SEPARATIONS PROCESS RESEARCH UNIT (SPRU) DISPOSITION PROJECT (DP)

SPRU PM-20-001

DEMOLITION COMPLETION REPORT FOR SPRU FACILITY

Prepared By: William Duggan, Engineering Manager

Approved By: Jeff Selvey, Project Manager

August 20, 2020

AECOM Energy & Construction, Inc.

2131 S. Centennial Avenue
Aiken, SC 29803

CONTENTS

LIST OF FIGURES

LIST OF TABLES

DEMOLITION COMPLETION REPORT

1 Introduction

This report describes the major activities undertaken to complete the decommissioning and demolition (D&D) of the Separations Processing and Research Unit (SPRU) facilities located at the Knolls Atomic Power Laboratory (KAPL). The U.S. Department of Energy (DOE) exercised its authority under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) non-time critical removal process to remove the Nuclear Facilities and clean up underlying and adjacent soil remediate contamination at the SPRU site. The project also implemented Resource Conservation and Recovery Act Interim Corrective Measure (RCRA ICM) Work Plans to address the Solid Waste Management Units (SWMUs) and Area of Concern (AOC) in the buildings and adjacent soils. This report documents the major activities performed by AECOM Energy & Construction, Inc. (formerly known as URS) under contract to DOE, summarizes health and safety statistics, and discusses lessons learned. The D&D activities have been completed to restore the site for future industrial reuse to meet both DOE and New York State Department of Environmental Conservation (NYSDEC) criteria for the cleanup of residual radiological and chemical contamination.

The approach to D&D was consistent and compliant with federal and state regulatory requirements, as well as conforming to the local noise ordinance work hours. Remediation of the SPRU site entailed the processing of the H2 tank sludge; D&D of the G2 and H2 Buildings, basements, and connecting tunnel; removal of chemically and radiologically contaminated soil beneath and outward from the buildings and on the hillside; recovery and offsite disposal of groundwater from the Building H2 footer drain collection system; and offsite disposal of generated waste. All work performed was protective of site workers, the public, and the environment, and in compliance with DOE Orders, contract requirements, and federal and state environmental regulations.

Additional detailed information concerning D&D activities are provided in the SPRU Disposition Project Decommissioning Plan – Revision 4 (SPRU-DD-004) dated August 29, 2012 (D&D Plan). This document also includes references to sections in the D&D Plan as well as other SPRU documents for additional information where appropriate.

2 Description of SPRU Facilities

2.1 SPRU History

The SPRU facilities were constructed in 1947 - 1949 to research the separation of plutonium and uranium from radioactive material encased in aluminum, known as slugs. SPRU operated between February 1950 and October 1953, when research activities ceased following successful development of the reduction oxidation (REDOX) and plutonium uranium extraction (PUREX) processes subsequently used by Hanford and the Savannah River Sites. The research was performed on a laboratory scale; SPRU was never a production plant. The SPRU Upper Level site includes the G2 Main Processing Building, the H2 Waste Processing Building and associated tank farm, a connecting underground tunnel, surrounding asphalt and gravel roadways, and the hillside to the west. Figure 1 is an aerial view from 2009 of the SPRU Upper Level prior to the start of field work for this project. A layout of the area after construction of enclosures for the G2 and H2 Buildings (2013) is provided as Figure 2. An isometric view of the building structures, including the underground connecting pipe tunnel, is shown in Figure 3.

Building G2 contained laboratories, hot cells, separations process testing equipment, and process tunnels in the basement.

Building H2 contained equipment and tanks for processing radioactive liquid waste from the G2 process pilot plant. Waste generated in G2 was sent to H2 through piping in the tunnels and also in drums. H2 also processed waste from the laundry, hot incinerator scrubber, and from other KAPL site laboratories conducting research.

A reinforced concrete pipe tunnel system transported liquid waste, process chemicals, and reuse water between the SPRU buildings, laboratories, equipment and nearby non-SPRU laboratories and buildings. As part of that system, the G2-H2 Tunnel transported liquid waste and process liquids from G2 process areas and other buildings to the H2 liquid waste process and storage areas. The G2-H2 Tunnel connected the G2 Hot and Process Tunnels on the south to the H2 Pipe Tunnel on the north.

Various decommissioning and decontamination activities occurred in the SPRU facilities prior to the award of a contract in December 2007 to demolish the SPRU buildings and associated facilities. This report discusses the actions associated with the removal of Building G2, Building H2 and tank enclosure, and the G2/H2 pipe tunnel, and the decontamination of the E1 and G1 pipe tunnels. Remedial actions were completed in 2018 and site restoration was finished in 2019.

2.2 G2 Building Facilities

The G2 Building facilities served as the head-end of the process where slugs of irradiated fuel were dissolved into an acid solution for subsequent separation of recoverable uranium and plutonium. Building G2 was used heavily between 1950 and 1953 to test chemical processes for separating plutonium and uranium from radioactive material encased in aluminum.

Building G2 consisted of a steel-framed, transite-sided building containing heavily shielded concrete cells. The building was a multistory 150-foot long structure (north-south), 100 feet wide (east-west), 35 feet high at the northeast corner, and 45 feet high at the southwest corner with five levels at elevations of 325 feet above mean sea level (amsl), 337 feet (ground level), 348 feet, 355 feet, and 357 feet. Figure 4 shows an isometric view of the G2 structural layout. Figure 5 is a figure from the Historical Site Assessment [DOE 2006, April 2006] showing the building in greater detail. The greyed-out components had been removed as of November 2004.

Use of the SPRU G2 facility for REDOX and PUREX research was terminated in June 1953. Shortly afterwards, the Control Room, portions of the constant head tank levels, the Rotameter Room, and change rooms were converted to a machine shop, test areas, drafting rooms, engineering and scientific offices, and library space for KAPL research. From the mid-1950s to the early 1990s, portions of Building G2 were modified and used by KAPL office workers and laboratory personnel. Seven process tanks (Tank# 316, 327, 331, 332, 334, 336, and 351) were removed from the G2 Building in 2006.

Figure 1. SPRU Upper Level Facilities (2009)

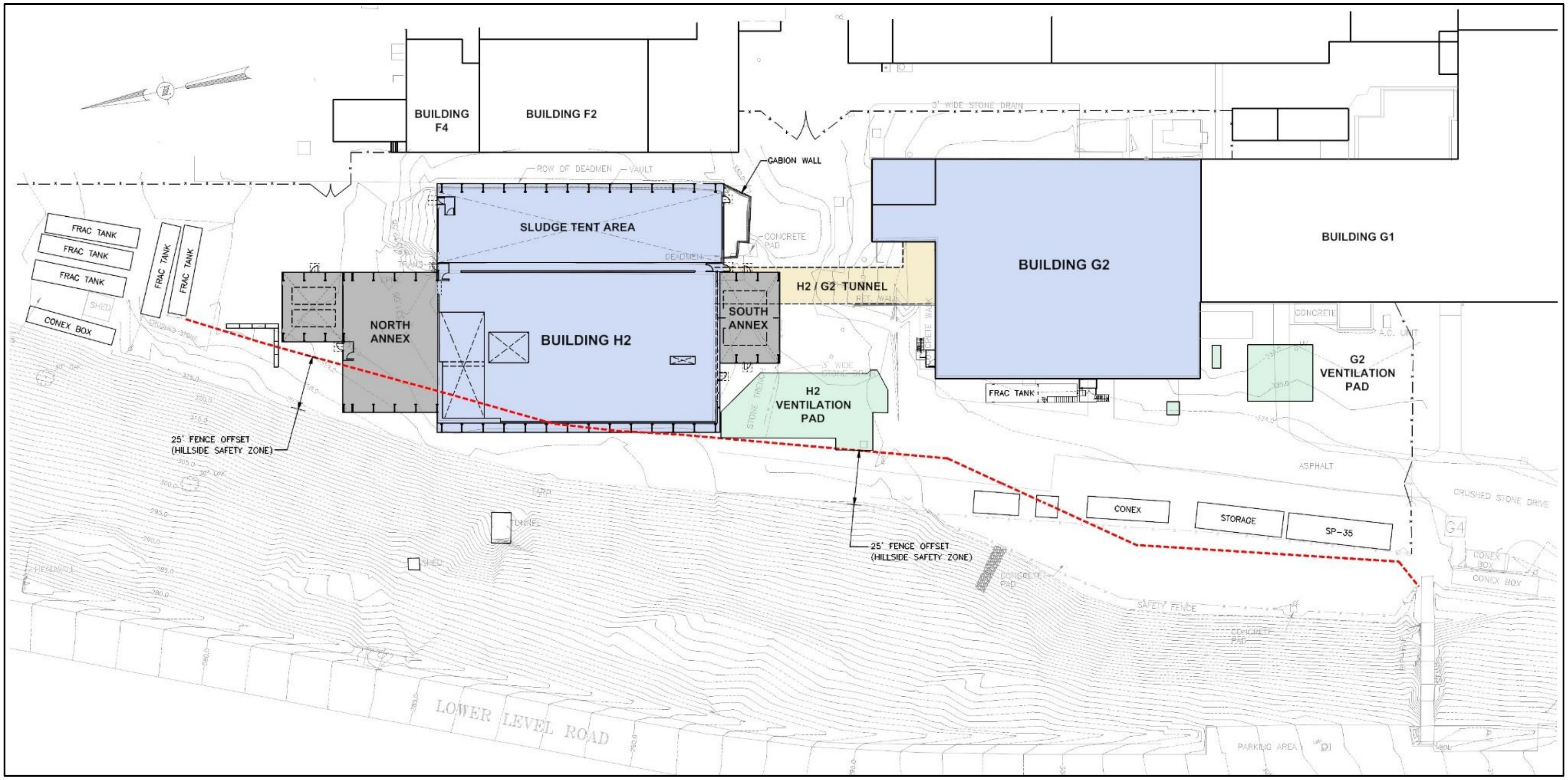


Figure 2. SPRU Upper Level Layout with Enclosures in Place

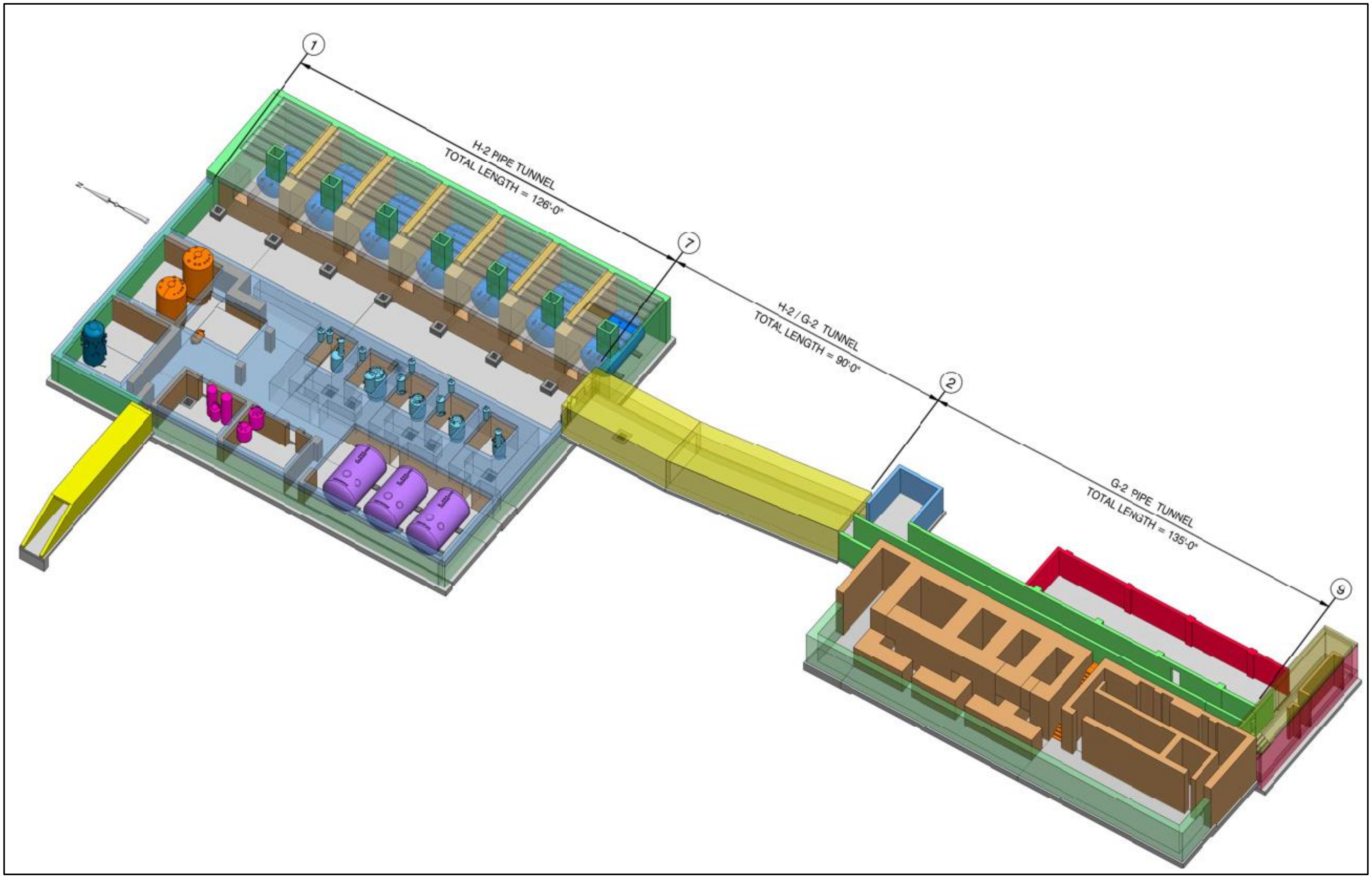


Figure 3. Isometric View of SPRU Building Complex

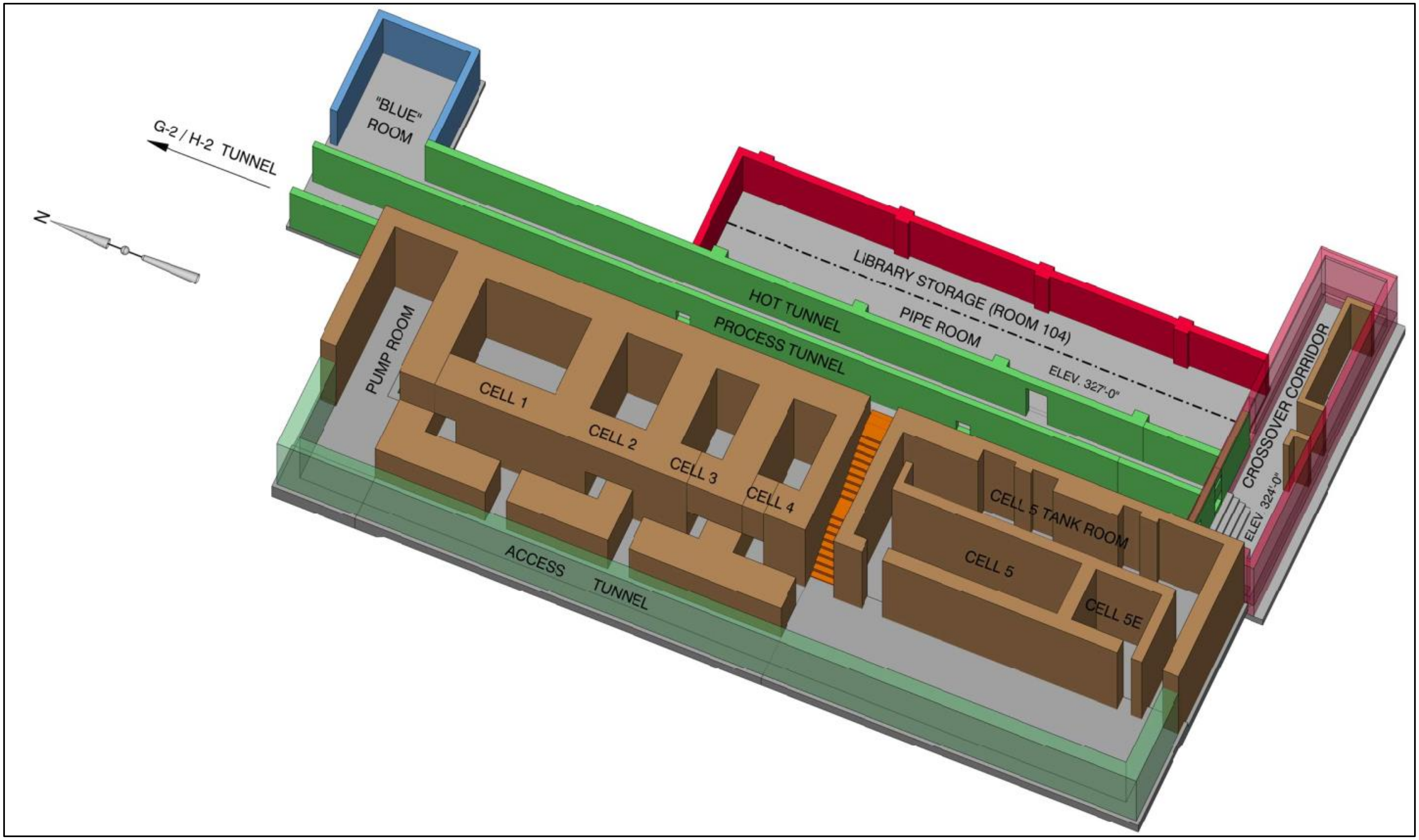


Figure 4. Isometric view of G2 building structure

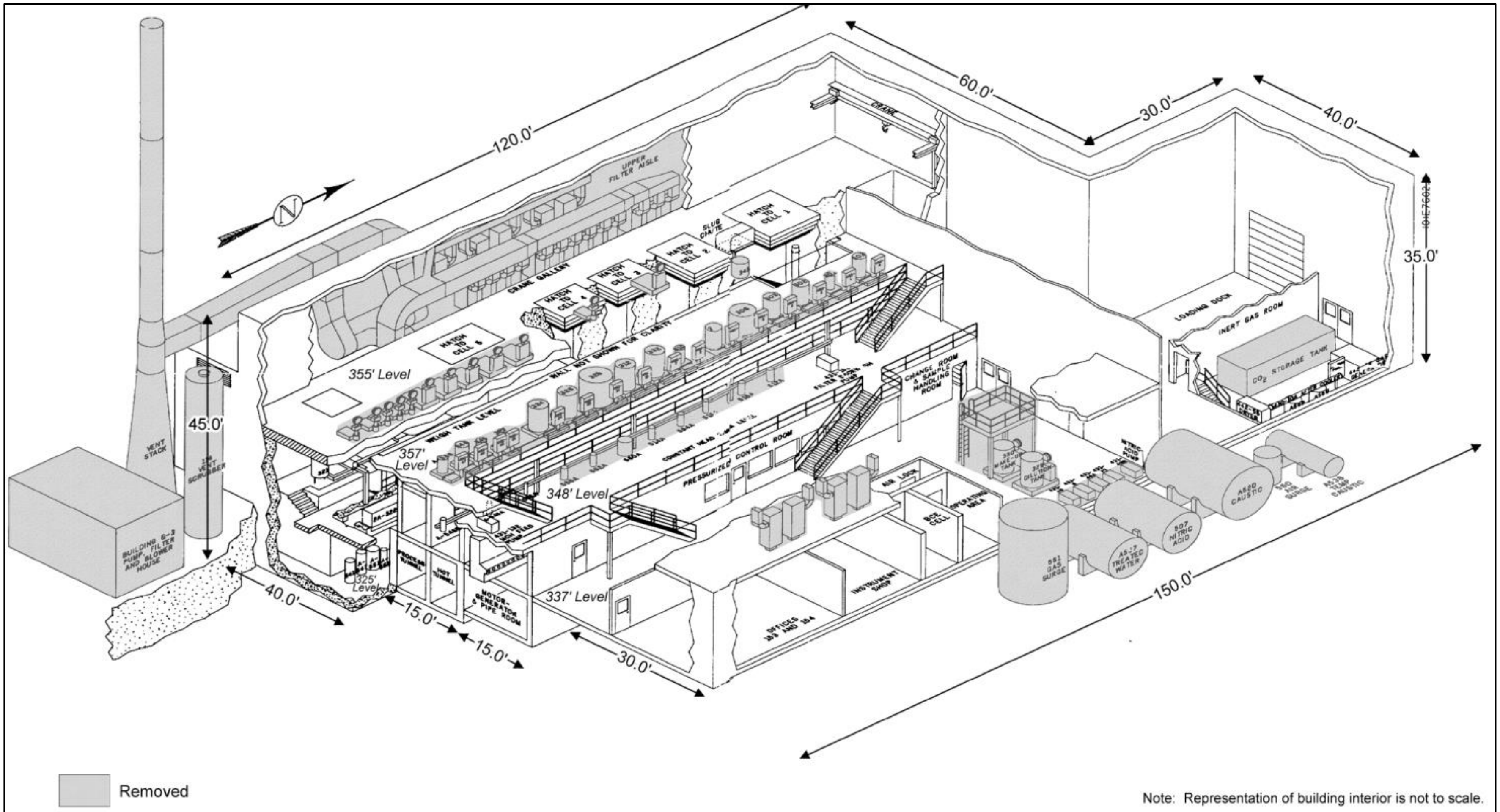


Figure 7-4. G2 Support Area Isometric Drawing, Approximate Current Conditions, November 2004

(Source – R-001949)

Figure 5. Detailed schematic of G2 Building (Figure 7-4 from HSA)

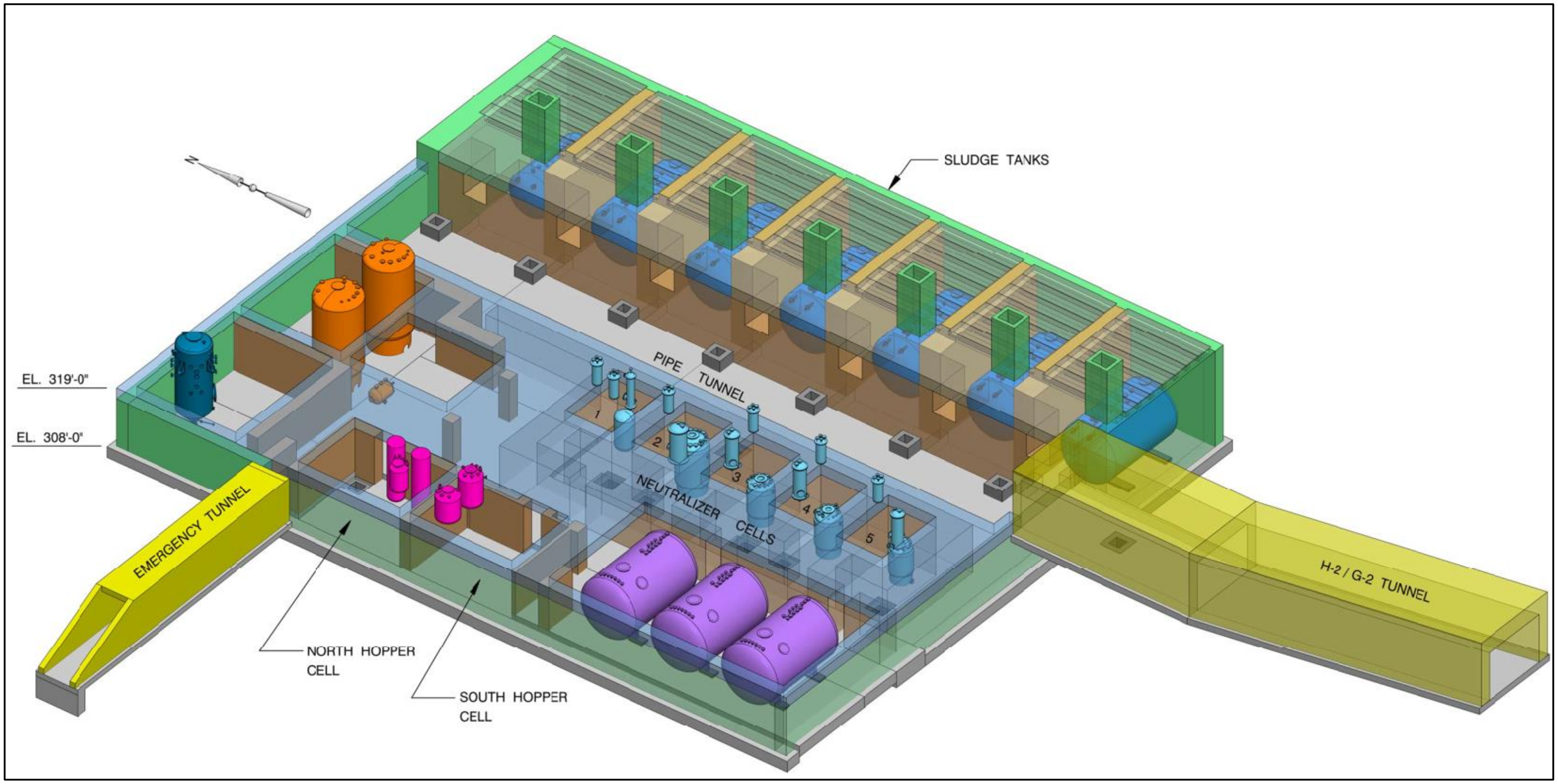


Figure 6. Isometric view of H2 building and G2/H2 Pipe Tunnel structure

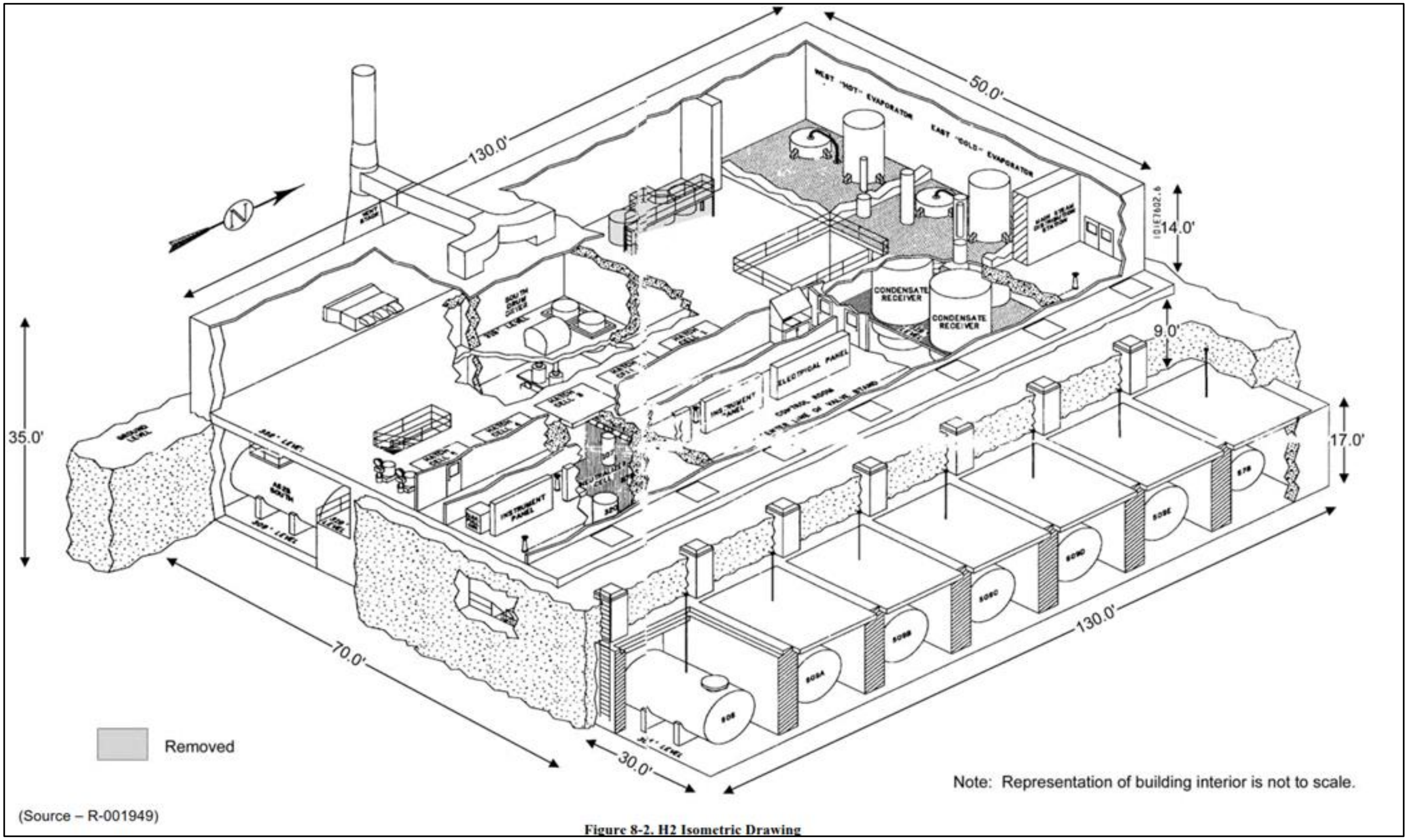


Figure 7. Detailed schematic of H2 Building (Figure 8-2 from HSA)

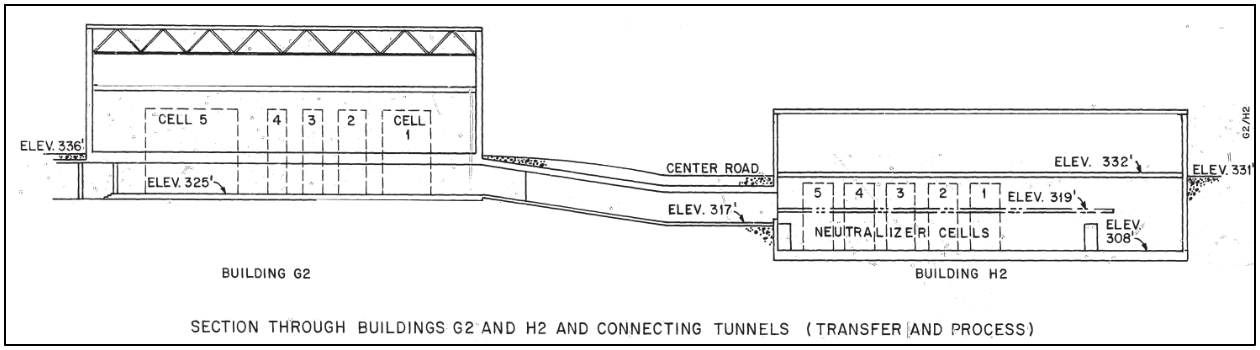


Figure 8. Elevation of G2 and H2 Buildings (view from east)

2.3 H2 Building and Tank Farm

The H2 Building and related support facilities were constructed between 1947 and 1949 and operated in support of the REDOX/PUREX processes performed in Building G2 from February 1950 to October 1953. The H2 Tank Farm was comprised of seven vaults on the east side of H2, each housing a single tank for the storage of liquid waste. The H2 Tank Farm received H2 Building processing solutions, separation solvent recovery bottoms, and various solutions arising from groundwater and surface water intrusion into the vaults. Additional historical information for the SPRU can be found in Nuclear Facility Historical Site Assessment for the Separations Process Research Unit (SPRU) Disposition Project (DOE 2006a) and the D&D Plan (SPRU-DD-004). Figure 6 shows an isometric view of the H2 structural layout. Figure 7 is a figure from the Historical Site Assessment [DOE 2006a] showing the building in greater detail. The greyed-out components had been removed as of November 2004.

The H2 Building was located approximately 90 feet north of the G2 Building and contained approximately 27,900 square feet of floor space on three levels (elevation 309, 319, and 332 feet). Approximately 70% of Building H2 (309-foot and 319-foot levels) was located below ground level and was defined by concrete walls 2 feet thick on the north, south, and west sides, and 8 feet thick between the tank farm and pipe tunnel on the east, with a 2-foot thick concrete foundation. The above grade portion of Building H2 was constructed of structural steel with corrugated transite siding.

The H2 Tank Farm consisted of one 5,000-gallon and six 10,000-gallon stainless steel storage tanks in seven underground concrete vaults on the east side of the H2 building. The area of the H2 Tank Farm covered approximately 3,900 square feet at the 304’ elevation. Interior vault dimensions were approximately 14 feet wide by 24 feet long by 16 feet high for each vault [KAPL 1998]. The concrete walls between vaults and the outer north vault wall were approximately 4 feet thick; the east and south perimeter walls were 2 feet thick; and the west wall of the tank vaults was 8 feet thick. The vault floor was a concrete slab about 3 feet in thickness poured directly on the till. During vault construction, a waterproof sealant was applied to the floors and walls, and copper water stops were installed to prevent water infiltration [CH2M Hill, 2003].

Following SPRU decommissioning in 1953, H2 Tank Farm use continued for storage of liquid waste from KAPL facilities until 1978. Highly radioactively-contaminated liquid was typically neutralized, concentrated, and transferred to the H2 Tank Farm for storage and later solidification and waste shipment. Tank Farm use was terminated shortly after the Radioactive Materials Laboratory Reuse System was brought online in 1978. Following cessation of the SPRU research effort in 1953, Tank Farm use continued for storage of liquid waste until 1978. The first comprehensive cleanout of the tanks occurred in 1965, when SPRU and other KAPL waste in the tanks 505 and 509A was removed and disposed off-site. Between March and October 1978, the Tank Farm tanks were emptied of all liquid waste. After 1978, miscellaneous KAPL liquid wastes were transferred into various H2 tanks.

2.4 G2/H2 Tunnel

The G2/H2 Pipe Tunnel housed the piping that connected the waste transfer and utility piping between the G2 and H2 Buildings. The G2/H2 tunnel consisted of a 90-foot long reinforced concrete structure 9 feet high by 12 feet wide, with a 3 feet thick roof, 2 feet thick walls, and 14 inch-thick floor slab. The floor sloped to a sump located approximately 15 feet from Building H2. The tunnel contained fire protection lines and a gas analyzer system. Two stainless steel drain lines transferred radioactive waste from the radioactive materials laboratory, chemistry, and Building D4 complex to the Building H2 liquid waste collection tanks. Two other heavy-duty plastic supply lines transferred clean processed reuse water to the laboratories. The elevation view in Figure 8 shows the connection between the buildings.

2.5 E1/G1 Tunnels

Between 1950 and 1954, SPRU facilities and multiple KAPL laboratories managed liquid waste using drain lines that traversed a series of tunnels to the H2 waste management process equipment. Treated process liquids were returned to laboratories in Buildings E1, G1, D4, and Radioactive Material Laboratory (RML) through pipes in the H2, G2, and G1 Tunnels.

During or shortly after the SPRU research activities ended, p-traps and vents were installed in E1 and G1 laboratory drains to collect chemicals such as heavy metals and mercury. The RML radioactive liquid waste reuse system was activated in 1977, using the SPRU tunnels to transport liquid waste from the RML and the D, E, and G buildings to H2 for treatment and processing. This was a “closed loop” system that treated wastewater in ion exchange resin columns in H2 and returned clean water to the laboratories. After 2001, when drain lines from the D, E, and G building complex were rerouted to a waste management facility in building E11, only the RML continued to use the H2 radioactive liquid waste reuse system.

After SPRU research operations ended in 1953, at least two contamination events occurred in the E1 and G1 East tunnels. When water infiltrated the E1 and G1 Tunnels in the late 1980s and early 1990s, the E1 interceptors overflowed due to pump failure, filling the sump with water and sludge and highly contaminating the E1 tunnel and sumps. In 1983, an interceptor tank connected to the RML reuse system overflowed in the Crossover Tunnel connecting the G1 tunnel to the G2 tunnel.

3 Decommissioning and Demolition Approach

A Decommissioning Plan [SPRU DD-04, Rev 0] was developed as the implementing document to describe the technical approach and assumptions to fulfill the Task Order requirements for the deactivation, demolition, and removal (DD&R) scope of activities in accordance with the proposal accepted for the contract award. The Plan, approved by DOE, covered the decommissioning of Building G2, Building H2, the G2/H2 Tunnel, tanks, piping, and other equipment associated with the buildings and tunnel; the removal of contaminated soil; and the decontamination of the E1 and G1 tunnels. The particular approach described in that plan was followed during initial decommissioning activities, as described in Section 4. A revised approach was developed after the radiological contamination incident in September 2010 discussed in Section 5. Recovery steps are discussed in Section 5. The revised decommissioning activities, as described in Section 6, followed similar concepts with the main difference being that much of the decontamination work was performed in enclosures with HEPA-filtered ventilation.

As set forth in the Task Order, the decommissioning project would be completed when:

- The SPRU nuclear facilities; Building G2, Building H2, the tank enclosures, and the interconnecting pipe tunnel have been removed;
- The pipe tunnels in the basements of Building E1 and G1 have been decontaminated;
- The common wall between Building G2 and Building G1 has been repaired and restored after demolition of G2, as specified in the Task Order;
- Incidental contaminated soil underlying and surrounding the nuclear facilities from past operations and caused by demolition operations during the Task Order have been removed to the levels specified in the Task Order;
- Wastes have been shipped and disposed of off-site;
- Final reports for the removal of the facilities and incidental contaminated soils are completed and approved by DOE;
- The excavation and other disturbed areas are restored to grade with structural fill and properly compacted;
- Contractor temporary trailer and storage areas are removed, and the areas are graded for proper drainage and re-seeded or paved, as appropriate

The project activities were generally organized by area, as described in the following sections.

3.1 Building G2 and G2/H2 Pipe Tunnel

This area included Building G2 and the interconnecting pipe tunnel between Buildings H2 and G2. Many active utilities supporting Buildings G2 and H2 passed through Building G2, or were in the ground adjacent to these facilities.

3.1.1 Deactivation of G2 utilities

Prior to the start of physical demolition, G2 utilities were to be isolated and temporary power provided to the ventilation system. This would also isolate the “pass-through” utilities that feed H2. H2 ventilation and the Hillside Drain would be provided with temporary power prior to G2 going “cold and dark.”

3.1.2 Decontaminate G2 to the Extent Needed to Allow for Open-Air Demolition

Building G2 radiological stabilization efforts were to ensure that removable contamination and fixed contamination that could be released during open air demolition were addressed to meet criteria established in SPRU-RC-302 based on potential emissions. Stabilization efforts would be based on the radiological, asbestos, beryllium, and other hazardous materials characterization results, as well as other as-found conditions in areas of the building that have not yet been accessed.

3.1.2.1 G2 Hot Cells
Characterization of the hot cell equipment was needed to verify whether the equipment was flushed and drained as indicated in the HSA. Based on the as-found status, an option would be that the equipment could be left in place with a fixative applied for subsequent removal during the open air building demolition.

3.1.2.2 Process Piping
The choice of decontamination or removal of pipe sections prior to demolition would be based on the characterization results. Applying fixative to contaminated surfaces was identified as the preferred stabilization method, with removal of piping to be conducted only as necessary. Such pre-demolition removal would be done using the glove-bag method, though internal fixing and plugging (with a foam-type product) could also be used.

3.1.2.3 Asbestos and Lead Abatement
Asbestos characterization identified that asbestos was prevalent in floor tile, wall panels, and utility piping installation. Trained asbestos workers were to remove the asbestos from G2, using standard industrial methods (glove bags, hand removal, scrapers, fixatives, etc.).

A lead characterization program would identify additional lead wastes beyond the known shielding in specific areas of the building. Lead wastes would be removed prior to demolition, to the extent possible, and managed in accordance with the waste management program.

3.1.2.4 Universal Waste Abatement
Universal wastes consist of items such as fluorescent light bulbs, non-leaking PCB ballasts, mercury switches, circuit boards, etc. Such materials would be removed prior to open air demolition and disposed in accordance with the waste management program.

3.1.3 Prepare G2 for Demolition
In order to protect the G1 Building and associated tunnels during the demolition, the doors between the buildings and the tunnels would be blocked in. The G2/H2 tunnel would also be blocked to isolate the H2 Building from demolition activities.

After work was complete in the interior of G2, the ventilation would be deactivated, the HEPA filters removed, and the ductwork sprayed with fixative.

3.1.4 Demolish G2 to Slab
Open air demolition of G2 would proceed in a series of steps:

- Controlled removal of the transite panels by asbestos-trained crews.
- Cripple steel columns and remove cross-bracing. Place steel plate on the G1 Wall facing G2.
- Demolish the steel structure and size reduce on the ground
- Demolish the slabs for the first floor and above and the hot cells' concrete walls
- Demolish the basement and tunnel walls, and excavate sub-slab soils as needed

3.1.5 Backfill G2 Footprint to Grade
The Decommissioning Plan anticipated using the G2 footprint as a staging area during the remediation of the rest of the SPRU facilities. After soil excavation was done and surveys and sampling verified the area met the clean-up criteria, a report would be submitted to DOE and NYSDEC documenting the

results and seeking approval for backfill. The Plan anticipated that the decision could be made to backfill at risk prior to formal approval in order to minimize safety concerns due to site conditions and to mitigate impacts from weather.

3.2 Building H2 and Tank Vaults

This area includes Building H2 and the tank vaults immediately to the east. Excavation work also included the piping and other utilities remaining from the prior removal of the H1 Cooling Tower to the north of H2 and removal of the H2 septic system.

A number of activities in the H2 Building would be similar to those undertaken for G2:

- Deactivate Remaining Utilities in H2
- Decontaminate H2 to the Extent Needed to Allow for Open-Air Demolition
- Decontaminate Tank Vaults to the Extent Needed to Allow for Open-Air Demolition
- Demolish H2 to Grade
- Excavate from West-to-East until Vault Walls are Reached
- Excavate Tank Vaults

Two activities unique to H2 relative to the G2 demolition were the clean-out of the tanks in the H2 Tank Vaults and the mitigation of potential impacts to the adjacent F Buildings during the actual removal of the vaults.

3.2.1 Cleanout of H2 Sludge Tanks

The seven tanks were each in their own vault 14 ft wide by 24 ft long, and 16 ft deep, surrounded by thick concrete walls. Each vault was covered with a series of 3 ft wide concrete T-bar sections, and the entire vault area was covered with approximately 10 ft deep soil to match the grade surrounding H2.

Access to the tanks would be achieved by removing the soil overburden. A large enclosure with HEPA-filtered ventilation would be erected over the vaults. Tank cleanout would be accomplished using a high-pressure, low-volume water stream to mobilize the sludge heel in the tanks, with a low-pressure rinse used to direct the mobilized sludge towards a diaphragm pump. Wastes from the tanks would be consolidated into one tank. A processing system would then be installed on that tank to allow for removal of the waste, mixing with solidification agent, and containerization. The containers would then be shipped for off-site disposal.

3.2.2 Support F4/F2/F3 Foundation

During the post-award planning process, a concern arose that the removal of the vaults could affect the stability of the adjacent F Buildings due to the depth of the tank vault excavation. The Decommissioning Plan identified the concern and indicated that options presented for DOE's consideration would include building a retaining wall, installing shoring, stabilizing the vertical slope face, or alternately, leaving the H2 vault tank walls in place to meet the OSHA requirements.

3.3 G2/H2 Tunnel

Piping runs with waste from KAPL laboratories and the G2 Building pass through this tunnel to the waste processing facilities in H2. The activities planned for the tunnel were similar to those for G2 and H2:

- Characterization to determine what piping and sumps needed to be removed prior to demolition and excavation.
- Removal of piping and sumps necessary to meet open air requirements
- Tunnel excavation

3.4 E1/G1 Tunnels

The tunnel system started in the Building E1 basement and continued through the basement areas of Buildings E1 and G1. The tunnels in G2, H2, and the connecting tunnel were addressed in those areas. The interceptors and sump in the Radioactive Materials Laboratory (RML) tunnel (also referred to as the E1/G1 tunnel) required additional attention in addition to the piping in the E1 South and G1 West tunnels. Entrance to all of the tunnels were by access hatches within the KAPL security area inside the respective buildings.

The original scope regarding the E1 and G1 Tunnels involved deactivating and removing piping and the interceptors followed by decontamination of the concrete surfaces. Based on the as-found conditions, physical configuration, and logistical considerations, the scope was modified to instead stabilize the asbestos and perform limited decontamination of the concrete and pipe surface. Fixative would then be applied to lockdown any residual loose contamination.

4 Initial Demolition Activities

Responsibility for G2 was transferred from Naval Reactors Laboratory Field Office to the DOE SPRU Field Office in November 2008, and for H2 and the remainder of the Upper Level area in April 2009. URS then undertook a series of mobilization and characterization activities in preparation for demolition of the SPRU nuclear facilities.

4.1 Mobilization

In order to facilitate access to the site and to provide office and storage space near the operations, URS installed a new access road to the Upper Level from the KAPL Lower Level Road and built out the west hillside to make room for trailers.

Access to the SPRU site was previously through the KAPL security area. In order to have access for workers without the complications of DOE security clearances or escorts, the KAPL security fence was moved to exclude the SPRU area. Installation of a new access road included removing concrete impediments, installing a new fence, relocating a power pole and associated cables, installing new security devices and cabling, erosion and sedimentation controls, traffic controls, and a stone-paved access road.

At the top of the hill, west of the G1 and G2 Buildings, the hillside was built out to provide space for office and equipment trailers. The built-out portion was removed and regraded during the site restoration after remedial activities were completed.

4.2 Pre-Demolition Characterization

Characterization of G2, H2, and the tunnels was carried out as set forth in the SPRU DP Characterization Plan, SPRU-DD-007. Characterization activities were intended to identify and quantify the radiological and chemical constituents in the various waste streams. The purpose of the Characterization Plan was to support determination of the following:

- The number of waste streams present;
- Estimated volumes of each waste stream;
- To provide quantitative information about each contaminant present to determine disposal options;

Figure 9 Excavation of H2 Vault Area. Looking South on November 23, 2009

- To determine final decontamination strategies;
- To identify general radiation and contamination levels for the purpose of providing personnel protective measures;
- To aid in the worker estimates for D&D planning efforts;
- To determine potential exposure pathways for workers, the public, and the environment;
- To aid in the planning of work identified in the Decommissioning Plan.

The investigations included asbestos and beryllium characterization as drivers for abatement activities.

4.3 Pre-Demolition Activities

Activities undertaken during the pre-demolition period fall into three main categories: preparing for H2 tank waste processing; preparing the interiors of the G2 and H2 Buildings; and work in the E1/G1 tunnels.

4.3.1 H2 Tank Vaults

In order to access the tank vaults, it was necessary to remove the soil cover and expose the concrete planks covering each vault. After the vault footprint was excavated in late 2009, an enclosure was constructed to provide a protected environment with filtered ventilation. Figure 9 shows the excavation to expose the top of the tank vaults and the tank vault access silos. The H2 Building is to the right in the photo. The completed “Big Top” enclosure is shown in Figure 10. On the left of the enclosure is the East Road and the KAPL F Buildings.

Water had collected in all the tank vaults. Some of the vaults had overflowed through the sumps into the H2 Tunnel. Preparation for processing the sludge wastes and ultimate demolition of the vaults included pumping out the water in the vaults. The water was collected in totes and subsequently shipped for off-site disposal.

Plumbing was set-up within the Big Top to consolidate the sludge into Tank 509E from the other six tanks. Samples of the consolidated sludge were collected on September 27, 2010 to support waste processing and disposal planning.

4.3.2 G2 and H2 Building Interior Preparation

In preparation for demolition of the buildings, activities in the two main SPRU buildings included asbestos abatement and removal of hazardous and universal wastes.

The work in the buildings also included isolating G2 from G1 and blocking up the G2/H2 tunnel to separate the buildings from each other. Sealing of the new wall in the crossover tunnel between G1 and G2 (Room 103) was completed on August 6, 2010.

At the end of the preparatory work, the ventilation systems were secured, the filters removed for disposal, and the fan units were “locked down” with fixative.

The interiors of the buildings were surveyed and fixative was applied in accordance with SPRU-RC-302 to limit potential emissions during demolition. Open air demolition of G2 started on August 12, 2010 with the separation of structural beams connecting the G1 and G2 Buildings. Inside work continued in H2 until open air demolition started on September 23, 2010.

4.3.3 E1/G1 Clean-out

Contamination surveys were conducted ahead of the start of pipe venting and draining in June, 2010. Work crews performed asbestos abatement and pipe removal in the E1 tunnels. Samples were collected from the E1 North interceptor on September 16, 2010. Work in the tunnels ceased as part of the shutdown after the H2 contamination event on September 29, 2010.

Figure 10 H2 Vault Enclosure ("Big Top") looking south - March 11, 2010

5 Contamination Event During H2 Demolition

5.1 Incident

By September 29, 2010, demolition of Building H2 had removed the roof structure, ventilation stack, and most of the exterior and interior walls above the ground level floor (332' elevation). On that day, demolition crews were removing and size reducing six evaporator system components that extended above and below the 332' elevation. As the crew broke for lunch a frisker alarmed and a radiological controls technician (RCT) was summoned for assistance. Personnel were directed out of the immediate area due to elevated background radiation readings in the area and conducted a frisk, finding contamination on both boots of each of the four equipment operators.

In response to the boot contamination event, further radiological surveys were conducted outside the demolition area and a review of air samplers surrounding the area was performed. Two perimeter air samples showed elevated readings. Work in the SPRU H2 area was discontinued pending further investigation. KAPL was notified of the contamination and they started extensive surveys outside the SPRU boundary. KAPL's surveys identified contamination on the grounds and some roofs near the SPRU site. Bioassays were subsequently performed on over 100 KAPL workers that had been in the vicinity at the time of the event or that assisted in radiological surveys or subsequent cleanup activities. All bioassay results were below the detection level.

The following day, September 30, 2010, in preparation for incoming Tropical Storm Nicole, the crew pushed debris into several piles on the H2 building slab and sprayed fixative on the piles and the evaporator components. Other preparation work was done to control storm water runoff, including the establishment of a temporary berm.

During September 30, 2010, and into October 1, 2010, the SPRU project experienced exceptionally heavy rains due to the tropical storm. The rainfall total of greater than 7 inches exceeded a 100-year rain event for the area. This extraordinary rainfall led to releases of contaminated water from the site. One release path was an overflow from a fractionation (frac) tank used to collect water from the H2 hillside drain sump. Samples of the remaining tank water were found to be above regulatory discharge limits. The frac tank had about 17,000 gallons of available capacity prior to the storm, relative to the previous maximum daily collection of approximately 4,000 gallons.

The second release path was from water from the H2 basement running out of the escape tunnel and through a leaking berm that had been constructed against the tunnel door. The water flowed out onto the hillside within a posted soil contamination area. Radioactivity in the water was approximately 100 times the discharge limit for the SPRU treatment system. No elevated counts were found outside the soil contamination area.

A separate release occurred several weeks later due to a failure of the system that collected contaminated water from the hillside drain sump. A rounds operator discovered that the sump was overflowing during a heavy rain storm. Electricians were called in and repaired the control panel within a few hours of discovery. It was estimated that approximately 630 gallons of water was released during that event.

5.2 Investigation and Report

Based on the estimated cost to remediate the accident and event circumstances, the Department of Energy appointed a Type B Accident Investigation Board to investigate the accident. The Board focused the investigation on the contamination event resulting from decontamination and demolition work that occurred at the SPRU H2 facility on or about September 29, 2010. A report was issued by the Board, *Type B Accident Investigation Report Radiological Contamination Event During Separations Process Research Unit Building H2 Demolition September 29, 2010* [DOE 2010]. That report contains details of the events and timeline of the incident, and delineates the conclusions of the Board regarding the circumstances that led up to the accident.

The Board identified the direct cause of the accident as the open air demolition of the evaporator system components. Two root causes were identified which they felt if eliminated would have prevented the uncontrolled spread of contamination.

1) The failures by [the contractor] to fully understand, characterize, and control the radiological hazard.
2) The failure by [the contractor] to implement a work control process that ensured facility conditions supported proceeding with the work.

Based on the conclusions regarding the actions leading up to the event, the Board made Judgments of Need, which are managerial controls and safety measures believed by the Board to be necessary to prevent or minimize the probability or severity of a recurrence of this type of accident. Some of these

Judgments of Need were related to the technical work, such as contamination control and the execution of the Radiation Protection Program. The majority of the Judgments were more programmatic in nature and focused on the need to enhance the work planning process, including improving the communication paths for employee feedback on work processes and safety concerns,

After the accident and in light of the Investigation Board's findings, SPRU demolition work was halted to allow for realignment of the work planning and control processes, including DOE oversight.

6 Incident Recovery Activities

6.1 Enclosures and Ventilation

Modifications to the contract in response to the Investigation Board's findings pushed a revised project approach to include doing a substantial amount of decontamination in enclosures with filtered ventilation to meet lowered emission levels prior to the open air demolition of the structures. Subsequent regulatory actions by USEPA led to requirements for obtaining construction approvals under 40 CFR 61, the National Emission Standards for Hazardous Air Pollutants (NESHAPs), for monitored ventilation.

The need for the air permits delayed construction until the approvals to construct were issued in November 2011. The G2 Building enclosure and ventilation system were commissioned in September 2012, with the H2 system being completed in February 2013. The H2 enclosure, shown being constructed in Figure 11, also enclosed the separate tent (visible on the right in the photo) that had been built for processing the H2 tank sludge. In addition to the building ventilation systems, a separate approval was obtained in August, 2011, from EPA for the operation of Portable Ventilation Units (PVUs), smaller capacity units that could be temporarily deployed for smaller areas.

Work activities in the buildings were limited during the construction of the enclosures and ventilation systems. Maintenance activities, including water management, and some characterization work continued. Major project activities resumed in March 2013.

Figure 11. Construction of the steel frame for the H2 enclosure

6.2 Building Characterization

As a basis for limiting releases from the open air demolition operations, the revised Task Order established that "the desired goal for airborne concentrations outside the DOE EM work area is normal background (within two statistical deviation units is considered background)." In order to support evaluation of the potential emissions and to assist in waste management, a characterization program was undertaken of the concrete, piping, and equipment throughout the cells, tunnels, tank vaults and general building areas, in accordance with SPRU-DD-007-A, *SPRU Disposition Project Characterization Plan Addendum*, and related sampling plans.

Over 300 characterization samples were collected, including concrete cores; coupons from piping, equipment, and cell liners; sediment and liquids from tanks and sumps; and smears from room surfaces and within components. Radiation surveys were also performed as part of the sample collections. Sampling was performed in accordance with SPRU sampling and analysis plans (SAPs) and included both onsite analysis in radioactive count rooms, as well as offsite analysis though DOE-approved and certified laboratories. Samples included analyses for both radioactive and hazardous constituents. The results were presented in reports for each building: *Data Summary for the G2 Building* [RSI 2015a] *and Data Summary for the H2 Building* [RSI 2015b].

6.3 Open Air Analysis

The revised Task Order imposed additional requirements for decontamination under the enclosures in order "to ensure demolition operations occur safely and do not impact the workers, KAPL operations, the public, or the environment." One new requirement established criteria for loose contamination alpha and beta-gamma levels at the start of open air demolition with two-steps. One limit was a level to be met after gross decontamination; the second was a lower set of lower limits that could be met by further decontamination or by applying fixative. Compliance with the contractual limits was to be documented by smears prior to starting open air demolition. The loose contamination criteria did not apply after initiating open air demolition.

The acceptable amount of fixed contamination remaining prior to open air demolition was to be determined by evaluating the potential suspension of radioactivity in air as a result of demolition operations. Regulations in 40 CFR 61 (NESHAPs) and the DOE Order 5400.5 establish dose limits for the off-site public and unmonitored workers, respectively. A requirement in the modified Task Order established that "The desired goal for airborne concentrations outside the DOE EM work area is normal background (within two statistical deviation units is considered background)." This criterion was referred to as the "Fence Line Goal". The analysis of potential impacts to show compliance with the regulations and contractual requirements was documented in three calculations: an estimate of the radiological inventory [SPRU 2015a]; an estimate of the dose to the Maximally Exposed Off-Site Individual (MEOSI) [SPRU 2015b]; and the fence line concentration [SPRU 2015c]. Satisfying the contractual goal of "background concentration" at the fence line met the DOE Order requirement for exposure of an unmonitored worker based on the low dose associated with the variation around the background airborne radioactivity.

The calculations of the potential dose to the MEOSI and the estimated fence line concentrations demonstrated that releases during the demolition of the buildings would not exceed the regulatory requirements or contractual goals.

6.3.1 Demolition Radiological Inventory

A calculation of the SPRU radiological inventory was developed in EEC-15-003, Open Air Demolition Radionuclide Inventory [SPRU 2015a] using the information developed in the building characterization programs [RSI 2015a], [RSI 2015b]. The inventory was developed for different media such as concrete, piping, and the steel plate liners in the cells. Conservative assumptions such as censoring out non-detects or using the maximum detected concentration for specific nuclides in a given medium were used to develop a bounding estimate of the overall inventory. Breaking down the inventory by medium allows the calculation of emissions to be performed using appropriate release factors for different media, such as crushing concrete versus cutting pipe or metal liners. The inventory calculation identified some areas or materials that had sufficiently high contamination such that they would require removal or decontamination under the enclosure.

6.3.2 MEOSI Dose Calculation

The exposure limit that the MEOSI dose was compared to is 0.1 mrem per year, corresponding to the exemption level below which a separate EPA approval is not required. The analysis for estimating the dose to the MEOSI followed the 40 CFR 61 Appendix D methods which are approved by the US Environmental Protection Agency (EPA) for use in doing exemption calculations. The evaluation in *Open Air Demolition Appendix D Emission Estimate*, EEC-15-004 Rev 3 [SPRU 2015b], showed that the MEOSI would receive 0.07 mrem/yr. Because the calculated dose was less than the 0.1 mrem/yr threshold in 40 CFR 61.96, the open air demolition activities were exempt from the requirement to submit an application for approval or notification of startup for the modification of the SPRU facilities in moving to open air demolition.

6.3.3 Fence Line Concentration Analysis

The fence line goal was to be below the background gross alpha and gross beta-gamma concentrations as determined by weekly KAPL measurements at a series of locations around the SPRU project area. The statistical analysis of the KAPL historical samples established the target levels as 2.6E-14 µCi/ml gross beta-gamma and 2.8E-15 µCi/ml gross alpha, based on the mean plus two standard deviations. The calculation of the concentrations at the project boundary was documented in *Open Air Demolition Fence-line Concentrations*, SPRU-EEC-15-005 Rev 3 [SPRU 2015c].

The fence line calculation used the same inventory as the MEOSI dose analysis described above. As with the inventory calculation, the analysis used bounding assumptions to ensure that the impacts from the demolition activities would satisfy the Task Order goal. The two most significant assumptions in that regard were to take no credit for any emission mitigation techniques and to average the emissions over the operating time frame (50 hours per week) versus the full week sampling period of 168 hours. Using these assumptions resulted in an average estimated gross beta-gamma concentration of 1.67E-14 µCi/ml and an average gross alpha of 1.43E-15 µCi/ml. These results were 64% and 51% of the respective target goals.

Based on the characterization effort and the open air analysis, the buildings would meet the target inventory after decontamination of the designated concrete spots and removal of the equipment and piping specified in the inventory calculation. While the removable contamination was an insignificant contributor to the potential emissions, additional decontamination in the buildings was driven by the obligation to meet the residual loose contamination contractual limits.

7 Resumed Demolition and Remediation Activities

After completion of the enclosures and commissioning of the HEPA-filtered ventilation systems were completed in February 2013, the project efforts turned to the processing of the tank sludge wastes and the preparation of the building interiors for open air demolition. Planning for the sludge processing up until mid-2013 was based on the expectation that the sludge waste would be shipped to the DOE waste facility at the Nevada National Security Site (NNSS, formerly referred to as the Nevada Test Site). Due to political circumstances that arose at that time, the plan shifted to send the treated waste to the WCS facility. Table 1 shows the time frame of activities after the building enclosures were in place and the ventilation systems were activated.

Table 1. Post-Enclosure D&D Activity Schedule

ACTIVITY	TIME FRAME
Sludge Processing	September 2013 – February 2014
G2 Decommissioning under enclosure	March 2013 – April 2016
H2 decommissioning under enclosure	June 2014 – November 2017
G2 Open Air demolition	June 2016 – April 2017
H2 Open Air demolition	November 2017 – July 2018
E1/G1 Tunnel Decontamination	February 2018 - June 2018
Site Restoration	October 2018 – July 2019

7.1 H2 Tank Waste Processing

Wastes in the H2 tanks had been consolidated into the 509E tank prior to the contamination accident. The resulting 9600 gallons of waste contained approximately 38 curies (Ci) of Cs-137, 11 Ci Sr-90, and 5 Ci of Pu-239, among numerous other radionuclides. The waste had to be containerized and solidified for shipment to the disposal facility while accounting for the high radiation level.

7.1.1 Characterization and Waste Form

Sampling was performed of the waste in each individual tank prior to consolidation for planning purposes. Several samples were collected from the combined material in Tank 509E for both radiological and chemical constituents. Three samples were analyzed for hazardous constituents, and all three passed the Toxicity Characteristic Leaching Procedure (TCLP). Based on the TCLP results, the tank sludge was determined to not be RCRA hazardous waste.

Radiological analysis of the consolidated sludge showed that the Cs-137 concentration was about 1.2E7 pCi/g on a dry weight basis, or about 500,000 pCi/g in the as-found sludge with 95.6% moisture. The transuranic concentration on a wet basis was about 75 nCi/g, which was below the TRU waste limit of 100 nCi/g. This meant that the waste could be disposed of as low-level waste. The high radiation level associated with the waste meant that the liners holding the solidified material would need to provide some significant shielding in order to allow shipping without additional packaging to meet the over-the-road dose limits.

With the high concentration of alpha emitters and the mixture of chemical wastes, it was uncertain what solidification mix would be appropriate to ensure proper setting and strength. There was also some concern that using a mixture of all or nearly all Portland Cement could result in a high temperature during curing and possibly lead to cracking of the waste form. A treatability study was performed to determine the right agent and determine what temperatures might be seen during the treatment, with a goal of obtaining sufficient curing within 24 hours to meet operational considerations. The study was performed by the Vitreous State Laboratory at The Catholic University of America in Washington, DC. [VSL-13R3150-1, May 2013]. The recommended recipe was to use a water-to-binder (w/b) ratio of 45%, with a binder mix of:

- 40 wt% Blast Furnace Slag
- 40 wt% low calcium fly ash
- 20 wt% Ordinary Portland Cement
- 2.5 wt% NaOH (based on dry mix mass)

The sodium hydroxide was an option to be added to the 40-40-20 mix based on observation of the result of the first actual mixes at full scale. If setting did not occur in the desired 24 hour time frame, then the NaOH accelerant could be added to the mix for future liners.

7.1.2 Sludge Processing Preparation

In recognition of the large amount of radioactivity in the sludge and the associated personnel and environmental risks, the Sludge Retrieval and Solidification System (SRSS) received particular attention with regard to assembly and procedural development. System testing was conducted offsite prior to equipment movement to SPRU. This allowed the crew to practice assembly away from the radiation hazards and ensured that the equipment would function as designed when installed at SPRU. It also allowed SPRU procedure writers and quality assurance representatives to observe the testing and refine the operating procedures because they saw the equipment working first hand. Testing offsite also avoided impacting SPRU daily operations. The system was designed for the parts of the processing to occur in separate “skids” that could be easily installed with a well-known foot print once delivered to SPRU. The mixing skid and the sludge skid are shown in Figure 12. As seen in the close-up of the mixing skid in Figure 13, each skid was enclosed within booth-like confinements to reduce the risk of contamination spread if a leak or hose break were to occur. There were also several containment tents assembled around groups of skis to provide additional protection during operation but also during the post-processing disassembly.

As the preparations were being completed, a Management Self-Assessment (MSA) was performed to determine that the sludge processing operation was adequately planned and the hazards properly accounted for. The objectives of the MSA were to evaluate specific parts of the preparation as follows:

- SSC-1: the adequacy of key structures, systems and components has been shown to support the safe performance of sludge processing operations at SPRU.
- COMP- 1: Sufficient numbers of qualified line and support personnel are available to effectively and safely conduct sludge retrieval and solidification activities.
- RCP-1: A radiological protection program is effectively implemented for sludge processing
- OPS-1: Sludge processing procedures are issued, adequate, correct, and useable and contain the required limits and controls to support safe and effective field operations.
- AOP-1: Potential off-normal operations are well defined with approved procedures established that define response actions and communications (internal and with KAPL).
- HAZ-1: Sludge processing operations procedures and work documents have the necessary controls to mitigate the physical and industrial hygiene hazards that are inherent in this work.
- QA-1: Sludge operating procedures incorporate quality control actions and acceptance criteria for parameters affecting the acceptability of the final product for disposal.
- CON-1: Conformance to the requirements from the Task Order (Mod 035), Section C.10.2, Tank Vault Sludge Removal Operations, will be reviewed during the MSA.

Each of the objectives was broken down into multiple Lines of Inquiry. Included in the LOIs was the need to verify the training of the operations staff, that all plans and procedures had been walked through, and that start-up testing of the entire system had been completed. The MSA team also observed the start of hot operations, and issued their report approving operations in August 2013.

7.1.3 Sludge Processing Operations

The sludge processing operations were performed within the Sludge Processing Tent (SPT, also called the “Big Top”), constructed over the tank farm and within the overall H2 enclosure. The HEPA-filtered ventilation from the SPT discharged into the overall H2 ventilation envelope, which then went through additional HEPA filtering before discharge to the environment.

The processing system was designed to retrieve the waste from the 509E tank and transfer it to a container where the sludge could be mixed with the solidification agent, allowed to cure, and then sealed for shipment. In order to obtain relatively consistent batches as the sludge was pumped from the tank, a mixing system was installed to agitate and recirculate the waste, and thus resuspend the solids that would settle out. The sludge was then pumped to a day tank from which it could be sampled to ensure that the batch was within the target limits from a radiological perspective. If it exceeded the limits, the waste could be returned to Tank 509E for further mixing. Otherwise, the waste would be moved to a solidification liner, which had a mixing blade pre-installed. After blending with the dry mix, the blade would be detached and left in the liner. The Solidification Liner functioned as the shipping container for transport of the solidified waste sludge to the disposal facility. This liner was designed to meet all required DOT (49 CFR), Class 7 waste criteria for transport and disposal. Figure 14 shows a filled liner being placed down for surveying prior to shipment. A total of 14 shipments were made, with two liners per flatbed (Figure 15).

Sludge waste processing began in August 2013. The final solidified tank sludge shipment occurred in February 2014.

General Subject	Assoc Doc	Pic ID	Date	Specific Location	Pic Description	Photographer	Comment
SRSS MSA equipment installation photographs 7.01.13	N/A	SRSSMSA-009	07/01/13	SPT	SPT Retrieval enclosure looking south showing 509E tank vent HEPA B-230, mixing skid SK-308 and sludge skid SK-301	Dean Powell	N/A

Figure 12. SRSS skids installed within containment enclosure inside the SPT

General Subject	Assoc Doc	Pic ID	Date	Specific Location	Pic Description	Photographer	Comment
SRSS MSA equipment installation photographs 7.01.13	N/A	SRSSMSA-011	07/01/13	SPT	SPT Retrieval enclosure looking east showing mixing skid SK-308	Dean Powell	N/A

Figure 13. Mixing skid for the Sludge Retrieval and Solidification System

Figure 14. Loaded sludge liner being placed for survey and inspection

Figure 15. Flatbed shipment of two tank sludge liners

7.2 Building Decontamination

Removal of equipment and piping progressed in the G2 and H2 Buildings as the tank waste processing proceeded. Work in the enclosures continued until DOE approved the open air demolition for each building in turn.

Water had accumulated in the basement of both buildings and needed to be managed while the buildings were exposed to the elements. After the enclosures were completed, precipitation no longer entered the buildings and the accumulated water could be pumped into storage tanks and ultimately shipped for offsite disposal.

7.2.1 G2 Building

The features that most significantly affected the planning and execution of the removal of the G2 Building were the process cells and the remaining equipment and piping. Though nominally flushed at the end of the SPRU research and development effort in 1953, there remained substantial contamination and high radiation levels, exceeding 1 R/hr in some locations.

7.2.1.1 Removal of Piping and Equipment

In order to meet the DOE requirements for loose contamination on the walls and in any remaining equipment or piping, it was deemed necessary to remove the process equipment and the majority of the piping from the cells and scabble the walls down to the required levels. As an example, Figure 16 shows a schematic of the equipment that was present in G2 Cell 1, the room with the highest dose rates. Figure 17 is a photograph of the cell in May 2014, prior to the start of equipment removal. The red coating is a contamination fixative applied during the 2010 decommissioning activities. Some of the piping that ran from G2 over to H2 in the basement pipe tunnels is shown in Figure 18.

Preparation of the building for open air demolition involved equipment and piping removal from the five cells and the Lower and Upper Sample Aisles. Tanks and large pieces of equipment were removed intact where possible. Four vessels were left in place due to being in inaccessible locations and not being able to be rigged prior to demolition. The sumps in each cell were cleaned out and decontaminated, but the steel liners on the floors and sumps themselves were left in place. Piping embedded in the 5’ thick concrete walls between cells and the sample aisles was left for removal during building demolition, but were filled with paint or fixative and foamed at the ends in order to mitigate releases during demolition.

Contamination control included using non-permitted PVUs to ventilate localized work areas such as the process cells. These PVUs discharged to the interior of the G2 enclosure and were not part of the NESHAPs-monitored emissions. The overall building ventilation was what was monitored in accord with the NESHAPs requirements.

Pumping and disposing of water that accumulated in the lower levels of the G2 basement continued throughout the decommissioning effort.

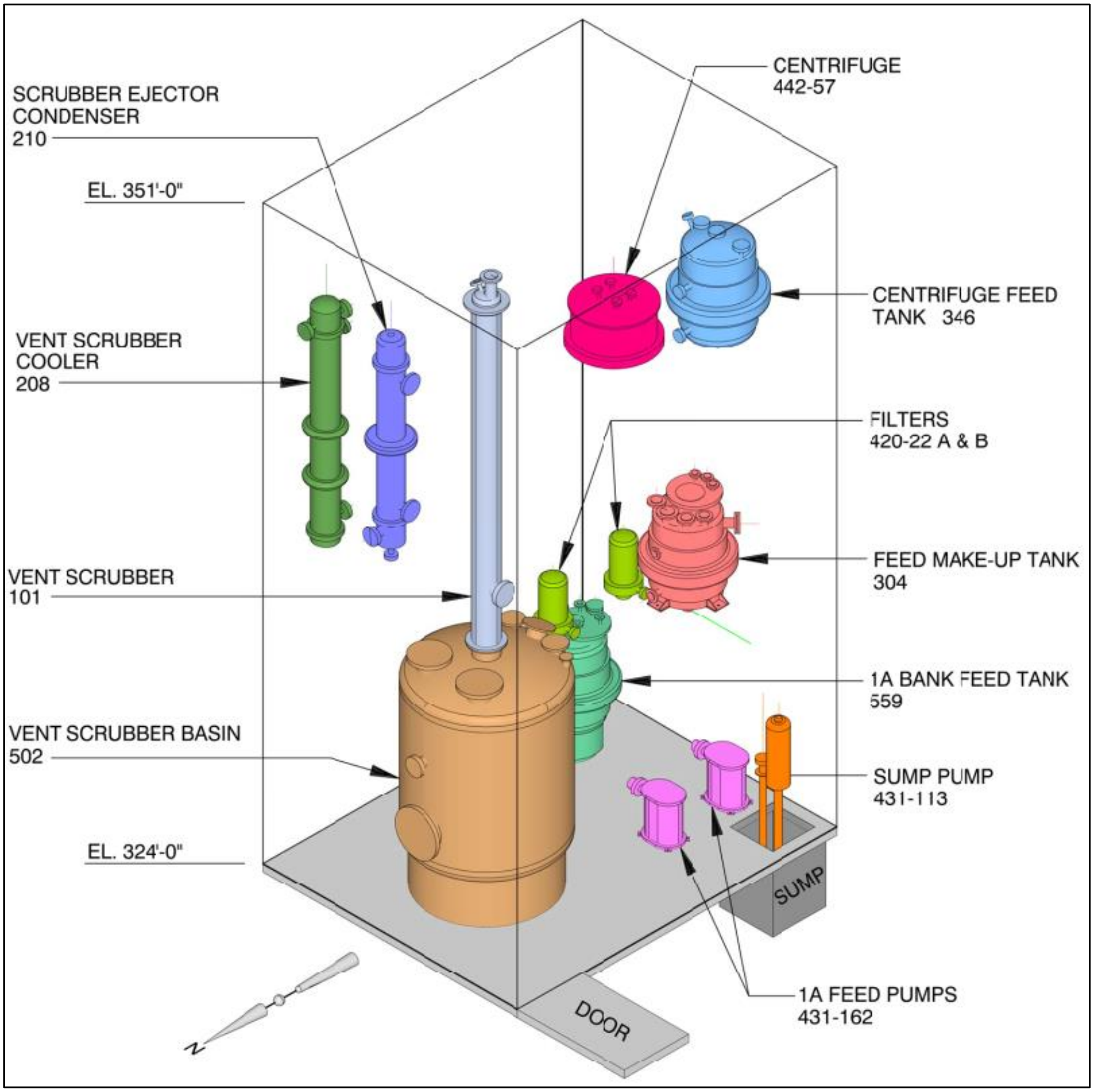


Figure 16. Schematic of equipment in G2 Cell 1

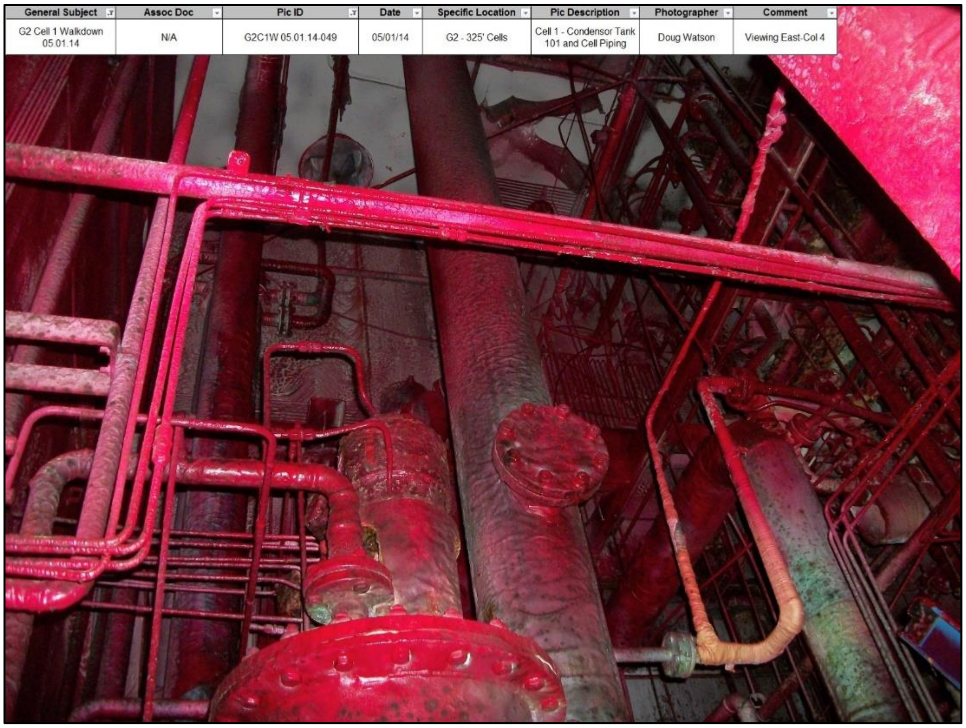


Figure 17. Process equipment and piping in G2 Cell 1

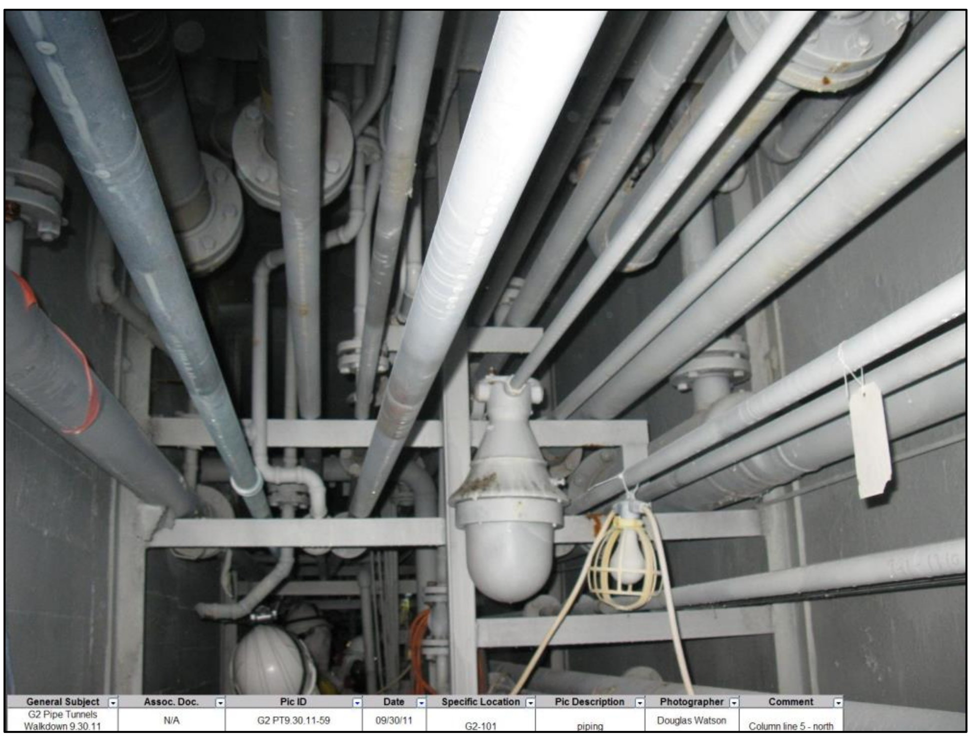


Figure 18. Piping in G2 Pipe tunnel (September 2011)

7.2.1.2 Decontamination to Open Air Level

After equipment and piping was removed from each area, walls were scraped or scabbled to decontaminate down to the loose limits. Demolition activities conducted under the enclosure were limited to hot spots and those areas that could not be easily decontaminated to meet open air criteria.

As removal of the cell contents progressed, the surfaces were decontaminated and then surveyed and sampled to document that they were consistent with the residual criteria developed in the open air analysis. The decontaminated walls in G2 Cell 1 can be seen in Figure 19 and compared to the starting condition shown in Figure 17. The remaining radiological inventory was calculated for each room and compared against the expected inventory if that area had been at the open air-based concentrations. DOE and their verification contractor, the Oak Ridge Institute for Science and Education (ORISE), required that each of the 32 areas in the G2 Building be below the portion of the open air inventory attributable to that area. Substantial effort was expended in decontamination and multiple surveys to achieve those levels, and the final conditions were documented in a separate report for each area. The post-decontamination characterization of the G2 Building showed that the total remaining radiological inventory was less than 20% of the nominal open-air limit. Under DOE direction, the characterization results and residual inventory calculation were subjected to independent verification by ORISE prior to DOE's approval for open air demolition.

DOE granted approval for open air demolition of the G2 Building on June 28, 2016.

7.2.1.3 Evaluation of Harmonic Delamination

The G2 Building layout did not allow for substantial demolition of the concrete within the enclosure. This was due to a combination of structural limitations and logistical difficulties in getting the necessary equipment to inaccessible locations. In order to reduce the duration and amount of concrete hammering to remove the extensive 5 ft thick walls around the cells, a plan was developed to use explosives to harmonically delaminate the concrete, embedded pipes, and rebar. Instead of "dropping" the building and structure, the approach was to soften much of the concrete so that it could be removed by scooping rather than hammering. Evaluation of the shocks to nearby buildings and equipment showed that the impacts would be within acceptable levels, and a safety plan for the use of explosives was developed. However, DOE and KAPL eventually ruled out the harmonic delamination approach due to concerns about dust generation and air emissions from the detonation.

Figure 19. Scabbled walls in empty G2 Cell 1

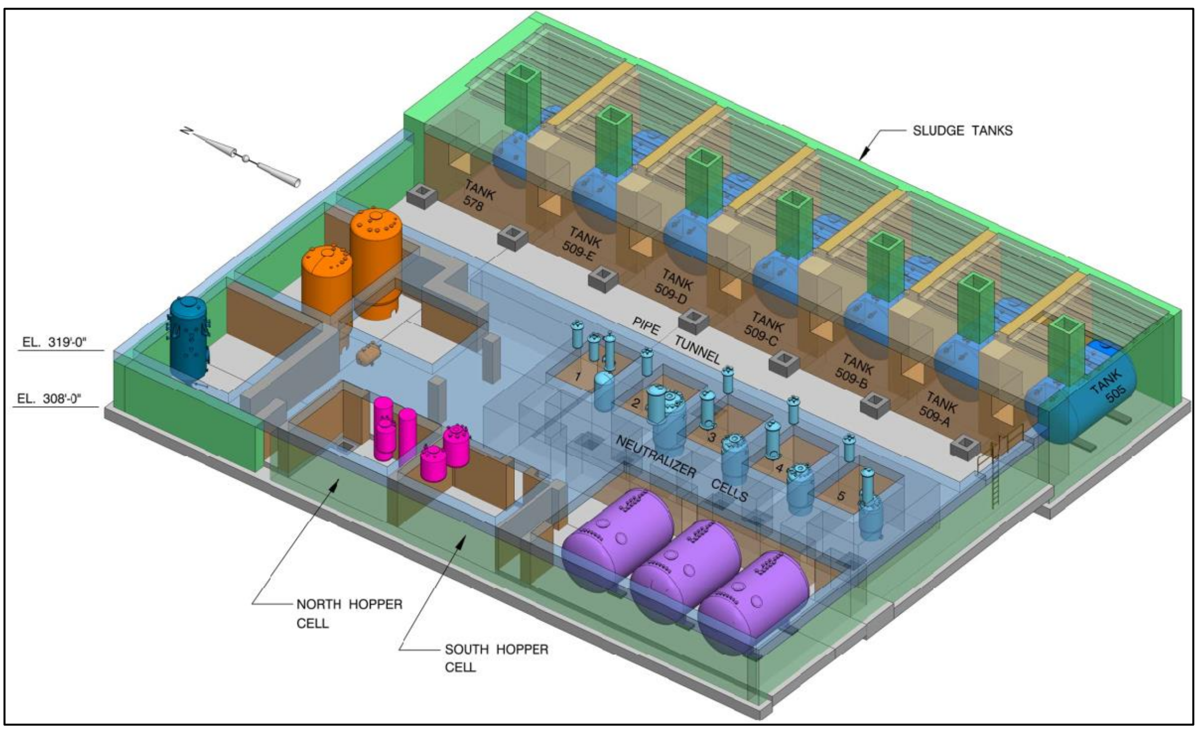


Figure 20. Building H2 schematic showing major equipment

7.2.2 H2 Building

The requirements to prepare the H2 Building for open air demolition were similar to that for G2 in that there were chemical processing cells with highly radioactive equipment and extensive contamination in the concrete. The effort in H2 posed additional challenges to deal with the seven large sludge waste tanks and the deep vaults they were located within, as well as the three large evaporator waste tanks in the southeast corner of the basement. The H2 Building had been demolished down to grade level (332' level) prior to the radiological incident in September 2010, so a new steel frame had to be constructed in order to enclose the work on the H2 Building and Tank Farm. The tent containing the tank sludge processing effort was within the new enclosure.

While sludge processing was underway in the Tank Farm, cleanup work in the H2 Building was less intensive than in G2 to avoid impacting the sludge processing activities. The work level increased after the sludge processing was complete in February 2014 but the G2 effort was prioritized in order to open that footprint for when the H2 open air demolition would be occurring. The crews working the piping and equipment removal in G2 transitioned to the H2 Building while the characterization team verified the open-air readiness of G2.

7.2.2.1 Decision to do Demolition Within Enclosure

Removal of the piping and equipment in the H2 Tunnel and the neutralizer cells was accomplished using the same methods as in G2. In H2, though, the level of effort to decontaminate the remaining structure to open air conditions could be weighed against the option to demolish most of the interior walls and floors because the H2 steel structure was supported by the below-grade outside walls and not by the original building, as was the case with G2. In addition, the H2 building had a generally more open layout which would allow access with larger equipment to do the demolition. It was recognized that it would be less efficient to do the demolition within the enclosure under controlled ventilation due to smaller machines and impacts from exhaust fumes. However, given the recent experience with G2 and the time and effort that would be needed to decontaminate the H2 interior surfaces to meet DOE's requirements, it was decided that demolition would be performed under the enclosure to the extent possible without compromising the structural support of the enclosure. This would minimize the amount of concrete surface that needed to be decontaminated to open air levels.

The thick concrete walls around the H2 neutralizer cells were similar to the process cells in G2, as seen in Figure 20. In H2, however, the tank vaults had much more thick concrete than existed in G2. An 8' thick concrete wall ran the length of the building, approximately 130 feet, to separate the H2 Tunnel from the vaults, which were separated from each other by 4' thick walls. Each vault was 14' wide by 24'long, and 18' deep. They were topped with T-shaped concrete slabs 3' wide, 2' thick, and 16' long, which rested on ledges formed on the top of the partition walls.

7.2.2.2 Sludge Tank Removal

Prior to the start of the major demolition, the empty sludge tanks had to be removed and shipped for offsite disposal. The "Big Top" tent covering the vaults and the sludge processing equipment was removed to clear the 322' elevation. To allow access to the vaults from above, the 16' x 3' planks were individually removed by a crane staged on the H2 Tunnel roof. Due to the high level of residual radioactivity in the tanks, special shipping containers were designed and constructed to allow each tank to be shipped in one piece and meet the over the road radiation limits. The shipments went as overweight and oversize to the Alaron facility in Pennsylvania where the tanks were segmented and then transshipped to the Waste Control Specialist disposal facility in Texas. Figure 21 shows Tank 509A being lifted and loaded into the custom-built shipping container. Each tank was painted to lock down any surface contamination to mitigate risks of cross contamination during the loading process. The oversize “Yellow Bird” shipping container is shown leaving the site past G2 in Figure 22.

7.2.2.3 H2 Demolition Within Enclosure

The KAPL F Buildings were located less than 20 feet east of the H2 Tank Vaults, and the bottom of the vault slabs (302’) were much deeper than the F Building foundation slabs (325’). This caused concern for potentially impacting the structural integrity by removing the supporting soil near the F Building foundations. Consideration was given to leaving some or all of the tank vaults in place to continue to provide the necessary support. However, sampling of the concrete in the vault walls and floor showed that it could not meet the DOE clean-up criteria. Based on that characterization it was decided that the vaults would be removed along with the rest of H2 and a sheet pile wall would be installed to support the F Buildings prior to the vaults’ demolition.

The amount of demolition that could be performed inside the H2 enclosure was limited by two primary concerns. One was the need to maintain the structural support for the F Buildings being provided by the eastern wall of the tank farm. The other structural limitation was that the enclosure was anchored to the outside wall of the H2 Building on the south, west, and north sides, and to the external tank farm wall on the east. The demolition plan required leaving some of each of the partition walls in the vaults to serve as buttresses for east wall. Similarly, portions of the interior walls were left in place along each of the other outside walls to support the walls and the enclosure steel.

After removal of the contaminated piping and equipment, the interior demolition was accomplished using hydraulic hammers to take down the walls and floors, as shown in Figure 23 for the demolition of the 8’ thick tunnel wall and the partition walls between tank vaults. After the concrete pieces were size reduced, the debris was loaded into intermodals and the containers closed prior to being taken out of the enclosure and staged at the Lower Level Rail Bed (LLRB) for shipment to the disposal facility. The substantial amount of demolition within the enclosure allowed for an alternate approach to disposition of three 10,000 gallon tanks in the southwest corner of the basement under the 332’ floor. When the demolition had created sufficient access and space to allow the tanks to be dragged from their location into the open area, each tank was cut up for placement in intermodal disposal containers. This was much less expensive than shipping them for segmentation like the same-size tanks from the vaults. Figure 24 and Figure 25 show the interior of the H2 at the completion of the inside demolition with the building ready for open air.

7.2.2.4 Decontamination to Open Air Criteria

After the gross demolition was completed to the extent allowed by the structural analyses the remaining surfaces were decontaminated to meet the removable contamination levels. This included removing the dust that had accumulated on the enclosure’s steel structure during the demolition activities. Concrete sampling was also conducted to verify that the residual fixed contamination satisfied the NESHAPs and Fence Line requirements. Areas in the G2/H2 Tunnel and Tank Vault 578 (northernmost) had higher contamination levels than the task order limits due to structural and access limitations, but the overall remaining levels were well below the calculated allowance. As was done with the G2 Building, verification that the decontamination and demolition within the enclosure had achieved the designated inventory was verified by sampling and survey prior to removal of the building enclosures and open air demolition. ORISE again provided DOE with independent verification of the contamination status.

DOE granted approval for open air demolition of the H2 Building and H2/G2 Tunnel on October 12, 2017.

Figure 21. Tank 509A being loaded into custom shipping container

General Subject	Assoc Doc	Pic ID	Date	Specific Location	Pic Description	Photographer	Comment
H2 Tank 509B in Shipping Container on Truck 02.04.15	N/A	H2T509BSCT 02.04.15-002	02/04/15	SPRU Site near G2 Building	H2 Tank 509B is in Shipping Container on Truck	Unknown	N/A

Figure 22. Shipping Tank 509A in custom oversize container

Figure 23. Demolition of H2 tank vaults under enclosure

Figure 24. West side of H2 basement after completion of "inside" demolition

Figure 25. H2 tank vaults ready for open air demolition

7.3 Open Air Demolition

7.3.1 G2 Demolition

Open air demolition of the G2 Building began in June, 2016, after DOE concurrence that the interior met the open air criteria. The ventilation system was shut down and the electrical power was disconnected. After verification that all utilities had been disconnected and that the G2 Building was “cold and dark”, the HEPA filters were bagged out and the interior of the ventilation duct work was covered in fixative to lockdown the surface contamination.

In order to create some working area within the G2 footprint, physical demolition of the building started with the autoclave area in the northeast corner of the building. Work then moved to the steel structure on the west side, which exposed the concrete cells. The eastern portions of the building and enclosure were left standing while demolishing the cells, acting as a windbreak to mitigate dispersion towards the eastern site boundary with the KAPL site by the prevailing west wind. After the cells were removed down to the basement level, as shown in Figure 26, the remainder of the building structure was demolished, followed by the G2 Tunnel. Approximately 80% of the basement slab and walls were removed, leaving the northwest corner in place for removal later along with the G2/H2 pipe tunnel. This sequencing was to avoid impacting the adjacent VOC Area of Concern (AOC) and to allow continued use of the road that was necessary for bringing empty waste intermodals into H2 and taking out the loaded containers. The concrete that was temporarily left in place would be removed along with the H2/G2 Tunnel at the end of the H2 demolition and excavation work.

Demolition of the G2 structure and concrete was performed primarily using processors and hydraulic hammers, respectively. Dust suppression controls involved water cannons and misters as seen in Figure 27 during the demolition of the west side of G2. A berm around the G2 area was used to contain the dust control water and precipitation. Water that collected in the basement and subsequent excavation was collected in frac tanks for ultimate shipment to an off-site disposal facility. The demolition debris – steel beams, concrete, and cell floor liners - was piled and size reduced on the G2 footprint, and loaded into intermodal waste containers. The intermodals were then moved to the LLRB and staged for offsite disposal.

Following the removal of the building debris and clean-up of the soil in the building footprint, sampling and radiation surveys were performed in accordance with the MARSSIM Final Status Survey Plan for the G2 area to demonstrate that the area met the radiological cleanup criteria. Separate chemical sampling was performed following the *RCRA Interim Corrective Measure Work Plan G2 VOC Area of Concern (AOC-008)*. The G2 area was backfilled to meet the required compaction specification (>98%) after the radiological results were accepted by DOE and the chemical results accepted by NYSDEC.

General Subject	Assoc Doc	Pic ID	Date	Specific Location	Pic Description	Photographer	Comment
G2 Open Air Demolition Area 5 Progress 11.02.2016	TYP1-671	G2OADA5P 11.02.2016 -004	11/2/2016	G2	G2 Demolition Progress	Deschamps, Robert	N/A

Figure 26. View of the G2 basement after removal of the G2 cells

General Subject	Assoc Doc	Pic ID	Date	Specific Location	Pic Description	Photographer	Comment
G2 Open Air Demolition Area 3 West Annex Progress 08.08.2016	TYP1-671	G2OADA3WAP 08.08.2016-012	8/8/2016	G2	Demolition Progress West Annex	Deschamps, Robert	N/A

Figure 27. Open air demolition of the west side of G2 using mister for dust suppression

7.3.2 Demolition of H2 Building and H2/G2 Tunnel

As with the G2 Building, the open air demolition of H2 started with the shutdown and removal of the ventilation system. After the enclosure fabric was cut down from the framing, shears were used to cripple and bring down the steel structure starting at the south end (Figure 28). The beams were then size reduced to fit into the intermodals for disposal.

General Subject	Assoc Doc	Pic ID	Date	Specific Location	Pic Description	Photographer	Comment
H2 Open Air Demolition 10.27.2017	TYP1-672	H2OAD 10.27.2017- 001	10/27/2017	H2	Steel Removal	Powell, Dean	N/A

Figure 28. Demolition of H2 enclosure steel frame

Removal of the western half of the H2 basement and the H2 emergency tunnel was accomplished during the installation of the sheet pile wall. After the sheet pile wall was completed the tank vault wall could be removed without impacting the F Building structure. Demolition work then progressed from the H2 basement to the removal of the G2/H2 Tunnel and then to the remaining part of the G2 Building that had been left in place to allow for continued use of the adjacent road and avoid intruding into the VOC AOC.

The bottom of the H2 basement slab was over 30’ below the surrounding grade level. To safely remove the concrete walls and floors required a substantial layback in the adjacent soil, some of which was not contaminated. For those areas where soil was expected to meet the geotechnical and contaminant reuse criteria, the excavated layback material was sampled and surveyed while being stockpiled. Laboratory analyses were used to verify the acceptability of the material, which was ultimately used as fill elsewhere on site.

The H2 Ventilation Stack Pad was located on the west side of the H2 Building, but was outside the building and was expected not be contaminated. Samples and surveys of the pad after it had been exposed during the H2 excavation showed that the concrete was clean. DOE approved leaving the pad in place.

While the G2 footprint was undergoing the final stages of clean-up and excavation, confirmation surveys and sampling were undertaken in the H2 excavation.

The *Interim Corrective Measures (ICM) Work Plan for the Upper Level SWMUs* (SPRU-ENV-020) covered the remediation and sampling for the H2 Tank Farm (SWMU-031), H2 Processing Facility (SWMU-030), G2/H2 Tunnel (SWMU-057), and the soil at SPRU Fractionation Tanks 2 (SWMU-082). NYSDEC approved backfilling the area after the results were submitted in the *Preliminary Data Report for the SPRU Upper Level SWMUs* (SPRU-EEC-18-003). The remaining part of G2 was cleared with NYSDEC with submittal of *Preliminary Data Report G2 Area of Concern (AOC-008) Phase 2* (SPRU-EEC-18-004).

Radiological surveys and sampling were performed in accordance with the MARSSIM Final Status Survey Plans over several survey units covering the H2, G2, and Tunnel footprints. DOE approved backfill of the G2 and Tunnel areas on October 12, 2018. They approved backfill of H2 and the sump area on the hillside on October 24, 2018.

Based on the geography of the site, the backfilling started near the Upper Level access gate with the south end of the G2 area and moved north to fill in the Tunnel and then the H2 excavation. Site restoration activities are discussed in greater detail in Section 0.

7.4 E1/G1 Tunnel Decontamination

The G1 tunnels were physically isolated from the G2 Building by erection of walls in the Crossover Tunnel (Room 103). This separated them from the general SPRU work area and made them only accessible through the KAPL restricted area. Work in the E1 and G1 tunnels were therefore separate from the demolition of the G2 and H2 Buildings. The layout of the tunnels is shown in Figure 29.

The tunnels are pipe runs with walls, ceilings, and foundations that are at least 1 foot thick reinforced concrete. In E1 and G1, a pair of pipe tunnels are separated by a tunnel-aisle walkway, also referred to as a corridor, to allow personnel access. Waste and process piping within the tunnels is mounted along the walls or suspended from ceiling supports.

While the piping and equipment in the tunnels in the building basements were no longer active at the start of the SPRU project, KAPL work was ongoing in the floors above. This limited the ability to disturb the plumbing and physical structure, or to modify the ventilation systems. Based on the available characterization data, the decommissioning scope was modified so that the E1 interceptor system and piping would be left in place, and chemistry laboratory pipes and drain traps in E1 and G1 would be left intact and the outer surfaces of the piping would be radiologically decontaminated. In addition, because adequate ventilation systems to meet regulatory requirements were not present or able to be readily installed, removal of friable asbestos insulation was not possible. As much as feasible to do without disturbing the asbestos, pipes with friable insulation were to be HEPA vacuumed to remove potentially radioactive and beryllium containing dust, and or wet wiped to meet the radioactive decontamination requirements.

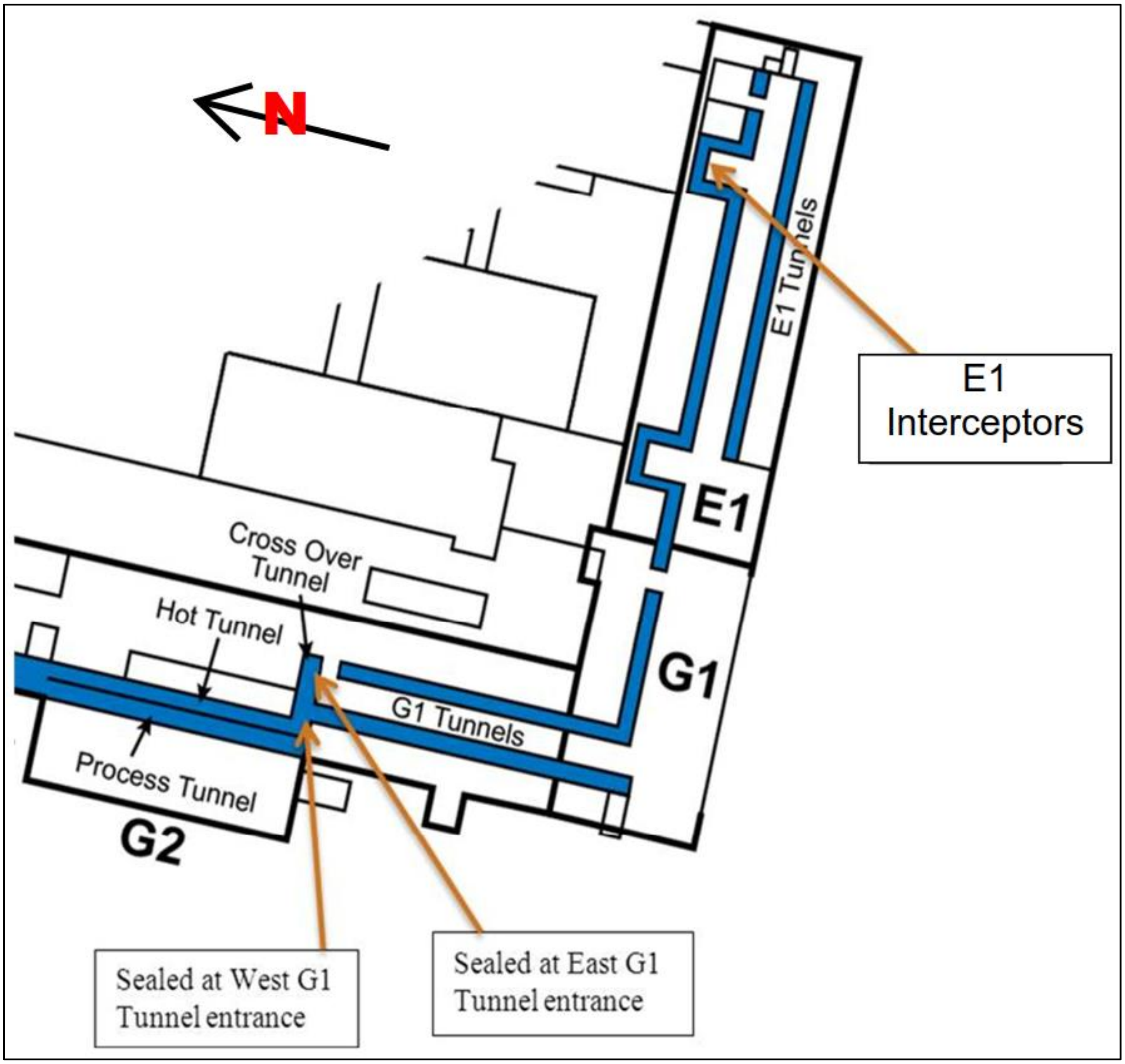


Figure 29. Tunnel layout in Buildings E1 and G1

Work in the E1/G1 Tunnels under the revised scope resumed in February 2018. Workers in the tunnels wore respirators and the tunnels were ventilated using PVUs that discharged outside the buildings. The initial efforts at that time were directed at removing the debris and waste bags that had been left in the tunnels when work was shut down in 2010. The crews then proceeded to clean up the tunnels, including remediating loose asbestos and decontaminating the tunnel surfaces, as shown in before and after pictures in Figure 30 and Figure 31. In particular, the crews carried out three specific activities:

- Removal of the interceptor in the G1 West Tunnel
- Cleaned out the sump in the E1 North Tunnel
- Sealed the interceptors in the E1 North Tunnel and installed HEPA filters on the vent pipes

Figure 32 and Figure 33 show the G1 West Tunnel before and after the interceptor removal. Figure 34 and Figure 35 show two views of the final “as-left” condition of the E1 interceptors.

Smear sampling of the tunnels’ loose contamination levels demonstrated that the post-fixative loose contamination was below the target levels of 100 dpm/100cm^2 alpha and 5,000 dpm/100cm^2 beta-gamma averaged over an area of one square meter.

Radiation surveys in the E1 North and South tunnels showed that those areas are generally below 0.2 mR/hr except near the interceptors in E1 North. The radiation levels adjacent to the shielded interceptors measured up to 5 mR/hr. Exposure rates above contaminated concrete near the interceptors were up to 9 mR/hr.

Radiation levels in the G1 West Tunnel were lower, though elevated above background in some areas due to residual fixed contamination in the floor. Exposure rates in the north end of the G1 West Tunnel were up to 90 μR/hr near floor level and up to 25 μR/hr at head level. These rates dropped moving to the south, where the rates near the access door were 5 μR/hr near the floor and 7.5 μR/hr at head level, or essentially at background. Instrument surveys on the floor of the west tunnel showed fixed alpha reading hot spots as high as 1400 dpm/100 cm^2 and beta/gamma as high as 2,200,000 dpm/100 cm^2. Radiation levels in the north end of the East Tunnel were slightly higher than in the West Tunnel. The exposure rate at floor level was 200 μR/hr and up to 50 μR/hr at head level. As with the West Tunnel, the radiation level decreased towards the south end of the tunnel, dropping to 15 μR/hr at the floor and 30 μR/hr at head level. Fixed surface contamination was higher throughout the East Tunnel, with the highest beta/gamma measurement at 3,500,000 dpm/100 cm^2 in the north end of the tunnel. The highest fixed alpha contamination measurement was 5,000 dpm/100 cm^2.

Fixed and removable contamination in the portion of the G1 Tunnel running West-East was below the detection limits. Exposure rates were measured at 30 – 40 μR/hr at head level and 15 - 20 μR/hr near the floor. This was consistent with some residual contamination in the remaining overhead piping.

Concrete samples were collected throughout the tunnels following the cleanup process in order to document the “as-left” condition. Two floor samples collected near the E1 interceptors showed high concentrations of Cs-137 (64,500 pCi/g and 3,380 pCi/g) and Sr-90 (1,420 pCi/g and 95.4 pCi/g). A sample from the north end of the G2 West floor, where water had accumulated at the bottom of the sloped tunnel floor, had Cs-137 at 468 pCi/g and Sr-90 at 27.5 pCi/g. The highest results at any of the other 22 sample locations throughout all the tunnels were 21.7 pCi/g Cs-137 and 6.5 pCi/g Sr-90.

Surveys were conducted in the E1 and G1 corridors (the walkways between the tunnels in each building) after the completion of work in the tunnels. The surveys showed that the dose rates were less than 0.2 mR/hr throughout the corridors. The sides of the floors in both corridors were posted as contamination areas due to residual contamination outside the SPRU scope. The center parts of the floors did not have removable contamination above the detection levels.

Figure 30. E1 Tunnel prior to decontamination

Figure 31. E1 Tunnel post-decontamination

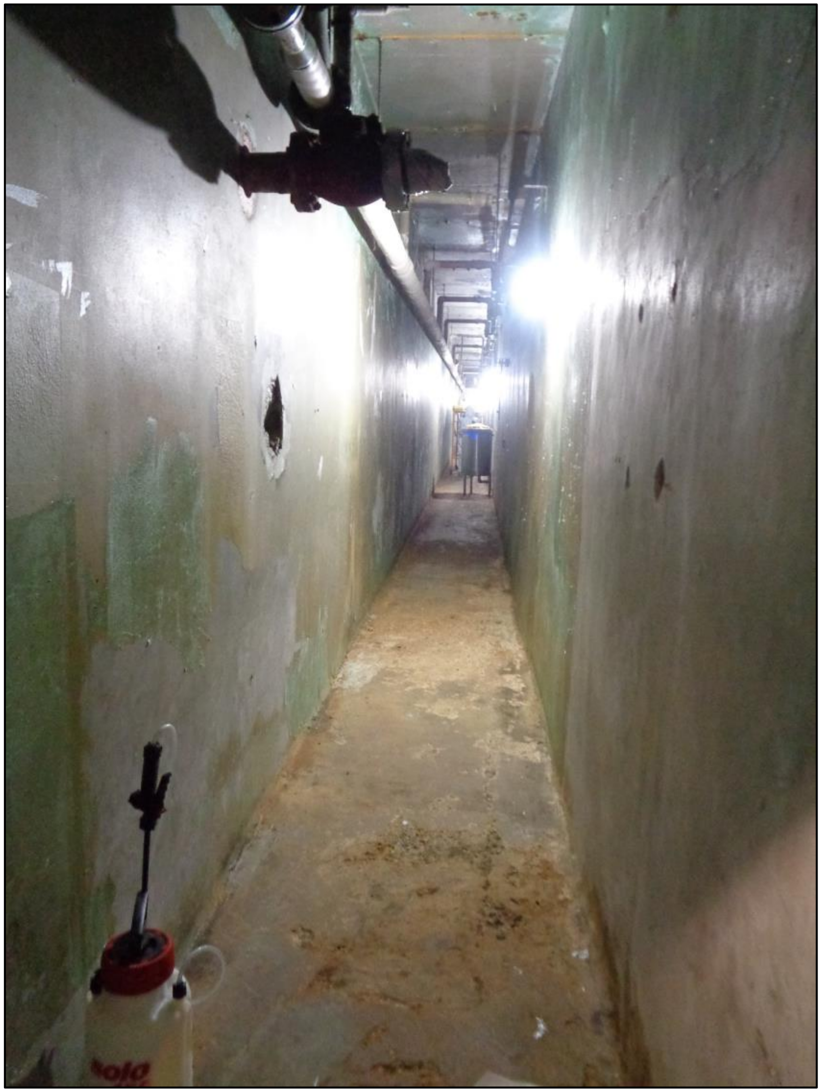


Figure 32. G1 Tunnel with interceptor in place

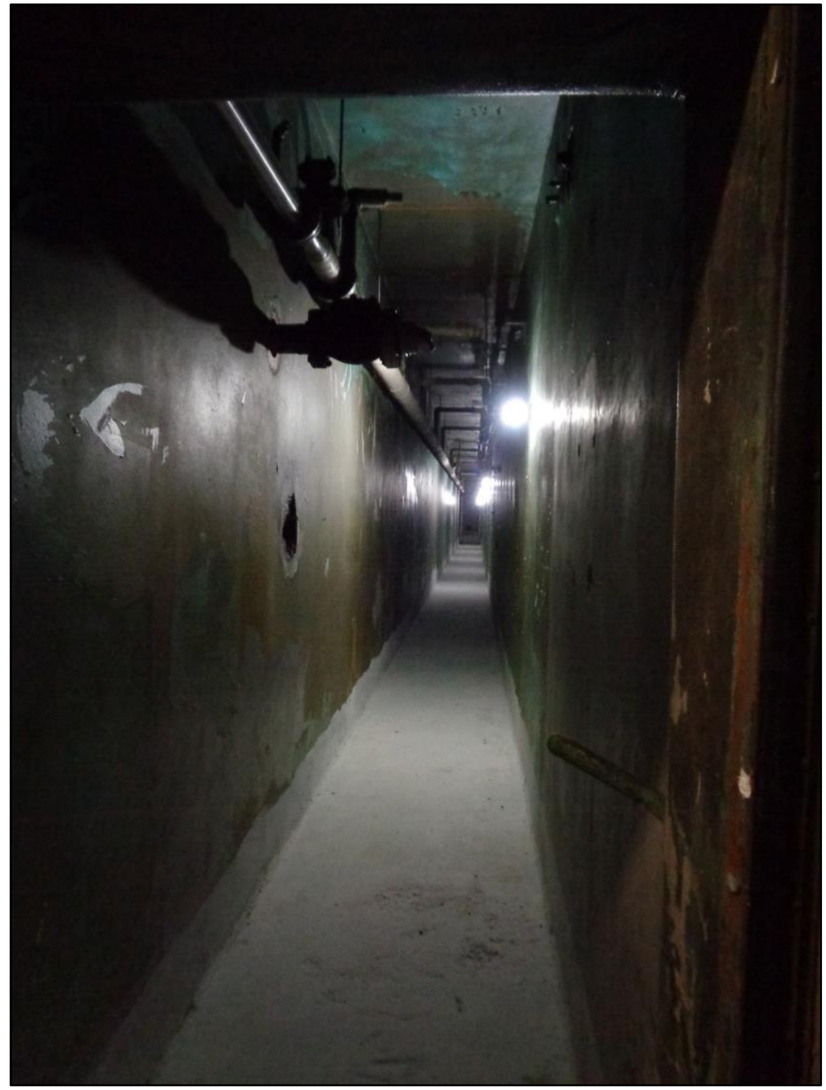


Figure 33. G1 Tunnel after interceptor removal and fixative applied

Figure 34. E1 Interceptors as-left condition. View from west

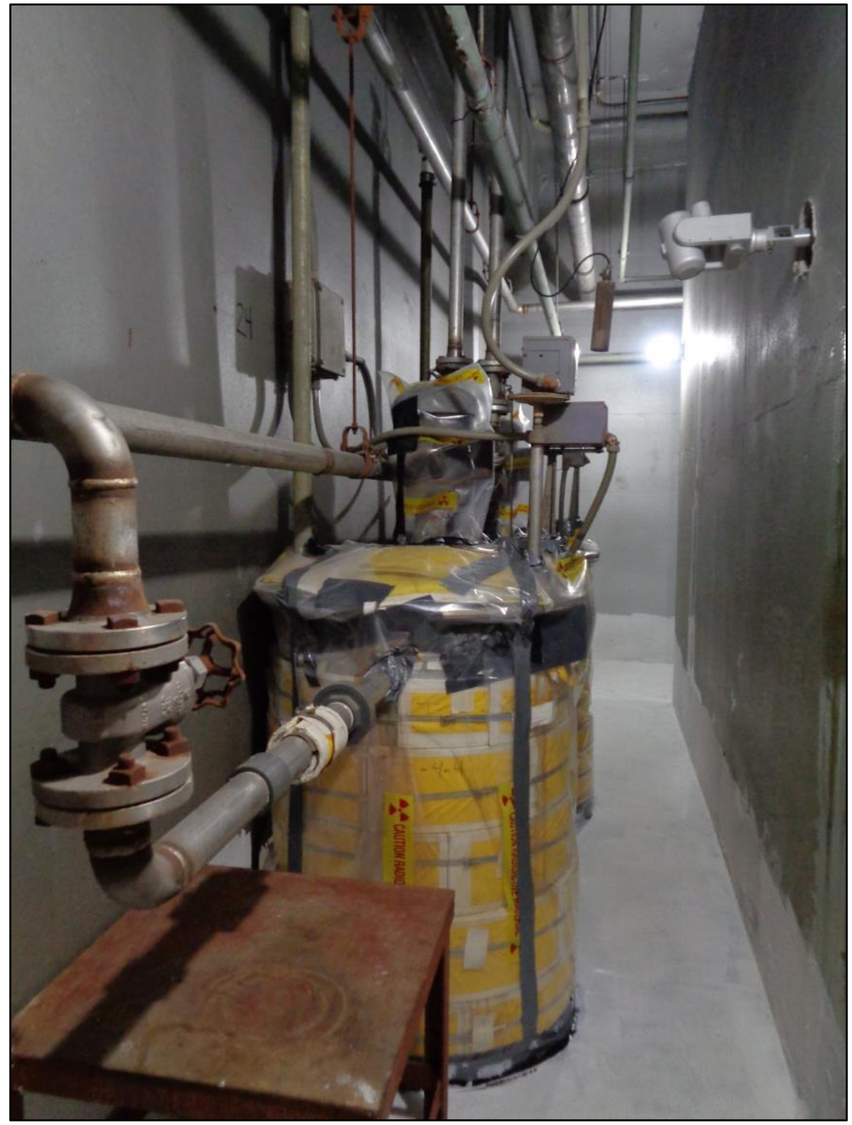


Figure 35. E1 Interceptors as-left condition. View from east

7.5 Auxiliary Activities

Throughout the SPRU field program, the project involved a range of activities to support the decommissioning. This included installation of facilities and equipment, and execution of safety and regulatory programs.

7.5.1 Support Facilities

The footprint in the SPRU Upper Level was very tight, with little room outside the buildings for personnel and storage trailers, or for operations. To partially address this problem, the south end of the west hillside was built out to provide space for trailers and equipment laydown. In order to separate the SPRU work area from the KAPL secure area, a fence was installed along the eastern side of the SPRU area and an access road was built from the Lower Level Road to the Upper Level outside the KAPL security fence to connect with the expanded hillside.

The Lower Level was used for several purposes. An asphalt pad was built as a base for a set of frac tanks connected to the tanks at the north end of the Upper Level to collect and store water pumped from the hillside sump and the building basements. A staircase was installed for personnel travel between the Upper and Lower Levels and to support the hoses connecting the tanks in the different levels.

Early in the project, some personnel and lab trailers were set up in the Lower Level across from the frac tank pad. As waste generation rates increased and more staging area was needed, the trailer space was moved to the administration trailer complex on the other side of the KAPL site and a staging area for waste containers was set up by laying a bed of crusher run material across a large portion of the Lower Level. The area was used to accept and store empty intermodals containers which were shuttled to the Upper Level as needed. The loaded containers were returned to the Lower Level to be prepped for shipment. An old asphalt pad in the Lower Level, previously used for KAPL waste operations, was set up to be used for storage of high dose wastes. After the frac tanks were demobilized near the end of the project, the high dose rate transuranic wastes were transferred to a longer-term storage area that had been set up on the frac tank pad.

7.5.2 Sheet Pile Wall Near F Buildings

A sheet pile wall between H2 and the F Buildings was installed during the start of H2 open air demolition but before any demolition of the H2 Tank Farm to provide the necessary stabilization for the F Buildings foundation. This would allow for removal of the east wall of the H2 tank vaults and the contaminated soil associated with the H2 Building footer drains without undermining the F Buildings. Prior to installation of the sheet piles, underground utility lines at the northeast corner of H2 were exposed, cut, and capped to remove the obstructions. All capped lines were terminated to the east of the sheet pile wall path. Use of the Silent Piler augering technology was needed to get the sheets deep enough into the very stiff native till. Two level of tiebacks were installed along the wall as the tank vault wall and soil were removed. Figure 36 shows the installation of the wall in progress. The sheets were left in place after site restoration in anticipation of providing some support during the future demolition of the F Buildings. The tops of the sheets were cut to be at least two feet below the final grade and the tiebacks, which extended beneath the F Buildings, were detensioned as the backfill was placed on the east side and provided the necessary support.

Figure 36. Installation of sheet pile wall west of F Buildings

7.5.3 Storm Drain Reroute

The stormwater drain in the SPRU area ran south to north along the west side of the G2 Building and then turned east between the G2 and H2 Buildings towards the KAPL site, passing under the G2/H2 Tunnel. Because the 24” diameter drain line passed through an area with volatile organic compound (VOC) contamination and was at risk of damage during the tunnel demolition, it was decided that a new section of drain would be constructed that would avoid those areas. The new storm drain line was installed to reroute the flow from the existing path from MCB-29 to MCB-8 to MCB-7 (KAPL side). The new (green) and abandoned (red) storm lines are shown in Figure 37,which is part of the final site plan drawing 29463-00-11-500 (Figure 44). New manholes (29B, 28B, and 27B) were installed to run the drain line east near the remaining G1 Building towards the KAPL E Buildings and then north along the SPRU-KAPL boundary fence to intersect with the existing drain line. The installation was done after the remediated G2 footprint had been backfilled.

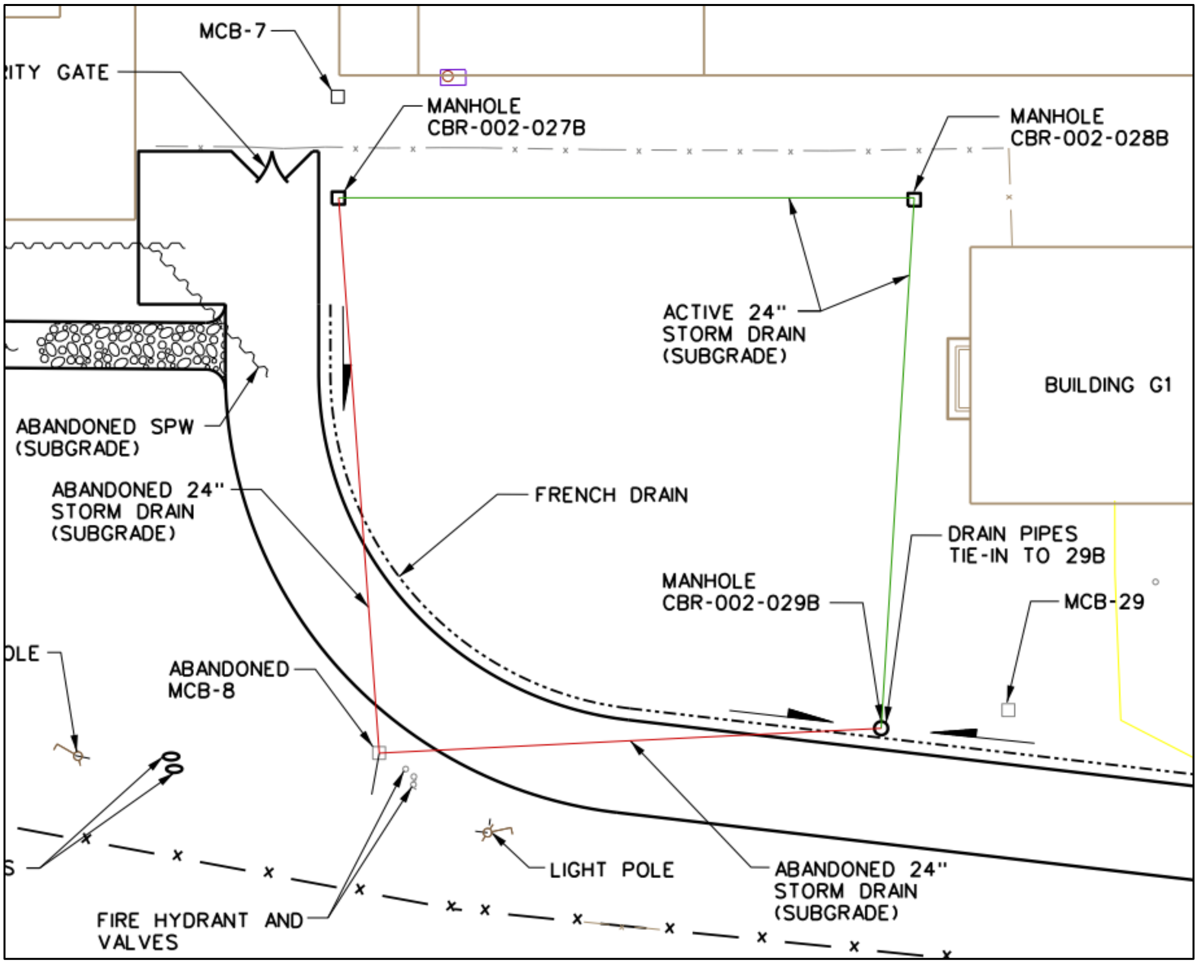


Figure 37. Final SPRU Site Plan showing Storm Drain Line

The G2 Building connections to and from storm sewer drain catch basin MCB-29 were removed and capped during soil excavation. MCB-30 was filled with grout prior to initiating D&D activities and was removed during demolition. The drain line from MCB-30 to the storm sewer system was located, cut and capped to prevent any surface water from inadvertently entering the system.

7.5.4 Work Planning

Individual activities to be carried out as part of the overall SPRU Project were defined and executed in accordance with the work planning and control process. The work documents define the scope of the activity and the conditions under which the work can be performed. There are six categories of work that vary in complexity and hazard, and which therefore required different levels of specificity in the planning.

1. Procedures - Developed and approved to provide direction for work; evaluated for hazards; and the associated training has been completed.
2. Routine Work Task (RWT) - Familiar, straightforward tasks that do not affect nuclear safety, do not increase the possibility of upset conditions, and have low potential risk of exposing workers to hazards not addressed in the worker training.

3. Craft Work Package (CWP) - Moderately complex, moderately hazardous activities. Development is coordinated by a Work Planner and follows the planning process for hazard analysis and work package development.
4. Multiple-Use Craft Work Package (MUCWP) - Moderately complex, moderately hazardous skill-of-the-craft activities that share hazards, controls, and limiting conditions. May be used multiple times for the same basic scope of work, against which Job Performance pages are written to define and provide context for the work.
5. Type 1 Work Package - Activities that pose a higher risk or for work that is complex and requires detailed work instructions and controls. Type I work packages are developed for single use and are prepared using a graded approach.
6. Urgent Work - Requires an immediate response but does not require activation of the SPRU DP Emergency Preparedness Plan. Urgent work is performed under the direction of the On-Call Manager to respond to or mitigate conditions that pose an imminent threat to safety, the environment, or security. Work is performed without delay, steps taken are documented, and there is no request for off-site assistance. Stabilization of the facility remains the primary consideration.

For each package, a Job Hazard Analysis (JHA) defines the safety, health, and environmental risks involved with the work. The level of detail in the task instructions varied depending on the complexity of the work and the types of risks involved. Radiological risks were specifically evaluated and mitigative measures defined in the Radiological Work Permit (RWP). Similarly, the Industrial Hygiene Task Evaluation Form (IHTEF) was used to address other hazards presented by the work.

Work packages were developed by the Work Planning Group in consultation with the associated managers, subject matter experts (SMEs), work supervisors, and work crews.

7.5.5 Radiological Controls

Radiation safety measures for the workers and the environment were implemented through the work planning process. The scope of each activity was planned to define the steps to be followed and the equipment to be used. Based on the radiological characterization of the area, a Radiological Work Permit (RWP) would be developed to define the personnel protective equipment to be used, such as anticontamination clothing and respirators. Dosimetry was used to track each worker's radiation exposure.

Air monitoring stations were arranged around the perimeter of the SPRU site to evaluate fugitive emissions against expected levels and compare against the task order target levels. Point source monitoring was used for the H2 Building, G2 Building, and when PVUs were used for specific small tasks outside those buildings. Point source monitoring results were reported regularly to the USEPA.

Trained Radiological Control Technicians (RCTs) conducted three primary types of radiation surveys and sampling. Characterization surveys were used to determine the condition of areas at the start of work activities. This defined the necessary postings and the associated access requirements for the area. Job coverage surveys supported ongoing work by monitoring the area during and after activities to verify that conditions were consistent with the RWP and that the work did not change the conditions in an unexpected manner. Regularly scheduled periodic surveys for general areas were used to verify that clean areas stayed clean and that contamination was not being spread inadvertently.

RCTs also assisted workers as they prepared to enter radiologically controlled areas and monitored them as they exited those areas.

7.5.6 Industrial Safety and Hygiene

Industrial safety issues were the most common hazards on the site, potentially present in all locations. The possibility of "slips, trips, and falls" was mentioned in every daily briefing, with an emphasis on housekeeping and personal awareness. Within work packages, proper operation of equipment and fall protection were commonly identified in the JHA and addressed through the IHTEF. Excavation safety became an issue in the latter stages of the projects as the buildings were demolished to below grade level.

IH technicians implemented a beryllium monitoring program at the start of the project to verify that buildings did not pose an exposure risk. Mercury monitoring was conducted throughout the building decontamination and inside demolition due to occasional detections of releases as pipes and equipment were removed. On such occasions work would be halted to address the issue, including implementing mercury-specific respirator cartridges, and, as feasible, removal of the source of the mercury.

IH monitoring was also performed on a regular basis to check for potential organic compounds that had been present in the RCRA Solid Waste Management Units (SWMUs) or detected during soil characterization activities.

7.5.7 Environmental Compliance

The SPRU project was executed to ensure that any contaminant releases were in compliance with applicable regulatory requirements. As an environmental remediation project, the two possible mechanisms were liquid discharges and air emissions.

Control of potentially contaminated water was addressed through a NYSDEC State Pollution Discharge Elimination System (SPDES) General Permit for Stormwater Discharges from Construction Activities in accordance with an approved Notice of Intent for the general permit (September 17, 2009). SPRU followed a NYSDEC-approved Stormwater Pollution Prevention Plan (SWPPP). Actions under the SWPPP included establishing berms around the demolition and excavation areas to contain the water used for dust mitigation and any precipitation that fell onto the contaminated footprint. Such waters were collected and disposed off-site. Weekly inspections were carried out throughout the project to verify that erosion controls such as silt fences and french drains were functional.

Construction of the H2 and G2 building enclosures and the ventilation systems were subject to approval by the USEPA under the National Emission Standards for Hazardous Air Pollutants (NESHAPs). The filtered discharges were monitored as point sources. These emissions were evaluated along with calculated fugitive emissions from the water handling and waste management to estimate the dose to the Maximally Exposed Off-Site Individual (MEOSI), with the results compared to the annual dose limit of 10 mrem to the MEOSI. The highest yearly dose calculated to the MEOSI from SPRU activities was 0.053 mrem in 2010, the year of the radiological incident. Fugitive releases from the demolition and excavation were calculated for their contribution to the MEOSI dose after the start of open air demolition.

7.5.8 Remediation Verification

Excavation of the H2 footprint was completed in July 2018, followed by radiological and chemical sampling to document compliance with the remediation criteria in July and August. The second phase of the G2 footprint remediation was completed in August 2018, and sampling occurred in August and September. A LIDAR survey was conducted of the completed excavations in September 2018, with the resulting contour map shown in Figure 38. The figure shows that some water had accumulated in the excavations in both footprints between the time of the confirmation sampling and radiological surveys and the LIDAR survey. That clean water was pumped out prior to backfill operations and discharge onsite, with most flowing into the storm drain system.

Verification that the site met the criteria for residual radioactivity (Table 2) was accomplished by implementing the *Final Status Survey and Confirmation Sampling and Analysis Plan (FSS/CSAP)*, [SPRU-RC-012, Sept 2018]. The SPRU area was broken down into 21 survey units for confirmation surveying and sampling in accordance with the Multi-Agency Radiological Site Survey and Investigation Manual (MARSSIM) [MARSSIM 2000]. The FSS results are summarized in the *SPRU Radiological Cleanup Report* [SPRU EEC-20-002, April 2020], which includes all the FSS reports as attachments. ORISE conducted independent verification of the final status survey and sampling activities.

The RCRA constituents of concern and the Soil Cleanup Objectives (SCOs) are listed in Table 3. The cleanup criteria for chemicals in soil are the more restrictive of the Residential or Ground Water Protection criteria as found in 6 NYCRR Part 375-6.8(b): Restricted Use SCOs. Verification sampling requirements for the Upper Level SWMUs were defined in the *RCRA Interim Corrective Measure Work Plan for the Upper Level SWMUs* [SPRU-ENV-020, October, 2018]. Similarly, the requirements for sampling in the G2 AOC were set forth in *RCRA Interim Corrective Measure Work Plan G2 Area of Concern (AOC-008)* [SPRU-ENV-017, July, 2018]. The results were reported to NYSDEC in *Interim Corrective Measures Report for Upper Level SWMUs and AOC* [SPRU EEC-20-001, May 2020].

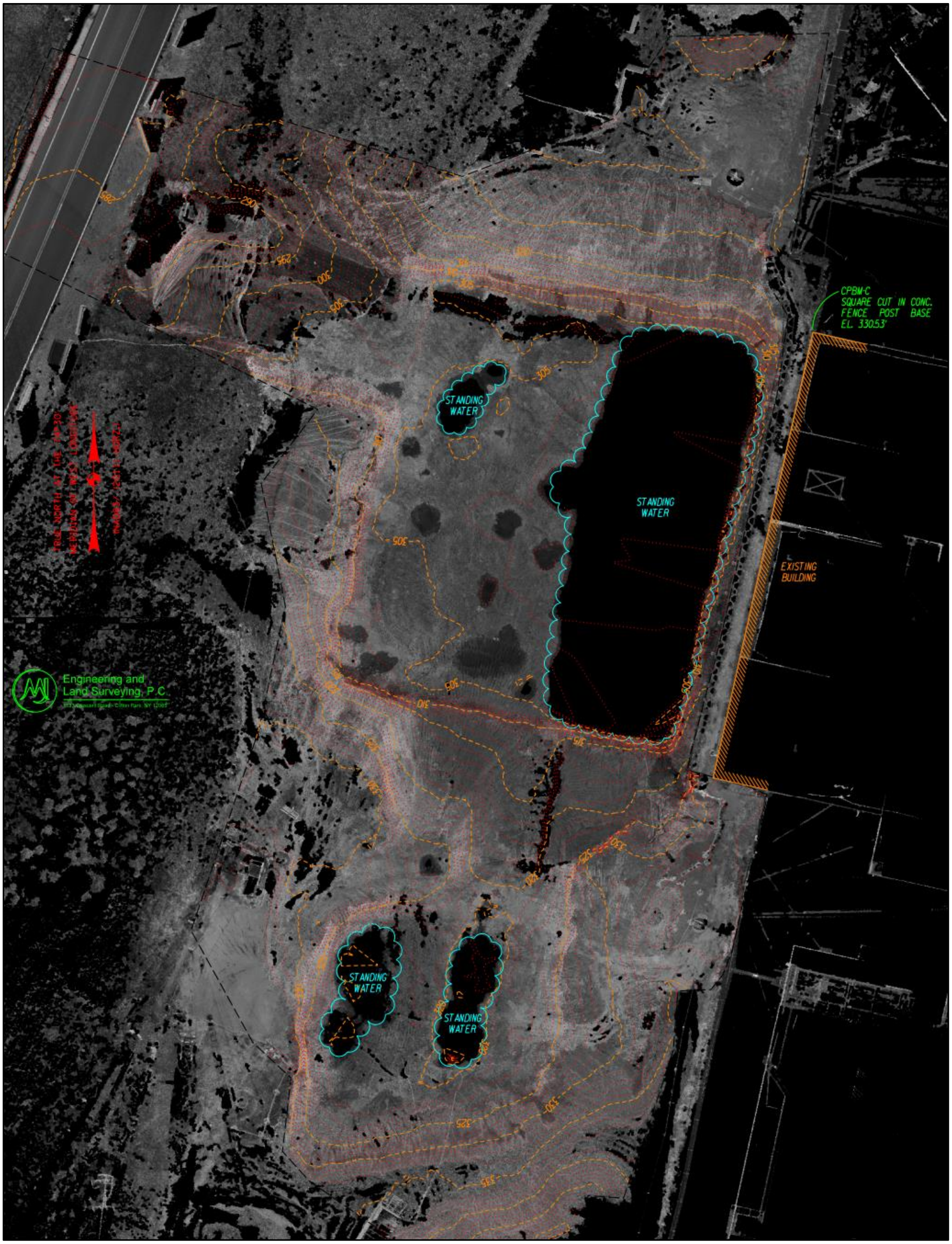


Figure 38. Contour map of SPRU Upper Level from LIDAR survey Sept. 2018

Table 2 SPRU Radiological Cleanup Criteria

Derived Concentration Guidelines (DCGL) Values for Cleanup at SPRU		
Radionuclide	**Industrial Land Use DCGL (pCi/g) Upper Level**	**Concrete Located at Depth (Primary Nuclides)**
Americium-241	595	595
Cesium-137	30	30
Cobalt-60	10.3	
Europium-152	22.8	
Europium-154	21.1	
Europium-155	892	
H-3 (Tritium)	3.38E+06	
Nickel-63	5.12E+06	
Plutonium-238	818	
Plutonium-239	737	737
Plutonium-240	738	
Plutonium-241	20,060	
Promethium-147	1.63E+06	
Samarium-151	6.73E+06	
Strontium-90	4,826	353
Technetium-99	1.17E+06	
Thorium-232	9.50	
Uranium-234	767	
Uranium-235	196	
Uranium-238	896	
Zirconium-93	1.37E+06	

Table 3 Constituents of Concern and Associated Soil Cleanup Objectives

Primary Constituents of Concern	SCO (ppm)
Antimony	12
Arsenic	16
Mercury	0.73
Zinc	2200
Acetone	0.05
1,1-DCA	0.27
1,1-DCE	0.33
cis-1,2-DCE	0.25
Methylene chloride	0.05
Methyl isobutyl ketone	1
trans-1,2-DCE	0.19
Toluene	0.7
Trichloroethylene	0.47
Vinyl chloride	0.02

Secondary Constituents of Concern	SCO (ppm)
Barium	350
Cadmium	2.5
Chromium (trivalent)	36
Cobalt	30
Iron	2000
Lead	400
Manganese	2000
Nickel	130
Selenium	4
Silver	8.3
Thallium	5
1-methylnaphthalene	NC
2-methylnaphthalene	0.41
2-chloronaphthalene	0.010
acenaphthene	98
anthracene	100
benzo(a)anthracene	1
benzo(a)pyrene	1
benzo(b)fluoranthene	1
benzo(ghi)perylene	100
benzo(k)fluoranthene	1
carbazole	NC
chrysene	1
fluoranthene	100
fluorene	100
indeno(1,2,3-cd)pyrene	0.5
methyl methacrylate	0.050
naphthalene	12
phenanthrene	100
pyrene	100
bis(2-ethylhexyl) phthalate	50
tributylphosphate	NC
2-butanone	0.12
benzene	0.06
ethylbenzene	1
tetrachloroethylene	1.3
xylenes(total)	1.6
Isopropyl benzene	2.3
Styrene	300

8 Site Restoration

Site restoration involved the backfill of the excavations, construction of service roads, and installation of security fencing and light poles.

Backfill of the south end of the G2 footprint occurred in November 2017 after DOE and NYSDEC concurrence that the confirmation sampling results satisfied the cleanup criteria. The remainder of the Upper Level was backfilled starting in October 2018 after the sampling results for the remaining area were accepted. The excavation conditions prior to backfill are shown in Figure 39 for H2 and in Figure 40 for G2. The exposed sheet pile wall is visible on the left side (east end) of the H2 excavation.

The backfill of the G2 footprint was done primarily with structural fill, a gravel with a maximum stone size of 2 inches. Wet areas at the bottom of the excavation were filled with 3” stone to form a stable, permeable platform for placement of the finer grained compacted fill. Using 12” lifts, the structural fill in the former G2 area was compacted to a minimum of 98% density to meet DOE requirements based on anticipation of future construction in that area. Compaction quality was verified by testing.

Access to the H2 footprint was gained through the G2 area. When the second phase of the backfill started in October 2018 it was necessary to construct a ramp through the G2 area down through the G2/H2 Pipe Tunnel excavation, as shown in Figure 41. The ramp provided access for haul trucks to deliver material to the deeper H2 excavation. As with G2, large stone was used to stabilize the wet areas prior to placing the imported structural fill. In addition, permeable geotextile was used over the large stone in the area of the tank vault to prevent the structural fill from entering the void space and potentially causing subsidence of the upper lifts.

Some materials that were excavated, such as the layback for the H2 excavation and the gravel used for surface stabilization in the H2 north yard, were believed to be clean. In anticipation of potential reuse as on-site backfill, these materials were sampled in accordance with MARSSIM and NYSDEC DER-10 criteria and surveyed in accordance with *Radiological Confirmation Sampling and Analysis Plan/Final Status Survey* [SPRU-RC-012] to verify that contamination was below the Derived Concentration Guideline Levels (DCGL) for radionuclides and the RCRA/NYSDEC chemical cleanup criteria. Some of the clean soil was used in the H2 backfill. In accordance with project agreement with DOE-SPRU, the reusable gravel was used to construct a roadway through the Red Pines area on the eastern side of the KAPL site to allow access to a future remediation project. The remaining clean soil that was not used as backfill, including the soil excavated for the storm drain re-route, was placed in the Red Pines soil management area.

The specification for placement of material in the rest of the Upper Level other than G2 was to achieve a minimum of 92% compaction density. Compaction testing was performed over the G2 area in accord with ASTM D-698, Standard Proctor. Compaction in the H2 area was based on a performance specification using multiple passes of the vibrating compactor over the placed structural fill.

All imported fill material was obtained from a NYSDEC-permitted source and evaluated in accordance with NYSDEC requirements.

The layout of the restored Upper Level is shown in Figure 42, which can be compared to the pre-demolition site layout shown in Figure 2. The layout with the final contour lines is shown in Figure 43.

Figure 44 shows the location of several subsurface features that were left in place:

- Abandoned MCB-8 and the storm drain line between that and new manholes 29B and 27B
- Sheet Pile Wall along the F Buildings
- H2 Vent Stack Pad

As shown on the figures, an asphalt road was installed between the Lower Level Road and the KAPL gate on the east side of the SPRU area. That road goes up along the access road built at the start of the SPRU field work. A gravel road connects the asphalt road to the gate to the north of the F Buildings.

A security fence was reinstalled along the west hillside and the north edge of the SPRU area. Lighting poles were installed along the west side to replace those that had been removed during the remediation activities.

Attachment 1 includes a series of SPRU site photographs showing comparisons of the conditions during remedial action with the restored conditions as of July 24, 2019.

Attachment 2 contains full size drawings of the final Upper Level conditions.

Figure 39. H2 excavation during radiological and chemical verification sampling

Figure 40. G2 excavation being dewatered prior to backfill

Figure 41. H2 backfill using access ramp from G2 area

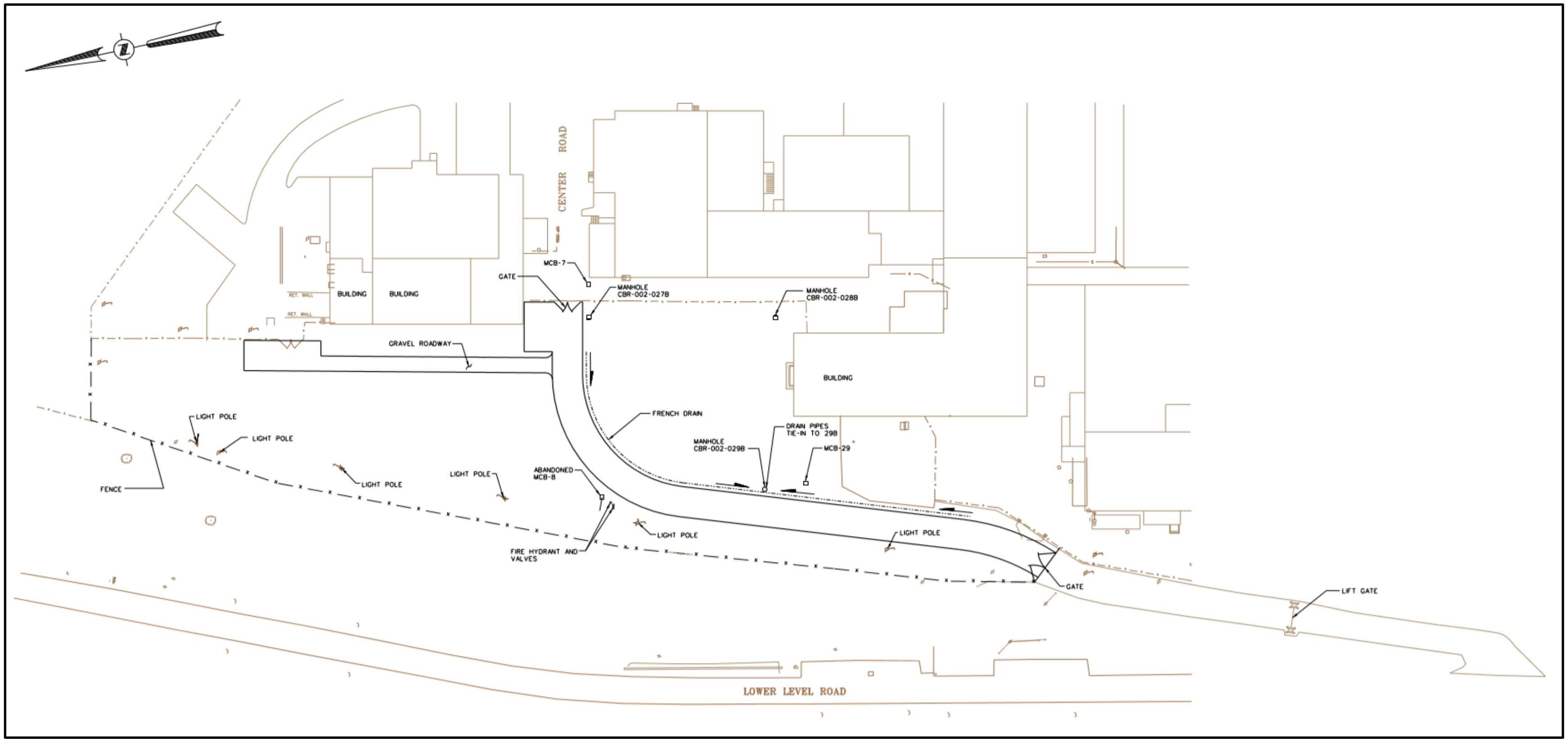


Figure 42. SPRU Upper Level layout after site restoration

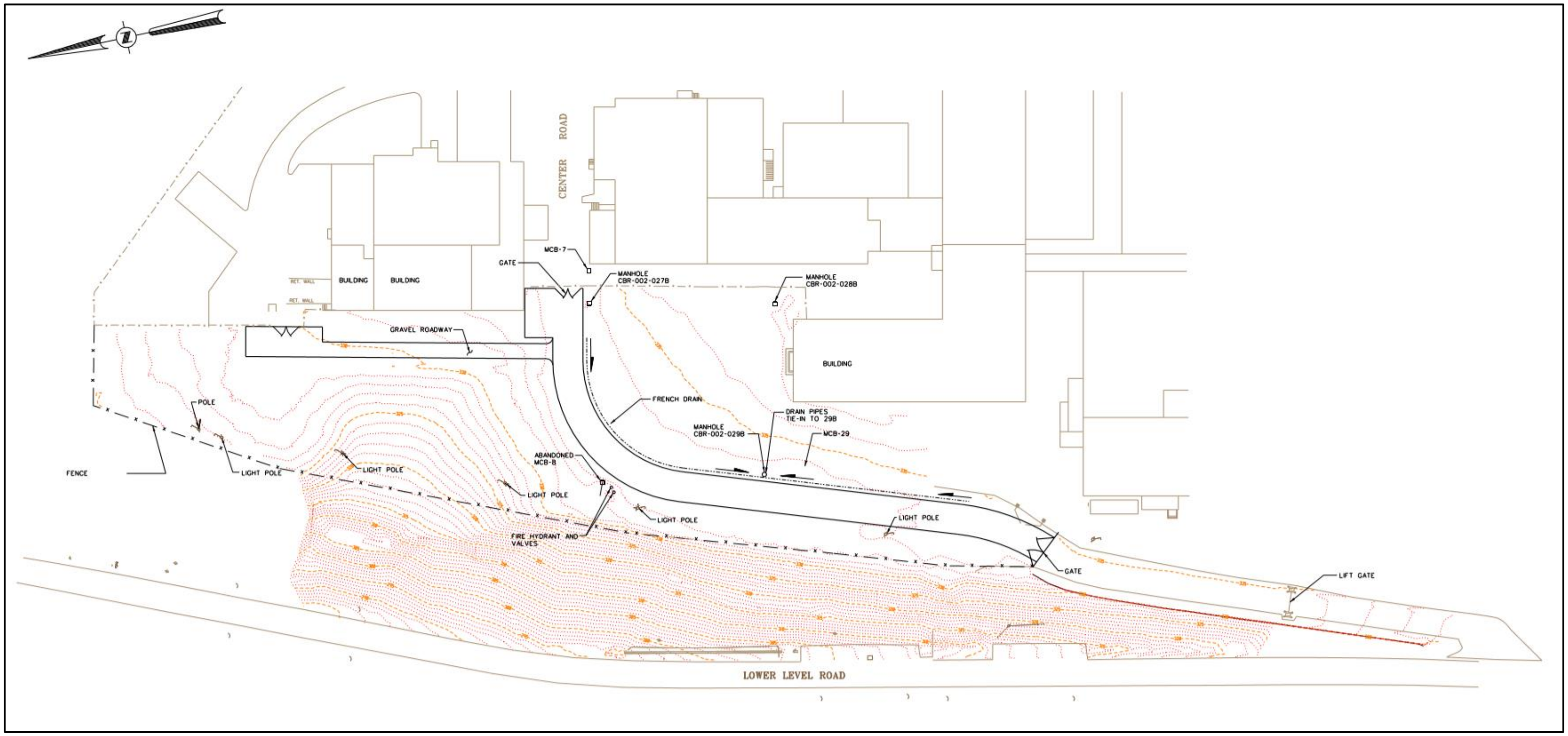


Figure 43. SPRU Upper Level contour map after site restoration

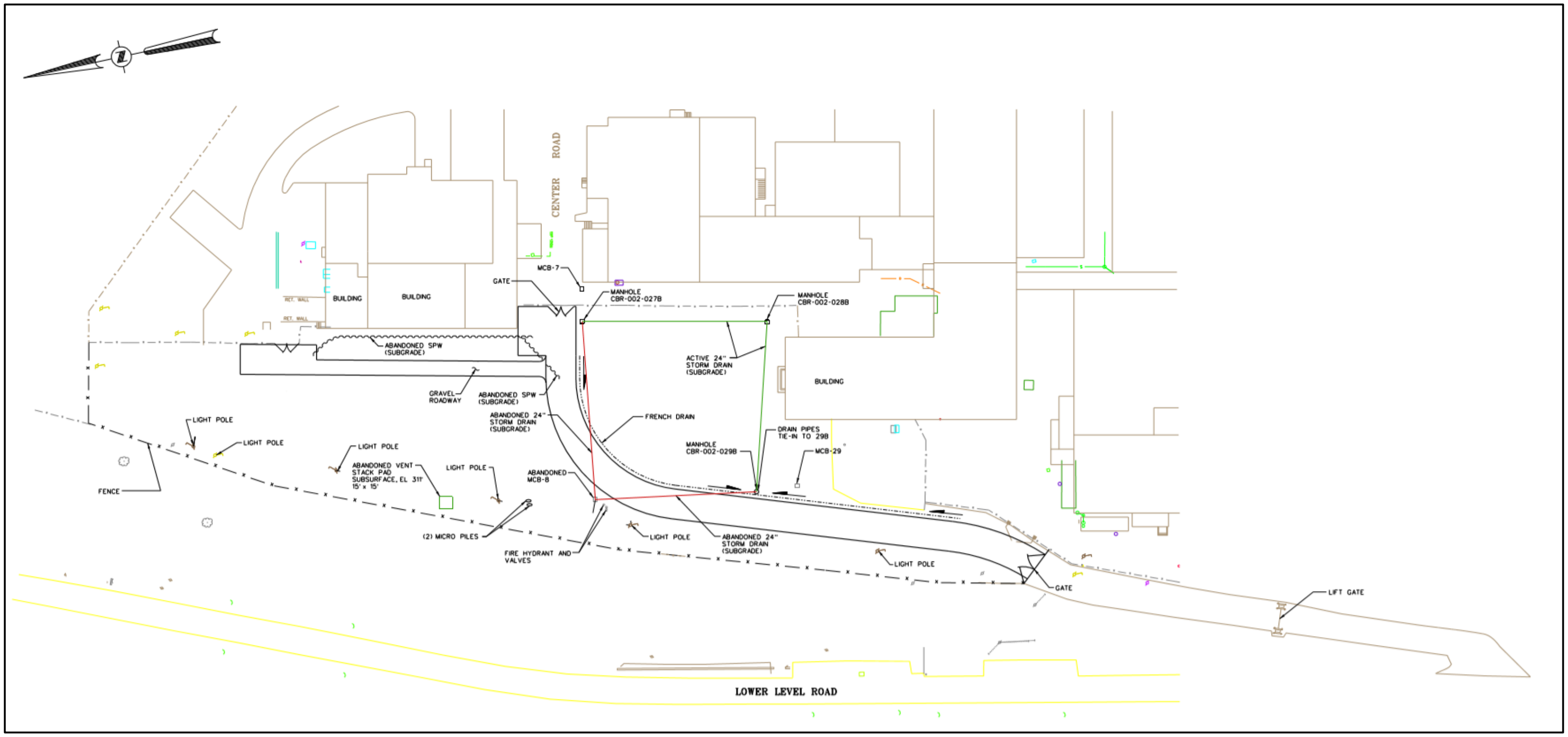


Figure 44. SPRU Upper Level showing sub-surface features remaining after restoration

9 Waste Management

The decontamination, decommissioning, and demolition of the SPRU facilities generated a range of waste types and forms. Waste types included industrial, hazardous, low-level radioactive (LLW), and mixed low-level radioactive (MLLW), which is both radioactive and hazardous, and transuranic (TRU and Mixed TRU). Waste forms included water, debris, soil, and stabilized forms such as solidified sludge. Industrial and universal wastes such as light bulbs, batteries, ballasts, and aerosol cans, were containerized for disposal or recycling as appropriate.

The main waste sources and waste types generated along with their primary disposal locations are listed in Table 4.

Table 4. Waste Source and Disposal Location

Waste Source	Waste Type	Disposal Location
Untreated water from Hillside Drain System (HSDS)	LLW – water untreated	PermaFix NW, Hanford, WA UCOR, Oak Ridge, TN SMS, Oak Ridge, TN
Treated water from HSDS	Free release treated water	On-site KAPL outfall
H2 basement water	LLW – water untreated	PermaFix NW, Hanford, WA UCOR, Oak Ridge, TN SMS, Oak Ridge, TN
G2/H2 Excavation Water	Free release treated water	On-site KAPL outfall
G2 Cell water	LLW – water untreated	PermaFix NW, Hanford, WA
H2 Tank Farm	LLW – solidified sludge	WCS, Andrews, TX
H2 Tank Farm (Secondary Waste)	LLW – sludge transfer system components, hoses, fittings, and associated debris	WCS, Andrews, TX
Building G2 and H2 enclosures, tunnel, equipment, debris, rubble	LLW	WCS, Andrews, TX
Oversize debris	LLW (oversize tanks)	Alaron, Wampum, PA WCS, Andrews, TX
Land area cleanup, soil and debris	LLW	WCS, Andrews, TX EnergySolutions, UT
Multiple areas, hazardous waste	Hazardous waste	Veolia miscellaneous facilities
Multiple areas, industrial waste	Non-hazardous waste	Veolia miscellaneous facilities
Multiple areas, mixed waste	MLLW (miscellaneous debris)	WCS, Andrews, TX EnergySolutions, PermaFix
Ion exchange media	LLW	WCS, Andrews, TX
Multiple areas	TRU, MTRU	Stored in SPRU LLRB

The disposal facility's contractual restrictions prevented transloading of intermodals in the relatively close Albany, NY, train yard up until early 2018. Prior to that time, the waste streams were mostly concrete and structural debris, and the intermodal waste containers were transported by truck to a rail spur in Binghamton, NY (a four hour round-trip) for transloading to rail, and then transported to the WCS disposal facility in Texas. As the waste included more soil and the mixture was suitable for transload to gondolas some of the shipments could be sent to Worcester, MA (three hour round trip), for ultimate disposal at the Energy Solutions facility in Utah. Towards the end of the project, the waste was mostly soil and bags could be used for quicker loading on-site, and for which an alternate transload site for WCS-bound waste was available in nearby Colonie, NY (less than an hour round trip). Tanks and other containers or waste packages not suitable for rail transportation were transported by truck to the appropriate treatment or disposal facility.

Most of the waste generated during the project was low level radioactive waste, primarily consisting of typical decommissioning wastes such as the piping and equipment from the buildings, structural concrete and steel, and contaminated soil. Site operations generated additional wastes in the forms of personal protective equipment (PPE), contaminated tools and equipment, and contaminant controls such as tarps and tents.

There were two specific waste streams requiring special management approaches: the H2 Tank Vault sludges and the tanks themselves. As discussed in Section 7.1, approximately 9600 gallons of residual liquid and sludge waste from the seven tanks in the H2 Tank Vaults were processed and solidified into 28 liners with a total weight of 222 tons. The liners were chosen to provide sufficient radiation shielding for transport purposes. A pair of containers were sent in each of 14 truck shipments for disposal at the Waste Control Specialists facility in Andrews, Texas. Figure 15 shows a shipment of the sludge containers.

Special shipping containers, as shown in Figure 22, were manufactured to allow for intact transport of the six 10,000 gallon tanks, individually, to the Alaron facility in Wampum, PA, where each highly contaminated tank was size-reduced into more easily transported pieces. The segmented tank pieces were then shipped in standard packages to the WCS facility for disposal.

A breakdown of the radioactive waste shipped for disposal is provided in Table 5. Figure 45 shows the annual amount of water shipped by tanker trucks, totaling about 6,991 m^3 over the six years, or about 7,708 tons. Because both building enclosures were in place from 2013 until mid-2016, most of the water shipped in that time frame was from the hillside sump. The volume of water collected in the building footprints increased after the building demolition moved to the open air phase. The excavation work was completed and sampling confirmed the residual contamination met clean-up criteria in September 2018, after which water no longer needed to be collected for off-site disposal.

As seen in Figure 46, the amount of radioactive waste generated by the decontamination and decommissioning was overwhelmingly from the building demolition work in 2017 and 2018. The mixed waste was mostly Lead removed from the buildings, but there were some materials, such as sediments from the building sumps, that were characteristically hazardous for other metals.

Table 5. Radioactive Waste Shipped for Disposal

	Net Annual Weight Shipped (tons)					
Year	2013	2014	2015	2016	2017	2018
Water	902	977	732	1,407	2,504	1,186
LLRW	559	704	478	5,181	21,324	30,800
H2 Tank Sludge	159	63				
Mixed	0.3	0.3	13.0	209.8	45.7	2.4

Table 6. Chemical Waste Shipped for Disposal

	Net Annual Weight Shipped (tons)					
Year	2013	2014	2015	2016	2017	2018
RCRA Hazardous	0.39	0.04	0.34	0.26	2.68	1.76
Universal	0.14	0.08	0.06	0.19	0.27	0.18
Non-hazardous	4.94	-	-	-	-	4.68

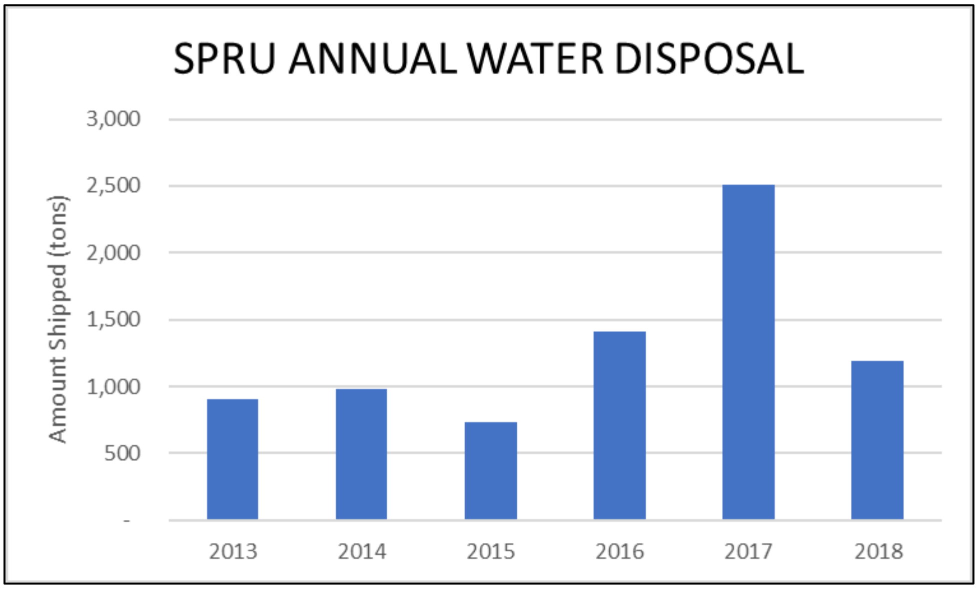


Figure 45. Annual water shipments from SPRU

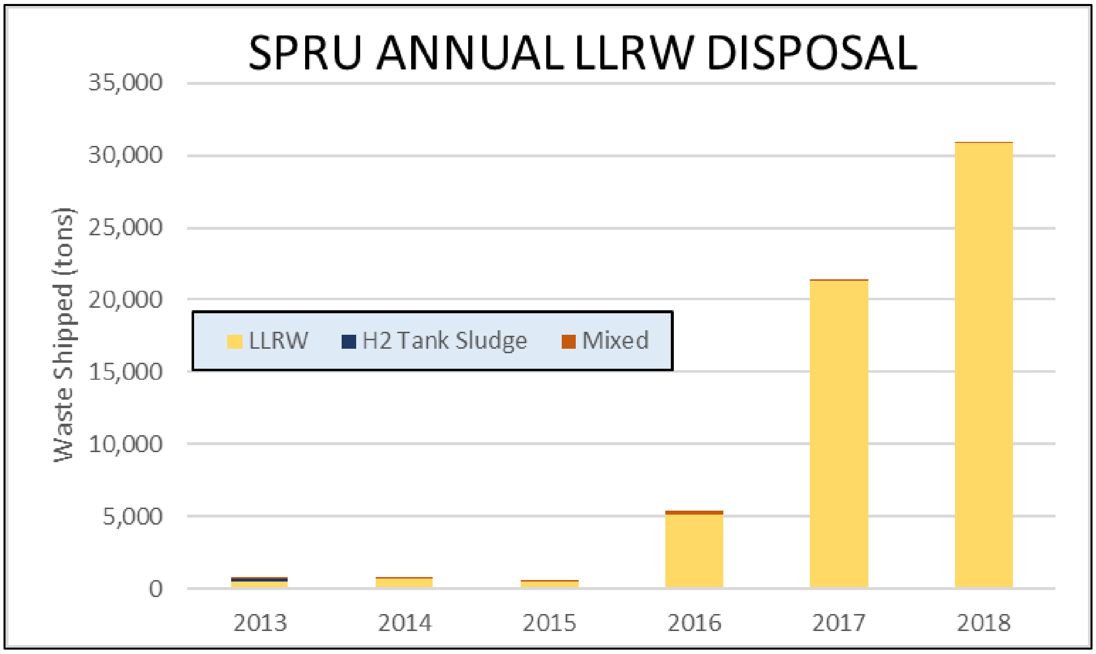


Figure 46. Annual Low Level Radioactive Waste Shipments

While the vast majority of the waste generated during the SPRU Project was classified as low level waste, some waste was classified as Transuranic waste (TRU) and remains in storage in the LLRB. The waste consists primarily of contaminated sump sediments, floor scrapings, piping, and components. Most of the wastes exhibit the RCRA toxicity characteristic for D008 (lead). Certain containers exhibit the characteristic for D007 (chromium) and one container exhibits the characteristic for D009 (elemental mercury). These wastes are managed as Mixed TRU (MTRU).

All of the TRU waste, including the MTRU, is stored in five conex boxes on the former frac tank pad in the LLRB Area, surrounded by concrete blocks for radiation shielding purposes. The conex boxes hold multiple containers, many with additional shielding in or around them. The area has been established as a RCRA temporary accumulation area (TAA-003) and DOE has entered into an Order on Consent with NYSDEC to address the management of the RCRA materials until a RCRA operating permit is in place. DOE retained responsibility for surveillance and maintenance, permitting with NYDEC, and future treatment and processing of the TRU and MTRU containers.

10 Health and Safety Statistics

This section addresses the maximum estimated dose based on air emissions from SPRU site operations, dosimetry results, and total recordable injury and lost workday rates.

10.1 Annual Offsite Dose Estimates

Table 7 lists the annual radiological dose estimated for the Maximally Exposed Offsite Individual (MEOSI) as determined by the CAP88-PC program. The analyses included the monitored discharges from the ventilation systems and fugitive emissions from demolition, waste handling, and soil excavation. The tabulated results were submitted to EPA in the annual NESHAPs report. The highest dose was in 2010, the year of the H2 contamination incident. The reported MEOSI doses increased in 2016 – 2018 over the previous few years due to the move to open air demolition and the increased contribution calculated from fugitive emissions. Doses for all years were less than the radiological NESHAPs annual limit of 10 mrem.

Table 7. Annual MEOSI Off-Site Dose

Year of Emission	MEOSI Committed Effective Dose Equivalent (mrem)*
2009	5.50 E-05
2010	5.30 E-02
2011	5.20 E-03
2012	1.07 E-03
2013	7.85 E-04
2014	3.68 E-04
2015	1.24 E-03
2016	2.57 E-02
2017	4.40 E-02
2018	2.92 E-02
2019	Project completed. Site released from radiological control in 2018.

*Includes dose from all sources and all pathways estimated using CAP88-PC program.

10.2 Worker Exposure

The radiation committed effective doses to SPRU workers received during SPRU project are summarized in Table 8. The radiation doses to the work crews were highest during the period of 2015 – 2016 when the highly contaminated equipment and tanks were being removed from the G2 and H2 cells, and the sumps and rooms were being decontaminated. Extensive work planning helped reduce the time involved in the work activities, and shielding was used to further reduce worker exposure when possible.

As a result of the efforts necessary to meet the decontamination requirements in the Task Order, the airborne releases during the demolition process resulted in no detectable increases in concentration at the site boundary. This means that there was no incremental airborne dose to the workers on the KAPL property.

Table 8. Annual Worker Radiation Dose Summary

Year	# Badged Workers	Total Collective Dose (Rem)	Average Worker Dose (mrem)	Maximum Worker Dose (mrem)
2009	97	0.288	3	120
2010	226	7.89	35	563
2011	277	0.179	1	24
2012	259	0.584	2	49
2013	233	2.90	12	246
2014	185	9.34	50	393
2015	231	69.2	300	1,541
2016	202	47.5	235	1,193
2017	162	5.19	32	400
2018	101	0.208	2	47
2019*	10	-	-	-

* Site released from radiological control in 2018.

10.3 Industrial Safety and Health

The annual safety statistics during SPRU operations are listed in Table 9. Based on the small work force, even the infrequent incidents on the SPRU project could have a significant impact on the statistics. For example, a single recordable incident in January 2017 resulted in a Total Recordable Incident Rate of 0.99 for the year. Following a wrist strain in the fourth quarter of 2015, the project completed the remainder of the building decontamination, all open-air demolition, and the site restoration, without any additional restricted work or lost time incidents.

Table 9. Annual SPRU Safety Statistics

Year	Total Recordable Incident Rate (TRIR)	Lost Workday Incident Rate (LWIR)
2008	0.0	0.0
2009	2.2	0.0
2010	1.6	0.8
2011	0.92	0.92
2012	0.96	0.00
2013	0.00	0.00
2014	1.82	0.91
2015	1.30	0.62
2016	0.70	0.00
2017	0.99	0.00
2018	1.18	0.00
2019	0.00	0.00

11 Lessons Learned

The SPRU Project took more than a decade to go from planning to execution and finally to site restoration. Over that time, the project team had to deal with the challenges of decommissioning, decontaminating, and demolishing a 60-year old, one-of-a-kind facility with high levels of residual radioactivity and limited characterization in the areas requiring the greatest attention. Typical of such projects, the approach to the work improved as the effort progressed, with the crews, management, and the DOE client learning how things could be done better and safer. The broadest and most significant examination of the project execution occurred after the H2 radiological release discussed in Section 5. The Type B investigation and corresponding identified weaknesses in project planning, work authorization and release, and oversight by management and the client, were documented in the report of the investigation team [DOE 2010, November 2010]. That event was also submitted to the DOE Occurrence Reporting and Processing System (ORPS) as report EM-WGI-G2H2-2010-0001.

The more common operational lessons learned on the job were recognized in a number of ways. The most immediate and least formal way was in post-job briefings with the work crews and supervisors to discuss what worked well and what did not. These were documented in the work package logs, discussed with the work planning team, and occasionally distributed more broadly depending on the potential applicability to the overall project team.

More significant matters that arose, particularly those involving safety or environmental issues, were documented and distributed internally and occasionally externally to the project, based on the applicability and potential interest. Table 10 provides a list of the Lessons Learned that were written up for DOE discussion and dissemination.

11.1 Operational Considerations

The most significant issues on the project arose early in the execution. These issues also had the most impact on the future of the project by affecting the methodologies and attitudes going forward. The most impactful were the changes made in the aftermath of the 2010 radiological release and the subsequent Type B investigation. A total of 29 occurrence reports were made to ORPS over the course of the SPRU project.

The following two Lessons Learned are discussed as examples of circumstances with broad implications to the functioning and attitude of the team going forward.

Table 10. Lessons Learned Log

Lessons Learned ID	Subject	Title
LL-SPRU-2009-36	Electrical Safety	Changes to Work Package Leads to 480-volt Cable Arc Flash
LL-SPRU-2010-09	Personal Contamination	High Temperatures Along with Crawling on Hands and Knees Leads to Personal Contamination
2011-URSMSLL-001	Environmental Protection	Inadvertent Release of Radioactive Material from the SPRU DP
2011-URSMSLL-002	Compliance (Waste Shipments)	Error in Waste Shipment from the SPRU DP
SPRULL-2012-001	Electrical Safety	SPRU DP Electrical Shock Event - G2 Facility
2012 SPRULL-2012-002	Work Planning	MSA 3 (G2/H2 Isolation Wall Pipe Removal Mockup/Demonstration) Weaknesses
2012 SPRULL-2012-003	Aerial Lift Use	SPRU DP Past Weakness in Use of Aerial Lifts During H2 Construction
2013 SPRULL-2013-001	Power Tool Safety	Facial Hair Removed when Entangled in Impact Wrench
2013 SPRULL-2013-002	Electrical Safety	Overheated Electrical Panel Components in Modular Office Units
2014 SPRULL-2014-001	Compliance (Sampling)	Broken Vial Containing Radioactive Sample Received at Analytical Laboratory
2014 SPRULL-2014-002	Worker Safety (Hot Work)	Damaged (burned) Fire Resistant Anti-Contamination Clothing During Hot Work
SPRULL-2014-003	Crane Use	Crane Boom Impacts H2 Enclosure Structure
SPRULL-2014-004	Waste Intermodals	Water in Intermodal Waste Shipping Containers
SPRULL-2014-005	Airborne Silica	Airborne Silica Overexposure Resulting from Concrete Saw Cutting
SPRULL-2015-001	PPE Implementation	Failure to Adequately Implement PAPR Change from Disposable PAPR Hoods to Reuseable 3M Helmets
SPRULL-2016-001	Electrical Safety	Compact Florescent Lightbulb (CFL) Overheated

11.1.1 Error in Waste Shipment

In November 2010, a shipment of waste was sent from SPRU to a disposal site in Utah. It was subsequently determined that the shipment had manifest errors and that some of the waste was not acceptable at the disposal facility based on its actual waste concentration. The waste classification error resulted in notifications to the US Nuclear Regulatory Commission and the Utah Division of Radiation Control. It was determined that miscommunication between the SPRU shipper who produced the manifest and the SPRU radiological engineer who calculated the shipping inventory resulted in mischaracterizing some of the waste and understating the overall quantity of radioactivity in the shipment. There was no peer review requirement at the time on the calculations or manifest. Also, while the shipper had questioned the original information based on a high dose rate on one container, he did not subsequently verify whether the requested analysis represented the entire shipment (as he thought) or just one drum (as the engineer actually calculated). The incident was reported under ORPS as number EM-WGI-G2H2-2010-0003.

A Lesson Learned (2011-URSMSLL-002) was developed that identified deficiencies in command and control; conduct of operations; communications; and project staffing. Recommendations included actions related to:

- Effective and timely communication
- Clear roles and responsibilities and proper oversight of work activities
- Technical inquisitiveness and willingness to stop

The responses to this event included actions specific to the waste management operations, but also some with broader reach. The direct changes included reorganization and increased staffing of the

Waste Management Team, and specific definitions of the roles and responsibilities of the team members. One broader change, which also applied to Waste Management, was the adoption of peer review requirements for calculations. Most far reaching was the need to "Reemphasize to all project personnel, including management, the need for enhanced technical inquisitiveness and willingness to stop when there are concerns regarding the technical adequacy of planned evolutions."

11.1.2 Work Package Development

In 2012, it was recognized that difficulties were being experienced at SPRU with the quality of field work package development for the complex radiological and hazardous material decontamination and decommissioning (D&D) activities. A Lessons Learned Bulletin was issued to outline steps for improving the process to a workable standard of expectations.

This was an important focus at that point in time. In Fall 2012 the construction of the G2 and H2 enclosures were nearing completion, and the restart of the decommissioning and decontamination activities were going to resume in the a few months, so the work was being planned while the construction was finished. The recommendations for strengthening the work planning process addressed both the methodological approach to developing the plans and the technical content.

- The Lessons Learned Bulletin recognized that the worker involvement (the folks doing the actual work) in work planning and procedure development was robust, but that planners needed to translate their contributions into functional plans.
- While SPRU had a robust and well thought-out procedure for Work Planning & Control (WPC), it was not always followed or did not always include some relevant disciplines. It was reinforced that the planning team needed to consist of capable people trained for that responsibility and knowledgeable about the work being planned.
- Planners were often using an existing plan as the starting point and reworking it for a new plan. This risked missing out on components required for the new plan that may not have been needed for the earlier activity. Use of a proven template or model procedure would eliminate basic problems with formatting but also allow the planner to capture all actions and notes.
- The planning team was not capturing the documents as approved with final comment resolution. The planning process needed to incorporate comment resolution forms to collect reviewers input and document how the comments were addressed, and then obtain concurrence from all reviewers. This also included version control so that any changes would go through an equivalent review process.
- Beyond just the planning process, a knowledgeable and qualified individual should be assigned to be responsible for the entire job from start to finish. The idea was that individual would manage all the work covered by the work package, including overseeing development of the package.
- The planning process had been being carried out on a somewhat ad hoc basis, without dedicating an appropriate team. This could lead to inconsistent approaches based on that group of individuals' knowledge on the particular scope. The planning team needed to incorporate subject matter experts and follow the planning procedure.
- There were inefficiencies in developing the procedures due to going through the review and comment cycle multiple times because different levels of the project team were involved at different times. Mentors and coaches were being brought in at the end of the review process and making their comments after a full cycle instead of being incorporated at the start in developing the approach and detailed steps.

- At that point of the project, DOE was reviewing all work packages, but they were not part of the plan development. Thus, the DOE review was often from scratch, which complicated the review and extended the development of the work packages. As with the mentors and coaches, the DOE representatives could be kept informed as the planning proceeded.

These changes streamlined the planning process and improved the quality of the packages for the duration of the project.

11.2 Program Considerations

In retrospect, there were two key aspects to the project that ultimately had significant impact on achieving satisfactory performance and completion. Both involved circumstances somewhat specific to the SPRU site, but the general concepts apply with regard to considering potential impacts outside the immediate project footprint.

11.2.1 Identify Potential Structural Impacts to Nearby Facilities

The D&D activities were impacted significantly in terms of project schedule and level of effort required for demolition of the H2 Building and associated support facilities based on the location of the KAPL F Buildings. The KAPL F Buildings were located less than 20 ft to the east of the tank vaults. Demolition of the tank vaults required the installation of sheet pile walls to provide geotechnical stability and support excavation and removal activities associated with the H2 Building and footer drains. Operations and logistics associated with both H2 and G2 demolition activities, transportation, and waste management on the SPRU site impacted project efficiencies and schedule of activities. The impacts associated with the F Buildings could have been identified and accounted for earlier in the project to allow for improved operational efficiencies and management of activities.

11.2.2 Identify Potential Environmental Impacts to Nearby Receptors

The methodology for determination and measurement of potential offsite radiological exposures resulting from project activities should be evaluated and established early in the process and prior to start of intrusive project activities. SPRU site operations were significantly impacted resulting in extensive project delays as a direct result of a lack of practical, referenceable, and demonstrable exposure criteria and radiological measurements at the fence line (SPRU site boundary). Radiological measurements at the site boundaries and the corresponding strategies for exposure estimates for nearby populations, including the maximum exposed individual, should be clearly and defensibly defined using practical criteria to ensure that site operations are conducted safely and efficiently, and provide for reasonable protection for the public and the environment.

12 References

CH2M Hill 2003 TSM-11. *Outside Areas Historical Site Assessment, SPRU Project*, CH2M Hill November 6, 2003.

DOE 2006a. *Nuclear Facility Historical Site Assessment for the Separations Process Research Unit (SPRU) Disposition Project*, April 2006, by Environmental Resource Group, LLC.

DOE 2006b *Land Area Historical Site Assessment for the Separation Process Research Unit (SPRU) Disposition Project (DP)*, December 2006 by Environmental Resource Group, LLC.

DOE 2010 *Type B Accident Investigation Report Radiological Contamination Event During Separations Process Research Unit Building H2 Demolition September 29, 2010*, dated November 23, 2010

KAPL 2001. Gervasio, W. J., KAPL. *Results of 1998 Separations Process Research Unit (SPRU) Tank Farm Vault Inspections*, Rev 2. February 2001.

MARSSIM, 2000 *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)*, Revision 1, DOE/EH-0624, Rev. 1. August 2000

RSI 2015a, *Data Summary for the G2 Building*, 29643-31-14-500-001, May 20, 2015

RSI 2015b, *Data Summary for the H2 Building*, 29643-31-14-500-002, June 11, 2015

SPRU 2015a, *Open Air Demolition Radionuclide Inventory*, EEC-15-003 Rev 4, March 30, 2016

SPRU 2015b, *Open Air Demolition Appendix D Emission Estimate*, EEC-15-004 Rev 3, March 23, 2016

SPRU 2015c, *Open Air Demolition Fence-line Concentrations*, SPRU-EEC-15-005 Rev 3, June 16, 2016

SPRU-DD-004, *SPRU Disposition Project Decommissioning Plan – Revision 0*, June 12, 2009

SPRU-DD-004, *SPRU Disposition Project Decommissioning Plan – Revision 4*, August 29, 2012.

SPRU-DD-007-A, *SPRU Disposition Project Characterization Plan Addendum*, Revision 1, dated September 3, 2014.

SPRU EEC-20-001, *Interim Corrective Measures Report for Upper Level SWMUs and AOC*, May 2020

SPRU EEC-20-002, *SPRU Radiological Cleanup Report*, April 2020

SPRU-ENV-001, *Environmental Protection Plan*, Revision 6, dated October 9, 2012.

SPRU-ENV-020, *RCRA Interim Corrective Measure Work Plan for the Upper Level SWMUs*, Revision 7, dated October 15, 2018.

SPRU-ENV-017, *RCRA Interim Corrective Measure Work Plan G2 Area of Concern (AOC-008)*, Revision 3, dated July 3, 2018.

SPRU-RC-001, *Radiological Controls Program*, Revision 10, dated June 8, 2016.

SPRU-RC-012, *Radiological Confirmation Sampling and Analysis Plan/Final Status Survey*, Revision 9, dated September 18, 2017.

SPRU-RC-102, *Radiological Work Permits*, Revision 12, dated February 4, 2015.

SPRU-RC-104, *ALARA/Engineering Controls*, Revision 11, dated May 5, 2016.

SPRU-RC-302 Rev 1, *Conditions for Demolition Technical Basis Document*, March 16, 2010

VSL-13R3150-1, Papathanassiu, Adonia E. et al., *Grout Formulation Testing for SPRU Waste*, Vitreous State Laboratory, The Catholic University of America, May 3, 2013

Attachment 1 - SPRU Site Restoration Photographs

Comparison of Remedial Action Conditions

Status as of

July 24, 2019

1. G2 area looking south at G1 April 12, 2017

2. H2 Enclosure looking north over G2 area August 29, 2017

3. H2 Area looking north July 3, 2018

4. H2 footprint looking south July 25, 2018


07.24.2019

5. G2 Foot Print 10/1/2018

6. H2 Foot Print looking south October 4, 2018

Attachment 2 – SPRU Final Site Layout Maps

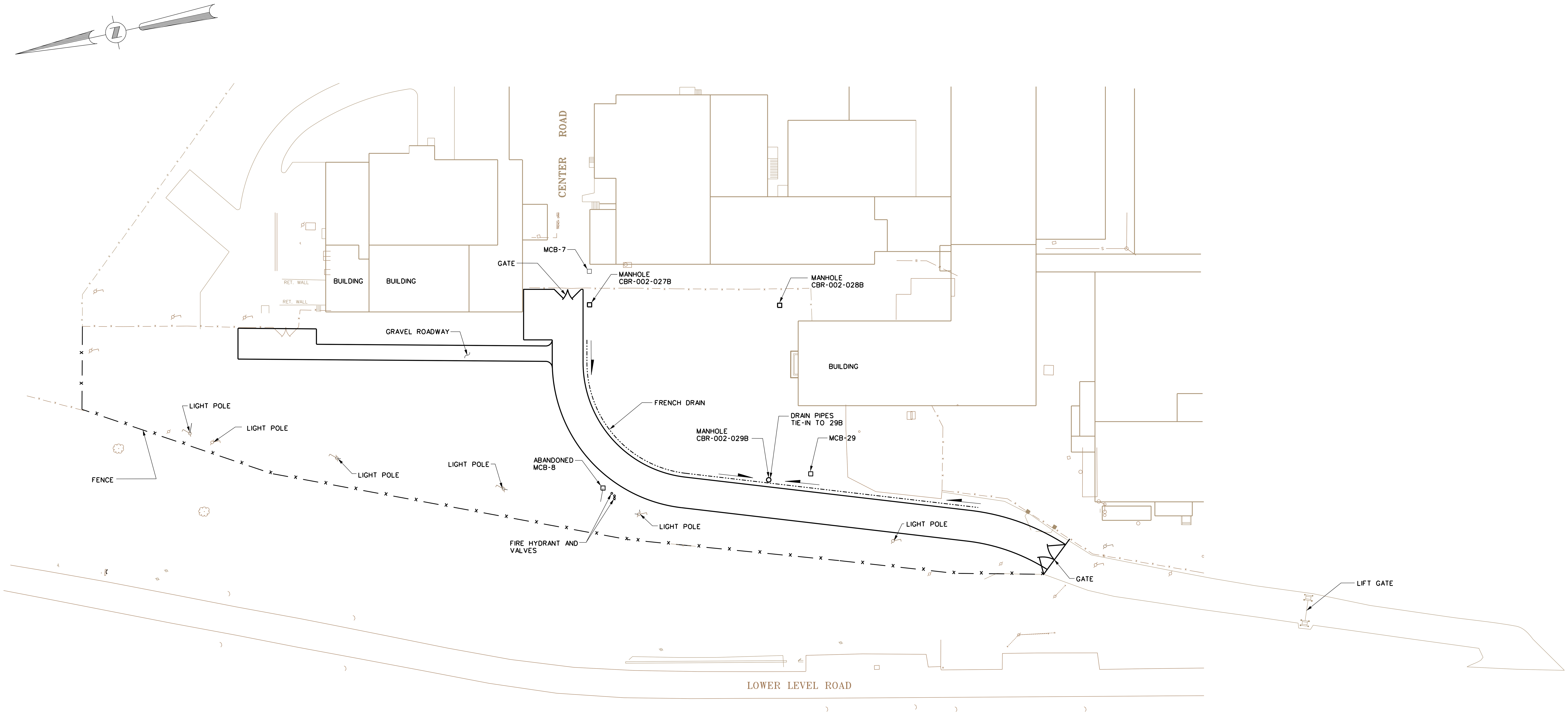
Drawings of SPRU Upper Level restored conditions

29463-00-11-020-100 - Surface features

29463-00-11-440-100 - Contour lines

29463-00-11-500-100 - Subsurface features

29463-00-11-020-100



PLAN

BAR SCALE
40 0 20 40 80
1 inch = 40 ft.

REV NO	DATE	REVISIONS	BY	CHKR
0	5/11/20	ISSUED AS ORIGINAL		

SPRU DISPOSITION PROJECT

SPRU UPPER LEVEL SITE PLAN
SURFACE FEATURES

PROJECT NO.: 29463	
DRAWN: JMP	DATE: 05/11/2020
CHECKED:	DATE:
SCALE: AS SHOWN	

URS
Washington Division
2131 SOUTH CENTENNIAL AVE
AIKEN, SC 29803
(803)502-9316
Washington Group International, Inc. dba Washington Division of URS Corporation

DWG. NO. 29463-00-11-020-100
REV 0

SPRU_D_BORDER_FINAL.DGN

PLAN

BAR SCALE 40 0 20 40 80
1 inch = 40 ft.

REV NO	DATE	REVISIONS	BY	CHKR
0	5/11/20	ISSUED AS ORIGINAL		

SPRU DISPOSITION PROJECT

PROJECT NO.: 29463

DRAWN: JMP DATE: 05/11/2020

CHECKED: DATE:

SPRU UPPER LEVEL SITE PLAN
SURFACE FEATURES W/ CONTOURS

URS Washington Division
2131 SOUTH CENTENNIAL AVE
AIKEN, SC 29803
(803)502-9316
Washington Group International, Inc. dba Washington Division of URS Corporation

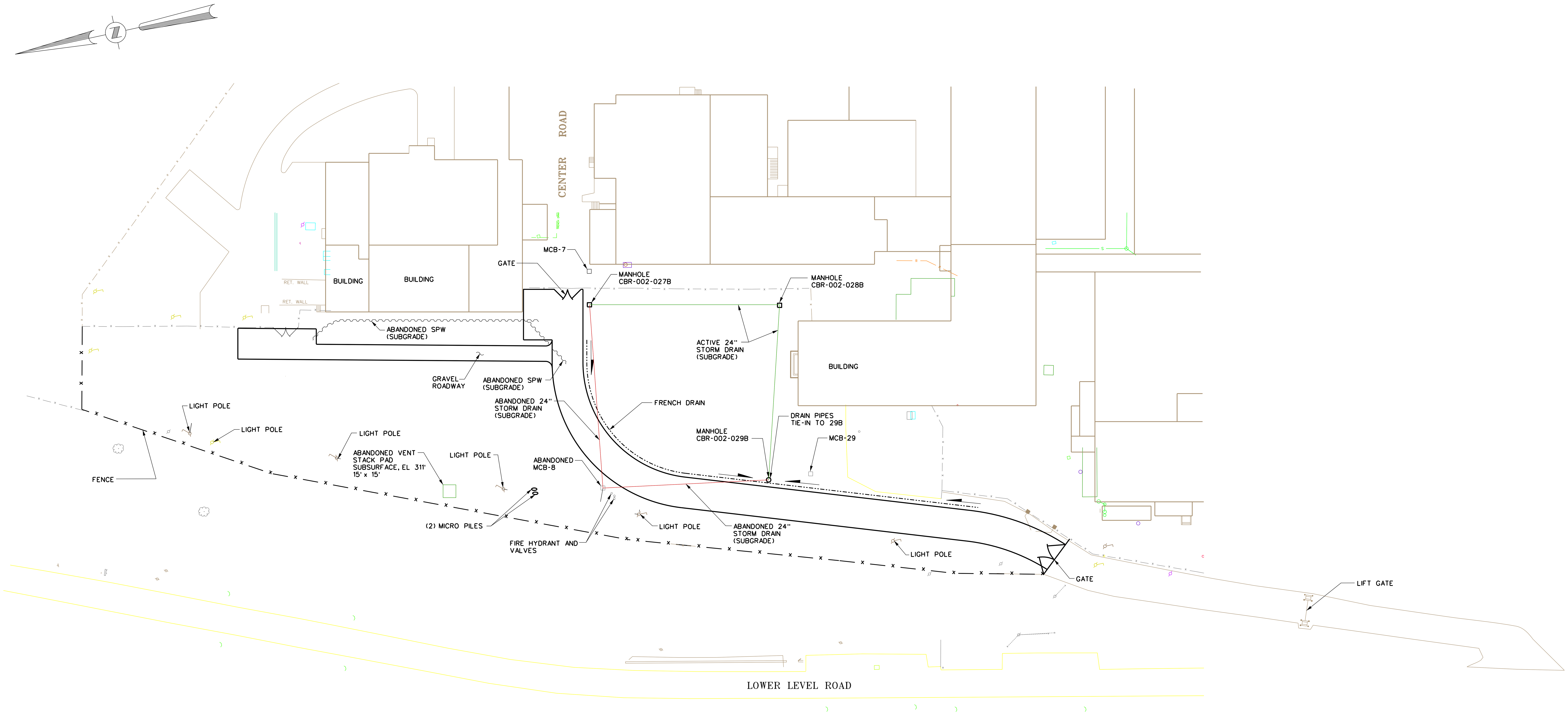
SCALE: AS SHOWN

DWG. NO. 29463-00-11-440-100 REV 0

29463-00-11-440-100

SPRU_D_BORDER.FINAL.DGN

29463-00-11-500-100



PLAN

BAR SCALE 40 0 20 40 80
1 inch = 40 ft.

REV NO	DATE	REVISIONS	BY	CHKR
0	5/11/20	ISSUED AS ORIGINAL	JMP	

PROJECT NO.: 29463
DRAWN: JMP DATE: 05/11/2020
CHECKED: DATE:
SCALE: AS SHOWN

SPRU DISPOSITION PROJECT

SPRU UPPER LEVEL SITE PLAN
SUB-SURFACE FEATURES

URS Washington Division
Washington Group International, Inc. dba Washington Division of URS Corporation
2131 SOUTH CENTENNIAL AVE
AIKEN, SC 29803
(803)502-9316

DWG. NO. 29463-00-11-500-100 REV 0

SPRU_D_BORDER_FINAL.DGN