. As agreed to at the Problem ID scoping meeting in September 2020, the RSER/EE/CA will evaluate a No Action alternative, two ISD removal action alternatives, and a total building removal alternative. A Core Team scoping meeting was held on April 12, 2021 to discuss the comparison of the NTC removal action alternatives to be evaluated in the RSER/EE/CA and the Core Team-preferred NTC removal alternative. As agreed to by the Core Team, the Revision 0 RSER/EE/CA will reflect Alternative A-2, ISD of First and Second Level Process Areas/Engineered Roof, as the preferred NTC removal action alternative. Submittal of the Revision 0 RSER/EE/CA for regulatory review is planned for September 2021.

Following the RSER/EE/CA and Action Memorandum, a single Removal Action Design Plan (RADP) is normally submitted. The RADP typically presents the design detail for the NTC removal action including a description of the removal action construction strategy, removal action activities, and design drawings. For Building 235-F, the Core Team agreed to a phased removal action approach as funding becomes available if execution as a single continuous project is not feasible.

SRS will submit a Removal Action Report (RAR) to document the completion of field implementation of the selected NTC removal action. If a phased removal action approach is implemented, SRS will submit a RAR after the completion of each phase. Once the final RAR is approved, Building 235-F will be removed from FFA Appendix K.1, *D&D Facilities to be Decommissioned*, and added to Appendix C.4, *D&D Facilities (or Remnants) that May Warrant Response Action* and Appendix C.5, *Area Operable Units*. The final NTC removal action (decommissioning) end state for Building 235-F will be documented as the CERCLA remedial action end state (i.e., requiring no further response action for protection of human health and the environment) in the F Area Operable Unit (FAOU) Record of Decision (ROD), SEMS Number 88. The FAOU ROD is scheduled for issuance in September 2039.

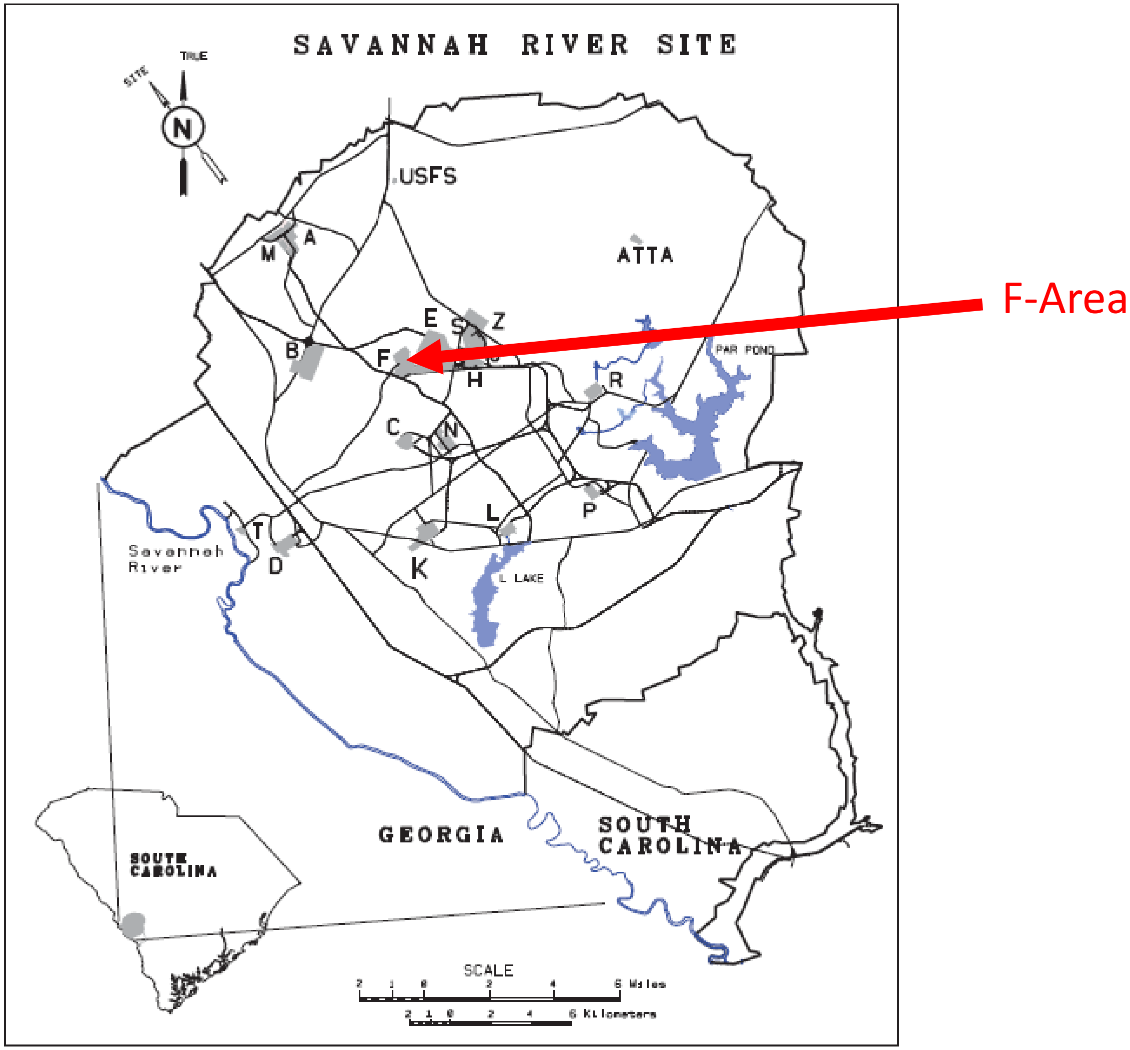


Figure 1. Location of F Area at SRS

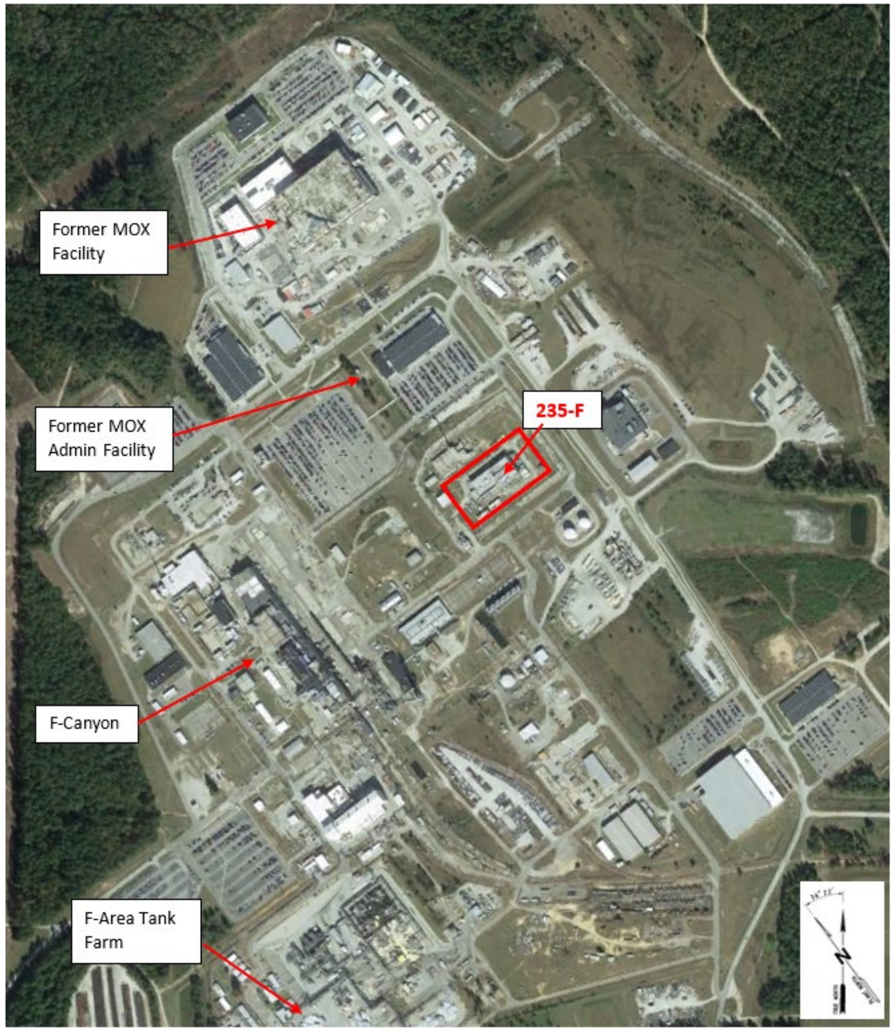
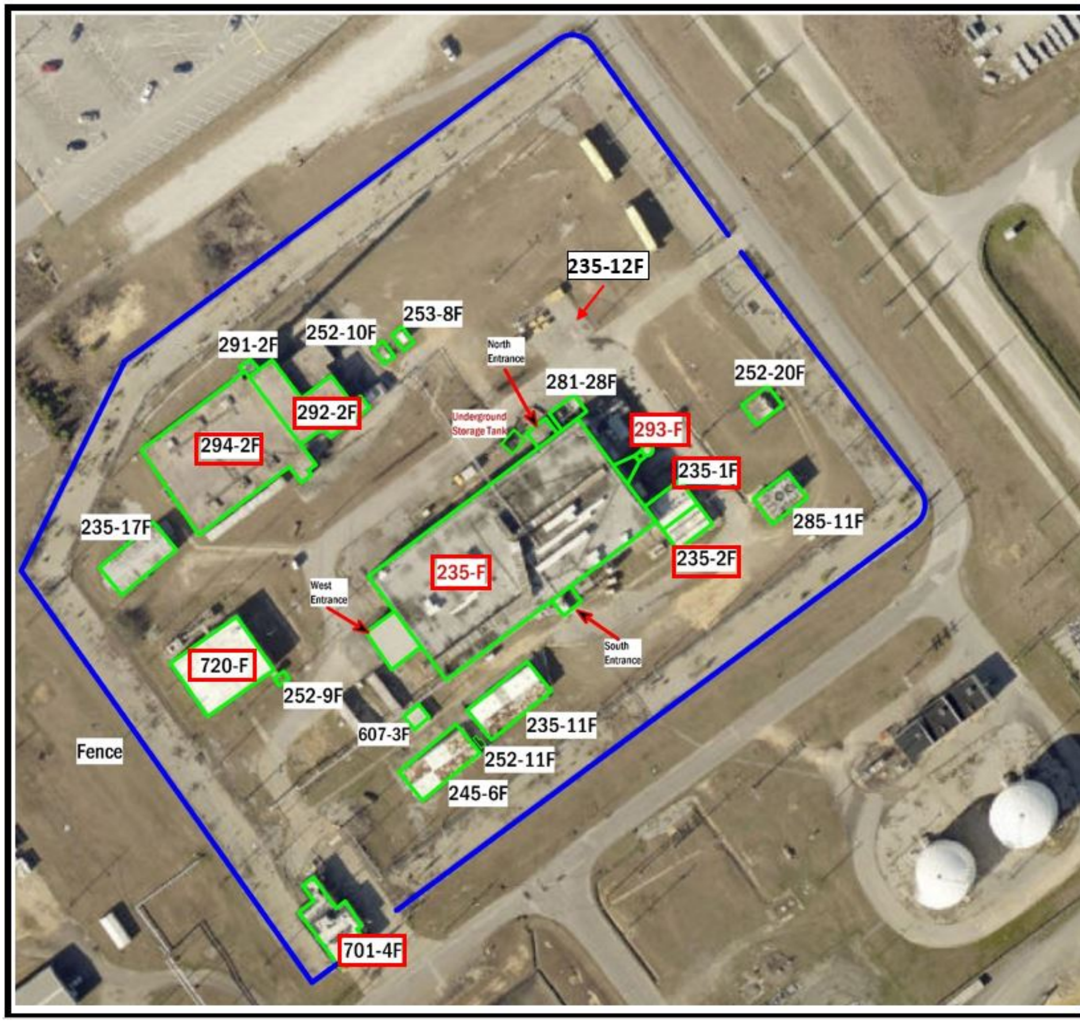


Figure 2. SRS F Area Aerial View of Building 235-F Location

Figure 3. Historical Photograph of Building 235-F (Prior to 293-F Stack Reduction)



Building Number	Facility
235-F*	Material Storage Building
235-12F	Storage Pad for B-25 Waste Boxes
235-17F	Emergency Storage Shed
235-1F*	Refrigeration Building No. 1
235-2F*	Refrigeration Building No. 2
235-11F	Office Trailer
245-6F	Office Trailer
252-10F	Secondary Transformer Station, for 292-F
252-11F	Secondary Transformer, 235-11F
252-20F	Substation for Building 235-F
252-9F	Secondary Transformer Station for 720-F
253-8F	15kV Outdoor Padmount Switchgear
281-28F	Spill Basin
285-11F	Induced Draft Cooling Tower
291-2F	Sand Filter Fan House Stack
292-2F*	Sand Filter Fan House
293-F*	Metallurgical Building Stack
294-2F*	Sand Filter for 235-F
607-3F	Sewage Lift Station
701-4F*	Gatehouse Entrance to 235-F
720-F*	Central Alarm Station (CAS)

* D&D Facilities on FFA Appendix K

Figure 4. Building 235-F and Surrounding Buildings and Structures

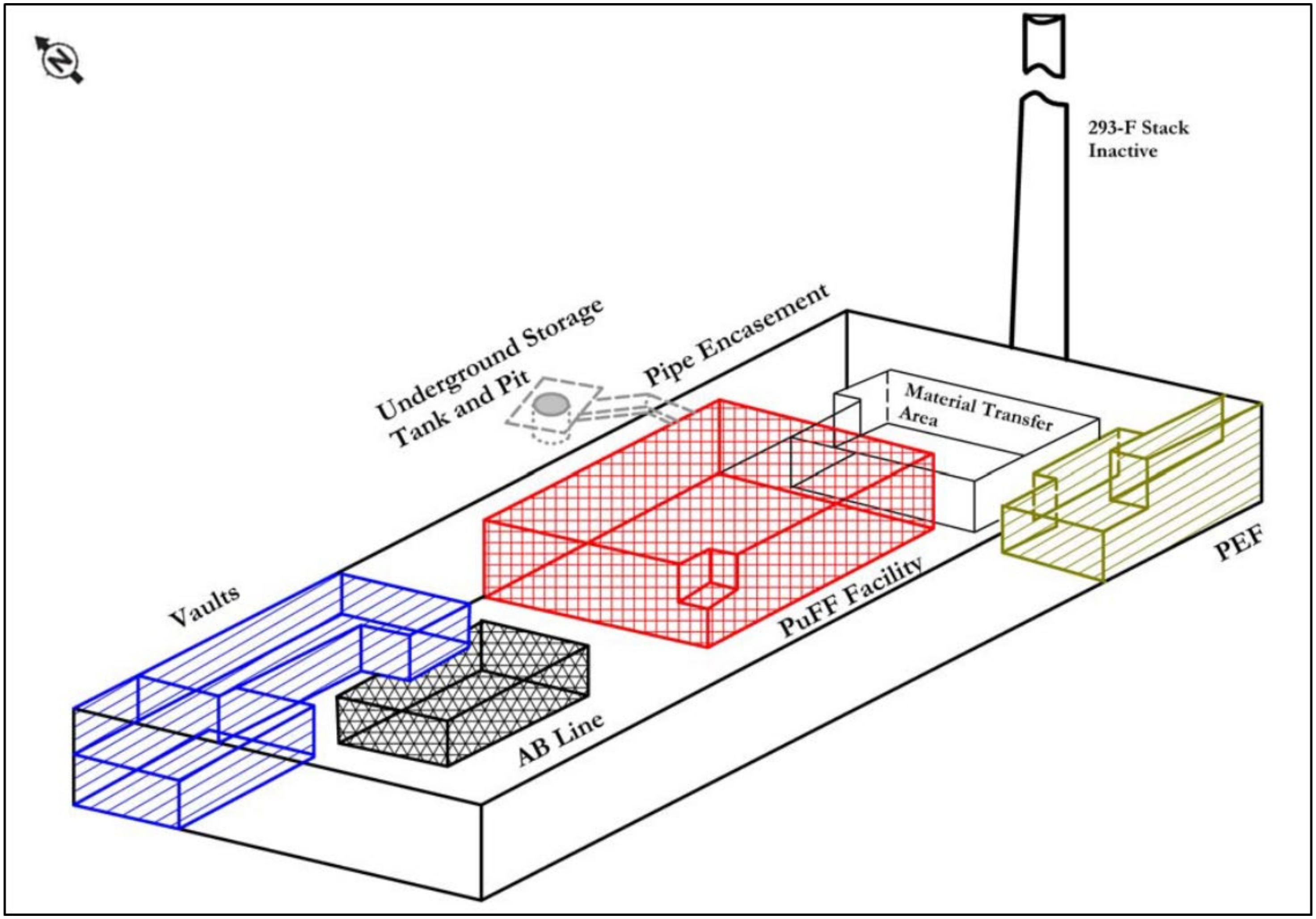


Figure 5. Conceptual View of Building 235-F First and Second Level Process Areas

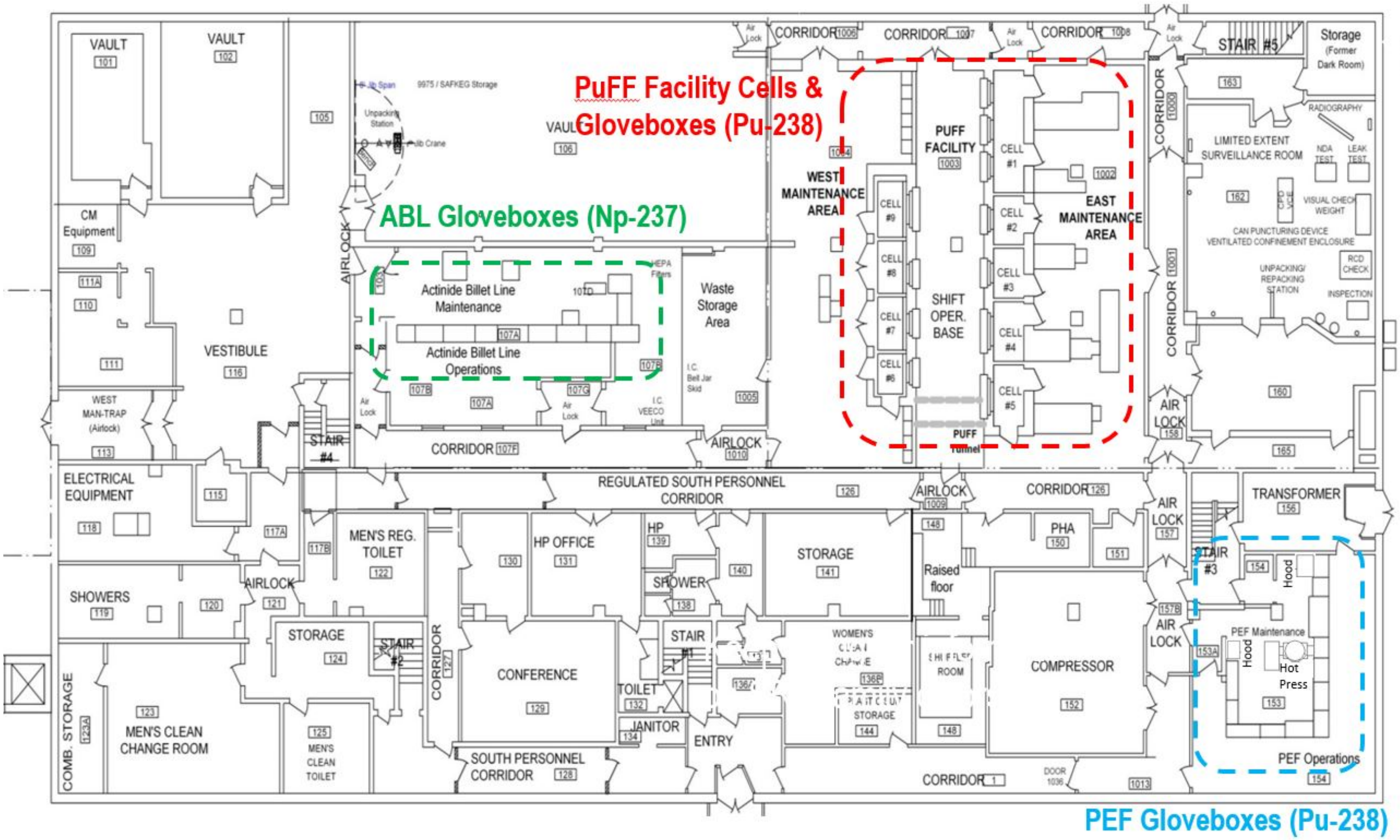


Figure 6. Layout of Building 235-F First Level

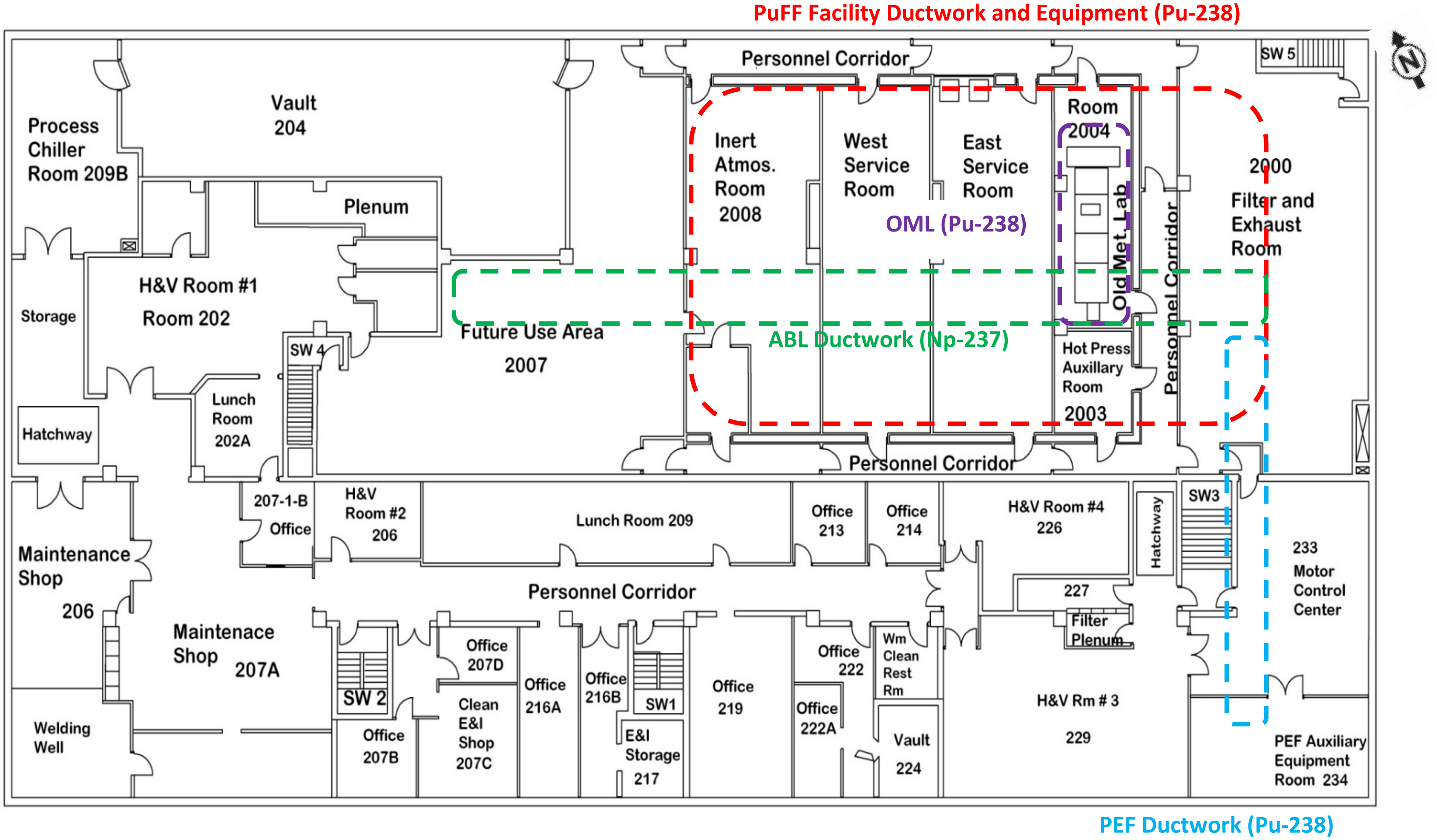


Figure 7. Layout of Building 235-F Second Level

Figure 8. Photograph of Height Reduced Abandoned Capped Stack (293-F)

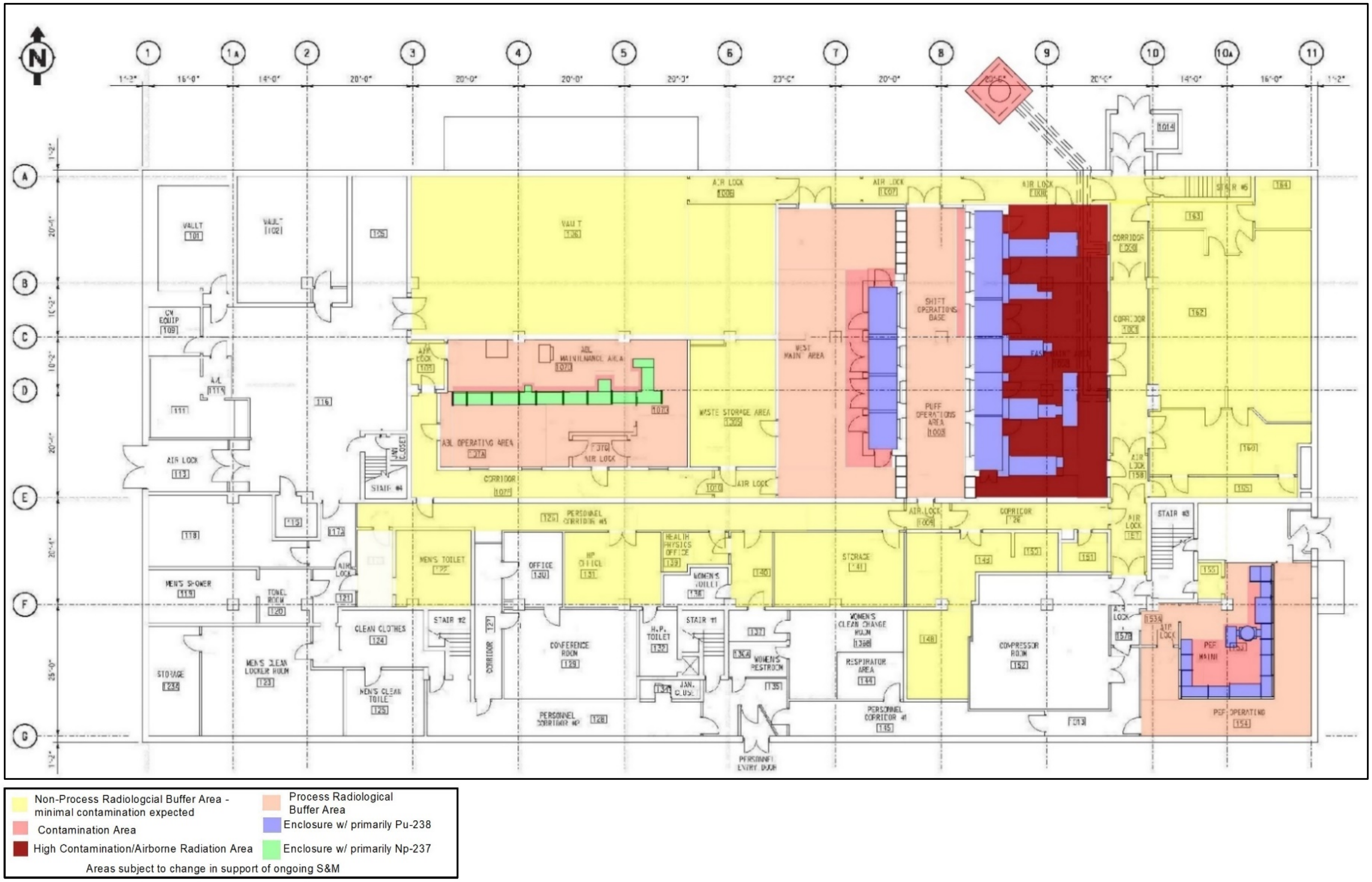


Figure 9. Building 235-F First Level Contamination (Radiological Holdup)

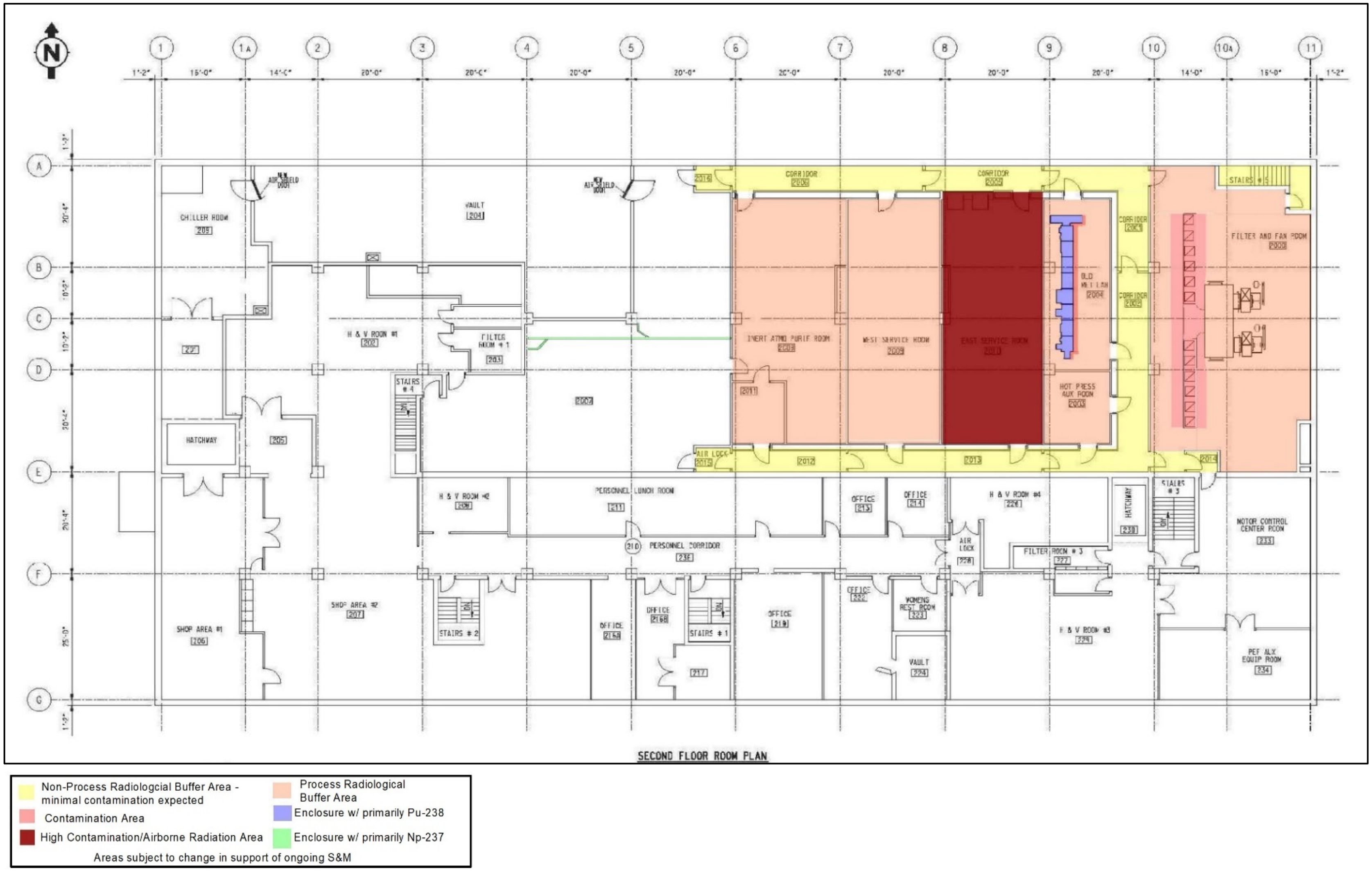


Figure 10. Building 235-F Second Level Contamination (Radiological Holdup)

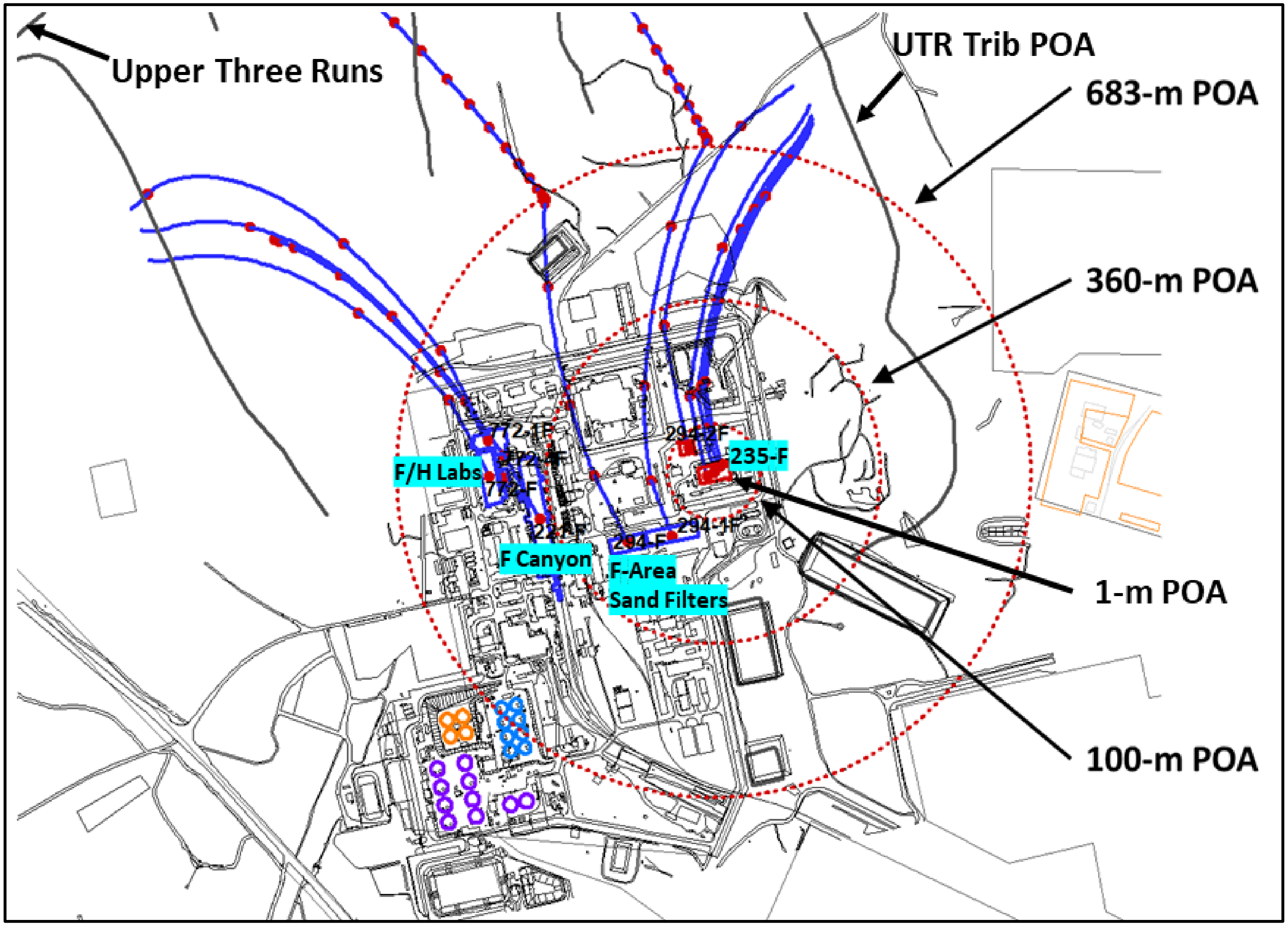


Figure 11. F&T Modeling Point of Assessment (POA) Boundaries

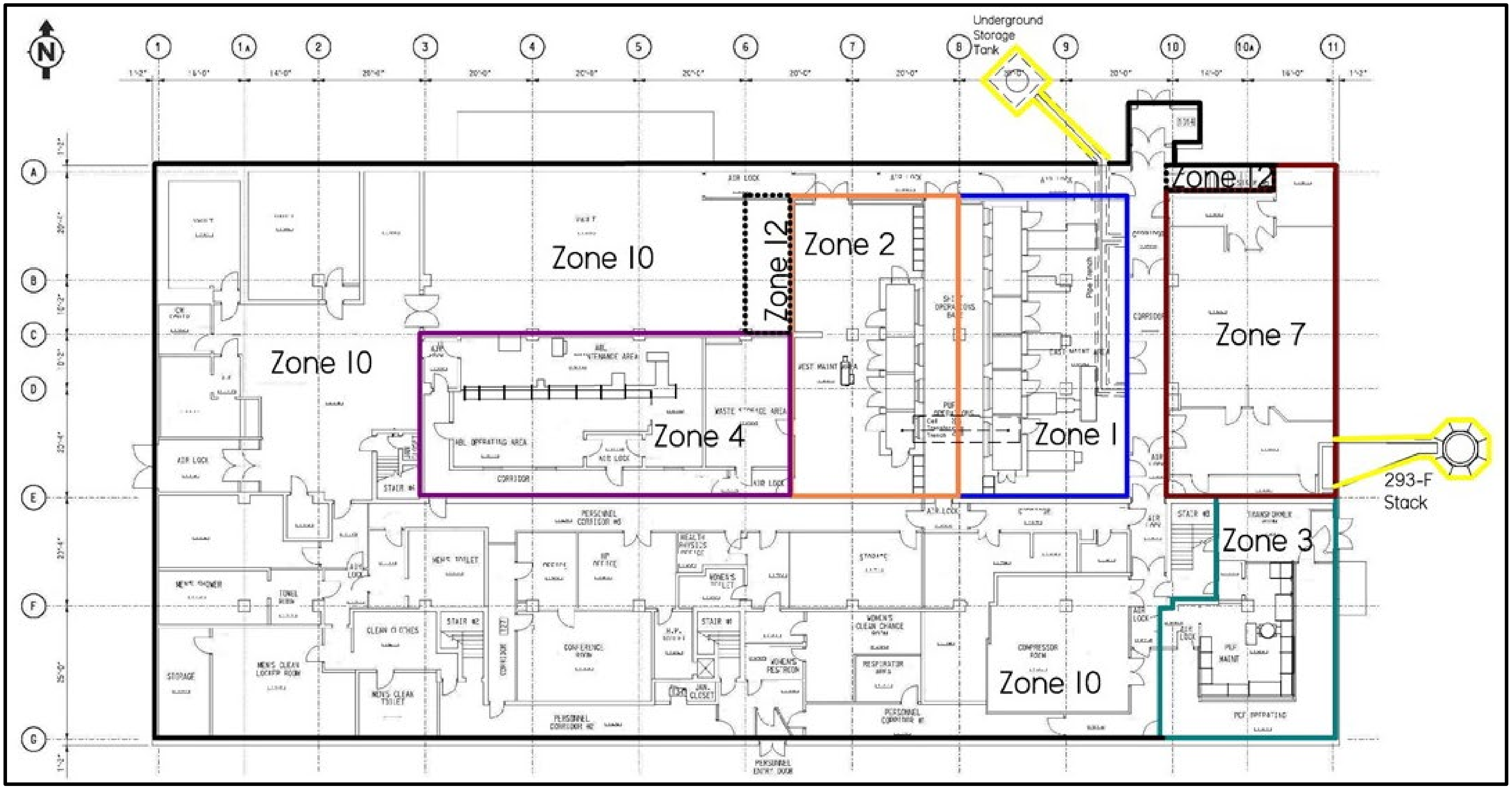


Figure 12. **Building 235-F First Level Decommissioning Zones**

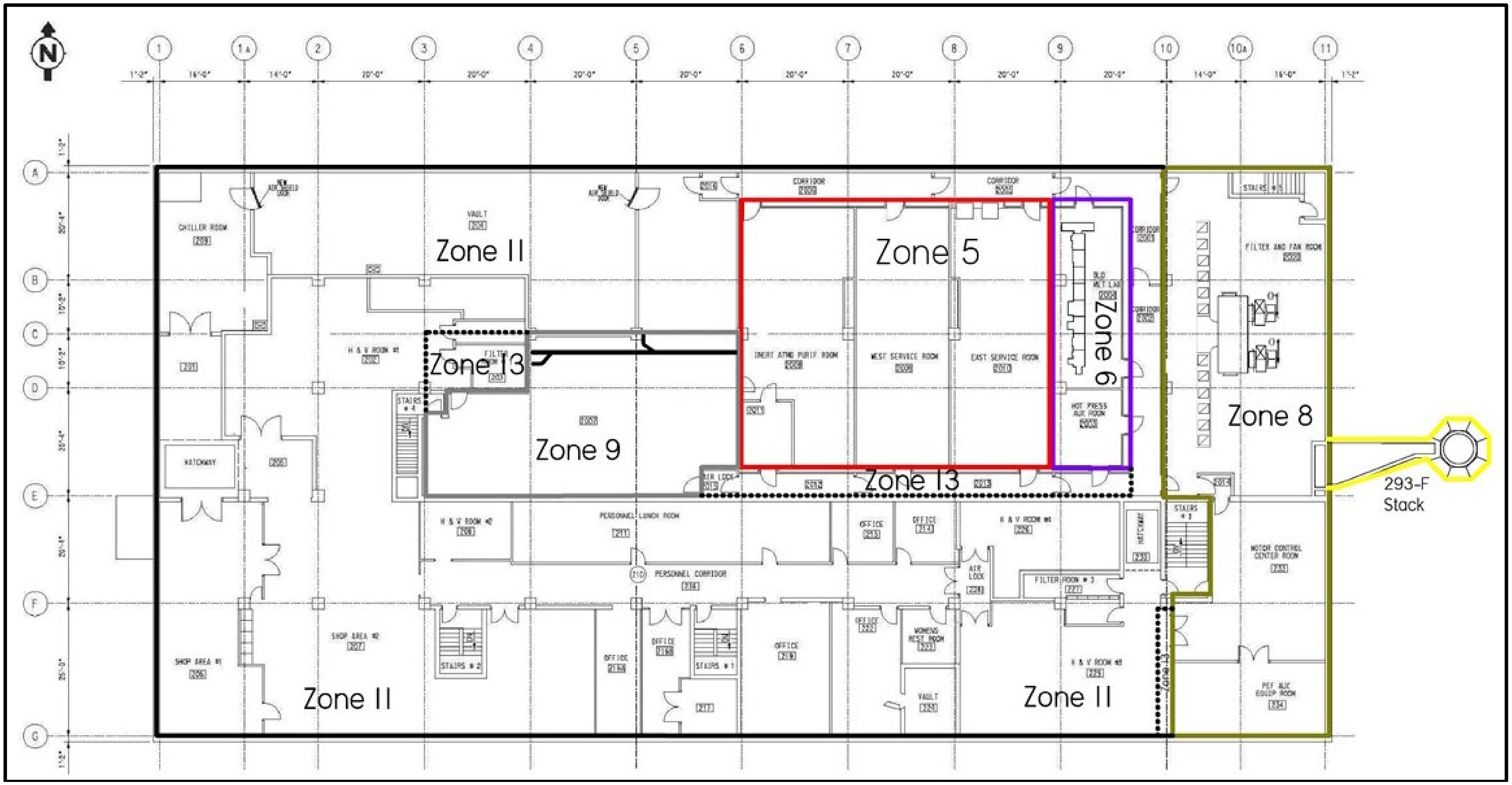


Figure 13. Building 235-F Second Level Decommissioning Zones

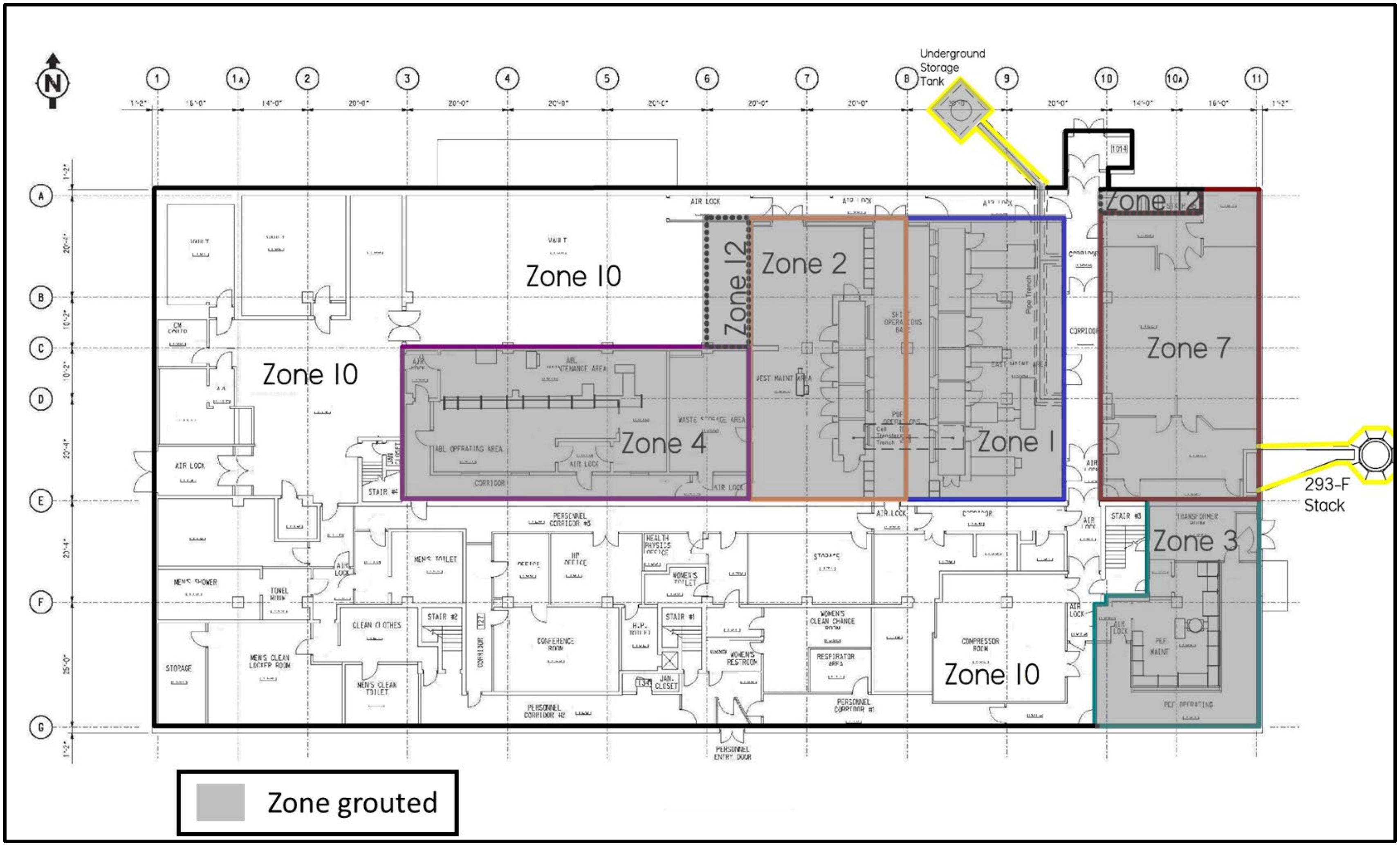


Figure 14. Alternative A-2. ISD of First and Second Level Process Areas /Engineered Roof (First Level View)

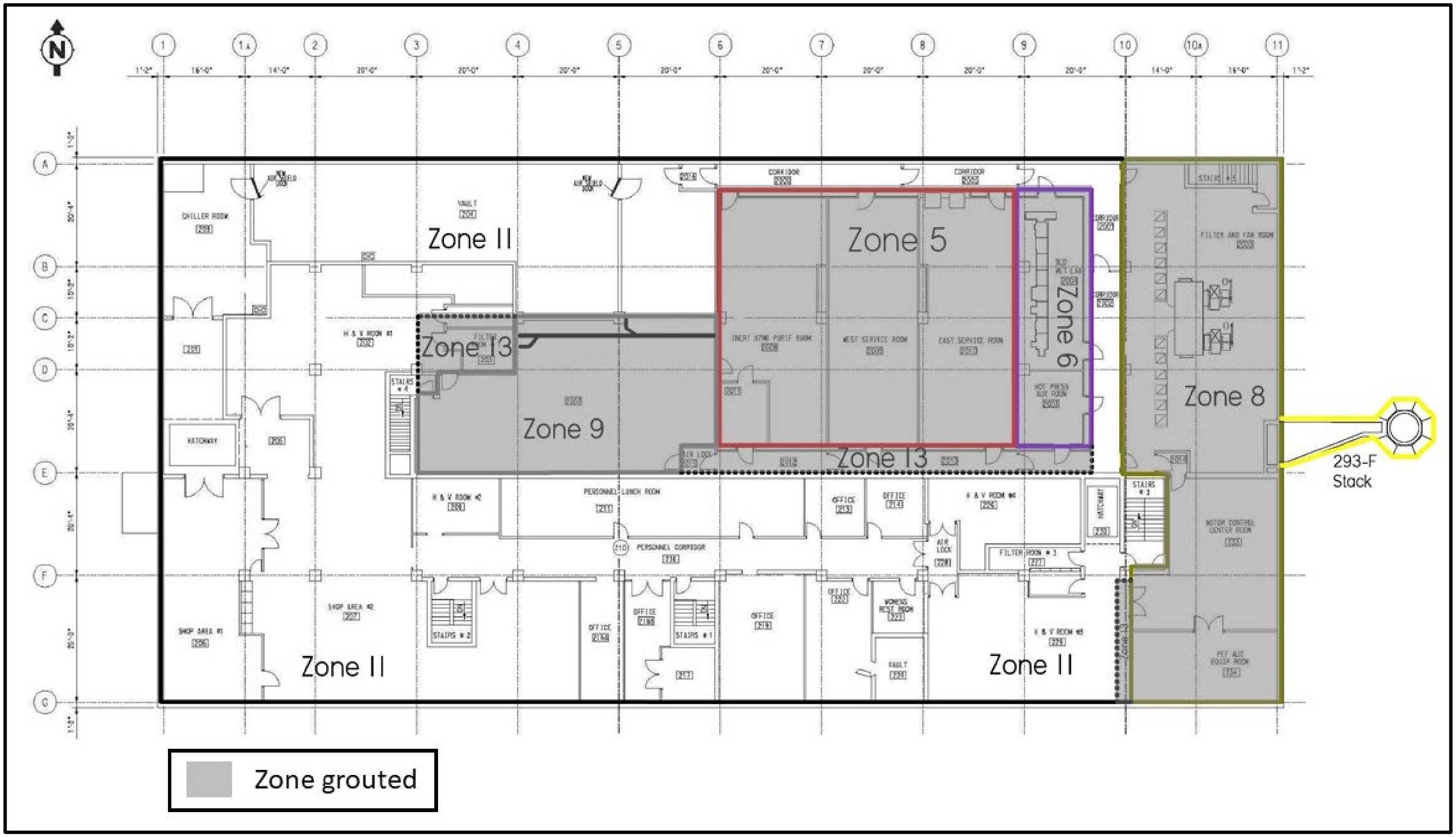


Figure 15. Alternative A-2. ISD of First and Second Level Process Areas /Engineered Roof (Second Level View)

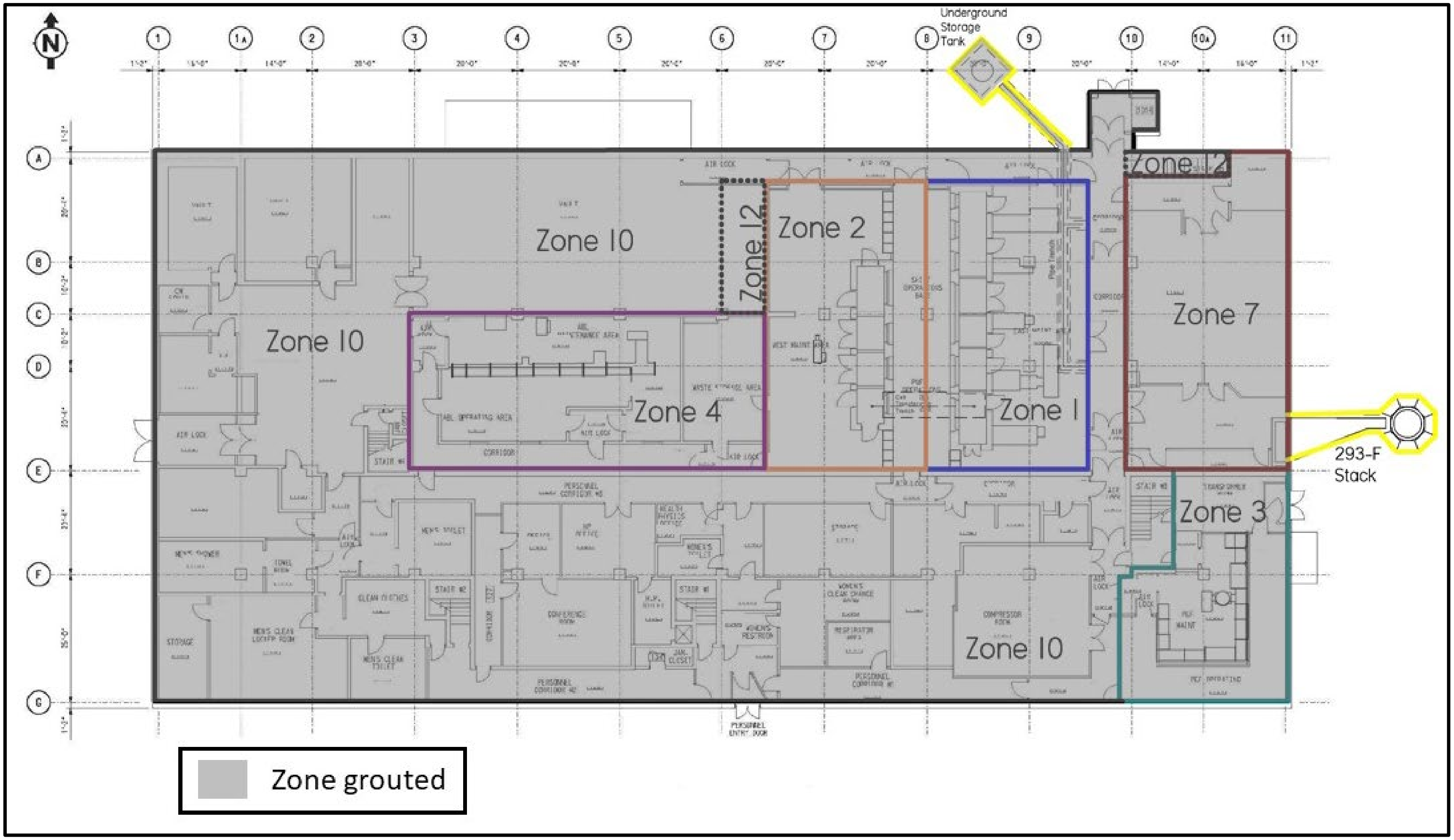


Figure 16. **Alternative A-3. ISD of Entire Building 235-F/Engineered Roof (First Level View)**

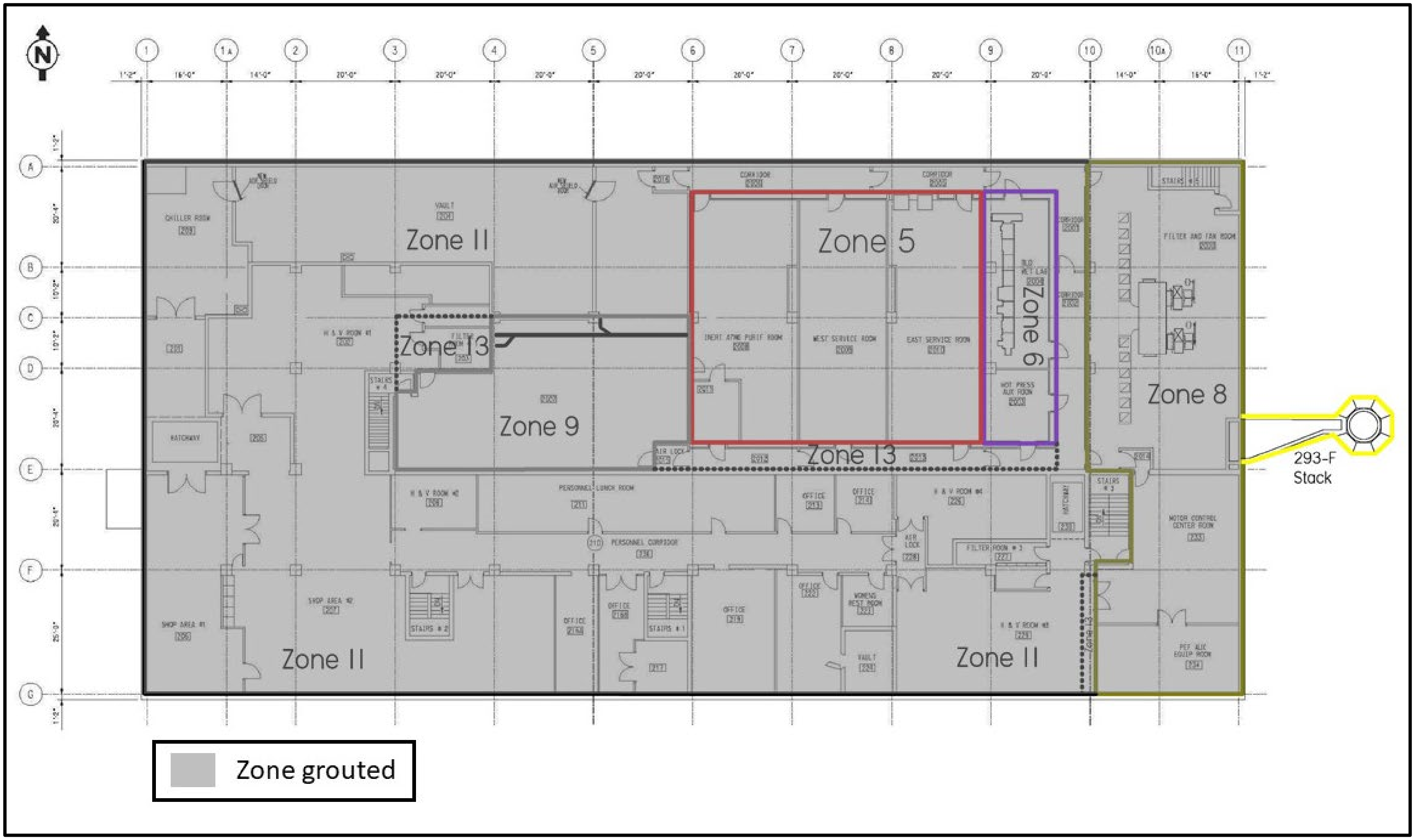


Figure 17. Alternative A-3. ISD of Entire Building 235-F/Engineered Roof (Second Level View)

Table 1a. Record of Key Agreements[5]

Date	Description of Agreement
10/30/2019[6,7]	• The Core Team agreed that the risk to the on-site worker is too great *(e.g., for a puncture/laceration accident, a single exposure dose of >100 rem exceeds the DOE-STD-3009 consequence threshold for a facility)* to justify the removal of any additional radiological material (i.e., predominately Pu-238 and Np-237) from the building. Groundwater impacts within 10,000 years can be mitigated by reasonable ISD approaches. • The Core Team agreed that no further removal of radiological material is necessary as long as USDOE commits to a building end state that is protective (i.e., protective of human health and the environment and meets groundwater limits to the extent practicable). • In accordance with the FFA, the Core Team agreed to proceed with a NTC removal action and development of a RSER/EE/CA to evaluate removal action alternative(s). An Action Memorandum documenting the preferred NTC removal action would be issued with recognition that funding would determine the ability to schedule and complete decommissioning. Core Team agreed that decommissioning can be performed in phases as funding becomes available. A Remedial Investigation Report with Baseline Risk Assessment and Feasibility Study will not be necessary prior to implementing the NTC removal action. *The ISD end state for 235-F is expected to be consistent with the final remedy for the eventual FAOU ROD.* • Core Team agreed that other non-radiological hazards that remain in the facility after deactivation (lead, PCBs, etc.) will be addressed as part of the NTC removal action evaluation. • Core Team agreed that the evaluation of removal alternatives will include a groundwater POA at the FAOU boundary, located approximately 360 m downgradient from Building 235-F. *It is expected that this POA will be consistent with the chosen POA in the eventual FAOU ROD.* • Removal action alternative selection will be based on the 0-10,000 year interval for F&T modeling consistent with NTC removal actions for SRS reactor buildings.

[5] Core Team agreements are documented at each phase and retained for each successive phase in order to maintain a comprehensive list for the life of the project.
[6] Letter, B.T. Hennessey (USDOE) to S.B. Fulmer (SCDHEC) and J. Richards (USEPA), *Building 235-F Regulatory Information Meeting (October 30, 2019)*, SEMS Number:88, IACD-20-113, dated November 15, 2019.
[7] Information in italics was added by the Core Team at the Problem ID Scoping Meeting, 9/15/2020.

Date	Description of Agreement
9/15/2020	• Core Team agreed that a risk evaluation for non-radiological constituents will be discussed qualitatively and quantified to the extent practicable in the RSER/EE/CA. • Core Team agreed to not evaluate a removal action alternative that would include relocating the second level contaminated process equipment/ventilation ducts to the first level and grouting only the first level due to the risk to the remedial worker. • Core Team agreed to evaluate the following four removal action alternatives in the RSER/EE/CA: (1) No Action (2) ISD of First and Second Level Process Areas/Engineered Roof (3) ISD of Entire Building 235-F/Engineered Roof (4) Complete Building 235-F Removal/Soil Cover • Core Team agreed that the Complete Building 235-F Removal/Soil Cover removal alternative was needed to provide a bounding case, but the CERCLA criteria evaluation for this alternative does not need to be as detailed as the evaluation for the more likely ISD alternatives. A "scoping level" evaluation with a rough order of magnitude cost estimate in the RSER/EE/CA is acceptable for the complete building removal alternative. • Core Team agreed that SRS will submit a RAR to document the completion of field implementation of the selected NTC removal action. If a phased removal action approach is implemented, SRS will submit a RAR after the completion of each phase.
04/12/2021	Based on the results of the comparative analysis, the Core Team agrees that Alternative A-2 provides the best balance of tradeoffs among the other alternatives with respect to the evaluation criteria.

Table 1b. Key Changes to the Scoping Summary[8]

CHANGES TO SCOPING SUMMARY			
Date	**Section**	**Description of Change**	**Rationale for Change**
April 2021	1.0	Updated the status section to explain that this scoping summary supports the comparative analysis of the NTC removal action alternatives agreed to at the September 15, 2020 scoping meeting and to identify the meeting objectives	Updated to support comparison of NTC removal action alternative scoping.
	4.2	Updated to include risk estimate for lead and PCBs.	Updated to address Core Team comment at the 9/15/2020 scoping meeting to quantify to the extent practicable a risk evaluation for non-radiological constituents.
	4.4	Updated Alternatives A-2 and A-3 to correct design of roof for 1000 years.	Text inaccurately showed design of roof as 750 years for Alternatives A-2 and A-3.
	6.0	Added Section 6 for the comparison of removal action alternatives. The OU Strategy section moved to Section 7.0	Added to support comparison of NTC removal alternative scoping and identify Alternative A-2 as the preferred NTC removal alternative.
	7.0	Updated OU Strategy section.	Updated to reflect current project scoping phase and Alternative A-2 as the preferred NTC removal alternative. Added disposition of Building 235-F from FFA Appendix K.1 to FFA Appendix C.4 and Appendix C.5 following decommissioning.
	Table 1b	Added Table 1b Key Changes to the Scoping Summary.	Identifies significant changes from the September 15, 2020 scoping summary.
	Table 3b	Added Table 3b Human Health Risk Estimate for Building 235-F (Non-radiological).	Added inventory estimate for lead and PCBs.
	Table 6	Updated NTC Removal Action Alternative descriptions.	Updated Table 6 to replace the detailed zone descriptions with a summary level description for each alternative.
	Table 7	Added Table 7 for Comparative Analysis of Removal Alternatives	Added to support NTC removal action alternative comparative analysis scoping.

[8] The purpose of the "Key Changes" table is to identify significant changes from the previous scoping version. The table eliminates the need for "redline" formatting on the draft copy to avoid confusion with redline changes made during the scoping meeting.

Table 2. Building 235-F Total Radiological Holdup[1]

Location	Pu-238 grams (g)	Percent of Pu-238	Np-237 (g)	Percent of Np-237
PuFF Facility Cell 1	[redacted]	[redacted]	-	-
PuFF Facility Cell 2	[redacted]	[redacted]	-	-
PuFF Facility Cell 3	[redacted]	[redacted]	-	-
PuFF Facility Cell 4	[redacted]	[redacted]	-	-
PuFF Facility Cell 5	[redacted]	[redacted]	-	-
PuFF Facility **Cell 1-5**			-	-
PuFF Facility Cells 6-9	[redacted]	[redacted]	-	-
PuFF Facility Exhaust Ductwork	[redacted]	[redacted]	-	-
PuFF Facility Inert Atmosphere Line	[redacted]	[redacted]	-	-
PEF	[redacted]	[redacted]	[redacted]	[redacted]
ABL				
ABL E1 Exhaust	[redacted]	[redacted]	[redacted]	[redacted]
OML	[redacted]	[redacted]	[redacted]	[redacted]
Rm 2000 E1 Exhaust	[redacted]	[redacted]	[redacted]	[redacted]
Rest of Building[2]	[redacted]	[redacted]	[redacted]	[redacted]
Entire Building[3]	[redacted]	-	-	-

[1] Inventory from *Characterization Report for Building 235-F, F-Area Material Storage Building (FAMS)*, G-ESR-F-00097, Revision 0, May 2020, Table 12.
[2] Rest of Building refers to radiological holdup exclusive of PuFF Facility Cells 1-5 and ABL.
[3] Entire Building is the total building inventory for Pu-238 and Np-237 from all locations.

Table 3a. Human Health Risk Estimate for Building 235-F (Radiological)

Receptor Scenario	Radionuclide	Entire Building 235-F Risk Estimate[1]	PuFF Facility Cells 1-5 Risk Estimate	Actinide Billet Line Risk Estimate
Default Industrial Worker	Pu-238	2.3E+09	5.9E+10	6.9E+08
	Np-237	4.1E+04	--	1.6E+06
	Total Risk =	**2.3E+09**	**5.9E+10**	**6.9E+08**

[1]Notes:

(a) Risk calculations for the default industrial worker receptor scenario were performed per the following equation: *Risk = (Concentration [pCi/m³] / Ambient Air BPRG [pCi/m³]) x 1E-06*

(b) The indoor worker Building Preliminary Remediation Goals for Radionuclides (BPRGs) for ambient air: Pu-238 = 1.69E-04 pCi/m^3; Np-237 = 2.79E-04 pCi/m^3.

(c) The entire Building 235-F volume was determined by summating from the first level volume of 8334.22 m^3 (294320.25 ft^3) (area 2025.43 m^2 [21801.5 ft^2] with a ceiling height of 4.1 m [13.5 ft]) and the second level volume of 8729.68 m^3 (308285.6 ft^3) (area of 2045.76 m^2 [22020.4 ft^2] with a ceiling height of 4.3 m [14 ft]).

The ABL volume was the combined volumes of rooms 107A and 107D (total area of 95.4 m^2 [1026.7 ft^2] with a ceiling height of 4.1 m [13.5 ft]) for a combined volume of 392.48 m^3 (13860.45 ft^3).

The east maintenance area (room 1002) was considered the primary area for a release from PuFF Facility Cells 1-5, resulting in a total volume of 564.79 m^3 (19946.25 ft^3) (area of 137.3 m^2 [1477.5 ft^2] with ceiling height of 4.1 m [13.5 ft]).

Table 3b. Human Health Risk Estimate for Building 235-F (Non-radiological)

Receptor Scenario	Constituent	Concentration (mg/kg)	USEPA RSL (mg/kg)	Risk	Hazard (HQ)
Default Industrial Worker	Lead	940	800	--	1.2
	PCBs	3900	0.942	4.1E-03	--

[1] Estimated concentrations from *Characterization Report for Building 235-F, F-Area Material Storage Building (FAMS)*, G-ESR-F-00097, Revision 0, May 2020, Appendix E.

Table 4. Summary of GoldSim Computed Peak of the Mean Doses/Concentrations for Np-237

ISD Alternative	POA (m)	Nuc	Gross Alpha (15 pCi/L)			Beta-Gamma (4 mrem/yr)			Radium (5 pCi/L)			Uranium (30 ug/L)		
			0-1K	0-10K	0-100K	0-1K	0-10K	0-100K	0-1K	0-10k	0-100K	0-1K	0-10K	0-100K
No Action	1	Np-237	75	1319	1319	1	18	18	0	0	0	0	0	0
	100	Np-237	6	265	265	0	4	4	0	0	0	0	0	0
Supports:	360	Np-237	0	69	69	0	1	1	0	0	0	0	0	0
Alternative A-1	Seepline	Np-237	0	21	21	0	0	0	0	0	0	0	0	0
	UTR Trib	Np-237	0	0	0	0	0	0	0	0	0	0	0	0
Grout Entire 235-F	1	Np-237	0	2	55	0	0	1	0	0	0	0	0	0
with Engineered Roof	100	Np-237	0	0	11	0	0	0	0	0	0	0	0	0
	360	Np-237	0	0	3	0	0	0	0	0	0	0	0	0
Supports:	Seepline	Np-237	0	0	1	0	0	0	0	0	0	0	0	0
Alternatives A-2, A-3	UTR Trib	Np-237	0	0	0	0	0	0	0	0	0	0	0	

Table 5. Summary of GoldSim Computed Peak of the Mean Doses/Concentrations for Pu-238

ISD Alternative	POA (m)	Nuc	Gross Alpha (15 pCi/L)			Beta-Gamma (4 mrem/yr)			Radium (5 pCi/L)			Uranium (30 ug/L)		
			0-1K	0-10K	0-100K	0-1K	0-10K	0-100K	0-1K	0-10k	0-100K	0-1K	0-10K	0-100K
No Action	1	Pu-238	0	614	3474	0	7	42	0	204	1123	0	0	0
	100	Pu-238	0	38	388	0	0	5	0	13	126	0	0	0
Supports:	360	Pu-238	0	9	99	0	0	1	0	3	32	0	0	0
Alternative A-1	Seepline	Pu-238	0	1	36	0	0	0	0	0	12	0	0	0
	UTR Trib	Pu-238	0	0	0	0	0	0	0	0	0	0	0	0
Grout Entire 235-F	1	Pu-238	0	0	4463	0	0	54	0	0	1456	0	0	0
with Engineered Roof	100	Pu-238	0	0	446	0	0	5	0	0	146	0	0	0
	360	Pu-238	0	0	114	0	0	2	0	0	37	0	0	0
Supports:	Seepline	Pu-238	0	0	36	0	0	0	0	0	12	0	0	0
Alternatives A-2, A-3	UTR Trib	Pu-238	0	0	0	0	0	0	0	0	0	0	0	0

Table 6. Description of NTC Removal Action Alternatives for Building 235-F

Building 235-F Final Decommissioning End State	A-1. No Action	A-2. ISD of First and Second Level Process Areas / Engineered Roof	A-3. ISD of Entire Building 235-F / Engineered Roof	A-4. Complete Building 235-F Removal / Soil Cover
Removal Action End State Description	▪ Building 235-F, underground storage tank and pipe trench, and abandoned capped stack (293-F) remain as is following deactivation activities (i.e., building deactivation end state represents baseline conditions). ▪ Hold-up and contaminated equipment remain in place. ▪ Hazardous material (e.g. lead shielding, leaded glass, lead based paints, PCB-based paints, and non-friable ACM) remains in place. __________ ▪ Building O&M required after deactivation. - Ventilation systems operate to maintain a vacuum within process enclosures using unconditioned air. - 294-2F Sand filter (294-2F) and exhaust stack (291-2F) remain in operation. - Assume roof collapse at 150 years, at which time additional response action will likely be necessary to mitigate exposure/spread of contaminants.	▪ Below grade transfer trenches grouted. ▪ Fixative applied on contaminated surfaces. ▪ Where possible, ventilation ducts relocated to floor prior to grouting or breached to allow grout to fill. ▪ Recombiners added to process enclosures to prevent hydrogen build up. ▪ Process enclosures sealed and formed prior to grouting. ▪ Zones1-9 and 12-13 are formed and grouted. ▪ Structural supports added to non-grouted rooms to support reinforced concrete roof addition. ▪ Roof structures (e.g. concrete ventilation ducts) removed as necessary, size reduced and disposed of. ▪ All exterior penetrations and doors are sealed. ▪ Engineered roof installed. ▪ Underground storage tank grouted/capped, and pipe trench grouted. ▪ Abandoned capped stack (293-F) permanently sealed.	▪ Below grade transfer trenches grouted. ▪ Fixative applied on contaminated surfaces. ▪ Where possible, ventilation ducts relocated to floor prior to grouting or breached to allow grout to fill. ▪ Recombiners added to process enclosures to prevent hydrogen build up. ▪ Process enclosures sealed and formed prior to grouting. ▪ All zones on first level are grouted with near simultaneous lifts throughout. ▪ All zones on second level are grouted with near simultaneous lifts throughout. ▪ Roof structures (e.g. concrete ventilation ducts) removed as necessary, size reduced and disposed of. ▪ All exterior penetrations and doors are sealed. ▪ Engineered roof installed. ▪ Underground storage tank grouted/capped, and pipe trench grouted. ▪ Abandoned capped stack (293-F) permanently sealed.	▪ Below grade transfer trenches grouted. ▪ Fixative applied on contaminated surfaces. ▪ Radionuclide hold-up from building removed, packaged, and transported off-site to a TRU waste disposal facility. ▪ Radiologically contaminated equipment/ventilation ducts removed, packaged, and transported off-site to a TRU waste disposal facility. ▪ Hazardous material and low-level radionuclide material removed and transported to appropriate disposal facility. ▪ Building demolished to slab and rubble disposed of as LLW. ▪ Abandoned capped stack (293-F) removed. ▪ Underground storage tank grouted. ▪ Soil cover constructed over slab, tank, and former abandoned capped stack (293-F) area.

Table 7. Comparative Analysis of the NTC Removal Action Alternatives for Building 235-F

	A-1. No Action	A-2. ISD of First and Second Level Process Areas / Engineered Roof	A-3. ISD of Entire Building 235-F / Engineered Roof	A-4. Complete Building 235-F Removal / Soil Cover
Effectiveness	**Low** **Pros:** • Short-term effectiveness to the SRS worker is adequate while S&M activities and ventilation of enclosures continue. **Cons:** • Does not achieve RAO to prevent exposure to hypothetical future industrial worker. Unmitigated risk (2.3E+9) are extremely high for hypothetical future industrial worker scenario. • Does not achieve RAO to prevent migration of radionuclide contamination to groundwater that result in exceedances of MCLs. • Risk to SRS workers impacts SRS missions. • Hold-up and hazardous substances remain in place with vulnerability to release increasing over time as the facility deteriorates.	**High** **Pros:** • Achieves RAO by preventing hypothetical future industrial worker exposure to contaminants. • Achieves RAO to prevent migration of contaminants to groundwater above MCLs at the POA. • Short-term effectiveness with respect to removal action worker achieved by minimizing entry into the cells/process enclosures. • Formwork mitigates grout movement and reduces the potential to spread contamination via flowing grout. **Cons:** • Increased removal action worker exposure during placement of formwork reduces short-term effectiveness. • Hazardous substances and PTSM remain entombed on site. • No unrestricted use.	**High** **Pros:** • Achieves RAO by preventing hypothetical future industrial worker exposure to contaminants. • Achieves RAO to prevent migration of contaminants to groundwater above MCLs at the POA. • Short-term effectiveness with respect to removal action worker achieved by minimizing entry into the cells/process enclosures. • Potential reduction in required formwork reduces removal action worker exposure during implementation. **Cons:** • Grouting rooms simultaneously increases potential for the spread of contamination within Building 235-F. • Hazardous substances and PTSM remain entombed on site. • No unrestricted use.	**Moderate** **Pros:** • Achieves RAO by preventing hypothetical future industrial worker exposure to contaminants. • Achieves RAO to prevent migration of contaminants to groundwater above MCLs at the POA. • A soil cover will prevent access and release of below grade contamination. **Cons**: • Short-term effectiveness is low due to the risk to the removal action worker and the potential to release airborne contamination during removal/demolition. • ACM removal increases risk of exposure to removal action workers. • Some contamination will remain entombed in grout in the below grade portions located under the removed cells. • No unrestricted use.

Table 7. Comparative Analysis of the NTC Removal Action Alternatives for Building 235-F (Continued/End)

	A-1. No Action	A-2. ISD of First and Second Level Process Areas / Engineered Roof	A-3. ISD of Entire Building 235-F / Engineered Roof	A-4. Complete Building 235-F Removal / Soil Cover
Implementability	**Moderate** **Pros:** Technically and administratively feasible. **Cons:** • Due to the amount of hold-up and Nuclear Safety concerns minimal S&M is required for Building 235-F, as well as operation of the E5 ventilation system and sand filter (294-2F) and exhaust stack (291-2F). • Eventually, conditions within the facility will deteriorate making S&M activities hazardous and requiring response action to mitigate exposure/spread of contamination.	**High** **Pros:** • Technically and administratively feasible as exemplified by other grouting projects at SRS. • Material resources are widely available. • Funding resources could be stretched over multiple years, allowing implementation in phases with the highest contaminated areas to be grouted first. **Cons:** • Includes significant amount of formwork to isolate process areas. • Requires structural supports in non-grouted rooms to support roof loading. • Roof demolition and construction present industrial hazards.	**Moderate** **Pros:** • Technically and administratively feasible as exemplified by other grouting projects at SRS. • Material resources are widely available. • Funding resources could be stretched over multiple years, allowing implementation in phases with the first level to be grouted in one year and second level in another. • Structural supports not required for roof loading. **Cons:** • Roof demolition and construction present industrial hazards. • Anchoring plan required. • Managing slick lines during simultaneous lifts is more difficult than Alternative A-2. • Commercial concrete plant production and truck availability/traffic logistics may not be able to meet the demands for simultaneous lifts. • Phased implementation is more restrictive than Alternative A-2.	**Low** **Pros:** None. **Cons:** • Significant technical challenges exist associated with deactivating and removing hold-up/process enclosures. • Robotic resources may be required due to significant worker exposure to radionuclides and the significant risk for accidental exposure. • Permitting will be required for the removal of ACM. • Minimal SRS experience with removal of high activity/low particle size contamination may result in airborne release. • Project completion is required as expeditiously as possible, requiring full funding resources at beginning of remedial action implementation since phased implementation is not practicable. • Waste handling will require nuclear material packaging and transportation to offsite disposal for TRU waste. • Building demolition and construction present industrial hazards. • Above and below grade interferences with soil cover footprint.
Cost	**$ 971M** (S&M for 150 years.)	**$ 92M**	**$ 100M**	**$ 201M**