Attachment 1

Final Status Survey Final Report Volume 1, Chapter 1, Revision 2

Final Status Survey Final Report Overview

Westinghouse Electric Company LLC, Hematite Decommissioning Project

Docket No. 070-00036

Westinghouse

Final Status Survey Report

Hematite Decommissioning Project

Final Status Survey Final Report Volume 1, Chapter 1

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Revision No. Effect. Date	**Revision**
0 09/14/2015	Revision 0 is the initial issuance of the Final Status Survey Final Report Overview.
1 01/07/2016	FSSFR Volume 1, Chapter 1, Final Status Survey Final Report Overview, Revision 1 supersedes Revision 0. Revision 1 incorporates resolution to NRC review comments as documented in the initial NRC document "*Resolution Table for Final Status Survey Report Volume 1, Chapter 1*" after discussions held during the November 5, 2015 NRC – Westinghouse teleconference.
2 See Cover Page	FSSFR Volume 1, Chapter 1, Final Status Survey Final Report Overview, Revision 2 supersedes Revision 1. Revision 2 incorporates resolution to NRC review comments received via the NRC publicly noticed teleconference conducted on 12/02/2016, and includes the following: - Indicate demobilization date of Perma-Fix. - Section 5.1.2 was inserted to provide detail on how U-234 values are inferred based on the ratio of U-238 to U-235. - Section 5.1.3 was inserted to provide detail on how the Ra-226 and Th-232 soil background values were developed and how they are applied in FSS. - Added Table 5-5, Radioactivity and Isotopic Ratios Relative to Enrichment. - Added Table 5-6, Ra-226 and Th-232 background soil values for FSS sample analysis.

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LIST OF ACRONYMS AND SYMBOLS

Am	Americium
BSA	Building Survey Area
CAD	Computer Aided Design
CHP	Certified Health Physicist
CFR	Code of Federal Regulations
cm	centimeter
CSM	Conceptual Site Model
DCGL	Derived Concentration Guideline Level
$DCGL_{BP}$	Derived Concentration Guideline Level Buried Piping
DP	Hematite Decommissioning Plan
EPA	U.S. Environmental Protection Agency
FSS	Final Status Survey
FSSFR	Final Status Survey Final Report
GIS	Geographic Information System
HDP	Hematite Decommissioning Project
HP	Health Physics
HRCR	Hematite Radiological Characterization Report
HSA	Historical Site Assessment
LSA	Land Survey Area
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
m	meter
Np	Neptunium
NRC	U.S. Nuclear Regulatory Commission
PSP	Physical Security Plan
PSA	Piping Survey Area
Pu	Plutonium
Ra	Radium
RAI	Request for Additional Information
ROC	Radionuclides of Concern
RSO	Radiation Safety Officer
SNM	Special Nuclear Material
SOF	Sum of Fractions
Tc	Technetium
Th	Thorium
U	Uranium
Westinghouse	Westinghouse Electric Company LLC

1.0 FINAL STATUS SURVEY INTRODUCTION

By application dated September 11, 2001, Westinghouse Electric Company LLC (Westinghouse) notified the U.S. Nuclear Regulatory Commission (NRC) that principal activities under license SNM-33, specifically those related to the manufacture of nuclear reactor fuel fabrication utilizing Low-Enriched Uranium, at the Hematite Site had ceased. Westinghouse submitted a change to the license application and NRC approved License SNM-33 Amendment Number 42 to modify the scope of licensed activities to those associated with decommissioning activities. Westinghouse's decommissioning goal is to reduce residual radioactivity to a level that permits termination of the license in accordance with 10 Code of Federal Regulation (CFR) 70.38(d) and release of the site for unrestricted use in accordance with NRC Regulations (10 CFR 20, Subpart E, Radiological Criteria for License Termination). Specifically, the requirements as set forth for license termination and unrestricted use are specified in 10 CFR Part 20.1402.

In accordance with 10 CFR 70.38(d) Westinghouse submitted a revision to the license application and DO-08-004, Hematite Decommissioning Plan (DP) {ML092330123} for NRC review and approval. There were two aspects to the DP that provided an opportunity for significant review. The first aspect was that a significant portion of the remediation of the site consisted of the excavation and removal of diffuse contaminated waste in burial pits with a possibility of identifying Potentially Recoverable Special Nuclear Material (SNM). The second aspect was a Final Status Survey (FSS) approach that provided two conceptual models based on the fundamental attributes of NUREG-1575, *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM). The conceptual models endeavored to address the technical aspects associated with the fact that much of the FSS to be performed on the site would be within excavations and not on flat open land areas as is the MARSSIM model.

As an outcome, the review and approval process by the NRC was a significant undertaking which resulted in numerous rounds of the Request for Additional Information (RAI) from the NRC and corresponding responses by Westinghouse. With the issuance of License SNM-33 Amendment 57 {ML112101640} and the DP Safety Evaluation Report {ML112101630} the Hematite Decommissioning Project (HDP) DP and associated documents were approved on October 13, 2011, by NRC letter {ML112101699}. On November 9, 2011, the NRC issued License SNM-33 Amendment 59 {ML112200209} which approved the Hematite Physical Security Plan (PSP). The revision to the PSP encompassed the security of Potentially Recoverable Material that, although highly unlikely, could possibly be discovered in the burial pit and red room roof burial areas. With the approval of the PSP, remediation activities were then authorized to commence.

Remediation activities commenced in the burial pit area on March 19, 2012, and also in other areas of the facility. Remediation activities were completed in the "south" section of the burial pit area in October, 2013, with FSS commencing in those areas in November, 2013. FSS results indicated that remediation had been successfully completed in the south burial pit area. During this time period the NRC completed inspection and confirmatory surveys in the south burial pit area and documented the results in inspection reports; 07000036/13001 {ML13154A125};

07000036/2013002 {ML13241A252}; and 07000036/2013003 {ML13336A408}. Remediation was completed in the red room roof area in March, 2013, with FSS commencing shortly thereafter. FSS results indicated that remediation had been successfully completed in the red room roof burial area. During this time period, the NRC completed inspection and confirmatory surveys in the red room roof burial area and documented the results in inspection report 07000036/2013002 {ML13241A252}.

In late 2013, and early 2014, both the NRC and Westinghouse assigned new personnel to the HDP. This provided an opportunity for both the NRC and Westinghouse to revisit various technical issues in regards to the FSS program. Additionally, in mid-2014 Westinghouse initiated the procurement of contractor services whose core competency is FSS. The contractor would be required to work to the existing HDP FSS program and procedures as they had previously been reviewed and approved by Westinghouse as well as undergone inspection by the NRC.

In November, 2014, remediation actives in the burial pit area were completed with the commencement of FSS activities scheduled for January, 2015. With the burial area and red room roof burial area remediation complete, Westinghouse notified the NRC of the de-escalation of the Physical Security Plan {ML14324A952}, as approved therein, as there was no longer the plausibility of identifying Potentially Recoverable SNM.

The assignment of new personnel by both NRC and Westinghouse required the alignment and mutual understanding of the DP and its technical aspects. To accomplish this task numerous onsite and conference call meetings were held, in addition to publicly noticed teleconference meetings. An outcome of these meetings was the outline and content of information to be provided in the Final Status Survey Final Report (FSSFR).

The format of the FSSFR would provide for documenting the resolution agreed upon to the various technical issues regarding FSS not otherwise specifically addressed in the DP. The FSSFR would also provide the FSS data necessary to demonstrate compliance with the release criteria.

Section 6.0 provides a description of how the FSSFR is organized utilizing a document system of volumes and chapters to provide the requisite information.

2.0 SITE DESCRIPTION

The Westinghouse Hematite Site is located on a site of about 228 acres in Jefferson County, Missouri, approximately 3/4 mile northeast of the unincorporated town of Hematite, Missouri, and 35 miles south of the city of St. Louis, Missouri. A map showing the general location of the site is presented in Figure 2-1. The area within a 5-mile radius of the site is presented in Figure 2-2.

Jefferson County is predominately rural and characterized by rolling hills with many sizable woodland tracts. The land area is classified as 51% forest, 33% agricultural with crops such as grain and hay, and approximately 16% urban, suburban, commercial, and unused or undeveloped. Although extensive development in the county has resulted from urban growth around St. Louis, agricultural land use is still predominant in the site's environs. Some areas, generally ½ to 5 miles from the site, have been developed as small to moderate sized subdivisions.

The site is situated between hills to the northwest and a terrace/flood plain of Joachim Creek, located along the southeast site boundary. As indicated in the DP, activities with SNM were conducted within an approximately 10-acre Central Tract adjacent to the site access road, State Road P. The remaining site property is woods and farmland, with no evidence of historic operations by Westinghouse or previous owners documented or identified. The current site boundaries and the Central Tract location are depicted in Figure 2-3.

The Central Tract area in which SNM licensed activities occurred is geographically bounded by an active railroad line which runs across the site southeast of the Central Tract; The North East Site Creek to the northeast; and, State Road P which bounds the northwest and southwest sides of the Central Tract. A site map of the Central Tract with the building locations remaining after remediation is complete are depicted in Figure 2-4.

3.0 SITE HISTORICAL OPERATIONS

The DP Chapter 2 provides a detailed discussion on site historical operations. Of relevance to the conduct of Final Status Surveys are the recent site operations which include decommissioning and demolition of the Process Buildings and the remediation of the Central Tract soils and the Site Pond sediments.

A chronology of major milestones in regards to progress towards commencing FSS are given below:

- Operations for the Federal Government (1956 to 1974)
- Commercial Operations (1974 to 2001)
- Cessation of Operations (June 2001)
- Demolition of Process Buildings (April – June 2011)
- Approval of the Decommissioning Plan (October 2011)
- Commence Remediation of the Burial Pit Area (March 2012)
- Commence Remediation of Balance of the Site (December 2012)
- Complete Remediation of the entirety of the Burial Pit Area for Potentially Recoverable SNM/De-escalation of Physical Security Plan (November 2014)
- Commence Final Status Survey Activities – South Section of Burial Pit Area (October 2013)
- Commence Final Status Survey Activities – North and Central Sections of Burial Pit Area (January 2015)

- Commence Final Status Survey Activities – Buildings (March 2015)

FSSFR Volume 3 contains summary information in regards to remediation of the various areas of the Hematite site. Figure 3-1, Conceptual Open Land Survey Units depicts the expected survey units and FSS class during decommissioning as presented in the Decommissioning Plan. This figure will be updated and provided in FSSFR Volume 3, Chapter 1 and in subsequent revisions as boundary or classification changes are made.

Figures 3-2 through 3-5 provide the conceptual building survey units for those buildings that will remain on-site at the completion of FSS. These figures will be updated and provided in FSSFR Volume 4, Chapter 1 and in subsequent revisions as boundary or classification changes are made.

4.0 ORGANIZATION AND RESPONSIBILITIES

FSS activities at HDP are conducted by two separate work groups under the authority of the Radiation Safety Officer (RSO). The two groups have distinctly separate roles and responsibilities. The HDP staff organization is comprised of Health Physics (HP) Supervision and Technicians whose role and responsibility is to ensure remediation of areas have been completed in accordance with site procedures and work packages. Upon successful remediation of an area, responsibility of the area is transferred to the FSS Organization for performance of the Final Status Survey in accordance with site FSS procedures. This work group is a contracted company whose core competency is Final Status Survey.

As described in the DP Chapter 9, the Hematite Decommissioning Project organization is led by the Project Director and a staff of functional area managers. Westinghouse responded to an RAI that provided a detailed description of the responsibility and authority of each functional area. The response was provided in Westinghouse letter HEM-11-37, *Response to Remaining NRC Request for Additional Information on the Hematite Decommissioning Plan Chapter 9* {ML110810978}. Figure 4-1 provides a depiction of the HDP Organization with FSS responsibilities.

4.1 HDP Staff Organization

4.1.1 Project Director – The HDP Director has overall responsibility to ensure safety and compliance during the decommissioning of the Hematite Site while complying with applicable laws and regulations.

4.1.2 Radiation Safety Officer – The Radiation Safety Officer has responsibility for all aspects of the Radiation Protection Program which includes:

- Providing overall technical support for the development and implementation of the FSS program and implementing procedures, technical basis documents, and the instrument and laboratory specifications and selection.
- Ensuring compliance with the Radiation Protection Program, FSS Plan and implementing procedures, the NRC license, and applicable NRC regulations and guidance.

- Reviewing and approving the qualification and selection of HP Staff and approving the content of training to HP Staff and other site personnel on FSS topics.
- Reviewing and approving FSS plans, Survey Area Release Records, and the FSS Final Report.
- Resolving issues or concerns raised by the NRC or other Stakeholders, as well as any programmatic issues raised by Westinghouse Management.
- Overseeing the assessment and analysis of survey data as appropriate.

4.1.3 Operations Manager – The Operations Manager is responsible for the safe and efficient execution of work performed by HDP Staff such as remediation and support of field FSS activities.

4.1.4 Quality Assurance Manager – The Quality Assurance Manager is responsible for evaluating subcontractor quality programs and procedures.

4.1.5 Environmental Health and Safety Manager – The Environmental Health and Safety Manager is responsible for the implementation of the Health and Safety Plan, and coordination of Environmental work activities conducted in survey units during FSS.

4.1.6 FSS Site Technical Representative – The Site Technical Representative is responsible for the coordination of contracted FSS activities between the site and the FSS subcontractor.

4.1.7 Field Engineer – The Field Engineer is responsible for the design of isolation and control measures.

4.1.8 HDP Health Physics Supervisors – The HDP Health Physics Supervisors are responsible for:

- The control and implementation of survey packages during field activities.
- The coordination of survey activities in preparation for FSS.
- Establishing survey unit isolation and control measures prior to and during survey activities and maintaining access control measures over completed survey areas.
- Survey area preparation (e.g., survey location identification, layout and accessibility needs).
- Ensuring sampling in preparation for FSS is conducted in accordance with applicable procedures and work instructions.
- Providing daily supervision and guidance to field survey and sampling crews, and performing quality checks of field activities.
- The coordination and scheduling of HP Technicians to support the decommissioning schedule.
- Ensuring all necessary instrumentation and other equipment is available to support survey activities.

4.1.9 Geographic Information System (GIS)/Computer Aided Design (CAD) Specialist – The GIS/CAD Specialist is responsible for the preparation of survey maps, layout diagrams, composite view drawings and other graphics as necessary to support FSS survey design and reporting.

4.1.10 HDP Health Physics Technicians – The HDP Health Physics Technicians are responsible for:

- Performing and documenting FSSs in accordance with the applicable site procedures and survey package instructions.
- Maintaining the pedigree of the instrumentation used for the surveys by implementing the procedural requirements for calibration, maintenance, and daily response checks.
- Informing supervisory personnel, as necessary, of unexpected conditions or anomalies encountered.
- Participating in survey area preparations as necessary.

4.2 FSS Organization

Perma-Fix Environmental Services, Inc. provided support for the performance of FSS at HDP and had been contracted to provide the service as of September 2014 until demobilization in January 2016.

4.2.1 Certified Health Physicist (CHP) – The CHP, who is located at the corporate office, provides technical support for the FSS Program, and reviews survey area release records.

4.2.2 Hematite FSS Program Manager – The Hematite FSS Program Manager is located at the corporate office and provides corporate support for HDP FSS activities.

4.2.3 FSS Site Supervisor – The FSS Site Supervisor is responsible for:

- Preparation of FSS Plans.
- The control and implementation of survey packages during field activities.
- The coordination of survey activities.
- Establishing survey unit isolation and control measures prior to and during survey activities and maintaining access control measures over completed survey areas.
- Ensuring FSS sampling is conducted in accordance with applicable procedures and work instructions.
- Providing daily supervision and guidance to field survey and sampling crews, and performing quality checks of field activities.
- The coordination and scheduling of HP Technicians to support the decommissioning schedule.
- Overseeing preparation of samples for transfer to on site or off site laboratories.

4.2.4 FSS Data Manager – The FSS Data Manager is responsible for:

- Evaluating remedial action support survey data in accordance with FSS Plan Development procedure.
- Assisting the FSS Site Supervisor in the preparation of FSS Plans.
- Coordinating with the offsite analytical laboratory for management of FSS analytical data.
- Validating and verifying analytical data; retaining and filing analytical data in the onsite FSS database.
- Evaluating analytical data in accordance with DP and FSS procedure requirements for use in Survey Area Release Records.

4.2.5 FSS Technicians – The FSS Technicians are responsible for:

- Performing and documenting FSSs in accordance with the applicable site procedures and survey package instructions.
- Maintaining the pedigree of the instrumentation used for the surveys by implementing the procedural requirements for calibration, maintenance, and daily response checks.
- Informing supervisory personnel, as necessary, of unexpected conditions or anomalies encountered.
- Participating in survey area preparations as necessary.

4.3 Off-site Laboratory

Test America (St. Louis), a Missouri Certified off-site laboratory, provided laboratory analysis on all soil samples collected as part of the characterization and FSS surveys. The off-site laboratory was responsible for samples received and the associated Quality Assurance and Quality Control of those samples.

4.4 Selection and Training of Personnel

The HDP Training Plan establishes the administrative controls necessary to ensure project and contractor personnel are adequately trained and qualified to perform their assigned duties, safely and in accordance with applicable requirements. The Training Plan specifies training to ensure personnel are adequately informed of the hazards, preventative measures, and procedures associated with performing their task. All on-site personnel receive radiation safety training, ranging from awareness of radiological postings for escorted visitors to radiation exposure reduction methods for Radiation Workers. Safety training is reinforced in plan-of-the day and toolbox topics briefings for individuals assigned to perform or oversee on-site physical work. This briefing covers selected components of one or more of the following topics: safety items, radiological protection, contamination control, criticality safety, As Low As Reasonably Achievable (ALARA), emergency response and other activities as dictated by the current work processes. Plan-of-the-day and toolbox topics alert personnel to accidents or “near misses” that

have occurred on the project, review project and industry lessons learned, and discuss employee safety concerns.

Individuals performing activities affecting quality will receive appropriate training to familiarize them with the quality requirements of the quality assurance program. The training required will be determined by functional areas working with training personnel, and will be based on individuals' past experience (e.g., work history, past qualifications, certifications, etc.), education and job description. Table 4-1 provides a list of core training required for Final Status Survey activities and the frequency of the training.

Specifically, Health Physics (HP) personnel who performed FSS tasks met the qualifications listed for Health Physics Technician Training and have received training and instruction commensurate with their duties regarding FSS. The RSO has approved all FSS personnel to perform work associated with their individual roles and responsibilities. Training records are documented in accordance with site requirements.

Health Physics Technician Training materials and records are available for inspection. NRC Inspection Report 07000036/2015001 {ML15118A946} provides the most recent NRC inspection activities related to FSS Program training.

5.0 SITE RELEASE CRITERIA

This section provides a summary discussion regarding site release criteria. Detailed discussion regarding site release criteria can be found in the HDP DP Chapter 5 {ML092330125}.

In order to demonstrate that the site meets requirements for unrestricted site release, site-specific release criteria or Derived Concentration Guideline Levels (DCGLs) were developed using dose modeling. The DP Chapter 5 describes the methods used to calculate the site specific DCGLs, for soils, buildings, and buried piping at HDP.

In DP Chapter 5 Conceptual Site Models (CSMs) were developed for soil and the surfaces of remaining buildings. The critical groups and exposure pathways were identified and described. Dose model parameters were selected and sensitivity analyses performed. DCGLs were then calculated for soil and building surfaces.

5.1 Radionuclides of Concern

Based on the facility operating history as provided in DP Chapter 2 and the characterization data as provided in DP Chapter 4, the Radionuclides of Concern (ROC) for the Hematite Site were identified and listed below:

- Uranium-234 (U-234);
- Uranium-235 (U-235+D)[1];
- Uranium-238 (U-238+D)[1];
- Technetium-99 (Tc-99);
- Americium-241 (Am-241);
- Neptunium-237 (Np-237+D)[1];
- Plutonium-239/240 (Pu-239/240);
- Thorium-232 (Th-232+C)[1]; and
- Radium-226 (Ra-226+C)[1].

The vast majority of residual radioactivity was attributed to U-234, U-235, U-238, and Tc-99. The transuranic radionuclides, including Pu-239/240, Np-237 and Am-241 are 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 during site characterization had been identified as a ROC at a limited number of locations within the area of the buried waste.

During characterization campaigns, Ra-226 was identified as a ROC at two locations in the in the burial pit area (see DP Chapter 4 for characterization details). At the time of characterization it was thought that the elevated Ra-226 was likely introduced into the burial pit area with waste as a result of installing contaminated equipment into the process operations. During remediation of the burial pit area it was identified that the Ra-226 was attributed to contaminated filter press plates that did not originate at the Hematite Site.

Bismuth-214 was identified in low concentrations in two scale samples from drains in Building 230 indicating the potential presence of Ra-226. However, the concentrations were less than one percent of the uranium concentrations and the operations conducted in Building 230 did not involve Ra-226. Therefore, Ra-226 was not included as a ROC in buildings.

No other radionuclides were encountered during remediation. The radionuclides identified during remediation were consistent with those radionuclides of concern provided in DP Chapter 5 ensuring the appropriate DCGLs are utilized for the purpose of demonstrating compliance with the release criteria.

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[1] The nomenclature "+D" indicates that the dose contribution of the short-lived progeny are accounted for by the parent and "+C" indicates that the dose contribution of the entire decay chain (progeny) in secular equilibrium are accounted for by the parent.

5.1.1 Disposition of Insignificant Radionuclides in Soil

As a matter of determining the ROCs for the HDP, Westinghouse also performed the necessary analysis of the ROCs to determine the Insignificant Radionuclides of Concern. As a part of the DP review and approval process Westinghouse submitted to the NRC Westinghouse document DO-08-008, Derivation of Surrogates and Scaling Factors for Hard-To- Detect Radionuclides. In summary, the analysis contained within the document stated that the aggregate dose contribution from Am-241, Np-237 and Pu-239/240 for each CSM was less than 10 percent of the TEDE; and thus, these radionuclides are considered to be insignificant radionuclides of concern.

During the DP review and approval process the NRC requested additional information regarding how the average concentration and associated statistics were determined. In Westinghouse letter HEM-10-80, Response to Request for Additional Information Concerning Hematite Decommissioning Plan: Chapter 14, Characterization Report and Surrogates Report {ML102140158}, Westinghouse responded to RAI HDPC-14-Q1 with the requested information.

5.1.2 Inferred U-234 Results

Of the Uranium ROCs shown in Section 5.1 above, U-234 cannot be detected using conventional field instrumentation during scan survey measurements of soil, or by gamma spectroscopy. The ratio of the U-238 to U-235 concentrations obtained from gamma spectroscopy were used to infer the U-234 to U-235 ratio based on observations of the enrichment in a large number of characterization samples, assumptions regarding the consistency of the enrichment shown by the characterization data, and published values for the enrichment based on isotopic ratios. These relationships are provided in Table 5-5. The process for inferring U-234 values was originally provided in DP Chapter 14 Section 14.1.4.3.3, and repeated in HDP-PR-FSS-721, *Final Status Survey Data Evaluation.*

The following data quality objectives (DQOs) and equations were used to estimate the concentration of U-234 based on the results of analysis by gamma spectroscopy for U-235 and U-238:

When U-235 is reported as negative or zero and U-238 is reported as positive, natural Uranium is assumed and the U-234 concentration will be set equal to the U-238 concentration.

$$C_{U\text{-}234}\ (\text{pCi/g}) = C_{U\text{-}238}$$

Equation 5-1

where:

$C_{U\text{-}238}$ = Concentration of U-238 (pCi/g)

When U-235 is reported as positive and U-238 is reported as negative or zero, highly enriched Uranium is assumed and the U-234 concentration is determined by multiplying the U-235 concentration by 32.50, which is the U-234:U-235 ratio based on the maximum enrichment (100 percent) from Table 5-5.

$$C_{U\text{-}234}\ (\text{pCi/g}) = 32.50 \times C_{U\text{-}235}$$

Equation 5-2

where:

$C_{U\text{-}235}$ = Concentration of U-235 (pCi/g)

When both U-235 and U-238 data are reported as positive, but the U-238:U-235 ratio for the data is less than 0.0001 (indicating highly enriched Uranium), the U-234 concentration is determined using Equation 5-2.

When both U-235 and U-238 data are reported as positive, but the U-238:U-235 ratio for the data is greater than 155.37 (indicating depleted Uranium), the U-234 concentration is determined by multiplying the U-235 concentration by the minimum U-234:U-235 ratio of 46.31 from Table 5-5.

$$C_{U\text{-}234}\ (\text{pCi/g}) = 46.31 \times C_{U\text{-}235}$$

Equation 5-3

where:

$C_{U\text{-}235}$ = Concentration of U-235 (pCi/g)

When both U-235 and U-238 data are reported as positive, the U-238:U-235 ratio for the data is used to determine the associated U-234:U-235 ratio from Table 5-5. The U-234 concentration is determined by multiplying the U-235 concentration by the U-234:U-235 ratio.

$$C_{U\text{-}234}\ (\text{pCi/g}) = R_{U\text{-}234:U\text{-}235} \times C_{U\text{-}235}$$

Equation 5-4

where:

$R_{U\text{-}234:U\text{-}235}$= Estimated U-234:U-235 ratio based on U-235:U-238 ratio using Table 5-5; and,

$C_{U\text{-}235}$ = Concentration of U-235 (pCi/g).

5.1.3 Ra-226 and Th-232 Background Soil Values

Since both Ra-226 and Th-232 are naturally present in soil, and the DCGLs for each nuclide equivalent to the 25 mrem per year dose criterion are only slightly higher than typical background soil concentrations, Ra-226 and Th-232 background will be subtracted from the gross soil sample results when comparing the soils sample results to the DCGLs and calculating the SOF for each sample.

The Ra-226 and Th-232 background soil values were first determined by the Historical Site Assessment (HSA), and presented in the Hematite Radiological Characterization Report (HRCR). Background soil samples were collected at 2 separate off-site locations, several samples were collected from each off-site area from the surface to a depth of three feet, and then again from a depth of three feet to a depth of 6 feet. A total of 32 samples were collected in total.

These 32 samples were sent to an off-site laboratory for analysis by gamma spectroscopy. As is a typical practice with gamma spectroscopy, some nuclides are actually measured by determining the activity of the nuclide daughter products that exist in equilibrium with the parent nuclide. Th-232 for example is determined by measuring the amount of Ac-228 in each sample as Th-232 (the parent nuclide) and Ac-228 (the daughter nuclide) are known to be in secular equilibrium. Ra-226 is also measured in this way by determining the amount of Bi-214 present in the sample (since the presence of U-235 will interfere with measuring the Ra-226 gamma activity directly), however since Ra-226 decays to Rn-222 which is a gas, and then decays to Bi-214, some of the Rs-222 can escape from the sample. Therefore Ra-226 samples are typically counted twice, once immediately after prepping and sealing the sample container (which prevents any gas from escaping), and once more after 21 days have passed. This 21 day period is called the ingrowth period because it is known that Bi-214 will reach secular equilibrium with Ra-226 after 21 days in a sealed container.

A review of the 32 off-site background soil samples was performed; the results were reported both with un-known ingrowth, and known ingrowth (a sample container that has been sealed for 21 days). The review indicated that for both the un-known ingrowth and known ingrowth the Th-232 background activity remained the same at an average of 1 pCi/g. However the review also indicated that for Ra-226, the un-known ingrowth background value was 0.9 pCi/g on average, while the known ingrowth background value was 1.47 pCi/g.

Once on-site FSS activities had begun and the need to identify an off-site borrow location had arisen, a new set of 32 off-site background samples was collected for the purpose of comparing the new off-site background samples to the proposed off-site borrow soil location. A review of these samples indicated that the Th-232, and un-known Ra-226 ingrowth sample backgrounds were equivalent to the backgrounds that were previously determined. But the known Ra-226 ingrowth background value determined by the new 32 off-site background samples was identified to be lower at an average of 1.07 pCi/g. When this new lower known Ra-226 ingrowth background value was compared to the Ra-226 results from the first group of survey units where FSS was performed (LSA 10-01, LSA 10-02, LSA 10-03, LSA 10-04, and LSA 10-12) it was determined to be a more appropriate measure of the true Ra-226 background values in soil for the Hematite Site. This evaluation was documented in the internal site memo HEM-15-MEMO-042, and administratively implemented the new known Ra-226 ingrowth background value of 1.07 pCi/g/

The background soil values used for the analysis of all FSS soil samples for Th-232, Ra-226 when ingrowth is unknown or less than 21 days, and Ra-226 when ingrowth is at least 21 days are provided in Table 5-6. These background soil values were used from the start of FSS to the completion of all FSS field activities on the Hematite Site.

5.2 Soil CSM and DCGLs

5.2.1 Conceptual Site Models for Soil

The conceptual model for soil includes the surface and subsurface geometry of the Contaminated Zone and the hydrogeological conditions of the site that affect radionuclide transport and exposure.

The soil contamination, including surface and subsurface, was modeled using two different source term geometries; 1) a soil column with three distinct layers that represent different exposure pathways and depths, and 2) a soil column with uniform contamination over the entire depth of the Contaminated Zone. Therefore, the surface and subsurface contamination is represented by four different geometries, or CSMs, as described below and shown in Figure 5-1:

The first subsurface geometry assumes a soil column that is comprised of three stratums as summarized and discussed below:

- Surface - surface soil to a depth of 15 centimeter (cm) below the ground surface;
- Root - subsurface soil starting at 15 cm and extending to 1.5 m below the ground surface to include the entire root stratum; and
- Deep - subsurface soil located below 1.5 meter (m) (i.e., below the root stratum) and extending to the bottom of the Contaminated Zone which was conservatively estimated to be 6.7 m below the ground surface.

The Surface stratum represents the typical surface contamination configuration, i.e., the top 15 cm of soil.

The Root stratum represents soil in the root zone (15 cm to 1.5 m) and accounts for the potential removal of soil due to erosion over the 1,000-year modeling period. The root depth is assumed to be 0.9 m and potential erosion over 100 years is estimated to be 0.6 m. Using the combined 1.5 m depth ensures that the thickness of the root stratum will equal or exceed the 0.9 m root depth for the entire 1,000-year period.

The Deep stratum represents soil below the root stratum starting at a depth of 1.5 m and extending to the bottom of the Contaminated Zone, which was conservatively estimated to be 6.7 m deep.

The second subsurface geometry is comprised of one stratum as described below:

- Uniform - uniform soil contamination from the ground surface to the bottom of the Contaminated Zone (6.7 m).

DCGLs were also calculated for an excavation scenario CSM to evaluate the effect of changing the in-situ soil configuration after license termination.

5.2.2 Soil DCGLs

DCGLs were calculated for each of the four CSMs discussed above including Surface, Root, Deep and Uniform. The four CSMs were designed to address the various configurations that may be present during remediation and at the time of the FSS. During the DP review and approval process the NRC did not agree that the Deep DCGLs were technically justified for evaluating unexcavated soil below 3 m. While the intruder construction scenario may not apply for depths below 3m, the intruder well scenario would still apply. To address this issue DCGLs were also calculated for an excavation scenario CSM to evaluate the effect of changing the in-situ soil configuration after license termination (DP Chapter 5.3.6). Through the RAI response to RAI HDP-C5-Q9 (Westinghouse letter HEM-10-105 {ML102850223}), Westinghouse committed to utilize the Excavation Scenario DCGLs in place of the Deep DCGLs.

The methods and calculations for demonstrating compliance with the DCGLs are discussed in detail in DP Chapter 14. Demonstration of compliance with the Uniform DCGL is simply a comparison of the DCGL to the average concentration of residual contamination regardless of the depth of the contamination. Compliance with the "three layer" geometry requires consideration of the Surface, Root, and Deep layers independently, depending on the depth of the contamination. Because each of the three DCGLs (Surface, Root, Deep) represent 25 mrem/yr from each layer independently, the unity rule will be used to demonstrate compliance if contamination is present in more than one soil layer.

The DP as submitted {ML092330123} contained site-specific DCGLs (Table 14-2) and adjusted site-specific DCGLs (Table 14-4) which accounted for the dose contributions from insignificant radionuclides. These DCGLs were revised as part of a RAI response, with the revised DCGLs presented in Appendix I of Westinghouse letter HEM-11-91, *Draft Supplemental Response to NRC Request for Additional Information on the Hematite Decommissioning Plan Excluding Chapter 11* {ML111730489}. These draft supplemental responses were provided in support of the scheduled June 24 and 27, 2011, conference calls for RAI resolution. These same site-specific and adjusted site-specific DCGLs were finalized and presented in Appendix I of Attachment 4 of Westinghouse letter HEM-11-96, *Final Supplemental Response to NRC Request for Additional Information on the Hematite Decommissioning Plan and Related Revision to a Pending License Amendment Request* {ML111880290}.

The methodology for demonstrating compliance with the site release criteria will be provided in FSSFR Volume 3 Chapter 1. Land Survey Area Release Records will be provided in FSSFR Volume 3. Tables 5-1 and 5-2 present the soil DCGLs.

5.2.2.1 Tc-99

In the DP Chapter 14.1.4.3.2, *Inferring Tc-99*, Westinghouse provided that in the reference document DO-08-008, "*Derivation of Surrogates and Scaling Factors for Hard-To-Detect Radionuclides,*" Revision 0, there was consistent distribution ratios in soil for the hard-to-detect radionuclide Tc-99.

During the DP review and approval process the NRC stated in RAI 1-1c that "Westinghouse may not have adequately characterized Tc-99 levels under Building 235, and in RAI 3-9 that

"Characterization for Tc-99 in contaminated soil/spent limestone at depth greater than the proposed depth of excavation and below the lower activity Tc-99." In response, Westinghouse letter HEM-11-56 {ML111260624} forwarded to the NRC "*Evaluation of Technetium-99 Under the Process Building.*" Furthermore, Westinghouse proposed a revision to DP Chapter 14.1.4.3.2 to address the issue that stated "*Surrogate relationships have been developed for Tc-99 and U-234 and are presented in Sections 14.1.4.3.2 and 14.1.4.3.3, respectively. However, the Tc-99 surrogate relationship is prohibited from use in the evaluation of analytical results to determine compliance with the final status survey dose criteria. Instead of a surrogate relationship, laboratory analysis for Tc-99 will be performed for all FSS samples.*"

With the commitment to analyze soil samples for Tc-99 established, the results of the analysis for Tc-99 would then be included in the Sum-Of-Fractions (SOF) calculation for determining compliance with the release criteria.

5.2.3 Building DCGLs

For the building surface DCGLs, two room sizes were considered for the DCGL calculations representing a small office and an open warehouse. The Small Office CSM resulted in the most limiting DCGLs. Considering the very low levels of residual surface contamination present in the buildings and the limited effort that is required to reduce surface contamination to acceptable levels, the DCGLs based on the Small Office CSM are used for all building surfaces. Area factors were developed for the Small Office by adjusting the area of the floor only and calculating a DCGL applicable to elevated measurements for each area.

Building Survey Area Release Records will be provided in FSSFR Volume 4. Table 5-3 presents the building and structural surface DCGLs.

5.2.4 Buried Piping

DP Chapter 5.5 provided that a limited amount of buried piping would remain at the time of license termination. As the geometry of the contamination in the buried pipe differs from the soil or building source terms a separate CSM was developed for the dose assessment and DCGL calculations for buried pipe ($DCGL_{BP}$). The buried pipe DCGLs are a function of the pipe diameter. The internal surface area increases as a square of the radius while the interior volume increases as a cube of the radius. Therefore, the $DCGL_{BP}$ increases as the pipe diameter increases. Table 5-4 provides the results of $DCGL_{BP}$ calculations for pipes with diameters ranging from 2 inches to 48 inches.

To gain NRC approval for the methodology to demonstrate compliance with the release criteria in response to a NRC RAI regarding DP Chapter 14 Westinghouse submitted letter HEM-12-73, *Request for Approval of the Hematite Final Status Survey Plan for Piping Remaining after Decommissioning* {ML12187A121}, which contained the final status survey plan for piping. By letter dated April 5, 2013 {ML13031A452}, the NRC provided the following "*Please note that the proposed Plan, modified in accordance with the staffs comments, appears to provide a reasonable path forward in the final status survey of piping at the site; however, NRC staff review and comment on the Plan does not equate to an automatic approval of the overall final*

status survey results. The NRC will review the Final Status Survey Report once the final status survey is complete."

Piping Survey Area Release Records will be provided in FSSFR Volume 5.

5.2.5 Groundwater

In response to RAI 3-4 in regards to clarifying the criterion for termination of post-remediation groundwater monitoring Westinghouse provided the following response: "*Post-remediation monitoring wells will be sampled quarterly after the completion of remediation until license termination. The data collected will be used to confirm that the sum of the annual dose from groundwater for all the radionuclides does not exceed the EPA Maximum Contaminant Level (MCL) of 4 millirem/year. Separately, the sum of the dose from all residual sources remaining after remediation, including soil and groundwater pathways, will be confirmed to result in an annual dose that does not exceed 25 millirem/year.*"

A detailed discussion on groundwater and groundwater sampling data will be provided in Volume 6. The dose contribution from groundwater for a survey unit will be provided in survey area release records (Volume 3).

6.0 FINAL STATUS SURVEY FINAL REPORT ORGANIZATION

This Final Status Survey Final Report is divided into the following volumes and chapters:

- Volume 1 - Introduction
  - Chapter 1 - Final Status Survey Final Report Overview
- Volume 2 - Reuse Soil
  - Chapter 1 - Final Status Survey Final Report Reuse Soil Overview
  - Chapters 2 through conclusion - Data Summary Reports for Reuse Stockpiles
- Volume 3 - Land Survey Areas (LSAs)
  - Chapter 1 - Final Status Survey Final Report Land Survey Area Overview
  - Chapters 2 through conclusion - Survey Area Release Records for LSA Survey Units
- Volume 4 - Building Survey Areas (BSAs)
  - Chapter 1 - Final Status Survey Final Report Building Survey Area Overview
  - Chapters 2 through conclusion - Survey Area Release Records for BSA Survey Units
- Volume 5 - Piping Survey Areas (PSAs)
  - Chapter 1 - Final Status Survey Final Report Piping Survey Area Overview
  - Chapters 2 through conclusion - Survey Area Release Records for PSA Survey Units
- Volume 6 - Groundwater

  - Chapter 1 - Final Status Survey Final Report Groundwater Overview
- Volume 7, Final Status Survey Final Report
  - Chapter 1 - Final Status Survey Final Report - Summary

7.0 FINAL STATUS SURVEY FINAL REPORT - SUMMARY

At the conclusion of all FSS survey activities and required groundwater monitoring FSSFR Volume 7, Chapter 1 - Final Status Survey Final Report – Summary will be submitted to the NRC for review. The FSSFR – Summary will present the following information;

- Land Survey Areas
  - A summary of LSA survey results
  - Summary data and SOF tables
- Groundwater
  - A summary of groundwater monitoring results
  - Summary data tables
- Building Survey Areas
  - A summary of LSA survey results
  - Summary data and SOF tables
- Piping Survey Areas
  - A summary of the PSA survey results
  - Summary data tables
- Conclusion
  - A final summary and conclusion in regards to acceptability for license termination

8.0 REFERENCES

8.1 DO-08-004, Hematite Decommissioning Plan (DP) {ML092330123}

8.2 Westinghouse letter HEM-11-37, *Response to Remaining NRC Request for Additional Information on the Hematite Decommissioning Plan Chapter 9* {ML110810978}

8.3 NUREG-1575, Multi-Agency Radiation Survey and Site Investigation Manual

8.4 License SNM-33 Amendment 57 {ML112101640}

8.5 Hematite Decommissioning Plan Safety Evaluation Report {ML112101630}

8.6 NRC letter dated October 13, 2011, *U.S. Nuclear Regulatory Commission Approval of: (1) Westinghouse Hematite Decommissioning Plan, (2) Revised License Application, (3) Exemption from the Requirements of 10 CFR 70.24 and 70.22(a)(4), and Issuance of Hematite License Amendment 57* {ML112101699}

8.7 License SNM-33 Amendment 59 {ML112200209}

8.8 NRC Inspection Report 07000036/13001 {ML13154A125}

8.9 NRC Inspection Report 07000036/2013002 {ML13241A252}

8.10 NRC Inspection Report 07000036/2013003 {ML13336A408}

8.11 NRC Inspection Report 07000036/2015001 {ML15118A946}

8.12 Westinghouse letter HEM-14-87, *Phased De-escalation of the Hematite Decommissioning Project Physical Security Plan per the Hematite Decommissioning Project Physical Security Plan Revision Dated September 11, 2013* {ML14324A952}

8.13 Westinghouse letter HEM-10-80, *Response to request for Additional Information Concerning Hematite Decommissioning Plan: Chapter 14, Characterization Report and Surrogates Report* { ML102140158}

8.14 Westinghouse letter HEM-10-105, *Remaining Responses to Request for Additional Information Concerning Hematite Decommissioning Plan: Chapter 5, Dose Modeling* {ML102850223}

8.15 Westinghouse letter HEM-11-91, *Draft Supplemental Response to NRC Request for Additional Information on the Hematite Decommissioning Plan Excluding Chapter 11* {ML111730489}

8.16 Westinghouse letter HEM-11-96, *Final Supplemental Response to NRC Request for Additional Information on the Hematite Decommissioning Plan and Related Revision to a Pending License Amendment Request* {ML111880290}

8.17 Westinghouse letter HEM-11-56, *Evaluation of Technetium-99 Under the Process Building* {ML111260624}

8.18 Westinghouse letter HEM-12-73, *Request for Approval of the Hematite Final Status Survey Plan for Piping Remaining after Decommissioning* {ML12187A121}

8.19 NRC letter dated April 5, 2013, *U.S. Nuclear Regulatory Commission Review of Westinghouse Hematite's Final Status Survey Plan for Piping, HDP-PO-FSS-800* {ML13031A452}

Table 4-1
Health Physics Final Status Survey Core Training

HEALTH PHYSICS TECHNICIAN REQUIRED TRAINING COURSES	COURSE CODE	ANNUAL OR INITIAL
General Employee Training	EHS-GEN-GET	A
Radiation Worker Training	EHS-GEN-RWT	A
Radiation Worker Training Practical Exercise	EHS-GEN-RWTPRAC	I
HAZWOPER 40 Hour	EHS-GEN-HAZ40	I
HAZWOPER Medical Evaluation	EHS-GEN-HAZMED	A
HAZWOPER Refresher	EHS-GEN-HAZREF	A
Health Physics Fundamental Training	HP-DS-FUND	I
Health Physics Technician Critical Procedure Review	HP-DS-TECHCRITPRO	I
Health Physics Baseline Practical Factors 1 of 4 101	HP-DS-PRAC-1-4	I
Health Physics Baseline Practical Factors 2 of 4 102	HP-DS-PRAC-2-4	I
Health Physics Baseline Practical Factors 3 of 4 201	HP-DS-PRAC-3-4	I
Health Physics Baseline Practical Factors 4 of 4 202	HP-DS-PRAC-4-4	I
HEALTH PHYSICS FINAL STATUS SURVEY TECHNICIAN REQUIRED TRAINING COURSES (In addition to the above courses)		
Final Status Survey Training	HP-DS-FSSURVEY	I
Final Status and Radiological Sampling and Reuse Soil	HP-DS-FSS710	I
Final Status Surveys and Sampling of Soil and Sediment	HP-DS-FSS711	I
Final Status Surveys of Structures, Systems and Components	HP-DS-FSS712	I

I Initial training only required.
A Initial and annual requalification required.

Table 5-1
Site Specific Soil DCGLs

Radionuclide	$DCGL_W$ (pCi/g) [a] By Conceptual Site Model				
	Surface Stratum	Root Stratum	Deep Stratum	Uniform Stratum	Excavation Scenario[d]
U-234	545.5	252.7	N/A	209.6	935.6
U-235 + D [b]	109.7	68.7	N/A	55.3	223.2
U-238 + D [b]	319.2	196.6	N/A	181	591
Tc-99	162	32.3	N/A	26.9	79.4
Th-232 + C [c]	5	2.1	N/A	2.1	5.6
Ra-226 + C [c]	5.4	2.3	N/A	2	5.8

[a] The reported soil limits are the activities for the parent radionuclide as specified.
[b] "+ D" = plus short-lived decay products.
[c] "+ C" = plus the entire decay chain (progeny) in secular equilibrium.
[d] Excavation Scenario DCGLs replace the Deep Stratum DCGLs.

Table 5-2
Adjusted Site Specific Soil DCGLs

Radionuclide	$DCGL_W$ (pCi/g) [a] By Conceptual Site Model				
	Shallow Stratum	Root Stratum	Deep Stratum	Uniform Stratum	Excavation Scenario[d]
U-234	508.5	235.6	N/A	195.4	872.4
U-235 + D [b]	102.3	64.1	N/A	51.6	208.1
U-238 + D [b]	297.6	183.3	N/A	168.8	551.1
Tc-99	151.0	30.1	N/A	25.1	74.0
Th-232 + C [c]	4.7	2.0	N/A	2.0	5.2
Ra-226 + C [c]	5.0	2.1	N/A	1.9	5.4

[a] The reported soil limits are the activities for the parent radionuclide as specified and were calculated using DP Chapter 14 Equation 14-1 to account for the dose contribution from insignificant radionuclides (see DP Section 14.1.3.2).
[b] "+ D" = plus short-lived decay products.
[c] "+ C" = plus the entire decay chain (progeny) in secular equilibrium.
[d] Excavation Scenario DCGLs replace the Deep Stratum DCGLs.

Table 5-3
Site Specific Building and Structural Surface DCGLs

Radionuclide	Occupancy $DCGL_W$ (dpm/100 cm^2) [a] By Conceptual Site Model	
	Small Office	Large Warehouse
U-234	20,000	49,000
U-235 + D [b]	19,000	37,000
U-238 + D [b]	21,000	49,000
Tc-99	13,000,000	13,000,000
Th-232 + C [c]	1,200	2,200
Np-237 + D [b]	2,700	4,000
Pu-239/240	3,500	5,300
Am-241	3,400	5,100

[a] The reported building DCGLs are in gross radioactivity limits rounded down (truncated) to two significant figures.
[b] "+ D" = plus short-lived decay products.
[c] "+ C" = plus the entire decay chain (progeny) in secular equilibrium.

Table 5-4
Buried Pipe Gross Activity DCGLs

Buried Pipe Diameter (inches)	Gross Activity DCGL (dpm/100cm^2)[a]
2	81,086
4	162,172
6	243,258
8	324,344
10	405,430
12	486,516
14	567,602
16	648,689
18	729,775
20	810,861
22	891,947
24	973,033
26	1,054,119
28	1,135,205
30	1,216,291
32	1,297,377
34	1,378,463
36	1,459,549
38	1,540,635
40	1,621,721
48	1,946,066

[a] The Gross Activity DCGL is based on the Root DCGLs for soil and the Activity Fractions from building drain samples.

Table 5-5
Radioactivity and Isotopic Ratios Relative to Enrichment

Enrichment (%)	U-234 Activity Fraction [a]	U-235 Activity Fraction [a]	U-238 Activity Fraction [a]	U-238:U-235 Ratio [a]	U-234:U-235 Ratio [a]
0.1	0.2285	0.0049	0.7666	155.37	46.31
0.2	0.2864	0.0091	0.7045	77.61	31.55
0.3	0.3358	0.0126	0.6516	51.69	26.64
0.4	0.3785	0.0156	0.6059	38.73	24.19
0.5	0.4157	0.0183	0.5660	30.95	22.73
0.6	0.4484	0.0206	0.5310	25.77	21.76
0.7	0.4775	0.0227	0.4999	22.06	21.07
0.72	0.4829	0.0230	0.4941	21.44	20.96
0.8	0.5034	0.0245	0.4721	19.28	20.56
0.9	0.5267	0.0261	0.4472	17.12	20.17
1.0	0.5477	0.0276	0.4247	15.40	19.85
1.1	0.5668	0.0289	0.4043	13.98	19.60
1.2	0.5842	0.0301	0.3857	12.80	19.39
1.3	0.6001	0.0312	0.3687	11.81	19.22
1.4	0.6147	0.0322	0.3530	10.95	19.07
1.5	0.6282	0.0332	0.3386	10.21	18.95
1.6	0.6407	0.0340	0.3253	9.56	18.84
1.7	0.6523	0.0348	0.3129	8.99	18.75
1.8	0.6631	0.0355	0.3014	8.48	18.67
1.9	0.6731	0.0362	0.2907	8.03	18.59
2.0	0.6825	0.0368	0.2806	7.62	18.53
2.1	0.6913	0.0374	0.2712	7.25	18.48
2.2	0.6996	0.0380	0.2624	6.91	18.43
2.3	0.7074	0.0385	0.2541	6.61	18.39
2.4	0.7147	0.0390	0.2463	6.32	18.35
2.5	0.7216	0.0394	0.2390	6.06	18.32
2.6	0.7282	0.0398	0.2320	5.83	18.29
2.7	0.7344	0.0402	0.2254	5.60	18.26
2.8	0.7403	0.0406	0.2191	5.40	18.24
2.9	0.7459	0.0409	0.2132	5.21	18.22
3.0	0.7512	0.0413	0.2075	5.03	18.20
3.1	0.7562	0.0416	0.2022	4.86	18.18
3.2	0.7611	0.0419	0.1971	4.70	18.17
3.3	0.7657	0.0422	0.1922	4.56	18.15

Table 5-5 (continued)
Radioactivity and Isotopic Ratios Relative to Enrichment

Enrichment (%)	U-234 Activity Fraction	U-235 Activity Fraction	U-238 Activity Fraction	U-238:U-235 Ratio	U-234:U-235 Ratio
3.4	0.7701	0.0424	0.1875	4.42	18.14
3.5	0.7743	0.0427	0.1830	4.29	18.14
3.6	0.7783	0.0429	0.1788	4.16	18.13
3.7	0.7822	0.0432	0.1747	4.05	18.12
3.8	0.7859	0.0434	0.1708	3.94	18.12
3.9	0.7894	0.0436	0.1670	3.83	18.11
4.0	0.7928	0.0438	0.1634	3.73	18.11
4.1	0.7961	0.0440	0.1599	3.64	18.11
4.2	0.7993	0.0441	0.1566	3.55	18.10
4.3	0.8023	0.0443	0.1534	3.46	18.10
4.4	0.8053	0.0445	0.1503	3.38	18.10
4.5	0.8081	0.0446	0.1473	3.30	18.10
4.6	0.8108	0.0448	0.1444	3.22	18.11
4.7	0.8135	0.0449	0.1416	3.15	18.11
4.8	0.8160	0.0451	0.1389	3.08	18.11
4.9	0.8185	0.0452	0.1363	3.02	18.11
5.0	0.8209	0.0453	0.1338	2.95	18.12
5.1	0.8232	0.0454	0.1314	2.89	18.12
5.2	0.8254	0.0455	0.1291	2.83	18.13
5.3	0.8276	0.0456	0.1268	2.78	18.13
5.4	0.8297	0.0457	0.1246	2.72	18.14
5.5	0.8317	0.0458	0.1225	2.67	18.14
5.6	0.8337	0.0459	0.1204	2.62	18.15
5.7	0.8356	0.0460	0.1184	2.57	18.16
5.8	0.8375	0.0461	0.1164	2.53	18.16
5.9	0.8393	0.0462	0.1145	2.48	18.17
6.0	0.8410	0.0463	0.1127	2.44	18.18
6.1	0.8427	0.0463	0.1109	2.39	18.18
6.2	0.8444	0.0464	0.1092	2.35	18.19
6.3	0.8460	0.0465	0.1075	2.31	18.20
6.4	0.8476	0.0466	0.1058	2.27	18.21
6.5	0.8492	0.0466	0.1042	2.24	18.22
6.6	0.8506	0.0467	0.1027	2.20	18.23
6.7	0.8521	0.0467	0.1012	2.16	18.24

Table 5-5 (continued)
Radioactivity and Isotopic Ratios Relative to Enrichment

Enrichment (%)	U-234 Activity Fraction	U-235 Activity Fraction	U-238 Activity Fraction	U-238:U-235 Ratio	U-234:U-235 Ratio
6.8	0.8535	0.0468	0.0997	2.13	18.24
6.9	0.8549	0.0468	0.0982	2.10	18.25
7.0	0.8563	0.0469	0.0968	2.07	18.26
7.1	0.8576	0.0469	0.0955	2.03	18.27
7.2	0.8589	0.0470	0.0941	2.00	18.28
7.3	0.8602	0.0470	0.0928	1.97	18.29
7.4	0.8614	0.0471	0.0915	1.95	18.30
7.5	0.8626	0.0471	0.0903	1.92	18.31
7.6	0.8638	0.0471	0.0891	1.89	18.32
7.7	0.8649	0.0472	0.0879	1.86	18.34
7.8	0.8661	0.0472	0.0867	1.84	18.35
7.9	0.8672	0.0472	0.0856	1.81	18.36
8.0	0.8682	0.0473	0.0845	1.79	18.37
8.1	0.8693	0.0473	0.0834	1.76	18.38
8.2	0.8703	0.0473	0.0824	1.74	18.39
8.3	0.8713	0.0474	0.0813	1.72	18.40
8.4	0.8723	0.0474	0.0803	1.70	18.41
8.5	0.8733	0.0474	0.0793	1.67	18.42
8.6	0.8742	0.0474	0.0783	1.65	18.44
8.7	0.8752	0.0474	0.0774	1.63	18.45
8.8	0.8761	0.0475	0.0764	1.61	18.46
8.9	0.8770	0.0475	0.0755	1.59	18.47
9.0	0.8779	0.0475	0.0746	1.57	18.48
9.1	0.8787	0.0475	0.0738	1.55	18.50
9.2	0.8796	0.0475	0.0729	1.53	18.51
9.3	0.8804	0.0475	0.0721	1.52	18.52
9.4	0.8812	0.0475	0.0712	1.50	18.53
9.5	0.8820	0.0476	0.0704	1.48	18.55
9.6	0.8828	0.0476	0.0696	1.46	18.56
9.7	0.8836	0.0476	0.0688	1.45	18.57
9.8	0.8843	0.0476	0.0681	1.43	18.58
9.9	0.8851	0.0476	0.0673	1.41	18.60
10.0	0.8858	0.0476	0.0666	1.40	18.61
10.5	0.8893	0.0476	0.0631	1.32	18.67

Table 5-5 (continued)
Radioactivity and Isotopic Ratios Relative to Enrichment

Enrichment (%)	U-234 Activity Fraction	U-235 Activity Fraction	U-238 Activity Fraction	U-238:U-235 Ratio	U-234:U-235 Ratio
11.0	0.8925	0.0476	0.0599	1.26	18.74
11.5	0.8954	0.0476	0.0569	1.20	18.81
12.0	0.8982	0.0476	0.0542	1.14	18.87
12.5	0.9007	0.0475	0.0517	1.09	18.94
13.0	0.9031	0.0475	0.0494	1.04	19.01
13.5	0.9053	0.0474	0.0472	1.00	19.08
14.0	0.9074	0.0474	0.0452	0.95	19.15
14.5	0.9094	0.0473	0.0433	0.92	19.23
15.0	0.9112	0.0472	0.0416	0.88	19.30
15.5	0.9130	0.0471	0.0399	0.85	19.37
16.0	0.9146	0.0470	0.0384	0.82	19.44
16.5	0.9162	0.0469	0.0369	0.79	19.51
17.0	0.9176	0.0468	0.0355	0.76	19.59
17.5	0.9190	0.0467	0.0342	0.73	19.66
18.0	0.9204	0.0466	0.0330	0.71	19.74
18.5	0.9216	0.0465	0.0318	0.68	19.81
19.0	0.9229	0.0464	0.0307	0.66	19.88
19.5	0.9240	0.0463	0.0297	0.64	19.96
20.0	0.9251	0.0462	0.0287	0.62	20.03
20.5	0.9262	0.0461	0.0277	0.60	20.11
21.0	0.9272	0.0459	0.0268	0.58	20.18
21.5	0.9282	0.0458	0.0260	0.57	20.26
22.0	0.9292	0.0457	0.0251	0.55	20.34
22.5	0.9301	0.0456	0.0244	0.53	20.41
23.0	0.9309	0.0454	0.0236	0.52	20.49
23.5	0.9318	0.0453	0.0229	0.51	20.56
24.0	0.9326	0.0452	0.0222	0.49	20.64
24.5	0.9334	0.0451	0.0215	0.48	20.72
25.0	0.9342	0.0449	0.0209	0.47	20.79
25.5	0.9349	0.0448	0.0203	0.45	20.87
26.0	0.9356	0.0447	0.0197	0.44	20.94
26.5	0.9363	0.0445	0.0192	0.43	21.02
27.0	0.9370	0.0444	0.0186	0.42	21.10
27.5	0.9376	0.0443	0.0181	0.41	21.17

Table 5-5 (continued)
Radioactivity and Isotopic Ratios Relative to Enrichment

Enrichment (%)	U-234 Activity Fraction	U-235 Activity Fraction	U-238 Activity Fraction	U-238:U-235 Ratio	U-234:U-235 Ratio
28.0	0.9382	0.0442	0.0176	0.40	21.25
28.5	0.9389	0.0440	0.0171	0.39	21.33
29.0	0.9394	0.0439	0.0167	0.38	21.40
29.5	0.9400	0.0438	0.0162	0.37	21.48
30.0	0.9406	0.0436	0.0158	0.36	21.56
30.5	0.9411	0.0435	0.0154	0.35	21.64
31.0	0.9417	0.0434	0.0150	0.35	21.71
31.5	0.9422	0.0432	0.0146	0.34	21.79
32.0	0.9427	0.0431	0.0142	0.33	21.87
32.5	0.9432	0.0430	0.0138	0.32	21.94
33.0	0.9437	0.0429	0.0135	0.31	22.02
33.5	0.9441	0.0427	0.0131	0.31	22.10
34.0	0.9446	0.0426	0.0128	0.30	22.18
34.5	0.9450	0.0425	0.0125	0.29	22.25
35.0	0.9455	0.0423	0.0122	0.29	22.33
35.5	0.9459	0.0422	0.0119	0.28	22.41
36.0	0.9463	0.0421	0.0116	0.28	22.49
36.5	0.9467	0.0420	0.0113	0.27	22.56
37.0	0.9471	0.0418	0.0110	0.26	22.64
37.5	0.9475	0.0417	0.0108	0.26	22.72
38.0	0.9479	0.0416	0.0105	0.25	22.80
38.5	0.9483	0.0415	0.0102	0.25	22.87
39.0	0.9487	0.0413	0.0100	0.24	22.95
39.5	0.9490	0.0412	0.0098	0.24	23.03
40.0	0.9494	0.0411	0.0095	0.23	23.11
40.5	0.9497	0.0410	0.0093	0.23	23.18
41.0	0.9501	0.0408	0.0091	0.22	23.26
41.5	0.9504	0.0407	0.0089	0.22	23.34
42.0	0.9507	0.0406	0.0087	0.21	23.42
42.5	0.9511	0.0405	0.0085	0.21	23.50
43.0	0.9514	0.0404	0.0083	0.20	23.57
43.5	0.9517	0.0402	0.0081	0.20	23.65
44.0	0.9520	0.0401	0.0079	0.20	23.73
44.5	0.9523	0.0400	0.0077	0.19	23.81

Table 5-5 (continued)
Radioactivity and Isotopic Ratios Relative to Enrichment

Enrichment (%)	U-234 Activity Fraction	U-235 Activity Fraction	U-238 Activity Fraction	U-238:U-235 Ratio	U-234:U-235 Ratio
45.0	0.9526	0.0399	0.0075	0.19	23.89
45.5	0.9529	0.0398	0.0074	0.19	23.96
46.0	0.9532	0.0396	0.0072	0.18	24.04
46.5	0.9534	0.0395	0.0070	0.18	24.12
47.0	0.9537	0.0394	0.0069	0.17	24.20
47.5	0.9540	0.0393	0.0067	0.17	24.28
48.0	0.9543	0.0392	0.0066	0.17	24.35
48.5	0.9545	0.0391	0.0064	0.16	24.43
49.0	0.9548	0.0390	0.0063	0.16	24.51
49.5	0.9550	0.0388	0.0061	0.16	24.59
50.0	0.9553	0.0387	0.0060	0.15	24.67
50.5	0.9555	0.0386	0.0058	0.15	24.74
51.0	0.9558	0.0385	0.0057	0.15	24.82
51.5	0.9560	0.0384	0.0056	0.15	24.90
52.0	0.9563	0.0383	0.0054	0.14	24.98
52.5	0.9565	0.0382	0.0053	0.14	25.06
53.0	0.9567	0.0381	0.0052	0.14	25.13
53.5	0.9570	0.0380	0.0051	0.13	25.21
54.0	0.9572	0.0378	0.0050	0.13	25.29
54.5	0.9574	0.0377	0.0048	0.13	25.37
55.0	0.9576	0.0376	0.0047	0.13	25.45
55.5	0.9578	0.0375	0.0046	0.12	25.53
56.0	0.9581	0.0374	0.0045	0.12	25.60
56.5	0.9583	0.0373	0.0044	0.12	25.68
57.0	0.9585	0.0372	0.0043	0.12	25.76
57.5	0.9587	0.0371	0.0042	0.11	25.84
58.0	0.9589	0.0370	0.0041	0.11	25.92
58.5	0.9591	0.0369	0.0040	0.11	25.99
59.0	0.9593	0.0368	0.0039	0.11	26.07
59.5	0.9595	0.0367	0.0038	0.10	26.15
60.0	0.9597	0.0366	0.0037	0.10	26.23
60.5	0.9599	0.0365	0.0037	0.10	26.31
61.0	0.9600	0.0364	0.0036	0.10	26.39
61.5	0.9602	0.0363	0.0035	0.10	26.46

Table 5-5 (continued)
Radioactivity and Isotopic Ratios Relative to Enrichment

Enrichment (%)	U-234 Activity Fraction	U-235 Activity Fraction	U-238 Activity Fraction	U-238:U-235 Ratio	U-234:U-235 Ratio
62.0	0.9604	0.0362	0.0034	0.09	26.54
62.5	0.9606	0.0361	0.0033	0.09	26.62
63.0	0.9608	0.0360	0.0032	0.09	26.70
63.5	0.9610	0.0359	0.0032	0.09	26.78
64.0	0.9611	0.0358	0.0031	0.09	26.86
64.5	0.9613	0.0357	0.0030	0.08	26.93
65.0	0.9615	0.0356	0.0029	0.08	27.01
65.5	0.9616	0.0355	0.0029	0.08	27.09
66.0	0.9618	0.0354	0.0028	0.08	27.17
66.5	0.9620	0.0353	0.0027	0.08	27.25
67.0	0.9621	0.0352	0.0026	0.08	27.33
67.5	0.9623	0.0351	0.0026	0.07	27.40
68.0	0.9625	0.0350	0.0025	0.07	27.48
68.5	0.9626	0.0349	0.0024	0.07	27.56
69.0	0.9628	0.0348	0.0024	0.07	27.64
69.5	0.9629	0.0347	0.0023	0.07	27.72
70.0	0.9631	0.0346	0.0023	0.07	27.80
70.5	0.9632	0.0346	0.0022	0.06	27.87
71.0	0.9634	0.0345	0.0021	0.06	27.95
71.5	0.9635	0.0344	0.0021	0.06	28.03
72.0	0.9637	0.0343	0.0020	0.06	28.11
72.5	0.9638	0.0342	0.0020	0.06	28.19
73.0	0.9640	0.0341	0.0019	0.06	28.27
73.5	0.9641	0.0340	0.0019	0.05	28.34
74.0	0.9643	0.0339	0.0018	0.05	28.42
74.5	0.9644	0.0338	0.0017	0.05	28.50
75.0	0.9646	0.0338	0.0017	0.05	28.58
75.5	0.9647	0.0337	0.0016	0.05	28.66
76.0	0.9648	0.0336	0.0016	0.05	28.74
76.5	0.9650	0.0335	0.0015	0.05	28.81
77.0	0.9651	0.0334	0.0015	0.04	28.89
77.5	0.9652	0.0333	0.0015	0.04	28.97
78.0	0.9654	0.0332	0.0014	0.04	29.05
78.5	0.9655	0.0331	0.0014	0.04	29.13

Table 5-5 (continued)
Radioactivity and Isotopic Ratios Relative to Enrichment

Enrichment (%)	U-234 Activity Fraction	U-235 Activity Fraction	U-238 Activity Fraction	U-238:U-235 Ratio	U-234:U-235 Ratio
79.0	0.9656	0.0331	0.0013	0.04	29.21
79.5	0.9658	0.0330	0.0013	0.04	29.29
80.0	0.9659	0.0329	0.0012	0.04	29.36
80.5	0.9660	0.0328	0.0012	0.04	29.44
81.0	0.9661	0.0327	0.0011	0.03	29.52
81.5	0.9663	0.0326	0.0011	0.03	29.60
82.0	0.9664	0.0326	0.0011	0.03	29.68
82.5	0.9665	0.0325	0.0010	0.03	29.76
83.0	0.9666	0.0324	0.0010	0.03	29.83
83.5	0.9667	0.0323	0.0009	0.03	29.91
84.0	0.9669	0.0322	0.0009	0.03	29.99
84.5	0.9670	0.0322	0.0009	0.03	30.07
85.0	0.9671	0.0321	0.0008	0.03	30.15
85.5	0.9672	0.0320	0.0008	0.02	30.23
86.0	0.9673	0.0319	0.0008	0.02	30.30
86.5	0.9674	0.0318	0.0007	0.02	30.38
87.0	0.9676	0.0318	0.0007	0.02	30.46
87.5	0.9677	0.0317	0.0007	0.02	30.54
88.0	0.9678	0.0316	0.0006	0.02	30.62
88.5	0.9679	0.0315	0.0006	0.02	30.70
89.0	0.9680	0.0315	0.0006	0.02	30.78
89.5	0.9681	0.0314	0.0005	0.02	30.85
90.0	0.9682	0.0313	0.0005	0.02	30.93
90.5	0.9683	0.0312	0.0005	0.01	31.01
91.0	0.9684	0.0311	0.0004	0.01	31.09
91.5	0.9685	0.0311	0.0004	0.01	31.17
92.0	0.9686	0.0310	0.0004	0.01	31.25
92.5	0.9687	0.0309	0.0003	0.01	31.33
93.0	0.9688	0.0309	0.0003	0.01	31.40
93.5	0.9689	0.0308	0.0003	0.01	31.48
94.0	0.9690	0.0307	0.0003	0.01	31.56
94.5	0.9691	0.0306	0.0002	0.01	31.64
95.0	0.9692	0.0306	0.0002	0.01	31.72
95.5	0.9693	0.0305	0.0002	0.01	31.80

Table 5-5 (continued)
Radioactivity and Isotopic Ratios Relative to Enrichment

Enrichment (%)	U-234 Activity Fraction	U-235 Activity Fraction	U-238 Activity Fraction	U-238:U-235 Ratio	U-234:U-235 Ratio
96.0	0.9694	0.0304	0.0001	0.00	31.87
96.5	0.9695	0.0303	0.0001	0.00	31.95
97.0	0.9696	0.0303	0.0001	0.00	32.03
97.5	0.9697	0.0302	0.0001	0.00	32.11
98.0	0.9698	0.0301	0.0000	0.00	32.19
98.5	0.9699	0.0301	0.0000	0.00	32.27
100.0	0.9702	0.0298	0.0000	0.00	32.50

Table 5-6
Ra-226 and Th-232 Background Soil Values for FSS Sample Analysis

Th-232 (any ingrowth)	Ra-226 (un-known ingrowth)	Ra-226 (known ingrowth)
1.0 pCi/g	0.9 pCi/g	1.07 pCi/g

Note: The above background soil values will be subtracted from the gross reported FSS soil sample analytical values for the purpose of determining sample SOF, demonstrating compliance with the $DCGL_w$'s, and ultimately calculating dose for the survey unit.

Figure 2-1

General Location of the Westinghouse Hematite Site

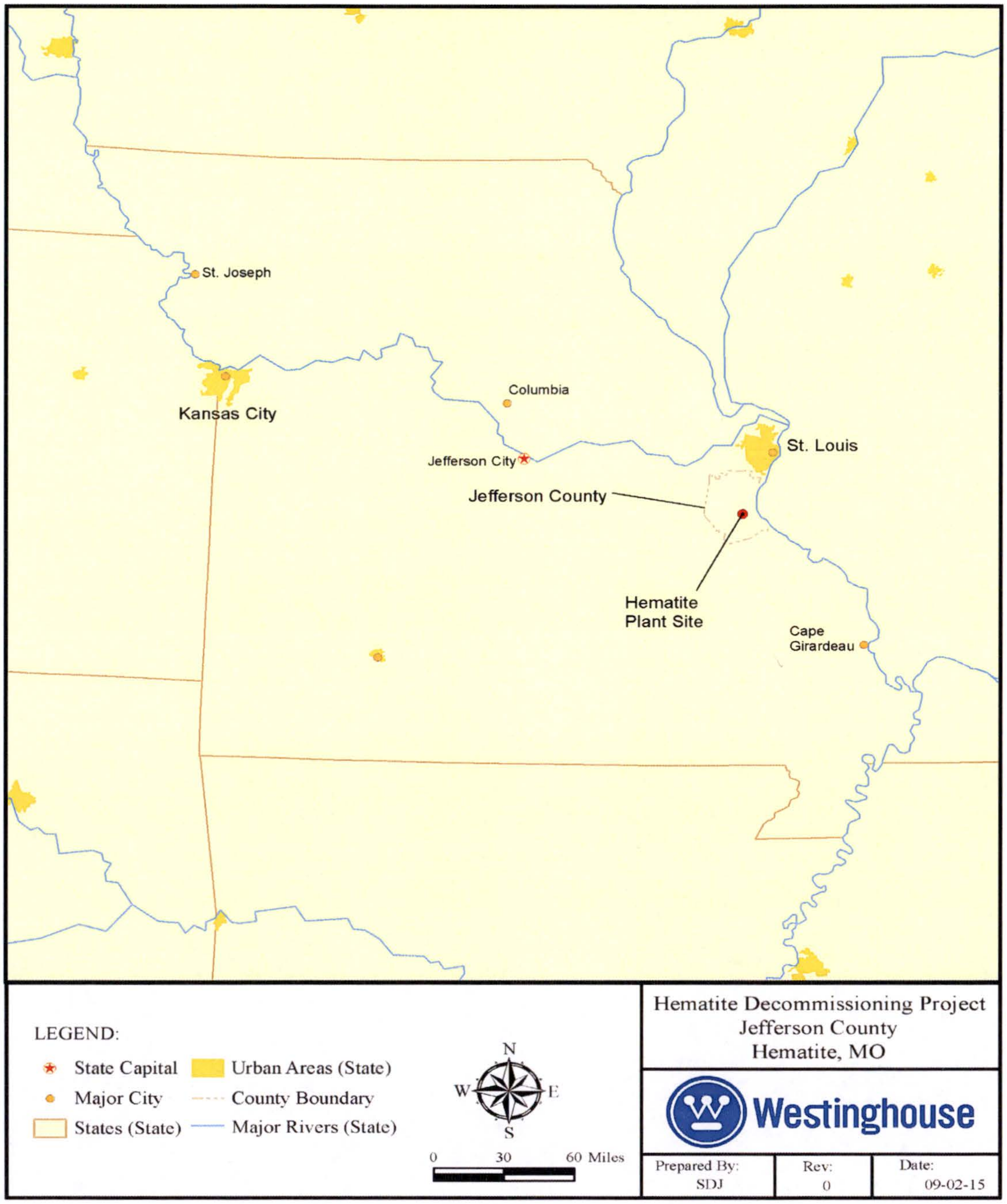
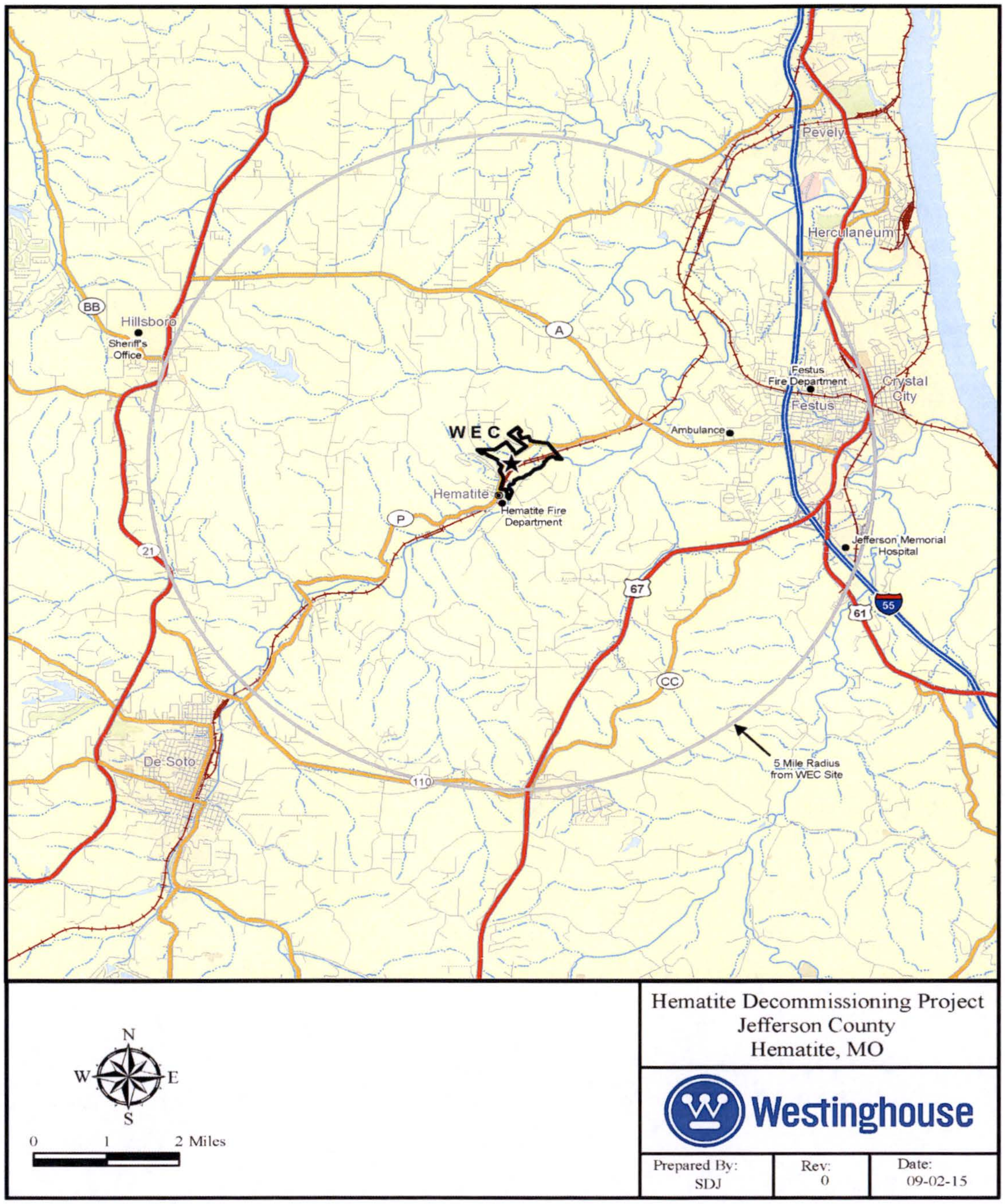


Figure 2-2

Area within 5-Mile Radius of the Westinghouse Hematite Site



Hematite Decommissioning Project Jefferson County Hematite, MO		
Westinghouse		
Prepared By: SDJ	Rev: 0	Date: 09-02-15

Figure 2-3

Westinghouse Hematite Site Boundaries and Central Tract Location

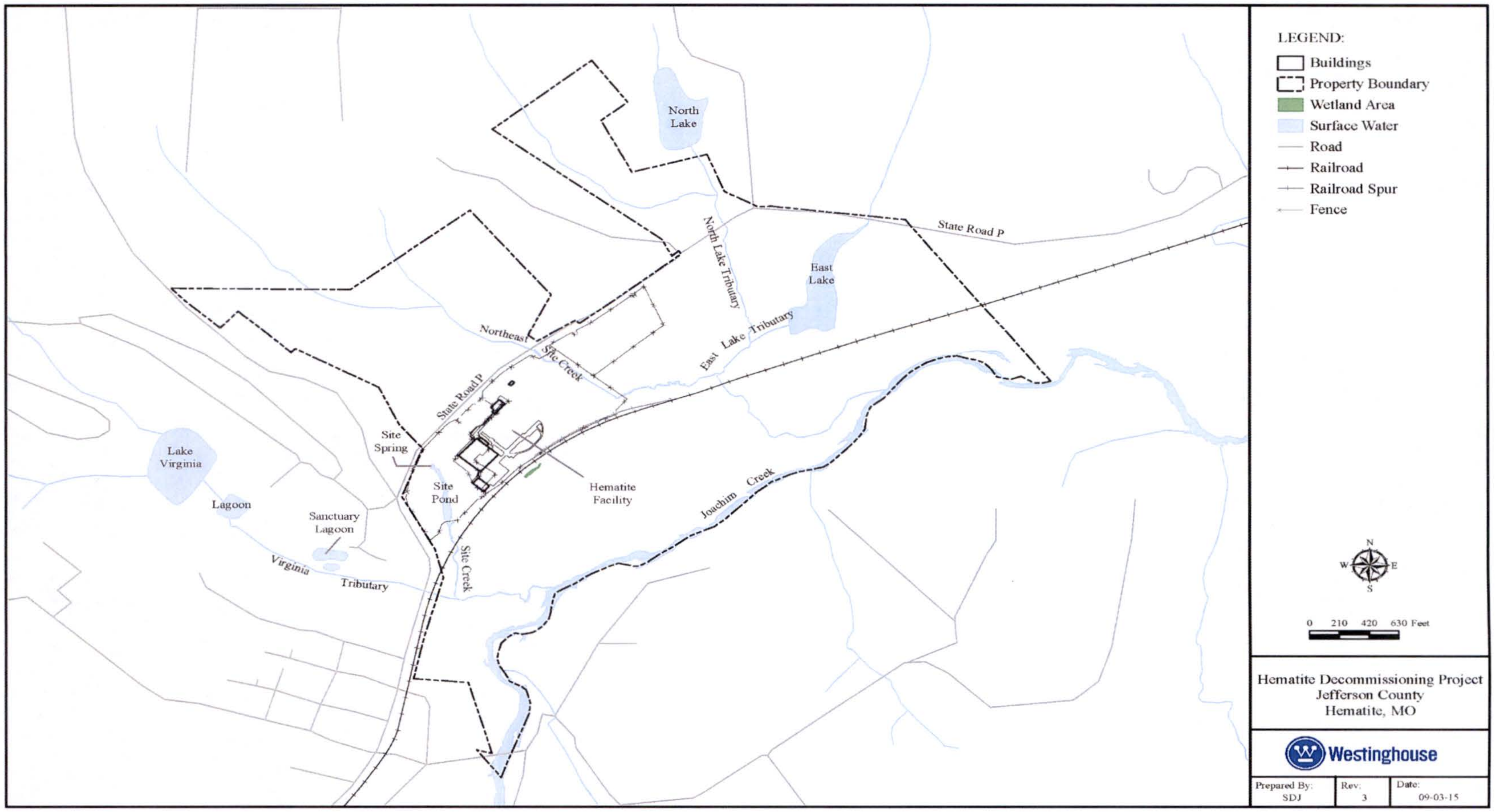


Figure 2-4

Westinghouse Hematite Central Tract

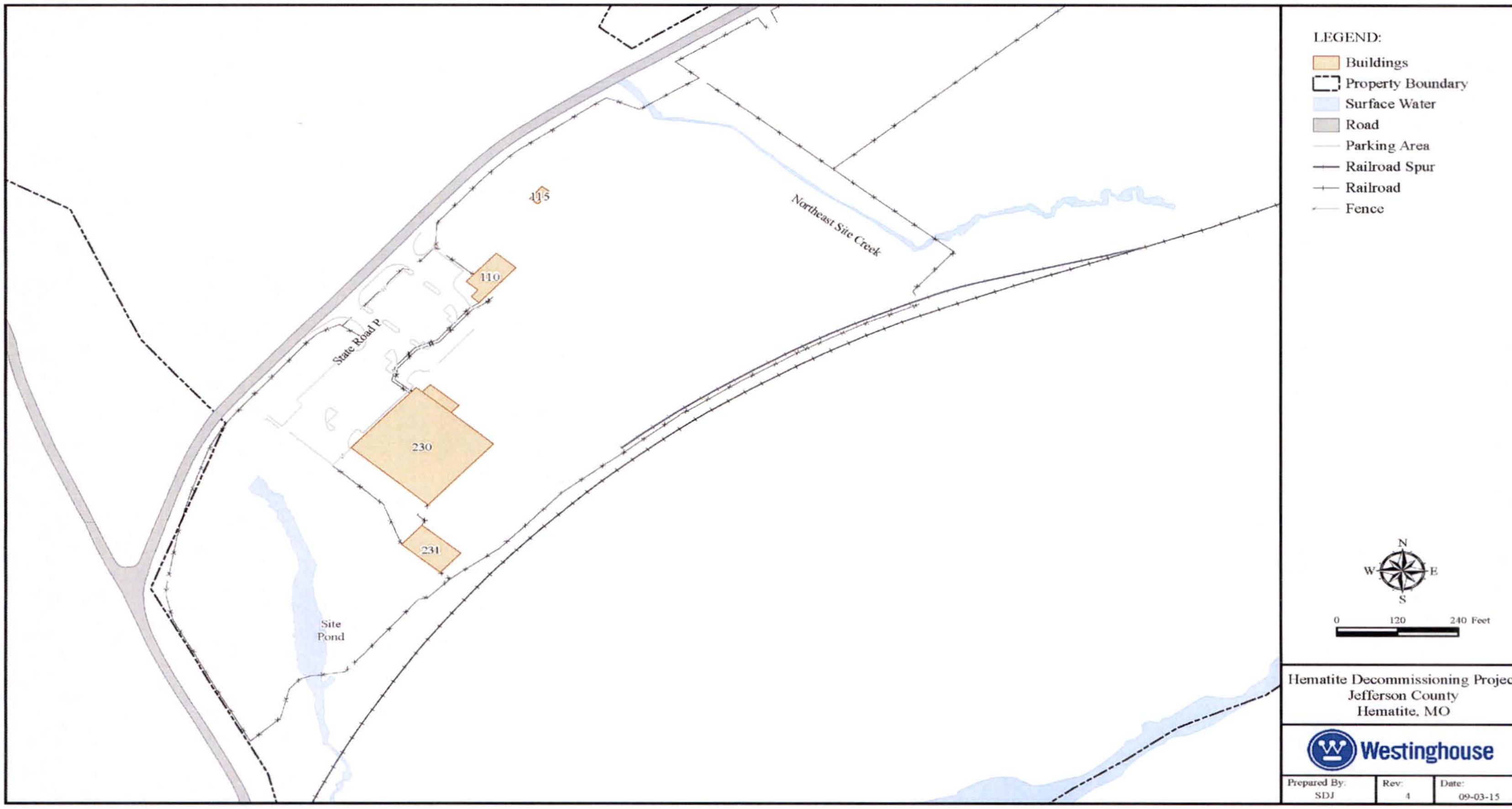


Figure 3-1

Conceptual Open Land Survey Units

Figure 3-2

Conceptual Building 110 Survey Units

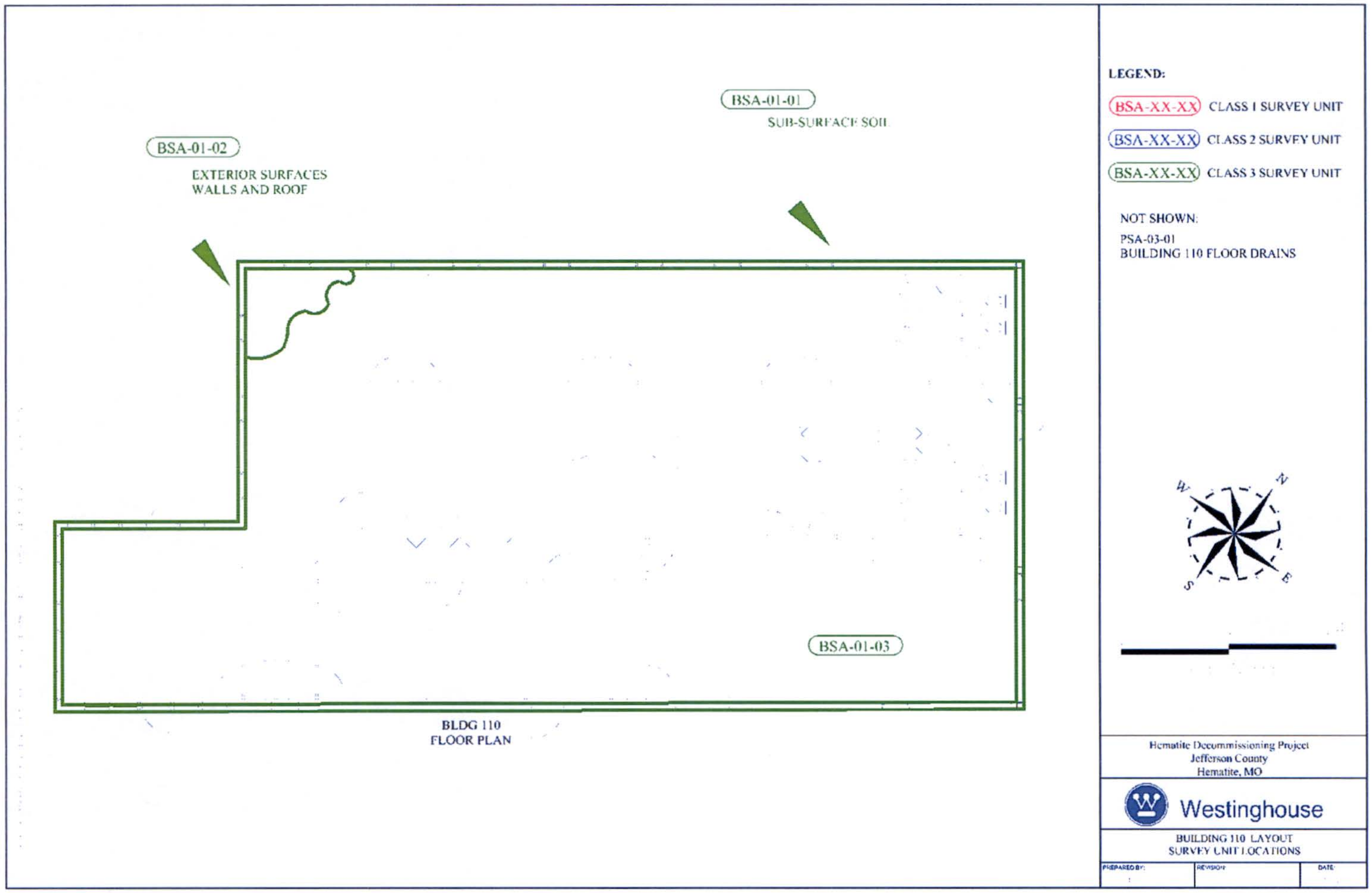


Figure 3-3

Conceptual Building 230 Survey Units (Ground Floor)

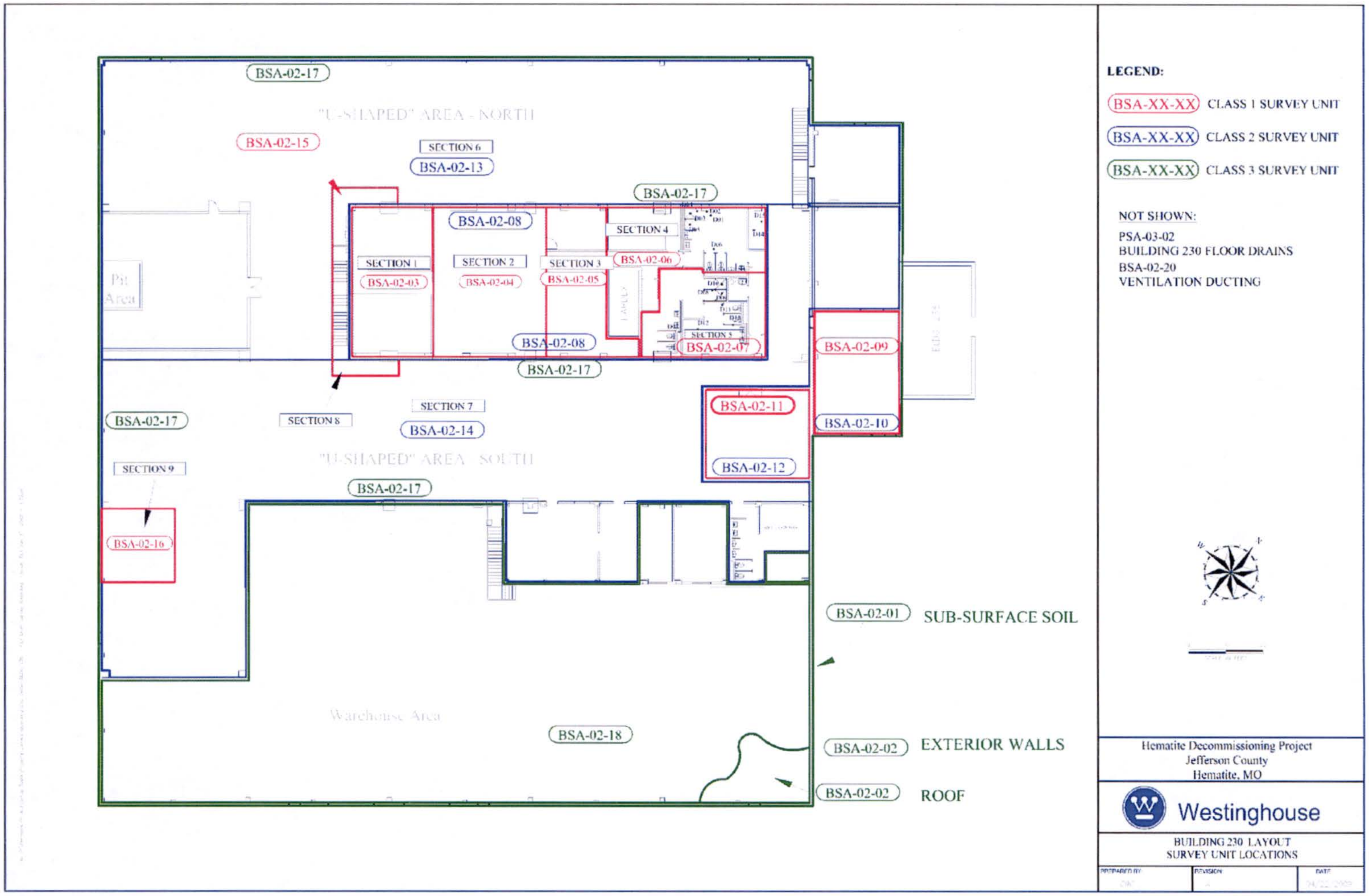


Figure 3-4

Conceptual Building 230 Survey Units (Mezzanine)

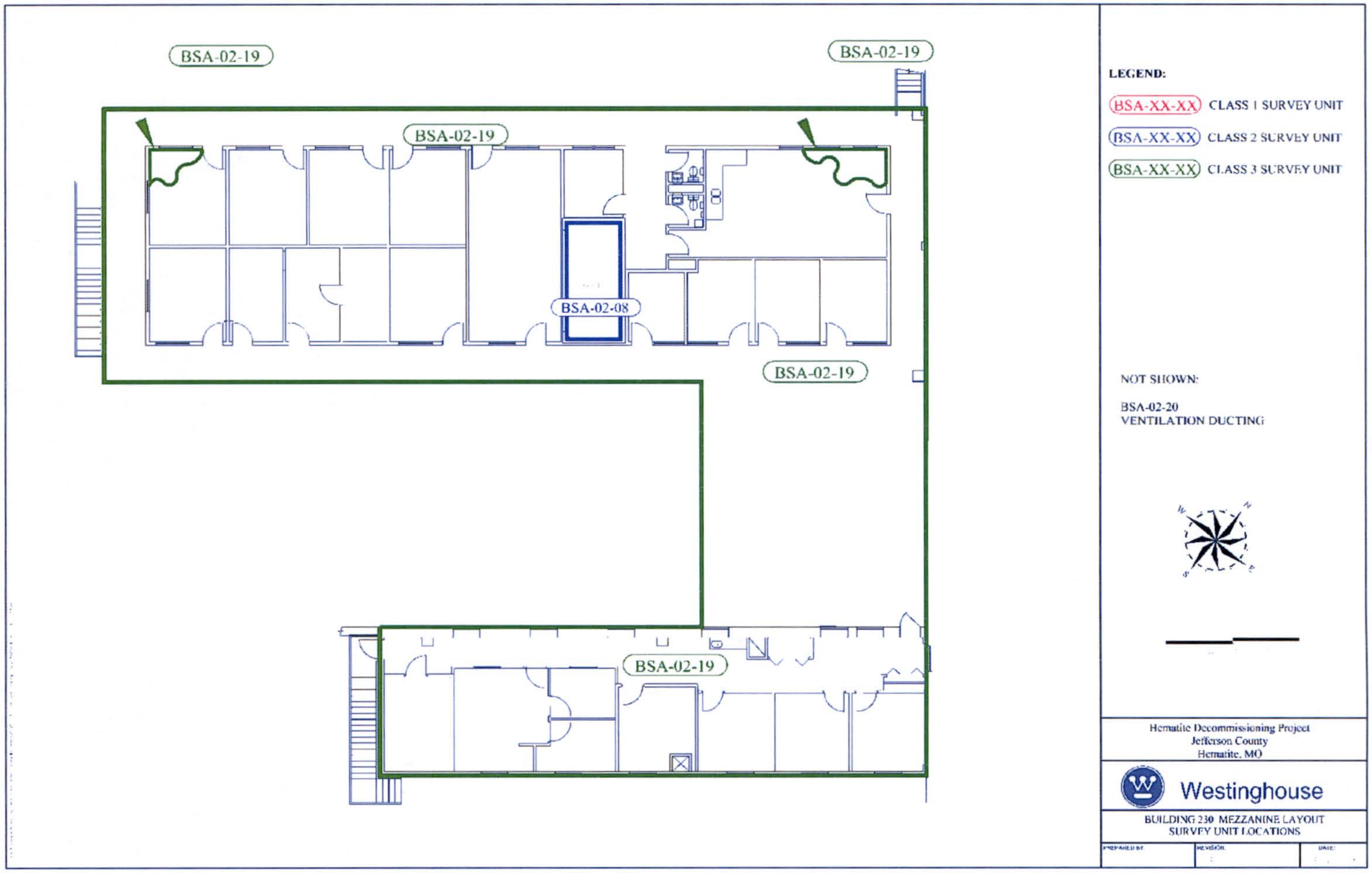


Figure 3-5

Conceptual Building 231 Survey Units

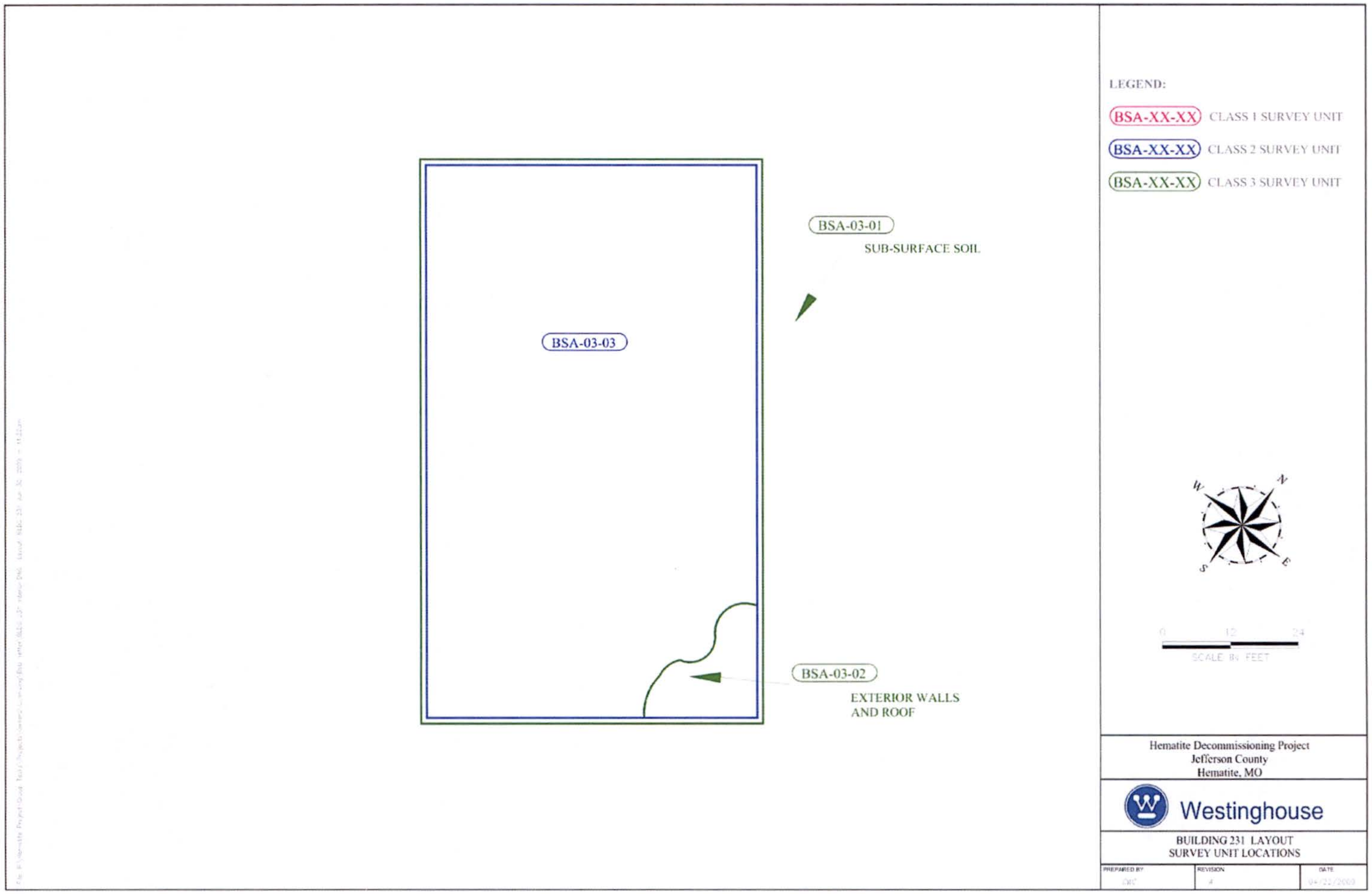
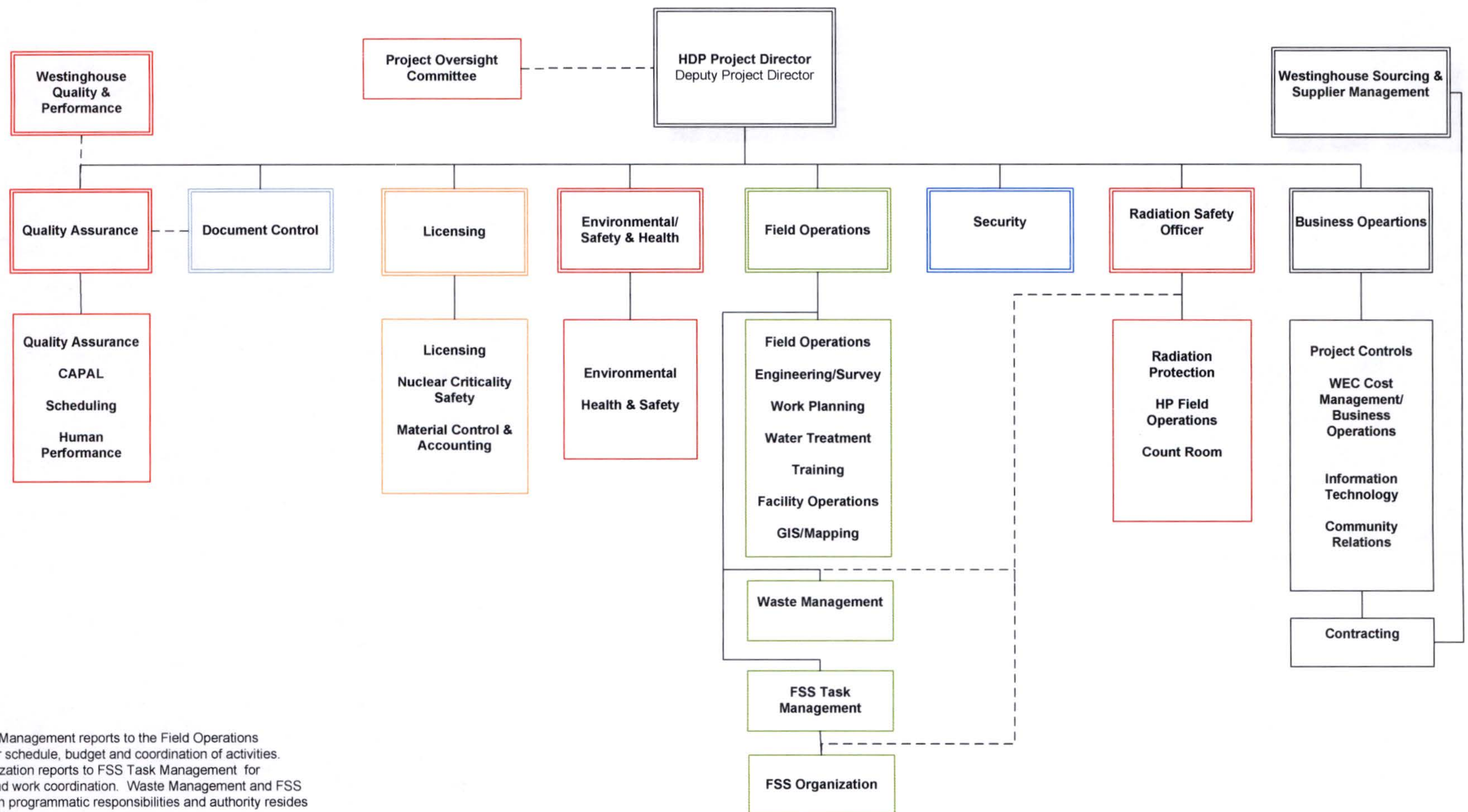


Figure 4-1

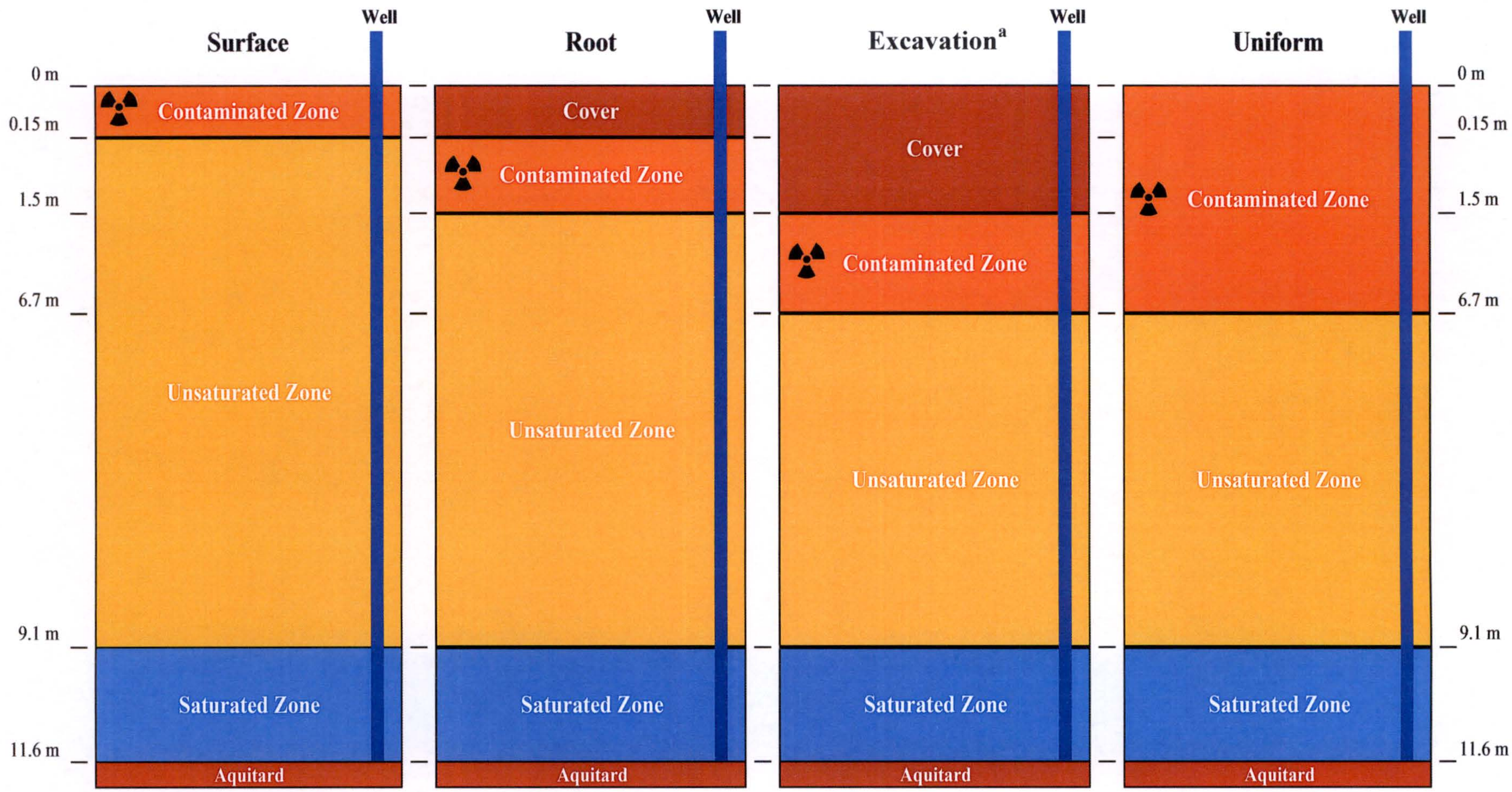
Hematite Decommissioning Project Organization



(1). Waste Management reports to the Field Operations Manager for schedule, budget and coordination of activities. FSS Organization reports to FSS Task Management for schedule and work coordination. Waste Management and FSS Organization programmatic responsibilities and authority resides with the RSO.

Figure 5-1

Conceptual Site Models for Soil DCGLs



Note: Figures are not to scale.

[a] Excavation Scenario DCGLs replace the Deep Stratum DCGLs