Westinghouse Non-Proprietary Class 3

Westinghouse

Hematite Decommissioning Project

Technical Report

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Acronyms

AEC	Atomic Energy Commission
Am	Americium
bgs	below grade surface
DCGLs	Derived Concentration Guideline Levels
DP	Decommissioning Plan
FSS	Final Status Survey
GWS	Gamma Walkover Survey
HEPA	High Efficiency Particulate Air
HDP	Hematite Decommissioning Project
L	Liter
MDC	Minimum Detectable Concentration
NaI	Sodium Iodide
NCS	Nuclear Criticality Safety
Np	Neptunium
PCE	Tetrachloroethylene
pCi/g	picocurie per gram
Pu	Plutonium
Ra	Radium
RASS	Remedial Action Support Surveys
RG	Remediation Goal
ROC	Radionuclide of Concern
SNM	Special Nuclear Material
SU	Survey Unit
Tc	Technician
Th	Thorium
U	Uranium
UF_6	Uranium Hexafluoride
UO_2	Uranium Oxide
WAC	Waste Acceptance Criteria

1.0 Executive Summary

The Westinghouse Electric Company's LLC (Westinghouse's) Hematite plant and previous licensees operated a fuel-cycle manufacturing facility from 1956 until 2001 under the authority of NRC License No. SNM-33. The Westinghouse license was subsequently amended to authorize decommissioning of the former manufacturing facilities. Decommissioning activities included the removal of Special Nuclear Material (SNM) inventory and shipment of stored waste materials during 2001 to 2003; the removal and disposal of process equipment during 2003 to 2006; and the demolition of former Process Buildings at the site in 2011.

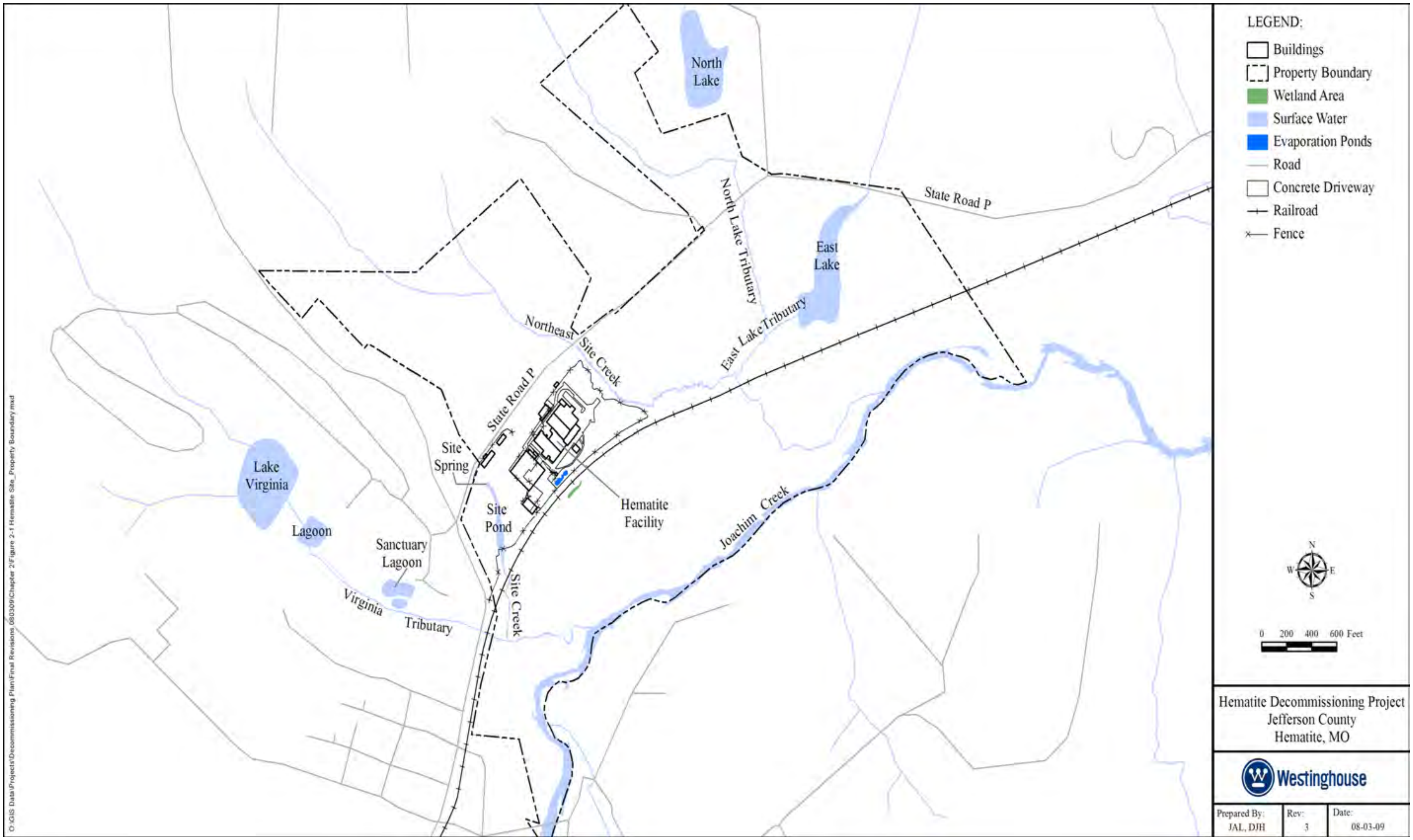
The Westinghouse Hematite Decommissioning Project (HDP) Historical Site Assessment "DO-08-005" describes the former Hematite manufacturing Site as consisting of approximately 228 acres. Figure 1 depicts the site/property boundary and specific features discussed in this section. The portion of the site where operational activities historically were conducted is referred to as the "Central Tract" and occupies an area of approximately 19 acres. The central tract area is bounded by State Road P to the north, the Northeast Site Creek to the east, the Union-Pacific railroad tracks to the south, and the Site Creek/Pond to the west. The Central Tract (Figure 2) encompassed the former manufacturing and administrative building locations, two Evaporation Ponds, the Site Pond and legacy waste burial areas. The remaining site area is predominantly pasture or woodland.

On November 9, 2011, Westinghouse's license was amended to approve the Hematite Decommissioning Plan (DP) that authorized the removal and remediation of contaminated buried materials, and soils beneath former manufacturing buildings and structures. Remedial activities to remove buried wastes in the former burial area were initiated in 2012 and completed during 2014. This document is a retrospective review to provide: 1) an overview of all the activities that were conducted to remediate documented and undocumented burial pits throughout the Burial Pit Area, and; 2) to provide additional assurance that there are no remaining undetected burials or pockets of significant contamination below the remediated burial area.

Through the implementation of the HDP DP and Final Status Surveys (FSS), Westinghouse has removed and disposed of buried contaminated debris and soils from the former burial pits, and will demonstrate that the area meets NRC regulatory requirements for unrestricted release. The information contained in this report is intended to supplement the information provided in each individual FSS Report for those survey units located in the Burial Pit Area.

Figure 1
Hematite Site / Property Boundary

Figure 2
Hematite Central Tract



2.0 Background

On-site burial was used as a disposal method for contaminated materials and wastes at Hematite starting in 1965 and lasting until 1970. These burials were authorized pursuant to Atomic Energy Commission (AEC) regulations 10 CFR 20.304 “On-Site Burial”, which was rescinded on January 28, 1981. The AEC regulation defined the burial criteria, such as number of burials per year, spacing of the pits, the thickness of the cover and the quantity of radioactive material that could be buried in each pit. Nominally, the pits were 20 feet wide by 40 feet long by 12 feet deep with an approximate cover depth of 4 feet.

Review of past manufacturing waste burial logbooks documented that 40 unlined burial pits were present in the Burial Pit Area. These Burial Pits were used to dispose of waste materials generated by the fuel fabrication processes. The logs of the waste burials contained a description of the waste buried, the weight of the uranium measured or estimated for that waste, and a cumulative total of the uranium buried in a particular pit. Some entries also listed percent enrichment for the uranium. The burial pit logs showed a wide variety of wastes that had been buried in the pits; the majority of the listed wastes were non-SNM waste, such as, contaminated trash, drums, pails, bottles, rags, etc. Additional waste materials that were listed include uranium process metals of various enrichments, metal wastes, liquid and solid chemical wastes, and high efficiency particulate air (HEPA) filters. Because the burial pit logbook records, employee interviews, and the operational uranium recovery process used during that time period consistently showed efforts to maximize recovery and utilization of uranium material whenever possible, it was presumed that there was little likelihood the documented burial pits would contain significant quantities of recoverable SNM.

Interviews with former employees also indicated that on-site burials may have occurred as early as 1958 or 1959. Available employee interview records indicate that three or four burials may have been performed each year, prior to 1965, for disposal of general trash and items that may have been slightly contaminated. Accordingly, it was estimated that 20-25 of these non-AEC 10 CFR 20.304 burials could exist for which there were no records. Burials prior to 1965 were not documented (logged), as they were not considered to contain significant quantities of SNM, and were not known to contain radioactive wastes. No information was available that indicated the specific nature of the waste material buried in the undocumented pits. Additionally, no evidence was found that indicated that burial of known uranium-bearing materials occurred prior to 1965.

These undocumented burials were also believed to have been in the same general area as the documented Burial Pits, and/or were in the proximity of site buildings in the eastern portion of the Central Tract (see Figure 3). Also, no specific information was located that indicated the specific nature of the waste material buried in these undocumented burial pits. Additionally, no evidence was found to indicate that burial of known uranium bearing materials (i.e., levels greater than free-release criteria) occurred during this time period.

Figure 3
Burial Pit Area

Based on the historical site assessment and various characterization studies, the following nuclides were identified at the Hematite site: uranium-234 (U-234), uranium-235 (U-235), uranium-238 (U-238), radium-226 (Ra-226), thorium-232 (Th-232), americium-241 (Am-241), neptunium-237 (Np-237), plutonium-239/240 (Pu-239/240) and technician-99 (Tc-99). The vast majority of the site residual radioactivity can be attributed to U-234, U-235, U-238, and Tc-99. The transuranic radionuclides, including Pu-239/240, Np-237 and Am-241 were present in only trace quantities that were introduced by the use of reprocessed uranium in the gaseous diffusion process. Thorium-232 is present in natural background and was identified as a radionuclide of concern (ROC) at a limited number of locations within the area of the buried waste. Radium-226 was identified as a ROC at two locations in the buried waste. Initially the elevated Ra-226 was thought to have been introduced into the Burial Pits with waste as a result of installing contaminated equipment into the process operations. However, during remediation activities, filter press plates contaminated with radium were found buried which were subsequently determined to have been brought in from offsite and buried, and were never part of any Hematite operation. In summary, as described in the HDP Decommissioning Plan, the primary ROCs are U-234, U-235, U-238, Tc-99, Th-232, and Ra-226. Because the Burial Pit Area was known to contain licensed activity greater than the proposed surface soil Derived Concentration Guideline Levels (DCGLs), it was classified as a Class 1 Area for conducting remediation activities.

The impacted area for the Burial Pit Area, based on characterization data, extended down to a depth of approximately 23 feet below grade surface (bgs). However, the only contaminant identified at the lowest depths was Tc-99. The Burial Pit Area was also known to contain a limestone fill area. In 1967, five dry scrubber columns were installed for removal of hydrogen fluoride from the off-gas associated with the conversion of uranium hexafluoride (UF6) to uranium oxide (UO2). These dry scrubber columns used limestone rock chips as the off-gas scrubber media. The limestone media was periodically replaced and the waste limestone stored outside or utilized as onsite fill material, including in the north portion of the Burial Pit Area. While the limestone was used as an off-gas scrubber media, it also has an affinity for Tc-99. During Hematite operations, the limestone scrubber media became contaminated with Tc-99. The only identified source of the Tc-99 was as a contaminant in Department of Energy supplied UF6 originating from reprocessed/recycled spent nuclear fuels. Therefore the primary areas impacted by Tc-99 were those locations where the waste limestone was disposed of following removal from the scrubbers.

Chlorinated Volatile Organic Carbons (VOCs), including Tetrachloroethylene (PCE), were used in a variety of production and other plant applications at Hematite. Based on information provided from interviews with former plant employees, these products were purchased in 55-gallon drum quantities, with incoming product drums typically stored outdoors in gravel or paved areas. Possible sources of PCE found in the Burial Pits, Evaporation Ponds, soils beneath building, and other site area include the following: liquid and solid wastes from processes in which PCE was used in a chemical conversion of UF6, and; liquid and solid wastes from use as a solvent for dissolving mastic in removing floor tiles. This is relevant because Tc-99 and VOCs tend to move together with water through the soil. If Tc-99 is moving through the soil, it will typically be where the VOCs are also present.

The identification of Tc-99 contamination was challenging and slowed the overall excavation and remediation process since field instrumentation did not exist for the measurement of Tc-99 during the excavation activities. As a result, the identification and quantification of Tc-99 had to be based on a laboratory analysis of soil samples. The typical turnaround time from collection to receipt of laboratory results took seven days.

Since there was potential for fissile material to exist in the buried materials, a nuclear criticality safety (NCS) screening and handling process was established specific to buried waste exhumation. The screening involved duplicate performance of radiological surveys using sodium iodide scintillation detectors on defined volumes of material to ensure that NCS limits had not been exceeded. The objective of the in situ radiological surveys was to identify any item or region of soil/waste with a fissile concentration exceeding 0.1 gram U-235 in any contiguous 1 liter (L) volume. The 0.1 gram U-235/1L threshold would provide a high degree of assurance that any items with an elevated (i.e., nontrivial) level of U-235 contamination would be identified.

Excavation and removal of the Burial Pit Area soil was initially planned to begin at the northwest corner and continue towards the east and south. The soil excavation plan was to be performed in multiple burial pits concurrently ensuring sufficient space for heavy equipment to operate, while maximizing the handling of material available for re-use as backfill and minimizing cross-contamination. The majority of materials buried in the Burial Pit Area were anticipated to be contaminated soil and trash; some laden with volatile organic carbons (VOCs), floor tiles, glass wool and laboratory glassware. Minor components of the buried waste volume were anticipated to include: acid-insoluble residue; filters; metallic debris; and, metallic oxides. However, because of the potential that fissile quantities of material could be found in the documented burial pits, excavations were performed in accordance with the limitations of the nuclear criticality safety assessment(s). The excavation and removal was typically performed using heavy construction equipment. In general, the order of techniques to be employed in removing soil and debris from the Burial Pit Areas was:

- Evaluate soil using in-situ gamma walkover surveys (GWS), VOC monitoring (with a Photo-Ionization detector) and visual inspection of the exposed surface, repeated for each newly exposed surface following a 1-foot lift removal;
- Excavate and remove soil in nominal 1-foot lifts;
- Excavate and segregate surface and subsurface soil based on: visual inspection; radiological and chemical survey/screening; supplemental sampling and analysis; the appropriate DCGLs; chemical Remediation Goals (RGs); and, the NCS Exempt Material Limit for potentially fissile material;
- Stockpile excavated soil at a safe distance adjacent to the excavation, or load into a haul truck for transfer to a waste consolidation area (WCA) for further visual inspection;
- Excavate objects encountered in the soil using heavy equipment; however, if deemed appropriate for the job more precise methods and equipment can be used (e.g., hand-shoveling); and,
- Employ sloping and benching during the excavation process, as required, and continue until visible wastes are removed and in-process surveys and soil sampling meet specified acceptance criteria.

In 2012, excavation and remediation of the Burial Pit Area soil began in both the northwest and southeast corners of the Burial Pit Area simultaneously. Excavation and removal of soil was performed concurrently, which optimized the efficiency in handling of equipment and movement of material. The burial pit waste excavation activities concluded in December 2014.

3.0 Excavation and Remediation Activities

The general locations of the former burial pits were known based on reviews of historical records, such as site aerial photographs taken during the time period the burials occurred, and the field observations of depressions that were visually discernible in the burial pit area ground surface. The localization of the pits was further helped based on visual clues, and physical work activities performed during the excavation activities. Specifically, as the overburden soil was removed it was easy to visually identify the location of a burial pit based on a change in soil color. Even the undocumented burial pits could be easily identified by a change in soil color in spite of the fact that their size and shape was not as well defined as the documented pits. See Figures 4 and 5. Additionally, the equipment operators conducting the excavation could distinguish when they were digging in a burial pit based on the difference in the hardness of the soil. Workers could even detect the difference in the soil hardness when walking over a burial pit, which tended to be soft and spongy. Adding to the visual and soil hardness cues, the burial pit was also radiologically identifiable based on a GWS once reaching the contaminated layer.

Figure 4
Example of Soil Discoloration where a Burial Pit was Located

Figure 5
Example of Multiple Burial Pits Visually Identifiable by a Change in Soil Color as Well as by Uncovering Trash and Debris

Initially the removal of the overburden began in 1 foot lifts as specified in the HDP DP. The intent of the 1 foot lifts was to ensure potentially fissile quantities of material could be identified for appropriate handling, and to enable waste to be identified and removed so a maximum volume of soil could be saved for reuse. The process called for in situ scanning to identify and remove soil areas exceeding 0.1g U-235/L. Any lumps of material that potentially exceeded 40g U-235 total would be separated out and undergo a more thorough evaluation utilizing close proximity radiological surveys to determine if further handling requirements were necessary to maintain NCS compliance. At this point any material that was identified ex-situ to be greater than 15g U-235 required segregation from the waste stream, and special handling for NCS Control purposes. The NCS evaluation performed at the time identified that material in-situ less than 40g U-235 could go unidentified with a 12 inch lift, but any of the material identified ex-situ greater than 15g U-235 still required segregation. It had been determined that these were adequate ex-situ survey controls to provide a wide margin of Criticality Safety, and also demonstrate compliance with offsite waste disposal acceptance criteria.

Within the first few months after excavation activities began, the NRC expressed concerns whether a NaI 2x2 detector could identify lumps of U-235 via in-situ scanning through a foot of soil, therefore allowing material between 15g and 40g U-235 to be excavated prior to segregation. After further review and discussion with the NRC, HDP made the decision to take the more conservative approach and abandoned the use of 12 inch lifts, with all future NCS controlled excavations performed in 6 inch lifts. Soil/debris in areas not subject to NCS controls was still excavated in 12 inch lifts. This change was initiated in August of 2012, approximately four months after site excavation activities began. See Figure 6.

Figure 6
Example of Worker Conducting a Gamma Walkover Survey (GWS) in the Burial Pit Area with a NaI 2 x 2 Detector

Overall the process of locating, assessing and removing debris from the burial pits was very labor intensive. For example, on several occasions hundreds of small plastic vials were found. In each case, every vial had to be separately surveyed by two independent technicians using different instrumentation. While the majority of materials located within the burial pits were as anticipated, 215 radium contaminated filter plates made of steel, cast iron, and plastic, about 3 feet by 3 feet in size, were unexpectedly found. See Figures 7 and 8. It was determined that these were brought to the Hematite site from an offsite entity. Figures 9 and 10 also show several examples of some of the waste from the burial pits.

Figures 7 and 8
Examples of Radium Contaminated Filter Plates Being Unearthed While Excavating in the Burial Pit Area


Figures 9 and 10
Examples of Debris that was Exhumed During Remediation Excavation of the Burial Pit Area


As excavation and remediation of the Burial Pit Area progressed, it became apparent that most of the buried debris was located in the north and south ends and typically in closely aligned pits, while the middle area had minimal debris and contamination. As sloping and benching practices were employed, and due to the close nature of the pits, large areas ended up being remediated as opposed to individual standalone pits. This had the advantage of providing additional assurance that any radiological contaminate that could have migrated laterally from a pit was also likely remediated. Also as expected, the burial pits were generally of similar depth. This was expected because of the equipment that would have in all likelihood been used to dig the pits. A normal sized backhoe would have been the expected heavy equipment employed, which has a typical maximum reach of about 10 feet (plus or minus) when digging a trench. This knowledge helped when excavating a burial pit as it provided an informal bound for the depth of the pit, as well as providing a solid basis for not expecting two burials to be placed one on top of another.

The effective area of the Burial Pit Area also expanded as excavation activities continued to locate undocumented burial pits and benching and sloping activities continued. As excavations moved towards the west, the area requiring NCS controls was expanded to encompass the expanded area. Figure 3 shows the original Burial Pit Area as envisioned prior to when excavations began, as well as the NCS Boundary that became the effective Burial Pit Area. While the debris identified in the "expanded" area to the west were common items of trash, HDP continued to employ NCS controls to ensure worker safety in the unlikely event fissile material was located. The area employing NCS controls was also expanded to the east and north as sloping and terrain issues dictated as excavation activities continued, but not because additional debris was found in those areas.

4.0 Completing Remediation

As excavation progressed in the Burial Pit Area, five activities came into play that determined the extent of remediation in a given survey unit (SU). They were: 1) ongoing remedial action support surveys (RASS), 2) conducting core bores to support moving out of criticality controls, 3) performing a final RASS, 4) sampling for VOC remediation, and 5) conducting final status surveys (FSS).

The RASS was conducted to: guide remediation activities, determine when an area or survey unit had been adequately prepared for FSS, and provide updated estimates of the parameters to be used for planning the FSS. During soil excavation, the RASS would serve to assess the potential concentration and amount of U-235 for comparison to the NCS Exempt Material Limit. In areas subject to NCS controls, a GWS with visual inspection was required to be performed independently by two different HP Technicians using two separate instruments prior to excavation of each layer of soil. In conjunction with the GWS, remediation areas were required to be visually inspected prior to exhumation of any material, unless specifically exempted. Once excavation of a SU reached a point where there were no longer any indications of waste indicative of a burial pit, and the RASS indicated the soil would meet the NCS Exempt Limits, core borings were conducted. The core bores were required to be dug 7 feet deep from the original surface, but at least 3 feet from the excavated surface, depending on the depth of the excavation. This allowed for a visual inspection to verify that there was no longer an indication of a burial pit below the excavated elevation (surface).

These core bores were systematically placed based on a 20 foot grid, eventually covering the entire Burial Pit Area. Core cuttings and the core bore hole were surveyed to provide radiological data to make a determination whether NCS controls could be suspended for that SU. The data was evaluated against pre-determined NCS Limits. The core cuttings were evaluated against a saturated soil value of 46k net counts per minute (ncpm), and the core bore holes were evaluated against a dry soil value of 63k ncpm. If the core bore data was less than the above criteria and no waste material indicative of a burial pit was found, it was used as a decision point that assumed the bottom of the burial pit had been reached and criticality controls were no longer necessary. Even though additional radiological remediation may still have been required for the soil surrounding a burial pit, by eliminating the NCS controls, work could progress at a faster pace and with fewer resources. (As a note, core bore data was not used in the development of the FSS Plan. It was only used in the assessment of the need for NCS controls.)

Following removal of NCS controls, remediation would often continue to remove any remaining radiological contamination in the soil surrounding the burial pit debris field. This work would continue in conjunction with RASS until it was determined the DCGLs for that SU would be met. At this time, radiological remediation would be complete unless additional remediation was required based on subsequent FSS activities. However, excavation in many cases continued after radiological concerns were addressed due to the need to remove VOCs in the soil. In a number of cases, VOC remediation resulted in the removal of soil down to the phreatic surface. Once all radiological and VOC remediation activities were completed, a final RASS survey was performed to ensure the area met required DCGLs and to obtain data for FSS design. The FSS was then performed to demonstrate the SU met the NRC unrestricted release requirements based on a GWS and soil sampling results.

5.0 Retrospective Review

Two issues were identified for examination during the retrospective review. The first issue involved the potential for a radioactive contaminate to migrate through the soil and collect in an area below where a burial pit or radioactivity was known to have existed. In this case, because an area of elevated contamination could pose a long term risk factor, it was sensible to examine the potential that an area like this could still exist in spite of the extensive remediation activities that were already performed. The second issue was whether another burial “pit” could potentially exist below where the current excavation activities ceased.

To address the first issue, Westinghouse evaluated the potential for the existing radionuclides identified at the Hematite to migrate through the soil. The primary nuclides of concern at Hematite are U-234, U-235, U-238, Ra-226, Th-232, and Tc-99. Of these radionuclides, only the Tc-99 has the potential to move downward through the soil and collect within a timeframe consistent with existence of the Hematite facility. The other nuclides are generally non-soluble and more readily bind to soil particles which retards their movement. Because Tc-99 is less likely to bind to soil and is more mobile it will travel more readily with water (and with VOCs). This is supported by the fact that Tc-99 has been identified at depths in the range of 30 feet in the area of the former Evaporation Pond. While both Tc-99 and uranium have been identified near the surface, only Tc-99 has been identified at depth.

The relationship of Tc-99 and VOCs is relevant because they both tend to migrate with water. Therefore, if the VOCs are found migrating through the soil, Tc-99 may also be resident in those areas. That is why final RASS and FSS activities were not performed until VOC remediation activities were completed. As excavation continued to remove VOCs there was always the potential to identify additional Tc-99 contamination that would require further removal following the completion of excavating VOCs. Conducting RASS and FSS after the VOCs were removed provided assurance no additional Tc-99 in excess of DCGLs would be left unremediated. Because the limestone waste from the scrubbers was the source of the Tc-99, all the limestone was also removed prior to completion of excavation, RASS and FSS activities.

A review was conducted of the Burial Pit Area surface and sub-surface soil sampling data summarized in the Hematite Radiological Characterization Report. The review indicated that 94 surface soil samples (at 0.0-0.5 feet) were analyzed for Tc-99. Fifty-five of the 94 samples had Tc-99 activity above the Minimum Detectable Concentration (MDC) with a maximum result of 68.3 picocurie per gram (pCi/g) and an average of 2.6 pCi/g. All of these areas were remediated when the overburden was excavated.

There were 89 soil samples within the root zone (0.5-5.0 feet) that were analyzed for Tc-99. One sample had a value of 33.8 pCi/g, and this area was remediated. Twenty-one of the 89 samples had Tc-99 activity above the MDC with a maximum result of 14.8 pCi/g and an average of 1.0 pCi/g. None of the results were in excess of the Tc-99 Uniform DCGL of 25.1 pCi/g or the Excavation DCGL value of 74.0 pCi/g. Although below the DCGL, many of these areas were still remediated in conjunction with excavation activities.

There were 144 soil samples within the deep zone (> 5.0 feet) that were analyzed for Tc-99. Twenty-seven of the 144 samples had Tc-99 activity above the MDC with a maximum result of 38 pCi/g and an average of 0.75 pCi/g. None of the results were in excess of the Tc-99 Excavation DCGL value of 74.0 pCi/g. Regardless, many of the areas where these samples were collected were also remediated.

There was also a concern that previous hybrid groundwater monitoring wells could have provided a conduit for Tc-99 to migrate downward. A hybrid well was a well that had been installed with a screen that extended from the overburden clay to the sand-gravel aquifer, which could allow transport between layers. Seven hybrid wells were located in the Burial Pit Area. For each of these seven wells, Tc-99 water sample results were evaluated to determine if any well analytical results for Tc-99 exceeded the MDC plus any measurement error threshold value. Only well BP-17 exceeded this threshold value. This well was located in the area where the limestone was buried so the higher level of Tc-99 in this well was not unexpected. In 2013, four borings were collected around BP-17 and an additional six investigation borings were collected in the vicinity of BP-17 to determine the extent of Tc-99. A total of 86 samples were collected from the ground surface to bedrock. No sample results exceeded the Tc-99 Excavation DCGL of 74 pCi/g. The maximum Tc-99 value identified was 59.6 pCi/g at 28-30 ft on the boring collected just east of BP-17. The remaining samples collected in the other three borings around BP-17 at the 28-30 foot interval contained a maximum value of 4.25 pCi/g.

In 2012, six hybrid wells and three groundwater monitoring wells were abandoned. When wells are abandoned they are over drilled using hollow stem augers of sufficient outside diameter to remove approximately two inches of surrounding soil, the well riser, well screen, and screened filter pack. Soil cuttings that are removed during the boring process are surveyed for indications of elevated radioactivity as a qualitative measure and sampled for laboratory analysis. For the six hybrid wells and three groundwater monitoring wells, radiological samples were collected in the cuttings of each 5 foot interval to the bottom of the boring which was in the range of 28-35 feet below ground surface. A total of 62 samples were collected with the maximum Tc-99 concentration of 21.1 pCi/g from the 5-10 foot interval of the BP-17 well cuttings.

In summary, based on sample results, it has been determined that there is very little probability that Tc-99 could exist at levels that exceed the excavation DCGL at a depth below where excavation activities ceased because there was very little Tc-99 that existed in the majority of the burial pit area to begin with. The Tc-99 that was identified was predominately in the areas where limestone had existed, which was expected since the limestone was the path by which the Tc-99 was introduced into the waste stream. In addition, most of the areas where the Tc-99 was identified were ultimately excavated.

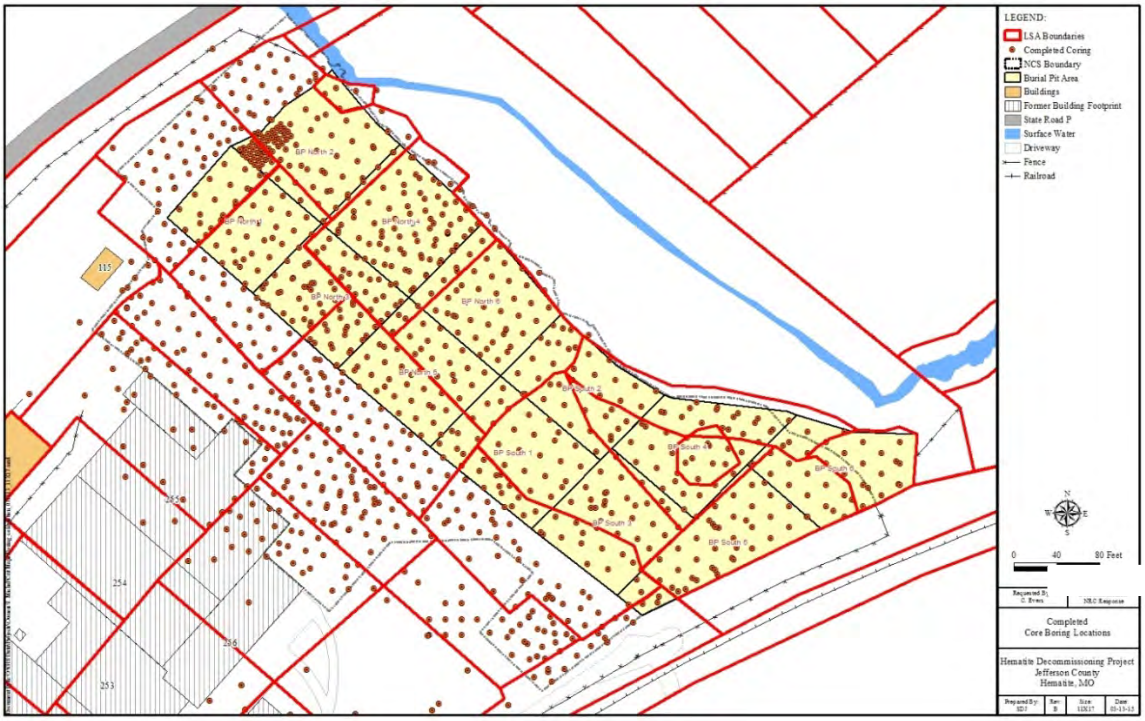
To address the second issue of whether another burial pit could potentially exist below where the excavation activities ceased, a number of factors were considered. While in some locations it is clearly demonstrated that another burial pit could not exist because the excavation went to the phreatic surface, in other areas it can be demonstrated through a combination of a number of factors together.

The first things considered were the nature of the burial pits themselves. The documented licensed burials were fairly easy to identify by location based on historical records, examination of site aerial photographs taken during the time period the burials took place, and depressions visually discernable in the ground surface. While a smaller amount of information was available in regard to the undocumented burials, what records and anecdotal evidence was available provided a reasonable estimate of where the burials were located. In addition, although the documented licensed burials were constrained in size by the regulatory criteria of width (20 feet), length (40 feet) and depth (12 feet), in reality they were found to be smaller than that, and were similar in size to the undocumented pits. The undocumented burials were expected to contain only minimally contaminated debris, but had no proscribed size limitations so would be of varying shapes and depth, dependent on the volume of waste being buried at any particular point in time. **In none of the historical records or anecdotal evidence, including input from former Hematite workers, was it indicated or implied that burial pits were stacked one on top of another.** Ultimately, the excavation remediation activities bore out what was expected. The sizes and locations of both the documented and undocumented burials were as expected. No burials of any kind were exhumed in a location outside the initially identified burial pit area or one on top of another.

The second factor to consider is the visual nature of the burial pits. At the start of the Burial Pit Area excavation the overburden layer of soil was removed. Once this overburden layer was gone, the location of a burial pit was visually observable based on the discernable change in soil color. They could also be identified by the equipment operators conducting the excavation by the difference in the hardness of the soil, and even the workers could detect the difference in the soil hardness when walking over the burial pit. In essence, the burial pits were very easy to visually identify. Also of significance is the burial pit could be radiologically identified, even before it was fully uncovered. In some instances the actual buried debris was encountered a few feet below the observable change in soil color/texture, but was still identifiable using a 2 x 2 NaI detector. Once the bottom of the burial pit was reached it was evident by the change in color of the soil, the hardness difference between the softer burial pit material and the hard native soil, a disappearance of debris, and, a sharp decline in radiological readings. Overall, the visually observable change in the soil conditions provided the best confirmation that there was no buried waste located further down.

As excavation/remediation was conducted, the depth at which the remediation was necessary to remove radiological debris varied throughout the burial area. Radiological surveys were conducted continually as the burial pits were remediated. Prior to NCS controls being suspended, core bores were taken to verify the burial pit had ended as evidenced by visual inspection, the radiation readings from the bore holes, and the bore holes cuttings. These core bores were systematically placed based a 20 foot grid over the entire burial pit area. A technical basis document (HDP-TBD-NC-205, *Assessment of the Adequacy of Lateral Subsurface Soil Sampling in the Burial Pit Area*) was developed to statistically verify the 20 foot spacing was acceptable to ensure an undiscovered burial pit should be identified with a high level of confidence. Figure 11 provides a map showing the locations of all the core bores that were conducted for criticality control purposes. While this process was not conducted for the purpose of demonstrating a SU was ready for FSS, the fact that over 600 bore holes were drilled does provide additional assurance that no other burial pit existed below the depth of an already remediated pit.

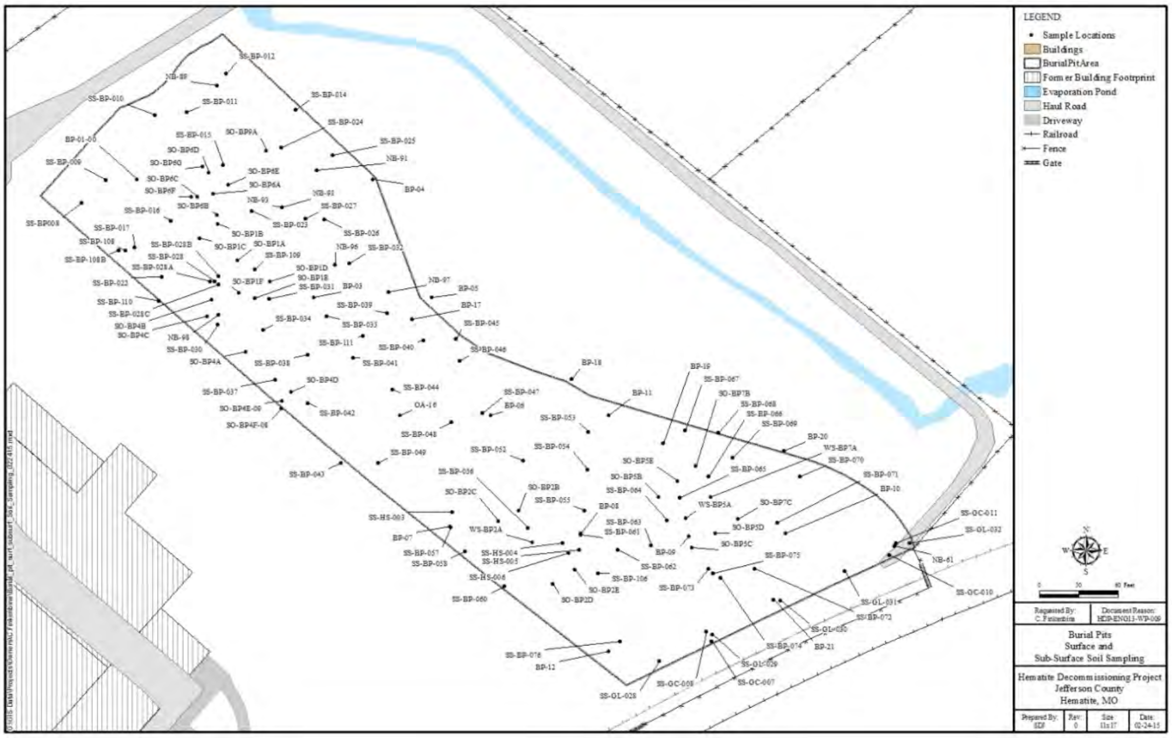
Figure 11
Core Bore Locations that were Performed for Nuclear Criticality Safety Control Purposes



Separate from the radiological remediation activities, excavation was also necessary to comply with State of Missouri regulatory requirements for VOCs. To meet the RGs for VOCs, a large portion of the burial pit area was remediated beyond what was required to remediate for radiological contamination. In some cases, this resulted in the entire core boring previously conducted for criticality concerns to be dug out as the excavation activities continued. In several locations, soil was excavated down to the phreatic zone. After all these activities, not one instance was identified where a second burial pit was located below an existing burial pit, or where radiological remediation activities had ceased.

A review was conducted to examine sample results from soil borings carried out from 2003 to 2014 for site characterization purposes. These borings provided evidence of both buried waste and the lack of buried waste. Due to criticality concerns, many initial borings were intentionally placed to avoid the burial pits. In subsequent characterization efforts, borings were conducted in the burial pits as well. Overall this provided a good mix of data that was representative of the entire Burial Pit Area. Figure 12 provides a map showing the locations of all the core borings on the Burial Pit Area. Based on the review, none of the sample results showed there was contamination at a depth that would be indicative of a second burial pit below an existing burial pit. The core boring data was also examined against final excavation elevations. While these results are summarized within the FSS Report for each individual SU, in summary, all areas of contamination identified through characterization surveys were remediated entirely or at a minimum, to levels below the applicable DCGL for that stratum and SU.

Figure 12
Location of Surface and Sub-surface Soil Sampling Locations in the Burial Pit Area



Lastly, following the completion of all remediation activities, and in accordance with the DP, final status surveys were conducted that involved a 100% walkover scan performed with a 2 x 2 NaI detector, and a proscribed number of systematic soil samples (and additional biased soil samples as necessary) collected for analysis. This has been or will be completed for each SU within the Burial Pit Area.

Figure 13 provides a map of the post remediation excavation depths in the Burial Pit Area. The depths shown are the feet of material excavated from the original surface elevation at that location. The maximum excavated depth was approximately 24 ½ feet.

Figure 13
Excavated Elevations of the Burial Pit Area Post Remediation

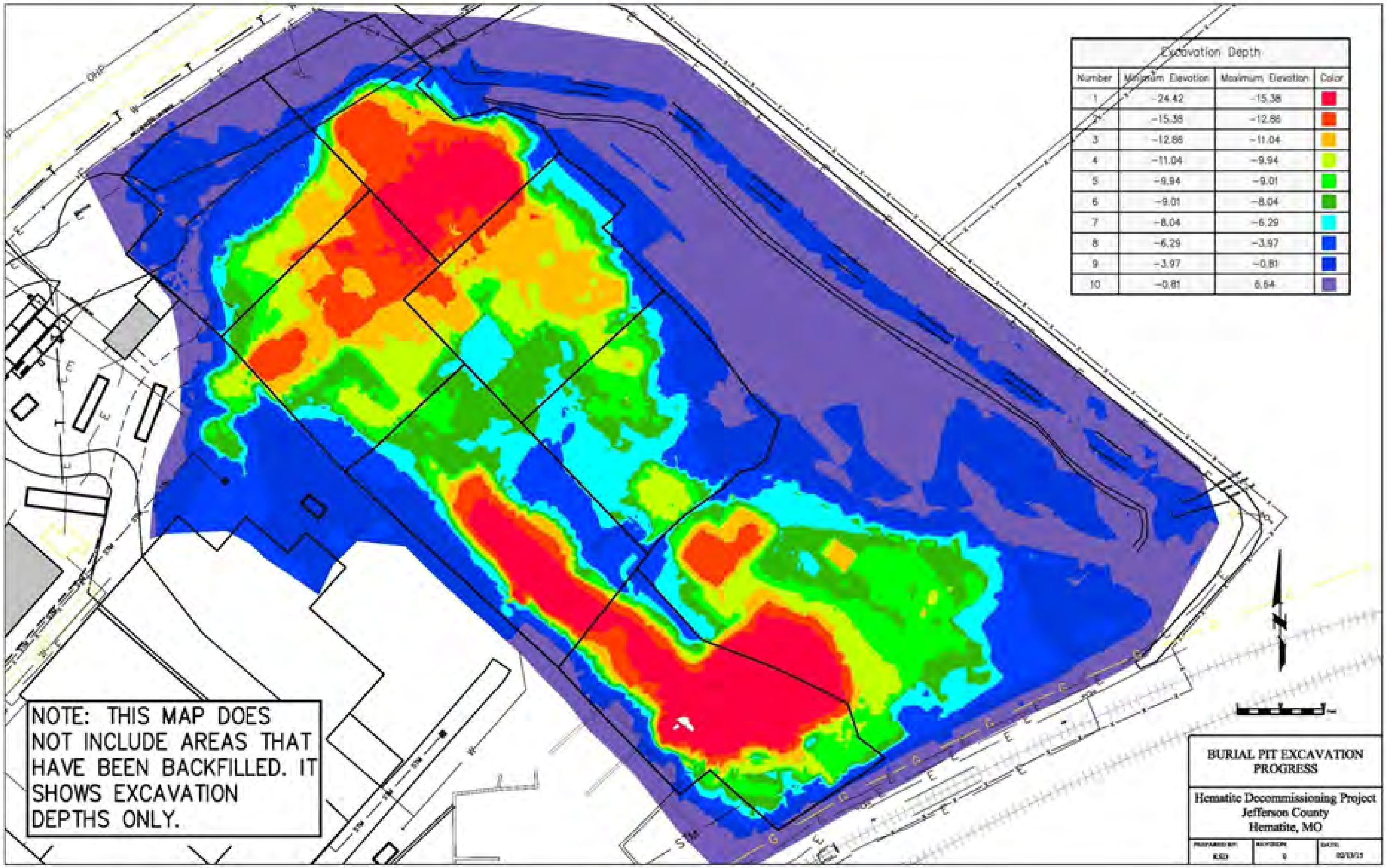


Figure 14 provides an aerial view of most of the Burial Pit Area taken on April 1, 2015. The photograph was taken after all remediation activities, both radiological and chemical, were completed. While a portion of the area had filled with water following the completion of excavation activities, the change in water color with depth helps visually identify the change in depth and extent of some of the excavated areas. The large excavation identified in the lower-left corner of Figure 14 is where a large number of burial pits were located in close proximity, and is near where the radium plates were found. The Burial Pit Area will be backfilled with clean soil from offsite and the site topography restored prior to license termination.

Figure 14
Aerial View of a Portion of the Burial Pit Area Post Remediation Looking West to East

6.0 Retrospective Review Conclusion

Based on the above retrospective review, all the above factors in combination provide an extremely high level of assurance that there are no undiscovered burial pits or localized elevated areas of contamination that were not remediated. This is based on, 1) the ability to visibly observe the locations of the burial pits during remediation activities, 2) criticality related core borings that were performed, 3) additional excavation activities to remove VOCs, 4) not one instance was identified throughout the burial area where a second burial pit was located below an existing burial pit, 5) characterization data based on borings in the Burial Pit Area demonstrates all known areas of radiological contamination were already below or were remediated below the applicable DCGLs, and 6) the acceptable analytical results of FSS soil sampling and 100% gamma walkover surveys.

7.0 References

6.1 DO-08-004, Hematite Decommissioning Plan

6.2 HEM-11-56, Final Supplemental Response to NRC Request for Additional Information on the Hematite Decommissioning Plan and Related Revision to a Pending Licensing Action

6.3 DO-08-005, Westinghouse Hematite Decommissioning Project Historical Site Assessment

6.4 HDP-TBD-NC-205, Assessment of the Adequacy of Lateral Subsurface Core Sampling in the Burial Pit Area