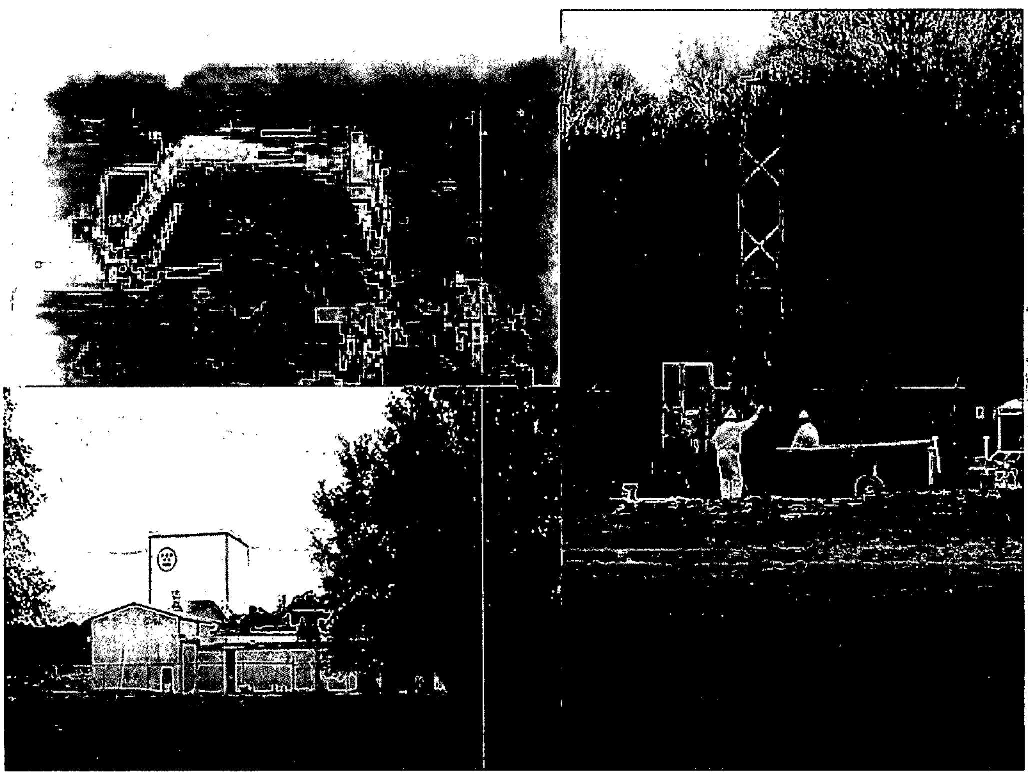
Westinghouse Non-Proprietary Class 3

Hematite Decommissioning Plan

August 2009



3300 State Road P, Festus, MO 63028

DO-08-004
Revision 0.0

HEMATITE DECOMMISSIONING PLAN
INDEX

Section **Page**

CHAPTER TABLE OF CONTENTS

CHAPTER TABLE OF CONTENTS

CHAPTER TABLE OF CONTENTS

Section **Page**

CHAPTER 5.0

CHAPTER TABLE OF CONTENTS

Section **Page**

CHAPTER TABLE OF CONTENTS

CHAPTER TABLE OF CONTENTS

CHAPTER TABLE OF CONTENTS

CHAPTER TABLE OF CONTENTS

CHAPTER TABLE OF CONTENTS

CHAPTER TABLE OF CONTENTS

Section **Page**

CHAPTER 15.0

PLAN LIST OF TABLES

Table No. **Title**

CHAPTER 1.0

None

CHAPTER 2.0

CHAPTER 3.0

CHAPTER 4.0

PLAN LIST OF TABLES

PLAN LIST OF TABLES

Table No. **Title**

CHAPTER 5.0

PLAN LIST OF TABLES

Table No. **Title**

CHAPTER 6.0

None

CHAPTER 7.0

CHAPTER 8.0

CHAPTER 9.0

None

CHAPTER 10.0

PLAN LIST OF TABLES

PLAN LIST OF TABLES

Table No. **Title**

CHAPTER 13.0

None

CHAPTER 14.0

PLAN LIST OF TABLES

PLAN LIST OF FIGURES

Figure No. **Title**

CHAPTER 1.0

CHAPTER 2.0

CHAPTER 3.0

PLAN LIST OF FIGURES

PLAN LIST OF FIGURES

PLAN LIST OF FIGURES

PLAN LIST OF FIGURES

Figure No. | **Title**

CHAPTER 12.0

None

CHAPTER 13.0

CHAPTER 14.0

PLAN LIST OF FIGURES

CHAPTER 15.0

None

PLAN ACRONYMS AND ABBREVIATIONS

%	percent
+ C	dose contribution of entire decay chain (progeny) in secular equilibrium is accounted for by the parent
+ D	dose contribution of the short-lived progeny is accounted for by the parent
$\mu Ci/cm^3$	microCuries per cubic centimeter
µCi/g	microCuries per gram
µCi/ml	microCuries per milliliter
µR/h	microRoentgen per hour
α	Type I error probability
ABB	Asea Brown Boveri
Ac-227	Actinium-227
ACM	Asbestos-containing Material
ADM	Simple Administrative Controls
ADU	Ammonium Diuranate
AEC	U. S. Atomic Energy Commission
AEC	Active Engineered Controls
AF	Area Factor
AHA	Activity Hazard Analysis
ALARA	As Low As Reasonably Achievable
ALI	Annual Limit On Intake
Am-241	Americium-241
AMSL	above mean sea level
ANS	American Nuclear Society
ANSI	American National Standards Institute
AOA	Area of Applicability
AOC	Area of Concern
AQCR	Air Quality Control Regions
ARARs	Applicable Or Relevant And Appropriate Requirements
ASME	American Society Of Mechanical Engineers
ASTM	American Society Of Testing Materials
β	Type II error probability
bgs	below ground surface
Bi-214	Bismuth-214
BMPs	Best Management Practices
BNFL	British Nuclear Fuels Limited

PLAN ACRONYMS AND ABBREVIATIONS

BPA	Burial Pit Area
BTV	Background Threshold Value
BZ	Breathing Zone
CAA	Controlled Access Area
CAM	Continuous Air Monitor
CCIS	Criticality Control Inventory System
CDBS	Collared Drum Buffer Store
CDE	Committed Dose Equivalent
CD-R	Compact Disk - Recordable
CDRA	Collared Drum Repacking Area
CDs	Collared Drums
CDSA	Collared Drum Storage Area
CE	Combustion Engineering Inc.
CEDE	Committed Effective Dose Equivalent
CFR	Code Of Federal Regulations
cm	centimeter(s)
cm/sec	centimeter per second
cm^2	square centimeters
cm^3/g	cubic centimeters per gram
CoC	Chain of Custody
cpm	counts per minute
cpm/100 cm^2	counter per minute per 100 square centimeters
CSC	Criticality Safety Control
CSM	Conceptual Site Model(s)
CZ	Contaminated Zone
d	days
Δ	delta
d′	index of sensitivity
DA	Disassociated Ammonia
DAC	Derived Air Concentration
DCDs	De-collared Drums
DCF	Dose Conversion Factor
$DCGL_{BP}$	Derived Concentration Guideline Level For Buried Piping
$DCGL_{EMC}$	Derived Concentration Guideline Level For Elevated Measurement Comparison

PLAN ACRONYMS AND ABBREVIATIONS

$DCGL_{EMC}$	Derived Concentration Guideline Level For Elevated Measurement Comparison
DCGLs	Derived Concentration Guideline Level(s)
$DCGL_W$	Derived Concentration Guideline Level For Statistical Testing
DDE	Deep Dose Equivalent
DNAPL	Dense Non-Aqueous Phase Liquids
DOE	U.S. Department Of Energy
DOSA	Drum Over-pack Storage Area
DOT	United States Department of Transportation
DP	Decommissioning Plan
dpm	disintegration per minute
dpm/100 cm^2	disintegration per minute per 100 square centimeters
dpm/m^2	disintegration per minute per square meter
DPT	direct-push technology
DQA	Data Quality Assessment
DQO	Data Quality Objectives
DSCC	deeper silty clay/clay
DSR	Peak Dose-To-Source Ratio
DSR_{GW}	Groundwater Dose-To-Source Ratio
EADM	Enhanced Administrative Controls
EDMS	Electronic Document Management System
EEMP	Effluent And Environmental Monitoring Plan
EH&S	Environmental Health And Safety
EM	Electromagnetic
EMC	Elevated Measurement Comparison
EML	Environmental Measurements Laboratory
EP 1	Evaporation Pond 1 (Primary Pond)
EP 2	Evaporation Pond 2 (Secondary Pond)
EPA	U.S. Environmental Protection Agency
ER	Environmental Report
Eu	Europium
FCSA	Field Container Storage Area
FEMA	Federal Emergency Management Agency
FGR	Federal Guidance Report
FID	Flame Ionization Detector

PLAN ACRONYMS AND ABBREVIATIONS

FMSA	Fissile Material Storage Area
FNMCP	Fundamental Nuclear Material Control Plan
FR	Federal Register
FS	Feasibility Study
FSS	Final Status Survey
ft	foot or feet
ft^2	square foot
ft^3	cubic feet
FVG	Fruits, Vegetables and Grains
g	gram
g/cm^3	grams per cubic centimeter
g/d	grams per day
g/m^3	grams per cubic meter
g/yr	grams per year
GA	General Area
GAC	Granulated Active Carbon
GERT	General Employee Radiation Training
gpd	gallons per day
gpm	gallons per minute
GPR	Ground Penetrating Radar
GPS	Global Positioning System
GWS	Gamma Walkover Survey
h	hour
H_0	Null Hypothesis
H_a	Alternate Hypothesis
HAER	Historic American Engineering Record
HASP	Health And Safety Plan
HCl	Hydrochloric Acid
HDP	Hematite Decommissioning Project
HEPA	High Efficiency Particulate Air
HEU	High Enriched Uranium
HF	Hydrofluoric Acid
HNO3	Nitric Acid
HP	Health Physics

PLAN ACRONYMS AND ABBREVIATIONS

HPGe	High-Purity Germanium
hr	hour or hours
hr	hour
hr^{-1}	per hour
HRCR	Hematite Radiological Characterization Report
HRGS	High Resolution Gamma Spectroscopy
HSA	Historical Site Assessment
HSUs	hydrostratigraphic unit(s)
HTDR	Hard-To-Detect Radionuclide
HVAC	Heating, Ventilation And Air Conditioning
IAEA	International Atomic Energy Association
ICRP	International Commission On Radiological Protection
in	inch
IP-1	Industrial Packaging -1
ISO	International Organization For Standardization
ISOCS	In Situ Object Counting System
JC	Jefferson City
K_d	distribution coefficient
keV	kiloelectron volt
kg/d	kilogram per day
kg/m^2	kilogram per square meter
kg/yr	kilogram per year
K_h	Hydraulic Conductivity
km	kilometer
KOH	Potassium Hydroxide
L	liter
L/d	liters per day
L/kg	liters per kilogram
L/yr	liters per year
LBG	Leggette, Brashears and Graham, Inc.
LBGR	Lower Boundary Of The Gray Region
lbs	pounds
LDR(s)	Land Disposal Restriction(s)
LEU	Low Enriched Uranium
LLRW	Low Level Radioactive Waste

PLAN ACRONYMS AND ABBREVIATIONS

m	meter or meters
M&TE	Measuring And Test Equipment
m/sec	meters per second
m/yr	meters per year
m^2	square meters
m^2/hr	square meters per hour
m^3	cubic meters
m^3/hr	cubic meters per hour
m^3/yr	cubic meters per year
MAA	Material Assay Area
MARSSIM	Multi-Agency Radiation Survey And Site Investigation Manual
MB	Mass-Balance
MC&A	Material Control And Accounting
MCW	Mallinckrodt Chemical Works
MDA	Minimum Detectable Activity
MDC	Minimum Detectable Concentration
MDCR	Minimum Detectable Count Rate
MDER	Minimum Detectable Exposure Rate
MDNR	Missouri Department Of Natural Resources
mg/d	milligrams per day
mL	milliliter
MMS	Modified Mercalli Scale
mR/hr	milliRoentgen per hour
mrem	millirem
mrem/yr	millirem per year
mSv	milliSieverts (1 mSv = 100 mrem)
MTSC	Material Transit And Storage Container
N	number of systematic measurement and sampling locations (Sign test)
N/2	number of systematic measurement and sampling locations (WRS test)
NA	Not Applicable
NAAQS	National Ambient Air Quality Standards
NAD83	North American Datum 83
NaI	Sodium Iodide
nC	number of composite samples
NCS	Nuclear Criticality Safety

PLAN ACRONYMS AND ABBREVIATIONS

NCSA	Nuclear Criticality Safety Assessment
NCSS	Nuclear Criticality Safety Signs
ND	Non-Dispersion
nEMC	number of systematic measurement and sampling locations (EMC test)
NIOSH	National Institute for Occupational Safety and Health
NIST	National Institute Of Standards And Technology
NMMSS	Nuclear Materials Management And Safeguards Systems
NP	Negative Pressure
Np-237	Neptunium-237
NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission
NS	Not Sensitive
NSSSC	near surface silt/silty clay
NVLAP	National Voluntary Laboratory Accreditation Program
OCA	Owner Controlled Area
OSHA	Occupational Safety And Health Administration
PA	Perimeter Air
Pa-234m	Protactinium-234 Metastable
PAPR	Powered Air Purifying Respirator
Pb	Lead
PCC	Partial Correlation Coefficient
PCE	Perchloroethylene
pCi	picoCuries
pCi/g	picoCuries per gram
pCi/L	picoCuries per liter
pCi/yr	picoCuries per year
PDF	Probability Distribution Function
PEC	Passive Engineered Controls
PEL	Permissible Exposure Level
PF	Protection Factor
PID	Photo Ionization Detector
PLHCP	Physician Or Other Licensed Health Care Professional
POC	Project Oversight Committee
PPE	Personal Protective Equipment
PQP	Project Quality Plan
PRCC	Partial Rank Correlation Coefficient

PLAN ACRONYMS AND ABBREVIATIONS

PSP	Physical Security Plan
Pu-238	Plutonium-238
Pu-239	Plutonium-239
Pu-239/240	Plutonium-239 and Plutonium-240
Pu-240	Plutonium-240
PVC	polyvinyl chloride
PWSD	Public Water Supply District
QA	Quality Assurance
QC	Quality Control
QMS	Quality Management System
R	Roentgen
RA(s)	Restricted Area(s)
Ra-224	Radium-224
Ra-226	Radium-226
Ra-228	Radium-228
RACM	Regulated Asbestos-containing Material
RASS(s)	Remedial Action Support Survey(s)
RB	Roubidoux
RCRA	Resource Conservation and Recovery Act
rem	Roentgen equivalent man
rem/yr	Roentgen equivalent man per year
RESRAD	computer code developed by ANL for Soil DCGL development
RESRAD-BUILD	computer code developed by ANL for Building DCGL development
RG(s)	Remediation Goal(s)
RI	Remedial Investigation
RIFS	Remedial Investigation Feasibility Study
RIS	Reporting Identification System
Rn-222	Radon-222
ROC	Radionuclides Of Concern
ROD	Record Of Decision
RP	Radiation Protection
RPP	Radiation Protection Plan
RR	Railroad
RSO	Radiation Safety Officer
RWP	Radiation Work Permit
RWT	Radiation Worker Training

PLAN ACRONYMS AND ABBREVIATIONS

σ	standard deviation (sigma)
SA	Sensitivity Analysis
SAIC	Science Applications International Corporation
SCBA	Self Contained Breathing Apparatus
SDS	Storm Drain System
SEA	Surrogate Evaluation Area
sec	second or seconds
sec^{-1}	per second
SF	Gamma Shielding Factor
SI	Sensitivity Index
SNM	Special Nuclear Material
SOF	Sum of Fractions
SRC	Standardized Regression Coefficient
SRRC	Standardized Rank Regression Coefficient
SSC	Structures, Systems And Components
SSNM	Strategic Special Nuclear Material
Sv/Bq	Sieverts per Becquerel
SVE	Soil Vapor Extraction
SWPPP	Storm Water Pollution Prevention Plan
SWTP	Sanitary Wastewater Treatment Plant
TAP	Total Absorption Peak
Tc-99	Technetium-99
TCE	Trichloroethylene
TCLP	Toxicity Characteristic Leaching Procedure
TEDE	Total Effective Dose Equivalent
Th-228	Thorium-228
Th-231	Thorium-231
Th-232	Thorium-232
Th-234	Thorium-234
TLD	Thermoluminescent Dosimeter
TLV	Threshold Limit Value
TRU	Transuranics
TSDF	Transportation Storage Disposal Facility
U-234	Uranium-234
U-235	Uranium-235

PLAN ACRONYMS AND ABBREVIATIONS

U-236	Uranium-236
U-238	Uranium-238
UC_4	Uranium CarbideUCL_{95} upper 95 percent confidence level for the mean
UCSA	Un-assayed Container Storage Area
UF_4	Uranium Tetrafluoride
UF_6	Uranium Hexafluoride
UNC	United Nuclear Corporation
UO	Uranium Oxide
UO_2	Uranium Dioxide
UO_4	Uranium Peroxide
USDA	U.S. Department Of Agriculture
USGS	U. S. Geological Survey
USL	Upper Subcritical Limit
V&V	Verification And Validation
VOC(s)	Volatile Organic Compound(s)
VOCTA	VOC Treatment Area
WAC	Waste Acceptance Criteria
WCA	Waste Consolidation Area
WEA	Waste Evaluation Area
WEC	Westinghouse Electric Company LLC
WHA	Waste Holding Area
WIMS	Well Information Management System
WMP	Water Management Plan
WMTP	Waste Management And Transportation Plan
WMW	Wilcoxon Mann Whitney
WRS	Wilcoxon Rank Sum
WTS	Water Treatment System
yr	year(s)

TABLE OF CONTENTS

LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

ALARA	As Low As Reasonably Achievable
CFR	Code Of Federal Regulations
CSM	Conceptual Site Model(s)
DCGLs	Derived Concentration Guideline Level(s)
DP	Decommissioning Plan
HDP	Hematite Decommissioning Project
m	meter
mrem	millirem
NRC	U.S. Nuclear Regulatory Commission
SNM	Special Nuclear Material
TEDE	Total Effective Dose Equivalent
yr	year(s)
WEC	Westinghouse Electric Company LLC

1.0 EXECUTIVE SUMMARY

This Hematite Decommissioning Project (HDP) Decommissioning Plan (DP) is provided by Westinghouse Electric Company LLC (WEC) in accordance with the requirements set forth in 10 CFR 20.1400 - 1404, §30.36, §40.42, and §70.38. The objective is to decommission the Hematite Former Fuel Cycle Facility, release the site for unrestricted use, and terminate the license. The HDP DP was prepared using the guidance set forth in NUREG-1757, Consolidated Decommissioning Guidance, Volume 1, Revision 2, and NUREG-1575, Multi-Agency Radiation Survey and Site Investigation Manual.

1.1 SITE AND LICENSEE INFORMATION

The Hematite facility is located on a site of about 228 acres in Jefferson County, Missouri, approximately ¾ miles northeast of the unincorporated town of Hematite, Missouri. Jefferson County is predominately rural and characterized by rolling hills with many sizable woodland tracts.

The facility is situated between hills to the northwest and a terrace/flood plain of Joachim Creek, located along the southeast site boundary. Activities with special nuclear material were conducted in an area adjacent to State Road P developed with buildings, infrastructure, and maintained landscaping. The remaining property is woods and farmland, with no documented evidence of historic operations by WEC or previous owners.

Licensee Name:	Westinghouse Electric Company LLC
Materials License Number:	SNM-00033
Docket Number:	070-00036
Licensee Address:	Hematite Decommissioning Project 3300 State Road P Festus, Missouri 63028

1.2 SUMMARY OF LICENSED ACTIVITIES

The original Special Nuclear Material (SNM) License for the Hematite facility (License Number SNM-33) was issued by the Atomic Energy Commission to Mallinckrodt Chemical Works on June 18, 1956.

From its inception in 1956 through 1974 the facility was used primarily in support of government contracts that required production of highly enriched Uranium products. From 1974 through closure in 2001 the facility operated as a low-enriched Uranium commercial fuel production plant. Over the lifetime of the facility there have been several owners. Mallinckrodt Chemical Works, Inc., United Nuclear Corporation, Gulf United Nuclear Fuels Corporation and General Atomic Company owned the facility during the government contracts phase of operations. Combustion Engineering, Inc. (whose stock was later acquired by Asea Brown Boveri), and WEC, owned the facility during the commercial nuclear phase of operations.

1.3 NATURE AND EXTENT OF SITE RADIOLOGICAL CONTAMINATION

The site impacted area contains structures, systems and equipment, radioactive waste burial pits, surface soil, sub-surface soil, sediment, and surface water, which are contaminated with licensed radioactive material in excess of natural background levels. WEC has determined that groundwater is demonstrably not contaminated, therefore the Hematite Site meets the Decommissioning Group 4 criteria specified in NUREG 1757, Volume 1. Supporting data and detailed discussions are provided in DP Chapter 4.

1.4 DECOMMISSIONING OBJECTIVE

By application dated September 11, 2001, WEC 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. WEC submitted a change to the license application and NRC approved License Amendment Number 42 to modify the scope of licensed activities to those associated with decommissioning activities. WEC's decommissioning goal is to reduce residual radioactivity to a level that permits termination of the license in accordance with 10 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.*

1.5 SITE-SPECIFIC DCGLs

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 DCGLs represent isotope-specific release criteria. However, it should be noted that multiple radionuclides will be present at the same time in varying quantities. As a result, the dose contribution from each radionuclide must be considered such that the total dose from all radionuclides does not exceed the dose base limit.

Conceptual Site Models (CSM) 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.

The soil DCGLs are specific to a given CSM and will result in a Total Effective Dose Equivalent (TEDE) of 25 mrem/yr to the average member of the critical group for that CSM. In the situation where residual contamination is distributed in soil such that multiple CSMs are applicable, the unity rule will be applied to account for the dose from each CSM and ensure the total TEDE does not exceed the criterion of 25 mrem/yr.

The soil DCGLs as calculated apply to the in-situ configuration of the residual contamination at the time of license termination. Because it is possible that the subsurface soil could be excavated at some time in the future, an excavation scenario was evaluated to ensure that the DCGLs would also be acceptable if the soil is excavated and brought to the surface. The excavated soil scenario assumes soil is excavated during a home construction of a 3 meter deep basement and the excavated soil uniformly mixed and spread over the ground surface. The excavation scenario DCGLs are conservatively used for soil below 1.5 meters.

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 should be required to reduce surface contamination to acceptable levels, the DCGLs based on the Small Office CSM will be 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.

For the remaining buildings that will not be demolished, the building drains and piping may contain residual contamination. These areas will be addressed in a different manner because the geometries of the pipes do not fit either the building or soil dose models. DCGLs for buried piping have been developed using the assumption that the piping disintegrates, leaving behind residual contamination which previously was located on the interior of the piping surfaces.

The DCGL development is described in DP Chapter 5.

1.6 ALARA ANALYSIS

In order to demonstrate that the site meets these requirements for unrestricted site release, an analysis is conducted to show that the residual radioactivity has been reduced to levels that are As Low As Reasonably Achievable (ALARA).

A simplified ALARA analysis was conducted to determine if additional soil remediation should be performed, to further reduce dose below the 25 mrem/yr dose basis of the DCGLs. Cost associated with this additional remediation was used as input for these calculations. These costs included: remediation, waste transport and disposal, worker accidents, traffic fatalities, and worker and public dose. The cost of waste soil disposal is significantly greater than any of the other costs. The calculation demonstrates that the soil DCGLs are ALARA even when using a conservative monetary discount rate. Therefore, additional remediation action to achieve residual radioactivity concentrations in soil less then the DCGL values is not warranted.

A simplified ALARA analysis was also conducted to determine if additional building or structural remediation should be performed, to further reduce dose below the 25 mrem/yr dose basis of the DCGLs. Cost associated with this additional remediation was used as input for these calculations. Two remedial actions are evaluated for this ALARA analysis: washing building surfaces and scabbling building surfaces. The ALARA analysis for washing building surfaces and surface scabbling shows that when a monetary discount rate of 0.07 is applied, the DCGLs for building surfaces are ALARA.

The ALARA analysis is provided in DP Chapter 7.

1.7 START AND END DATES

Decommissioning activities addressed by this DP are scheduled to start following NRC approval of this DP. The sequence and schedule of these activities are described in detail in DP Chapter 8. Decommissioning activities are projected to be completed approximately 3 years after approval of this DP.

A Gant chart schedule is provided as Figure 1-1. The identified activities are intended to provide an overview of the remaining activities and an estimated time schedule for each. The time frames for conducting the activities are dependent upon approval of the Decommissioning Plan. The conceptual schedule provided in this section is for general guidance and illustrative purposes only. An updated schedule will be maintained during decommissioning and will be available for review by regulatory agencies, including the NRC.

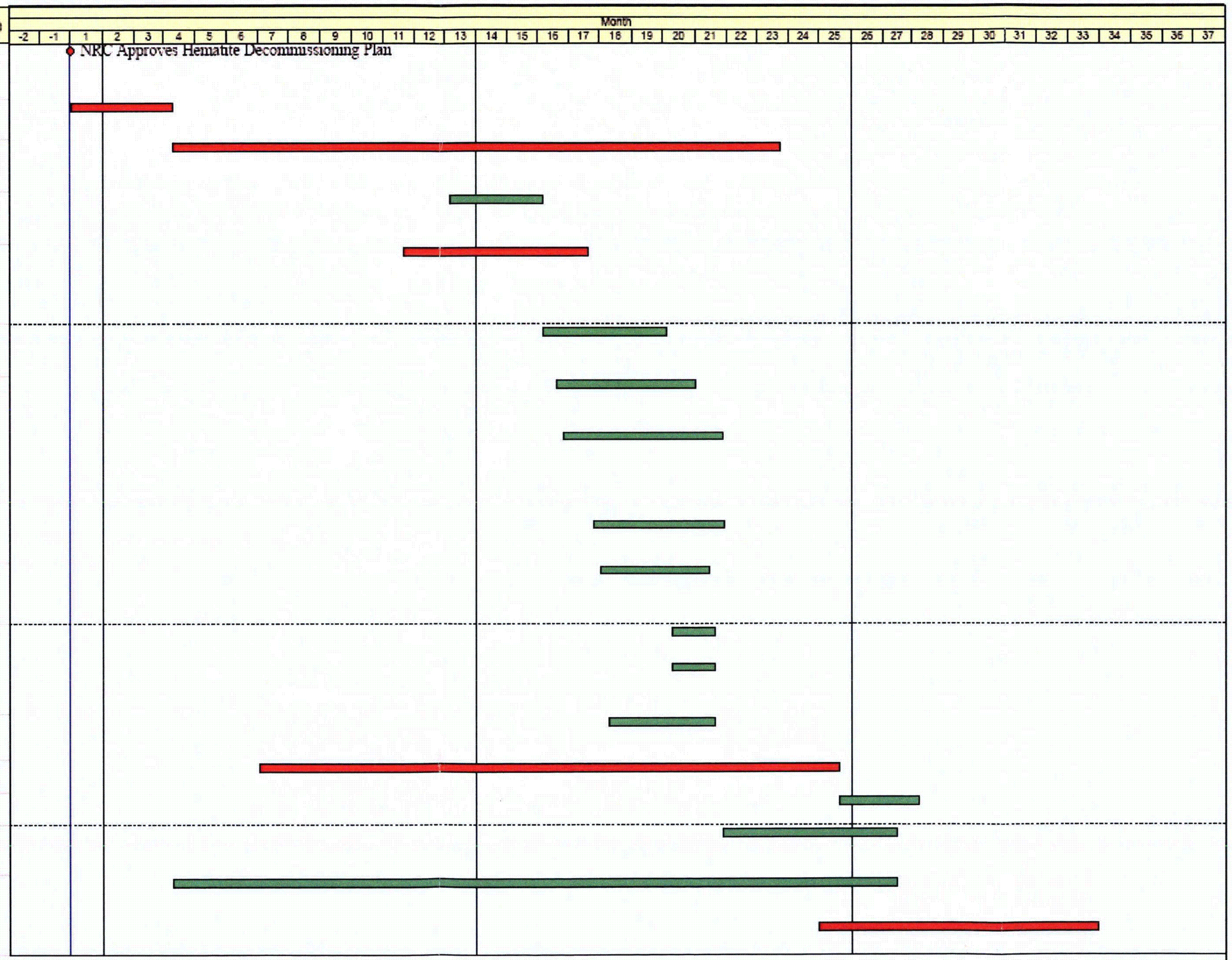
1.8 POST-REMEDIATION ACTIVITIES

Following the completion of subsurface soil remediation activities and prior to license termination, WEC will conduct final status survey activities in accordance with DP Chapter 14 as well as all necessary work to place the site in a final configuration.

Figure 1-1
Proposed Schedule for Hematite Decommissioning

Page 1 of 1

Activity ID	Activity Name	Duration (Work Days)
A1000	NRC Approves Hematite Decommissioning Plan .	0
A1010	Remediation Site Preparation	70
A1020	Burial Pits Remediation & Restoration	423
A1030	Former Leach Field Remediation & Restoration	65
A1040	Red Room Roof, Cistern Burn Pit & Barns Soil Remediation & Restoration	130
A1050	Site Pond Surrounding Areas Remediation & Restoration	87
A1060	Evaporation Ponds Remediation & Restoration	97
A1070	Slabs & Soils Beneath Buildings to be Demolished & Areas Around Building Exteriors, Remediation	110
A1080	Storm Drain System Remediation	92
A1090	Sanitary Wastewater Treatment System Remediation	76
A1100	Soil Remediation Areas	30
A1110	Remediation & Release of Remaining Structures	30
A1120	Demolition of other Structures	74
A1130	Final Status Surveys	405
A1140	Final Site Restoration	55
A1150	Decontamination & Demobilization	123
A1170	Water Treatment System	505
A1180	License Termination	196



Remaining Work ◆ Milestone
Critical Remaining Work

Hematite Decommissioning Project

Page 1 of 1

TABLE OF CONTENTS

TABLE OF CONTENTS
(Continued)

LIST OF TABLES

Table No. **Title**

LIST OF FIGURES

Figure No. **Title**

ACRONYMS AND ABBREVIATIONS

ABB	Asea Brown Boveri
ADU	Ammonium Diuranate
AEC	U. S. Atomic Energy Commission
Am-241	Americium-241
BNFL	British Nuclear Fuels Limited
CAA	Controlled Access Area
CE	Combustion Engineering Inc.
CFR	Code Of Federal Regulations
DA	Disassociated Ammonia
DOE	U.S. Department Of Energy
EP 1	Evaporation Pond 1 (Primary Pond)
EP 2	Evaporation Pond 2 (Secondary Pond)
ft^3	cubic feet
HDP	Hematite Decommissioning Project
HSA	Historical Site Assessment
HVAC	Heating, Ventilation And Air Conditioning
MCW	Mallinckrodt Chemical Works
NRC	U.S. Nuclear Regulatory Commission
Np-237	Neptunium-237
pCi/g	picoCuries per gram
Pu-238	Plutonium-238
Pu-239	Plutonium-239
Pu-240	Plutonium-240
Ra-226	Radium-226
RSO	Radiation Safety Officer
SNM	Special Nuclear Material
SWTP	Sanitary Wastewater Treatment Plant
Tc-99	Technetium-99
Th-232	Thorium-232
TRU	Transuranics
UF_4	Uranium Tetrafluoride
UF_6	Uranium Hexafluoride
UNC	United Nuclear Corporation
UO_2	Uranium Dioxide

ACRONYMS AND ABBREVIATIONS
(Continued)

UO_4	Uranium Peroxide
U-234	Uranium-234
U-235	Uranium-235
U-236	Uranium-236
U-238	Uranium-238
WEC	Westinghouse Electric Company LLC

2.0 FACILITY OPERATING HISTORY

This chapter provides a summary of Hematite Site historical operations, license activities and current site conditions consistent with the applicable guidance contained in Section 16.2 of NUREG-1757, "Consolidated Decommissioning Guidance, Decommissioning Process for Materials Licensees" (Reference 2-1). The Hematite Historical Site Assessment (HSA) (Reference 2-2) was used as the basis for the information presented in this chapter, including historical operations and events that have resulted in known or potential sources of residual radioactivity within the site boundary. As such, this information provides a framework for determining which site areas are potentially or known to be impacted by historical operations.

2.1 LICENSE NUMBER, STATUS AND AUTHORIZED ACTIVITIES

The following sections describe the current Hematite facility status and summarize activities authorized under Nuclear Regulatory Commission (NRC) Special Nuclear Material License No. SNM-33 (Reference 2-3) for the Hematite Site.

2.1.1 FACILITY STATUS

The Hematite Decommissioning Project (HDP) is owned and operated by Westinghouse Electric Company LLC (WEC). As detailed in the Hematite HSA, the Hematite facility produced nuclear reactor fuels for United States Navy and Army, conducted nuclear fuel research for the federal government, and fabricated nuclear fuel assemblies for commercial nuclear power plants under ownership of several companies during its operational period from 1956 to May 2001. Since permanent cessation of fuel fabrication operations, NRC-related activities at the Hematite Site have been limited to those associated with the transition to a permanently shutdown facility and decommissioning planning. These activities include Special Nuclear Material (SNM) inventory removal, process equipment removal and disposal, decommissioning planning, and site characterization.

A diagram of the 228 acre Hematite Site property is provided in Figure 2-1. Figure 2-2 provides additional detail of the facility's Central Tract (Figure 2-2). The Central Tract is the area of the site where operational activities were historically conducted. The Central Tract area is bounded by State Road P to the north, the Northeast Site Creek to the east, the Union-Pacific Railroad to the south and the Site Creek/Pond to the west. The site buildings and structures are currently utilized for office space and to house equipment and materials to support decommissioning activities. Table 2-1 provides descriptions of the current use and condition of facility buildings and structures.

2.1.2 FACILITY LICENSE AND AUTHORIZED ACTIVITIES

Activities at the Hematite Site involving possession and use of radiological material are authorized under NRC License No. SNM-33 (Reference 2-3). The Hematite license is maintained under and is based on the NRC requirements of Title 10 Code of Federal Regulations (CFR) Part 70, "Domestic Licensing of Special Nuclear Material" (Reference 2-4). The current authorized principal licensed activity is to decommission the site by removing the facilities safely from service and reducing residual radioactivity to a level that permits termination of the license.

The radionuclides, maximum activities, quantities and chemical forms currently (as of this writing) authorized under NRC License No. SNM-33 are presented in Table 2-2.

In addition to criteria authorizing possession of specific radionuclides, the current Hematite License No. SNM-33 provides specific conditions for decommissioning including those activities pertaining to:

1. reduction of license material through decontamination, waste preparation, packaging and shipment;
2. decommissioning planning activities such as site characterization;
3. maintenance of existing facilities;
4. decommissioning and decontamination of building and equipment; and
5. demolition of buildings.

Under the current site license requirements (i.e., prior to approval of this Decommissioning Plan), the Hematite facility is not authorized to conduct activities related to (1) soil and groundwater remediation, (2) final status surveys for NRC approval, (3) subsurface disturbance to include trenching, (4) on-site waste treatment, or (5) staging of material or equipment or waste in the Burial Pit Area except existing pads and roadways. The decommissioning activities described in this Decommissioning Plan and associated documents are intended to provide the basis for completing work activities in support of license termination and subsequent release of the site for unrestricted use pursuant to 10 CFR 20, Subpart E, "Radiological Criteria for License Termination" (Reference 2-5).

Table 2-3 provides a list of amendments to License No. SNM-33 since the most recent renewal on July 28, 1994, through Amendment 53.

2.2 LICENSE HISTORY

The following sections describe Hematite facility the general history of the Hematite facility including site ownership and operational activities with respect to radioactive material use and storage.

2.2.1 OPERATIONAL HISTORY

Historical operations at the Hematite facility can be characterized by two distinct time periods: (1) research and production of nuclear fuels for government-related projects (1956 – 1974), and (2) production of nuclear fuels for commercial nuclear power plants (1974 – 2001).

2.2.1.1 Facility Ownership

Mallinckrodt Chemical Works (MCW) purchased the original parcel of farmland that includes the Central Tract area. MCW owned and operated the Hematite facility until May 1961, when ownership was transferred to United Nuclear Corporation (UNC). UNC operated the site until 1971 when UNC and Gulf Oil Corporation (Gulf) entered into a joint venture forming the Gulf United Nuclear Fuels Corporation. The joint venture operated the facility until November 1973, at which time UNC sold its interest, and Gulf changed the name to Gulf Nuclear Fuels Corporation. In January 1974, the Hematite facility was transferred to General Atomic Company, a partnership between Gulf and Scallop Nuclear, Inc. The focus of operations during this time period was Uranium fuel research and production of fuels for various government applications.

The second period of operations began in May 1974, when the site was purchased by Combustion Engineering, Inc. (CE). Under ownership by CE, the focus of operations at Hematite facility was in the fabrication of fuel pellets using low-enriched Uranium (≤5 percent enrichment in the U-235 isotope). Asea Brown Boveri (ABB) acquired the stock of CE in 1989 and CE continued to fabricate fuel pellets and produce fuel assemblies for commercial power plants until 2000. In April 2000, the Hematite Site was acquired from ABB by the then parent company of WEC, British Nuclear Fuels Limited (BNFL), as part of the purchase of ABB's nuclear operations, and merged into WEC. WEC permanently ceased Hematite operations in June 2001 and the site then entered into decommissioning (Reference 2-2). On October 16, 2006, WEC was purchased by the Toshiba Corporation. WEC currently is indirectly owned by Toshiba Nuclear Energy Holdings US Inc.

2.2.1.2 Operations For The Federal Government (1956 To 1974)

The focus of operations during the period from 1956 until 1974 was Uranium fuel research, production of research reactor fuels, and production of fuels for United States Navy and Army reactors. Operations typically involved manufacture of Uranium compounds from natural and enriched Uranium; specifically, the conversion of Uranium Hexafluoride (UF_6) gas of various

Uranium-235 (U-235) enrichments to Uranium Oxide, Uranium Carbides, Uranium Dioxide (UO_2) pellets, and Uranium metals was performed. During this period, classified government projects dominated operations at the Hematite facility; specific details regarding the exact nature of all production processes and research conducted at the site prior to 1974 are not available to the current licensee. The following are examples of known projects during this timeframe (Reference 2-6):

1. production of Uranium metal for use in the U.S. Navy's nuclear-powered submarines and ships;

2. production of specialized Uranium Oxides for use in the U.S. Army's power reactors;

3. production of highly-enriched Uranium metal for test reactors utilized by the U.S. Navy;

4. production of Uranium-Beryllium pellets for use in the SL-1 (an experimental U.S. military nuclear reactor that was part of the Army's nuclear power program);

5. production of highly-enriched Uranium Zirconia pellets for naval reactors; and

6. production of highly-enriched oxides for use in the General Atomic's nuclear rocket projects.

A review of available licensing documents was performed for the period from the initial issuance of License No. SNM-33 in 1956 by the Atomic Energy Commission (AEC) until 1974 when the license was transferred to CE. This review identified that, during this period, Hematite was licensed to possess Uranium, including source material, and low- to high-enrichments. Because work was done on classified projects, descriptions of the chemical and physical form of the allowed materials are limited to general statements that include metals, oxides and other Uranium compounds.

2.2.1.3 Operations Between 1974 And 2001

The second period of Hematite facility operations began in 1974 with the purchase of the site by CE. Operations during this period were focused on fabricating fuel pellets using low-enriched (less than 5 percent enrichment of the U-235 isotope) Uranium. Starting around 1993, operations expanded to manufacturing of fuel assemblies to supply commercial nuclear power plants. The primary operations performed at Hematite during this time period were: (1) conversion of UF_6 to UO_2, (2) fuel pellet and fuel assembly fabrication, and (3) scrap recovery of Uranium compounds.

2.2.1.4 Atomic Energy Commission/Nuclear Regulatory Commission License History For The Hematite Facility

Federal regulations applicable to Hematite operation from 1956 to present include, but are not limited to, those contained in 10 CFR, Parts 20, 30 to 36, 40, 70, 71, 73 and 74. The original Special Nuclear Material License No. SMM-33 for the Hematite facility was issued on July 18, 1956, by the AEC. A review of SNM-33 license history yielded three distinct amendment periods. The first amendment period spanned from 1956 to 1977 and included 93 issued amendments. The second amendment period spanned from 1978 to 1994 and included 25 issued amendments. The current amendment period spans from 1994 to the present. The original License No. SNM-33 at times covered activities at the Mallinckrodt facility in St. Louis, Missouri, as well as the UNC location in New Haven, Connecticut. License No. SNM-230, issued to Mallinckrodt Chemical Works for the St. Louis facility in the same 1950's timeframe as License No. SNM-33, also covered some operations at the Hematite Site in the late 1950s and early 1960s. License No. SNM-33 currently covers only activities at the Hematite facility.

2.2.2 LOCATIONS OF RADIONUCLIDE USE AND STORAGE

The following section describes general building use throughout the operational time period of the Hematite facility. Operational process changes and corresponding building use and modifications are summarized in Table 2-4. This table also contains information on where radioactive materials were used and stored relative to site building, structures and outside areas.

2.2.2.1 Government Operations Period (1956 – 1974)

Hematite facility operations have evolved continuously in response to business strategies, process changes and technology advances. Figure 2-3 provides a historical layout of the facility buildings prior to 1974. Initial site construction in 1956 included one process building (Building 240), a utilities building (Building 250) and a material storage building (Building 235). Buildings 101 (Tile Barn) and 120 (Wood Barn) existed on the property prior to purchase by Mallinckrodt. It has been used to store both non-contaminated and contaminated equipment throughout the facility's operating period. While the physical layout of the Hematite facility was periodically modified, certain areas of the facility were dedicated to specific production processes.

2.2.2.1.1 Building 240

Building 240 housed equipment associated with the chemical conversion of Uranium into compounds, solutions and metals. Building 240 was further divided into areas for high-enrichment and low-enrichment Uranium processes. The "Red Room" (240-2) contained high-enrichment conversion processes. The "Green Room" (240-3) contained low-enrichment conversion processes and high-enrichment scrap processing. The "Blue Room" (240-4), which was further divided into three sections, contained in one section equipment for solvent extraction of low enriched Uranium from scrap. Another section of the Blue Room contained equipment for the manufacture of enriched Uranium compounds with enrichments between 5 and 20 percent, and a third section of the Blue Room contained equipment for research and development activities and a pilot plant for pressing and firing ceramic pellets of UO_2. The Red Room was specifically used for the reduction of UF_6 to Uranium Tetrafluoride (UF_4), the conversion of UF_4 to Uranium metal, high-enrichment Uranium scrap recovery, and other chemical conversion processes using highly-enriched Uranium.

2.2.2.1.2 Building 255

Building 255 (constructed in 1958-1959) was utilized for the fabrication of Uranium compounds into physical shapes. The building was segregated into areas associated with high-enrichment and low-enrichment processes. Building 255 included the Ceramic Plant, Item Plant, storerooms and offices. The Item Plant area of Building 255 was dedicated solely to classified, government-related projects involving Uranium compounds of high-enrichment, specifically operations associated with U.S. Navy nuclear fuel production. While the processes and products originating from the Item Plant were classified, it is known that the Item Plant was designed to blend UO_2 with other compounds to produce a U.S. Navy fuel product.

2.2.2.1.3 Other Use And Storage Areas

Areas of the Hematite facility used for storage were separated primarily by degree of enriched material or product stored. High-enrichment Uranium storage areas included Building 235, Building 250 and later, Building 252 (constructed in 1960). Building 235 was also used to store source material; and Building 250 housed a boiler, cooling tower pumps, a recycle hopper and a blending area. Building 251 was constructed in 1957 and 1958 and was used as a shipping/receiving dock area and for storage of scrap nuclear material for recycling.

Outside storage of materials and equipment was utilized routinely throughout the operational period of the Hematite facility. Concrete pads immediately outside of Building 240 were used for storage.

Building 101 was used for the storage of both clean and radiological contaminated equipment. The grassy area south of the original barns (Buildings 101 and 120) is also known to have been utilized as an equipment lay down area. The areas directly east and west of Building 252 were utilized as outside storage for drums filled with filtrates from the wet recovery process awaiting solidification and off-site disposal. High-enrichment scrap was held in an outdoor, fenced area south of the facility buildings.

Building 260, the Oxide Building, was constructed in 1967 and 1968 and housed the chemical reactors and process equipment used for converting UF_6 to UO_2 granules. Building 110 was constructed in 1972 and has been used for administrative functions and as a security point for ingress and egress to the site.

2.2.2.2 <u>Commercial Operations Period (1974 – 2001)</u>

Figure 2-4 provides a layout of the facility buildings in use during the period of fuel manufacture for commercial nuclear plants (1974 to 2001). Operations during this period were focused on fabricating fuel pellets using low-enriched Uranium (less than 5 percent enrichment) and fuel assemblies to supply various commercial nuclear power plants. The primary operations performed at Hematite during this period were: (1) conversion of UF_6 to UO_2, (2) fuel pellet manufacture, (3) scrap recovery, and later (4) fuel assembly fabrication. Between 1974 and 1992, fuel pellets were shipped to other facilities to be fabricated into fuel assemblies.

2.2.2.2.1 Oxide Conversion And Pellet Production

During the commercial nuclear plant period, Building 260 continued to operate as the Oxide Building for the production of UO_2 and the dock was used for UF_6 receiving. Also during this period, Building 101 was used to store emergency equipment and Building 120 used to store both clean and contaminated equipment. Building 251 used as warehouse, shipping, receiving, and storage area, and Building 252 was used for radioactive waste storage.

Building 253 was constructed in 1988 along with Building 254 in order to upgrade the facility with automated equipment, replacing Buildings 250 and 251. Building 253 included an operational area on the first floor that encompassed the original Building 250 area. This area included processing and decontamination facilities. The second floor contained an office administrative area and building utilities such as Heating, Ventilation, Air Conditioning (HVAC) and electrical panels. Building 254 was constructed in 1989, and was used for processing Uranium powder into pellets. Building 255 was used to house the Pellet Plant and was used for pellet fabrication, storage and packaging, including Erbia pellet fabrication. Bulk storage and recycle hoppers were used to transport and store Uranium Oxide in Building 254 and Building 255.

Building 256 was originally constructed as warehouse space in 1988, with Building Area 256-1 being utilized for pellet drying. Pellet trays were loaded into pans, dried in an electric oven using Disassociated Ammonia (DA) as a cover gas, then either stored or transferred to Building 230. Building Area 256-2 was the main warehouse for shipping pellets and powder, and receiving site supplies. It replaced the original receiving area and loading dock of Building 251.

2.2.2.2.2 Recovery Operations

Scrap recovery operations involved recovering Uranium utilizing a wet recovery process. The wet recovery process included oxidation, dissolution, filtration, precipitation, centrifuge and drying the Uranium Peroxide (UO_4) product. The UO_4 product was then converted back to UO_2 and returned to the processes described above. Scrap recovery operations were conducted in Building 240, and utilized holding tanks within a diked area located outside this building.

2.2.2.2.3 Fuel Rod And Assembly Operations

In 1992, fuel rod loading and fuel assembly operations were added to the Hematite processes with the construction of Building 230. Building 230 currently houses offices and storage areas. Building 115 was also constructed in 1992 and contained a diesel-driven fire pump and a diesel-driven electric generator; the fire pump was removed from the building in 2003, and no work was performed in this building with radioactive materials. Building 231 was added southwest of Building 230, sometime between 1996 and 1998, and was used for storage of contaminated materials and equipment.

2.2.3 RESIDUAL RADIOACTIVITY

The primary contaminants expected to be encountered in residual contamination at the site include Uranium isotopes U-234, U-235, U-238, and Tc-99. During at least the 1970s, the Department of Energy (DOE) supplied UF_6 from reprocessed spent nuclear fuels to various fuel fabrication facilities. Specifically, DOE provided the Hematite facility with UF_6 that was produced from recycled Uranium (Reference 2-8). This resulted in the introduction of Tc-99, and the potential for the presence of trace quantities of U-236 and transuranics (TRU), Plutonium-238 (Pu-238), Plutonium-239/240, Americium-241 (Am-241) and Neptunium-237 (Np-237).

Th-232 has been identified at one location within the Burial Pit Area, and Ra-226 has been identified at two locations within the Burial Pit Area. Th-232 is most likely the result of a limited amount of processing that was performed for the production of Thorium fuel. Ra-226 may be attributed to the receipt and use of contaminated equipment from MCW's St. Louis facility based on an interview with a former employee.

Chapter 4 of this Decommissioning Plan provides a more detailed discussion regarding radionuclides of concern at the Hematite facility.

2.3 PREVIOUS DECOMMISSIONING ACTIVITIES

Historical decommissioning activities conducted at the Hematite Site have included specific areas where work activities or events resulted in contamination. Figure 2-5 depicts the areas where previous decommissioning activities have occurred and areas containing known or potential residual radioactivity. Chapter 4 of this Decommissioning Plan contains additional details regarding characterization of these areas.

2.3.1 BUILDING 240 AND 255 (RED ROOM, ITEM PLANT AND RELATED AREAS)

The Red Room (Building 240, Area 240-2), Item Plant (Building 255) and related areas were used for high-enriched fuel production processes from 1956 until the early 1970s. During the CE purchase of the facility in 1974, these areas were identified as contaminated and partial decontamination efforts were undertaken in both building areas. Specifically, process equipment, duct work and exhaust fans were removed, the floors were scarified, and the Red Room and Item Plant areas were vacuumed, steam cleaned and painted. In the Red Room, three inches of concrete were added to the floor. Contamination in the Red Room Roof Burial Area was discovered in 1993 (Reference 2-6), and purportedly removed to below 30 pCi/g. However, subsequent investigation has shown contamination levels above 30 pCi/g in this area (Reference 2-6).

2.3.2 EVAPORATION PONDS

The Hematite facility has two evaporation ponds that were used for the retention of process filtrates, low-level liquid wastes, and high- and low-enriched Uranium-containing materials. The ponds were originally designed to receive filtrates from the low-enriched ammonium diuranate (ADU) conversion facility. The evaporation ponds consisted of a primary pond (EP-1) and a secondary, larger overflow pond (EP-2) with a 1.5 foot berm around each pond. The ponds were originally lined with approximately 10 inches of rock (nominal diameter of 0.5 to 3 inches). The size of the primary pond was approximately 30 ft by 40 ft, and the secondary pond was 30 ft by 85 ft. Figure 2-5 shows the locations of these ponds.

While the evaporation ponds were designed and built to receive filtrates from the low-enrichment processes, they were also used for the retention of both high- and low-enrichment recovery waste liquids. Historical documentation also indicates retention of other liquid waste solutions in the evaporation ponds (Reference 2-2). Examples of these waste liquids include acidic cleanup solutions, organic solvent solutions (perchloroethylene and trichloroethylene), oils, building sump contents and mop water. Use of the evaporation ponds was discontinued in 1978 by CE. In 1979 approximately 700 ft^3 of sludge was pumped out of the primary evaporation pond and sent for offsite disposal at a licensed burial facility between 1982 and 1984 (Reference 2-10).

Additional decommissioning efforts for the evaporation ponds were undertaken by CE in 1984 in response to NRC directives (Reference 2-11 and Reference 2-12). As a result, CE removed approximately 2,800 ft^3 of sludge, rock and soil from the primary evaporation pond in 1985. Detailed sampling following the remediation effort determined the average total Uranium contamination of the soil in the pond was below the 250 pCi/g total Uranium decontamination limit set by the NRC; however, spot contamination levels in excess of the limit remained.

Approximately 1,200 ft^3 of soil and rock were also removed from the secondary evaporation pond in 1987. Subsequent soil/sediment samples collected from the evaporation ponds following these remediation efforts revealed an average concentration of Uranium in the evaporation ponds below the 250 pCi/g limit; however, individual sample results showed soil/sediment contamination levels in excess of the limit remained (Reference 2-13).

On May 4, 1995, a Decommissioning Plan for the evaporation ponds was incorporated by amendment into the site license. Following additional characterization of the evaporation ponds, this Decommissioning Plan was revised based on more extensive characterization results (Reference 2-14 and Reference 2-15). The Evaporation Pond Decommissioning Plan was implemented over the next four years and resulted in the removal of approximately 6,000 ft^3 of additional soil/sediment for disposal. Surveys and sampling of the pond area conducted in 1999 indicated an average concentration of 170 pCi/g U-235, with several samples yielding higher, up to 745 pCi/g U-235. In addition, Uranium concentrations of approximately 100 pCi/g were detected at depths of 10 ft below grade (Reference 2-16). Remediation efforts associated with the evaporation ponds were suspended in 1999 to evaluate additional remediation techniques and options.

2.3.3 SOIL UNDER BUILDING 253

During construction of Building 253 in 1988 and 1989, an area of soil contamination was identified adjacent to Building 240. Contaminated soil was removed from this area until concerns developed about undermining the remaining building foundation. Prior to soil removal, concentrations up to 680 pCi/g were found. Following soil removal from this area, residual contamination averaged 17 pCi/g with a maximum value of 82 pCi/g (Reference 2-17 and Reference 2-18). Combustion Engineering requested the NRC allow spent limestone stored on-site, to be used as fill material for this area. The NRC allowed spent limestone, meeting a 30 pCi/g limit, to be used as fill below Building 253 with the understanding that the fill may have to be removed upon facility decommissioning (Reference 2-19 and Reference 2-20).

2.3.4 SITE CREEK

In 1995 it was identified that occasional upsets in the operation of the Sanitary Wastewater Treatment Plant (SWTP) over a period of time had resulted in contamination collecting in the Site Creek sediments, (Section 2.4.1 provides a more complete discussion of the SWTP). The effluent from the SWTP enters the Site Creek at Outfall #001, directly below the dam for the Site Pond. The contamination sediment had settled between the dam and the point where the Site Creek passes beneath the railroad tracks.

Prior to remediation, sediment samples showed total Uranium concentrations within the range of 40 pCi/g to 800 pCi/g. Remediation was accomplished by diverting the Creek and then removing the sediment with a backhoe to a depth of approximately 0.5 ft to 3 ft between the site dam and the railroad tracks. The removed material was dried and shipped to an offsite licensed disposal facility. Sediment was removed until the average remaining contamination was less than 30 pCi/g, with no single sample above 90 pCi/g (Reference 2-21). Remaining residual radioactivity after remediation of the Site Creek averaged 22 pCi/g, with a maximum concentration of 85 pCi/g. Samples taken at the confluence of the Site Creek and Joachim Creek did not indicate contamination had extended to Joachim Creek (Reference 2-22).

2.3.5 BUILDING SYSTEMS, EQUIPMENT AND MATERIALS

Removal of systems, components and wastes from inside facility buildings has been performed in two phases since the facility ceased operations in 2001. The first phase involved Uranium removal for reuse or disposal, and general removal of stored waste materials; this phase was conducted from 2001 to 2003. The second phase was conducted between 2003 and 2006 and included removal of Uranium for re-use; and removal of building systems, equipment and process materials for disposal or reuse in preparation for future building demolition. Demolition of buildings and structures has not been initiated; however, building demolition has been addressed in SNM-33 License Amendment No. 52 (Reference 2-23), pending additional characterization efforts.

The first phase of system, component and waste removal, related to Uranium removal and waste reduction, took place between July 2001 and March 2003. In addition, between 2003 and 2004, activities were conducted to remove systems and equipment that created interference in some buildings, and to provide a base for the start of decontamination and decommissioning (D&D) activities. The first phase included the following activities:

- Recovery of approximately 37 tons of enriched Uranium. The recovered Uranium was shipped off-site for re-use;
- Approximately 27 tons of clean scrap metal was shipped off-site for recycling;

- Approximately 19 tons of depleted and source material was shipped off-site to a licensed facility;
- Approximately 80 tons of low level radioactive waste (LLRW) trash was processed by on-site incineration;
- Approximately 60 tons of LLRW trash was shipped off-site to a licensed disposal facility;
- Approximately 5 cubic meters of LLRW oil was processed by on-site incineration;
- Approximately 260 cubic meters of slightly contaminated equipment and debris was shipped off-site to a licensed disposal facility;
- Approximately 68 tons of solidified LLRW liquids was shipped off-site to a licensed disposal facility;
- Approximately 571 tons of LLRW solids was shipped off-site to a licensed disposal facility;
- Nuclear fuel rod loading and fuel bundle assembly equipment was removed from Building 230 and shipped off-site to licensed disposal facility; and,
- The oxide conversion scrubber systems were removed from outside of Building 260 and shipped off-site to a licensed disposal facility.

The second phase of system, component and waste removal was to reduce site interferences for continued D&D preparations, and complete the removal of additional Uranium for off-site re-use. The second phase, beginning early in 2004 and continuing to 2005, provided the following:

- Removal of the Erbia Pellet Plant;
- Removal of the Oxide Conversion systems;
- Removal of the Pellet Drying systems;
- Removal of the Uranium Pellet Plant;
- Approximately 167 kilograms of enriched Uranium was shipped off-site for re-use;

- Approximately 217 tons of contaminated scrap metal was shipped off-site for recycling;
- Approximately 66 tons of clean scrap metal was shipped off-site for recycling;
- Approximately 703 tons of contaminated equipment was shipped off-site to a licensed disposal facility;
- Approximately 578 tons of contaminated soil was shipped off-site to a licensed disposal facility;
- Approximately 15 tons of miscellaneous clean scrap was shipped off-site for disposal;
- Approximately 12 tons of hazardous waste was shipped off-site to a licensed disposal facility; and
- Removal of the ammonia tanks from the area South of the Process Building. The ammonia tanks were shipped off-site for disposal.

2.3.6 FORMER DEUL'S MOUNTAIN (EXCAVATION MATERIAL FROM BUILDING 256)

During construction of a truck bay for Building 256 (1989), a large area of contaminated soil was excavated and stored along the southeast corner of the Central Tract (see Figure 2-5). This soil pile became known as "Deul's Mountain," using the last name of the employee who planned the construction and soil removal. The volume of the soil pile was approximately 1,100 cubic yards, and included building debris (cement and asphalt) in addition to native soils.

The soil and debris in the pile were removed (Loading/packaging work package - No. LVI-EWP-009-04-003) to original grade level and shipped for off-site disposal at a licensed facility (Reference 2-9). A characterization study for this area concluded that U-234, U-235 and U-238 were the only radiological isotopes of concern in this area. Uranium concentrations in the excavated soil ranged from 0.3 pCi/g to 22.8 pCi/g U-235, and from 1.4 pCi/g to 33.5 pCi/g U-238 (Reference 2-24).

2.4 SPILLS

Spills are defined in NUREG-1757 as "any uncontrolled release of radioactive materials at the site that have resulted in radioactive material being present in the site environs or any unusual occurrences involving the spread of contamination in and around the facility, equipment, or site" (Reference 2-1). Historical documents contain descriptions of small fires, releases, spills and leaks during the operating history of the facility. Generally these events were minor in nature, contained within buildings, and did not directly impact site environs. Events or practices that have resulted or potentially resulted in the release or spills of radioactive material are described in the following sections.

2.4.1 SANITARY WASTEWATER TREATMENT PLANT

The original facility SWTP was designed such that drains inside buildings were directed to a buried holding (septic) tank connected to a leach field. Figure 2-5 shows the location of the former system. Liquid wastes from personnel showers, mop water and small spills in process areas were directed to various floor drains leading to the septic tank and leach field of the former system. Between 1977 and 1978, the SWTP septic tank and leach field were bypassed and abandoned in place. The modified SWTP was connected to new wastewater treatment equipment located just northwest of the evaporation ponds. This modified SWTP is still in use and discharges to the Site Creek at Outfall #001 as shown on Figure 2-6.

Degradation of the existing buried SWTP discharge pipe was identified in 2007 when it was discovered that no flow existed at the effluent sampling point (Outfall #001). Degradation of the effluent pipe had progressed to the point that the majority of the liquid effluent entering this line did not reach the discharge point at the Site Creek. Evidence of subsurface contamination indicates that liquids from the degraded pipe leaked through cracks or breaks in the pipe, resulting in effluent migrating into the surrounding soils. Since the effluent of the SWTP may contain residual radioactivity (within approved regulatory release limits), it is expected that accumulation over time may require remediation of the soils in this area during decommissioning of this system and associated effluent piping.

2.4.2 BUILDING DRAINS, STORM DRAINS AND OUTFALLS

The Process drains for site buildings still remain in place and will be removed during decommissioning. However, due to incomplete ground piping information during the early periods of operation, it is possible that building drains and storm water drains are interconnected at unknown points below grade. This possibility in conjunction with known historical events (e.g., spills and leaks) results in the potential for residual radioactivity to have entered and potentially leaked to soil surrounding these buried piping systems. Thus, areas containing building floor drains or storm water piping are conservatively considered to be impacted by site operations.

Based on interviews with former site employees and remaining physical evidence (e.g., abandoned manhole covers and photographs), it appears that there was a former storm drain extending from the process building area to the Site Pond. The portion of the storm drain piping from the Building 230 area to the Site Pond was removed prior to the construction of Building 230; some of which was shipped offsite for disposal as low-level radioactive waste. A replacement storm drain was installed adjacent to Building 230. Records of radiological surveys or disposition of the soil surrounding this former storm drain were not located; therefore, the subsurface soil along the estimated former path of the drain piping is considered to be potentially impacted by site operations.

2.4.3 OTHER SPILLS

Spills inside process buildings may have entered floor drains and connected building sumps; however, small liquid spills did also occur outside of the facility structures. In 1984, an unknown quantity of acid insolubles from the wet recovery system was spilled onto the ground outside of Building 240. A description of this event stated that the residues were vacuumed off the ground and transferred to an empty drum. Barrels of spill material were staged behind (south of) Building 240 (Reference 2-25). Additionally, prior to construction of Building 253, the wet Uranium recovery process was conducted outside in the area where Building 253 was eventually constructed.

Occasional spills from the process buildings were absorbed into the soil below through joints in the concrete slab (Reference 2-26). In addition, an off-site low level radioactive liquid spill may have occurred around 1962. The incident has been mentioned during some interviews with past employees and was identified as the Blue Goose spill. The spill is thought to have occurred as a result of a truck hauling low level contaminated filtrate to an offsite facility, overturning at a road curve and spilling filtrate offsite. According to the interviews, the filtrate liquid would have been authorized for release only if the liquid met the effluent release standards in existence at the time. Research of early site records has not provided any additional information on this incident.

Several events in the past few years identified surface contamination of items and equipment located outside of the site restricted areas and to soil residual activity identified outside of the site restricted area. Evaluations of these events have indicated that the contamination and activity posed no significant risk to the health and safety of the workers or members of the general public.

2.4.4 FIRES

Two small Burial Pit fires occurred in 1966 (Reference 2-2). Documentation of these events indicated that these fires may have been caused by either spontaneous combustion, ignition by chemical means, or ignition of pyrophoric materials. Waste materials that were present in these pits included Uranium metal flakes, glass wool, process area trash and sample bottles. While documentation of these fires did not indicate any significant release of radioactive material, they do provide insight into the types of materials and hazards that may be present in the Burial Pits (see the next section for information on the Burial Pits).

2.5 PRIOR ON-SITE BURIALS

The practice of burying waste materials occurred during the early years of Hematite operations. Figure 2-5 shows the locations of the on-site Burial Pit Area which is described in the following sections.

2.5.1 DOCUMENTED BURIAL PITS

On-site burial was used as a disposal method for contaminated materials and wastes at Hematite from 1965 until 1970 in accordance with reference requirements and specific license authorizations. The detailed logbooks of waste burial described below document that the Burial Pit Area contains 40 unlined pits east of the buildings as shown on Figure 2-5. These Burial Pits were used to dispose of waste materials generated by the fuel fabrication processes. These on-site burials were created under the governance of AEC regulations contained in 10 CFR 20.304 (1964, Reference 2-27). These regulations described the spacing of the pits, the thickness of the cover and the quantity of radioactive material that could be buried in each pit (Reference 2-28). The nominal dimensions of each Burial Pit are 20 ft wide by 40 ft long by 12 ft deep and the regulations provided that these were supposed to include an approximate cover depth of 4 ft.

United Nuclear Corporation (and later Gulf United Nuclear Corporation) maintained detailed logs of waste burials occurring between July 1965 and November 1970. Each entry contains a date, 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 that particular pit. The weight of the contaminated item measured or estimated was determined to the nominal value of 1 gram which likely resulted in an over-estimate of the actual amount. Some entries also list percent enrichment for the Uranium. The Burial Pit logs show a wide variety of wastes being buried in the pits; the majority of the listed waste is non-SNM waste, such as, contaminated trash, drums, pails, bottles, rags, etc. Additional waste materials that are listed include Uranium process metals of various enrichments, metal wastes, liquid and solid chemical wastes, and HEPA filters (Reference 2-29).

On-site burial of radioactive waste materials was terminated in November 1970 as a result of an AEC violation issued to the Hematite facility for failure to adhere to revised AEC regulations concerning the quantity of material which could be buried onsite. AEC Inspection Wrap-up Meeting memo (Reference 2-30), states that a revision of 10 CFR 20 was enacted in June of 1970 that reduced burial limits for enriched Uranium. The licensee at the time had continued burial based upon the limits prior to June of 1970, resulting in the above AEC violation. It should be noted that the Burial Pit logbook records, employee interviews, and the operational Uranium recovery process used during this time period, consistently show efforts to maximize recovery and utilization of Uranium material whenever possible. Based on these records, WEC believes that there is little likelihood the Burial Pits contain significant quantities of recoverable SNM.

2.5.2 UNDOCUMENTED BURIALS

Interviews with former employees indicate that on-site burials (in addition to the burial practices under 10 CFR 20.304 [1964]) 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 relative to the current radiological free release standards of that period (Reference 2-31). Accordingly it is estimated that 20-25 burials may exist for which there are 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 (Reference 2-32). No information has been located to indicate the specific nature of the waste material buried in these undocumented pits. Additionally, no evidence has been found to indicate that burial of known Uranium-bearing materials (i.e., above free release criteria) occurred during this time period. These burials are believed to be in the area between the documented Burial Pits and the site buildings, under roadways in the eastern portion of the Central Tract area (see Figure 2-5).

2.5.3 SPENT LIMESTONE

In 1967, five dry scrubber columns were installed in Building 260 (Oxide Building) for removal of hydrogen fluoride from the off-gas associated with the conversion of UF_6 to UO_2. These dry scrubber columns used limestone rock chips as the off-gas scrubber media. The limestone media was periodically replaced; and, the waste limestone was stored outside Building 260, and also utilized as onsite fill material. The areas where "spent" limestone was known to be placed are shown in Figure 2-5. Discussions with site personnel indicates that initially some of the spent limestone may have been placed in a more easterly direction, towards the Northeast Site Creek, than presently shown in Figure 2-5. In addition, spent limestone that met a release criterion of 30 pCi/g was utilized as fill under the floor slab during construction of Building 253, as discussed above (Reference 2-19, Reference 2-20 and Reference 2-33).

During Hematite operations, the limestone scrubber media became contaminated with Tc-99 (Reference 2-34). The only identified source of the Tc-99 is as a contaminant of the DOE-supplied UF_6 originating from reprocessed/recycled spent nuclear fuels (see Section 2.2.3).

2.5.4 RED ROOM ROOF BURIAL AND CISTERN BURN PIT AREA

Sections of the Building 240 roof were buried in an area south of the Tile Barn (Building 101). The Red Room area of Building 240 was used for UF_6 conversion of highly-enriched Uranium. Soil contamination was discovered in 1993 during renovations to the Tile Barn (See Chapter 4 for soil contamination data). The Cistern Burn Pit Area, southwest of Building 101 (Tile Barn) and adjacent to the Red Room Roof Burial Area, was used to burn wood pallets that may have been contaminated. This general area was also known to have been used for temporary storage of scrap materials (Reference 2-2). The Red Room Roof Burial Area and the Cistern Burn Pit Area are shown in Figure 2-5.

2.6 REFERENCES FOR CHAPTER 2.0

2-1 U.S. Nuclear Regulatory Commission, NUREG-1757, "Consolidated Decommissioning Guidance, Decommissioning Process for Materials Licensees," Volume 1, Revision 2.

2-2 Westinghouse Electric Company Document No. DO-08-005, "Historical Site Assessment."

2-3 U.S. Nuclear Regulatory Commission, License No. SNM-33 (Docket No. 70-36).

2-4 Code of Federal Regulations, Title 10, Part 70, "Domestic Licensing of Special Nuclear Material."

2-5 Code of Federal Regulations, Title 10, Part 20, Subpart E, "Standards for Protection Against Radiation–Radiological Criteria for License Termination."

2-6 Science Applications International Corporation (SAIC) Document No. EO-05-002, "Remedial Investigation Report for the Westinghouse Hematite Site," Revision 1, Volume 1, January 2007.

2-7 U.S. Nuclear Regulatory Commission, Letter to Combustion Engineering, "License No. SNM-33 Amendment No. 15," November 18, 1996.

2-8 U.S. Department of Energy, Project Overview and Field Site Report, "A Preliminary Review of the Flow and Characteristics of Recycled Uranium throughout the DOE Complex 1951-1999," March 2001.

2-9 Westinghouse Electric Company, Letter to U.S. Nuclear Regulatory Commission, A. J. Nardi to G. M. McCann, "Description of Duel's Mountain Removal Activities to Support Interference Removal Activities, License Number SNM-33, Docket No. 070-036," June 24, 2003.

2-10 Combustion Engineering, Letter to U.S. Nuclear Regulatory Commission, "Proposed Decommissioning Plan for Evaporation Ponds," May 31, 1984.

2-11 U.S. Nuclear Regulatory Commission, Letter to Combustion Engineering, "Approval of SNM-33, Amendment No. 1," March 8, 1984.

2-12 U.S. Nuclear Regulatory Commission, Letter to Combustion Engineering, R. Page to H.E. Eskridge, "Amendment No. 3 and Safety Evaluation," October 3, 1984.

2-13 Combustion Engineering, Letter to U.S. Nuclear Regulatory Commission, "Status Report to Furnish Additional Data for the Hematite Evaporation Pond Decommissioning and The Spent Limestone Monitoring Projects," May 20, 1988.

2-14 Gateway Environmental Associates, Letter to R.W. Sharkey, "Exploratory Probehole Investigation for the Evaporation Ponds at the ABB Combustion Engineering Hematite Facility," April, 17, 1997.

2-15 Combustion Engineering, Letter to U.S. Nuclear Regulatory Commission, "Evaporation Pond Characterization," October 22, 1997.

2-16 U.S. Nuclear Regulatory Commission, Safety Evaluation Report, "Hematite License Amendment Application Dated May 30, 1997," January 26, 1998.

2-17 ASEA Brown Boveri/Combustion Engineering, Letter to U.S. Nuclear Regulatory Commission, J.A. Rode to D.J. Sreniawski, "Building 253 Construction Site Soil," May 14, 1990.

2-18 U.S. Nuclear Regulatory Commission, Memorandum, D.J. Sreniawski to G. Bidinger, "ABB-Combustion Engineering/Hematite Facility Request," May 31, 1990.

2-19 Combustion Engineering, Letter to U.S. Nuclear Regulatory Commission, "Spent Limestone Results," April 7, 1989.

2-20 U.S. Nuclear Regulatory Commission, Letter to ASEA Brown Boveri/ Combustion Engineering, C. J. Haughney to J. A. Rode, "Authorizes Backfill of Area of Bldg 253 Construction Site," July 2, 1990.

2-21 Combustion Engineering, Memorandum, "Remediation of Site Creek," January 22, 1996.

2-22 U.S. Nuclear Regulatory Commission, Letter to ASEA Brown Boveri/ Combustion Engineering, "Routine Safety Inspection - ABB Combustion Engineering, Hematite, MO, Inspection Report No. 70-00036/96001 (DNMS)," February 16, 1996.

2-23 U.S. Nuclear Regulatory Commission, Letter to Westinghouse Electric Company, A. Persinki to E. K. Hackmann, "Amendment No. 52 to Materials License No. SNM-00033 Authorizing Building Demolition at the Hematite Facility into the License," June 30, 2006.

2-24 U.S. Ecology, "Hematite Characterization Report for Deul's Mountain," November 21, 2002.

2-25 Combustion Engineering, Interoffice Correspondence, L. F. Deul to H. E. Eskridge, "Acid Insoluble Spill," September 1, 1988.

2-26 Combustion Engineering, Memorandum, D.R. Rohde, "Decontamination of Subsoil Beneath New Storage, Support & Office Building 253," August 24, 1989.

2-27 Code of Federal Regulations, Title 10, Part 20.304, "Disposal by Burial in Soil," 1964.

2-28 United Nuclear Corporation, Memorandum, F. G. Stengel to E. F. Sanders, "Burial of Material," May 14, 1965.

2-29 Hematite Burial Pit Log Books, Volumes 1 and 2, July 16, 1965 through November 6, 1970.

2-30 Gulf United Nuclear Fuels Corporation, Nuclear And Industrial Safety, Commercial Products Division, Memorandum NIS:DGD-70-332, Peter Loysen, "AEC Inspection Wrap-Up Meeting, November 5, 1970."

2-31 Westinghouse Electric Company, "Hematite Employee Interview Records, 2000 to 2008".

2-32 Combustion Engineering, Interoffice Correspondence, J. Rode to Bill Sharkey, "The Hematite Burial Grounds," March 5, 1996.

2-33 U.S. Nuclear Regulatory Commission, Safety Evaluation Report, "Authorization to Use Building 253, SNM-33 Amendment No. 18," January 29, 1991.

2-34 U.S. Nuclear Regulatory Commission, Memorandum, G. H. Bidinger to W. T. Crow, "Tc-99 at CE-Hematite."

Table 2-1

Current Building Use And Condition (As Of July 2009)

Building Number/Name	Description Of Current Use and Condition
Building 101 Tile Barn	Currently not used, posted as a radioactive material area, partially decontaminated, access restricted by lock
Building 110 Office and Security	Used for security access control and as an administrative office area for site decommissioning personnel and security personnel, unrestricted area, mostly uncontaminated
Building 115 Fire Pump House	Currently not used, an unrestricted area access to building within an area posted for radioactive material, access through the Controlled Access Area (CAA), fire pump removed, building empty, mostly uncontaminated
Building 120 Wood Barn	Currently not used, posted as a radioactive material area, partially decontaminated, access restricted by lock
Building 230 Rod Loading	Building used for decommissioning personnel, offices for administrative, engineering, health physics, document control, and others, in Controlled Access Area, mostly decontaminated
Building 231 Warehouse	Used for storage of facility equipment and supplies, in Controlled Access Area, mostly decontaminated
Building 235 West Storage Area	Used for storage of some contaminated equipment and occasionally as source storage, located within a radioactive material area and CAA, some fixed contamination on floor
Building 240 Process Building	Currently unused, some areas within posted as contamination areas, process equipment removed, a penetrating and lockdown encapsulant applied throughout, located within a radioactive material area and CAA, access restricted
Building 245 Well House	Building housed the site well, no longer in use and abandoned in accordance with state regulations, within CAA
Building 252 South Storage Area	Currently unused, posted as a contaminated area, a penetrating and lockdown encapsulant applied throughout, located within a radioactive material area and CAA, access restricted

Table 2-1 (continued) **Page 2 of 2**

Current Building Use And Condition (As Of July 2009)

Building Number/Name	Description Of Current Status
Building 253 Process Building	Currently unused, some areas within posted as contamination areas, process equipment removed, a penetrating and lockdown encapsulant applied throughout, located within a radioactive material area and CAA
Building 254 Process Building	Currently unused, some areas within posted as contamination areas, process equipment removed, a penetrating and lockdown encapsulant applied throughout, located within a radioactive material area and CAA
Building 255 Pellet Plant	Currently unused, some areas within posted as contamination areas, process equipment removed, a penetrating and lockdown encapsulant applied throughout, located within a radioactive material area and CAA
Building 256 Process Warehouse	Currently unused, areas within are posted as contamination areas, process equipment removed, a penetrating and lockdown encapsulant applied throughout, located within a radioactive material area and CAA
Building 260 Oxide Building	Currently unused, areas within are posted as contamination areas, process equipment removed, a penetrating and lockdown encapsulant applied throughout, located within a radioactive material area and CAA
Sanitary Wastewater Treatment Shed	Currently used Sanitary Wastewater Treatment Plant equipment for onsite treatment of site sanitary wastewater, within CAA.

Table 2-2

Byproduct, Source And/Or Special Nuclear Material Possession Limits - License SNM-33

Item	Material	Chemical And/Or Physical Form	Maximum Amount that Licensee May Possess at Any One Time
A	Uranium enriched to maximum of 5.0 weight percent in the U-235 isotope	Any (excluding metal powders)	1,250 kilograms U-235
B	Uranium, enriched to any enrichment in the U-235 isotope	Any (excluding metal powders)	350 grams U-235
C	Uranium (natural or depleted)	Any (excluding metal powders)	2,000 kilograms
D	Cobalt 60	Sealed sources	40 millicuries total
E	Cesium 137	Sealed sources	500 millicuries total
F	Byproduct material, including americium 241	Any	400 microcuries total
G	Special, Source and Byproduct Material	Any (residual contamination)	Existing at the Hematite Site on July 1, 2001
H	Californium 252	Sealed sources	23.77 micrograms

Table 2-3

List Of Amendments To License No. SNM-33
Since July 28, 1994 Renewal

Amendment Number	Description	Date Issued
1	Schedule of the Standby Trust Agreement	12/08/94
2	Organization changes	03/14/95
3	Delay in starting 1995 physical inventory	03/29/95
4	Evaporation pond decommissioning	05/04/95
5	Increase in possession limit	05/11/95
6	Revision to Fundamental Nuclear Material Control (FNMC) Plan	05/17/95
7	Delay in completion of biennial MC&A assessment	05/18/95
8	Temporary change of UF6 sampling procedure	08/23/95
9	Request for delay in conducting emergency exercise	11/27/95
10	Branch Technical Positions	12/20/95
11	Request for R-3 oxide conversion reactor change	01/31/96
12	Temporary change to UF6 receipt sampling procedure	04/15/96
13	Request for validation of criticality calculation method	06/21/96

Table 2-3 (continued)

List Of Amendments To License No. SNM-33
Since July 28, 1994 Renewal

Amendment Number	Description	Date Issued
14	Transitional Facility Attachment	07/18/96
15	Increase possession limit	11/18/96
16	Temporary change to UF6 receipt sampling procedure	02/06/97
17	Organizational changes	08/13/97
18	Request to update decommissioning plan for Hematite evaporation ponds	01/26/98
19	Revisions to the FNMC Plan	02/12/98
20	Authorize release of hydrofluoric acid	02/26/98
21	Changes in Chapter 4, "Nuclear Criticality Safety," of the license application	07/23/98
22	Extension to certain commitments in the FNMC Plan	01/27/99
23	Revision to Hematite Emergency Plan	03/18/99
24	Change of mailing addresses for corporate offices and facility	04/09/99
25	Revisions to the FNMC Plan	05/99
26	Time extension to report the results of the April 1999 physical inventory	06/02/99

Table 2-3 (continued)

List Of Amendments To License No. SNM-33
Since July 28, 1994 Renewal

Amendment Number	Description	Date Issued
27	Transfer and amend materials licenses, QA program approval, and COCs	06/23/99
28	Licensee name change	08/19/99
29	Temporary change to UF6 receipt sampling procedure	10/19/99
30	Revision to Physical Security Plan	12/02/99
31	Credit for neutron absorbers contained in fuel pellets	12/17/99
32	Temporary change to UF6 receipt sampling procedure	02/03/00
33	Licensee name change	03/13/00
34	Licensee name change	07/13/00
35	Delete certain license and license application commitments	08/31/00
36	Request for extension to certain commitments in the FNMC Plan	01/05/01
37	Licensee name change	04/10/01

Table 2-3 (continued)

**List Of Amendments To License No. SNM-33
Since July 28, 1994 Renewal**

Amendment Number	Description	Date Issued
38	Request for time extension to conduct SNM physical inventory	05/07/01
39	Plan for completion of CSPU analyses and DP for Hematite Facility	05/30/01
40	Organizational changes, name changes	10/15/01
41	Authorize exemption to fissile materials classification and package standards in transport	04/15/02
42	Change possession limits and change authorized activities to decommissioning activities	04/11/02
43	Deletion of Emergency Plan and two license conditions, change possession limits and authorized activities, approve new Site Manager, and designate a RSO	10/22/02
44	Change of Site Manager	01/28/04
45	Update Physical Security Plan and incorporate commitments	04/14/04
46	Alternate schedule request for Decommissioning Plan submittals	08/25/04
47	Chapter 2 license amendment	09/07/04
48	Revision to the FNMC Plan	11/24/04

Table 2-3 (continued)

List Of Amendments To License No. SNM-33
Since July 28, 1994 Renewal

Amendment Number	Description	Date Issued
49	Amendment to Section 3.2 of Chapter 3	01/03/05
50	SNM-33 License Renewal, continue license beyond the expiration date, Chapter 2, Revision 1, amend license to replace by name the RSO, and organizational changes	03/24/06
51	Revisions to the FNMC Plan	03/23/06
52	Approval of building dismantlement and demolition	06/30/06
53	Postponement of physical inventory	03/27/09

Table 2-4

Summary Of Building Historical Use

Building	Description Of Historical Use And Modifications
Building 101 (Tile Barn)	This building existed on the property prior to purchase by Mallinckrodt. The former dairy barn was designated as a temporary storage facility. It was used to store both clean and radiologically-contaminated equipment. This building was also used to store emergency equipment during the commercial nuclear phase of operations.
Building 110 Office / Security	Office Building 110 was constructed in 1972. It was and still is used for administrative functions and as a security point ingress/egress for the site.
Building 115	Building 115 was constructed in 1992 and contained a diesel driven fire pump and a diesel driven electric generator. The diesel fire pump was removed from the building in 2003. No work with radioactive materials was ever performed in this building.
Building 120 (Wood Barn)	This building existed on the property prior to purchase by Mallinckrodt. It was used to store both clean and contaminated equipment throughout the facility's operating period.
Building 230	Building 230 was constructed in 1992 and housed the fuel assembly fabrication equipment. This Building currently houses offices and material storage areas.
Building 231	Building 231 was added southwest of Building 230 sometime between 1996 and 1998. It was used for storage of contaminated materials and equipment.
Building 235 (West Storage Area)	Original building constructed in 1956. Housed the west storage area and utilized as the outgoing storage building. It was used to store final Uranium products. During the commercial nuclear era this building stored source material.

Table 2-4 (continued)

Summary Of Building Historical Use

Building	Description Of Historical Use And Modifications
Building 240	Building 240 was originally constructed with three separate rooms or areas. Within the building, Area 240-1 housed a lunchroom, offices, locker rooms, and laundry. Area 240-2 (the Red Room) was used for high-enriched conversion processes (≥20 percent U-235). The Red Room housed a general products line primarily used with high-fired UO_2 for fuel elements. It also housed a process line for the manufacture of Uranium metal, specifically the reduction of UF_6 to UF_4 and conversion of UF_4 to Uranium metal. Area 240-3 (the Green Room) contained equipment necessary for producing low-enriched materials, up to 5 percent enrichment. The main product was a ceramic-grade UO_2. The equipment in this area, like that in the Red Room, was also housed in special hoods for dust control and consisted of standard chemical plant equipment, e.g., tanks, pumps, filter processes, resistance dryers, resistance furnace, etc. An addition to Building 240 was constructed in 1958-1959 on the south end of the building and is known as Area 240-4 (the Blue Room). This area was further divided into three sections: one section contained equipment for solvent extraction of low-enrichment Uranium from scrap; another section was used for manufacturing middle-enrichment (5-20 percent) Uranium compounds; the third section contained the research and development activities and a pilot plant for pressing and firing ceramic pellets of UO_2. During the commercial nuclear era Building 240 was utilized as follows: Area 240-1 - offices and cafeteria; Area 240-2 - recycle and recovery area; Area 240-3 - incinerator and storage; and Area 240-4 - laboratory and maintenance shop. Area 240-2 (Red Room) roof was replaced in late 1984 to 1985. The removed roofing materials were buried onsite near Building 101.

Table 2-4 (continued)

Summary Of Building Historical Use

Building	Description Of Historical Use And Modifications
Building 250	Original building constructed in 1956 and housed a boiler, cooling tower pumps, a recycle hopper, a blending area, and a storage area. During the commercial nuclear era this building was utilized for the boiler room and warehouse, steam supply, and storage.
Building 251	Building was constructed in 1957-1958 and included a shipping/receiving dock. During the commercial nuclear era this building was used as warehouse, shipping and receiving, and storage area(s).
Building 252 (South Storage Area)	Constructed in 1960 in response to an increased need for storage. It was to be used for storing process materials as well as final product storage. During the commercial nuclear era this building was used for radioactive waste storage.
Building 253	Building 253 was constructed in 1988 along with Building 254 in order to upgrade the facility with automated equipment replacing Buildings 250 and 251. Building 253 included an operational area on the first floor that encompassed the original Building 250 area. This area included processing and decontamination facilities. The second floor contained an office administrative area and building utilities such as Heating, Ventilation, and Air Conditioning (HVAC) and electrical panels.
Building 254	Building 254 was constructed in 1989 following Building 253 in order to upgrade the facility with automated equipment replacing Building 251. Uranium powder was processed into pellets in Building 254.

Table 2-4 (continued)

Summary Of Building Historical Use

Building	Description Of Historical Use And Modifications
Building 255	Building was constructed in 1958-1959 with three separate areas housing the UO_2 pellet production facility. The majority of research and development activities occurred there. Area 255-1 (Item Plant) contained research and development offices and storage. Area 255-2 housed the low-enrichment UO_2 Pellet Plant (or Ceramic Plant). Area 255-3 contained a maintenance shop; general materials supply storage, depleted materials storage, and a laundry. During the commercial nuclear era this building housed the pellet plant used for pellet fabrication, storage, and packaging, including Erbia pellet fabrication.
Building 256	This structure was originally constructed as warehouse space in 1988. Building Area 256-1 was also utilized for pellet drying. Pellet trays were loaded into pans, dried in an electric oven using Disassociated Ammonia (DA) as a cover gas, then either stored or transferred to Building 230. Building Area 256-2 was the main site warehouse for shipping pellets and powder and for receiving site supplies. It replaced the original receiving area and loading dock of Building 251.
Building 260 (Oxide Building)	In 1967 and 1968, increased automation led to the addition of Building 260, the Oxide Building. Building 260 housed the chemical reactors and process equipment used for converting UF_6 to UO_2 granules. During the commercial nuclear era this building was the Oxide Building and dock used for UF_6 to UO_2 conversion and UF_6 receiving.

Figure 2-1

Hematite Site / Property Boundary

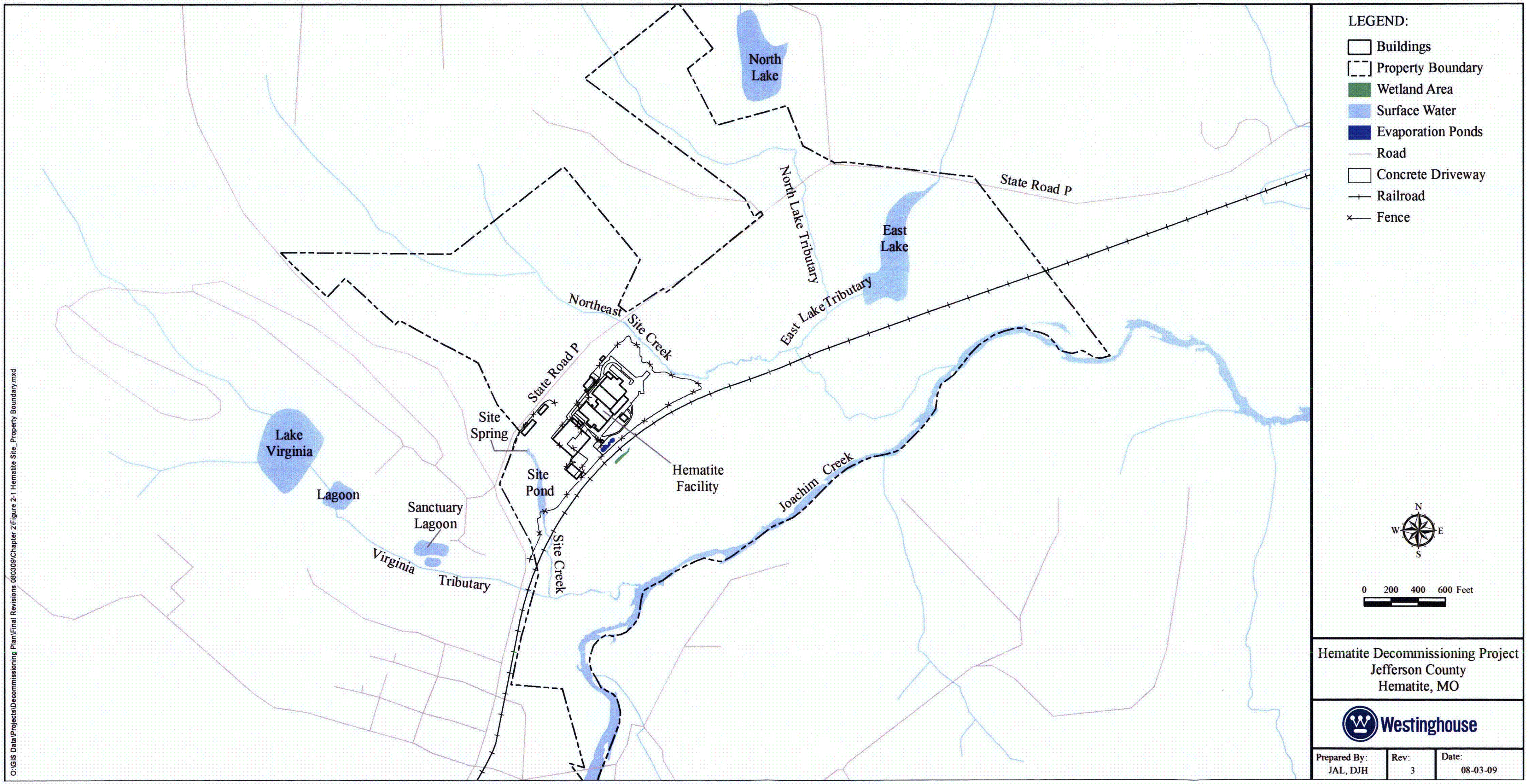


Figure 2-2

Hematite Central Tract

Figure 2-3

Hematite Site Layout 1956 – 1974

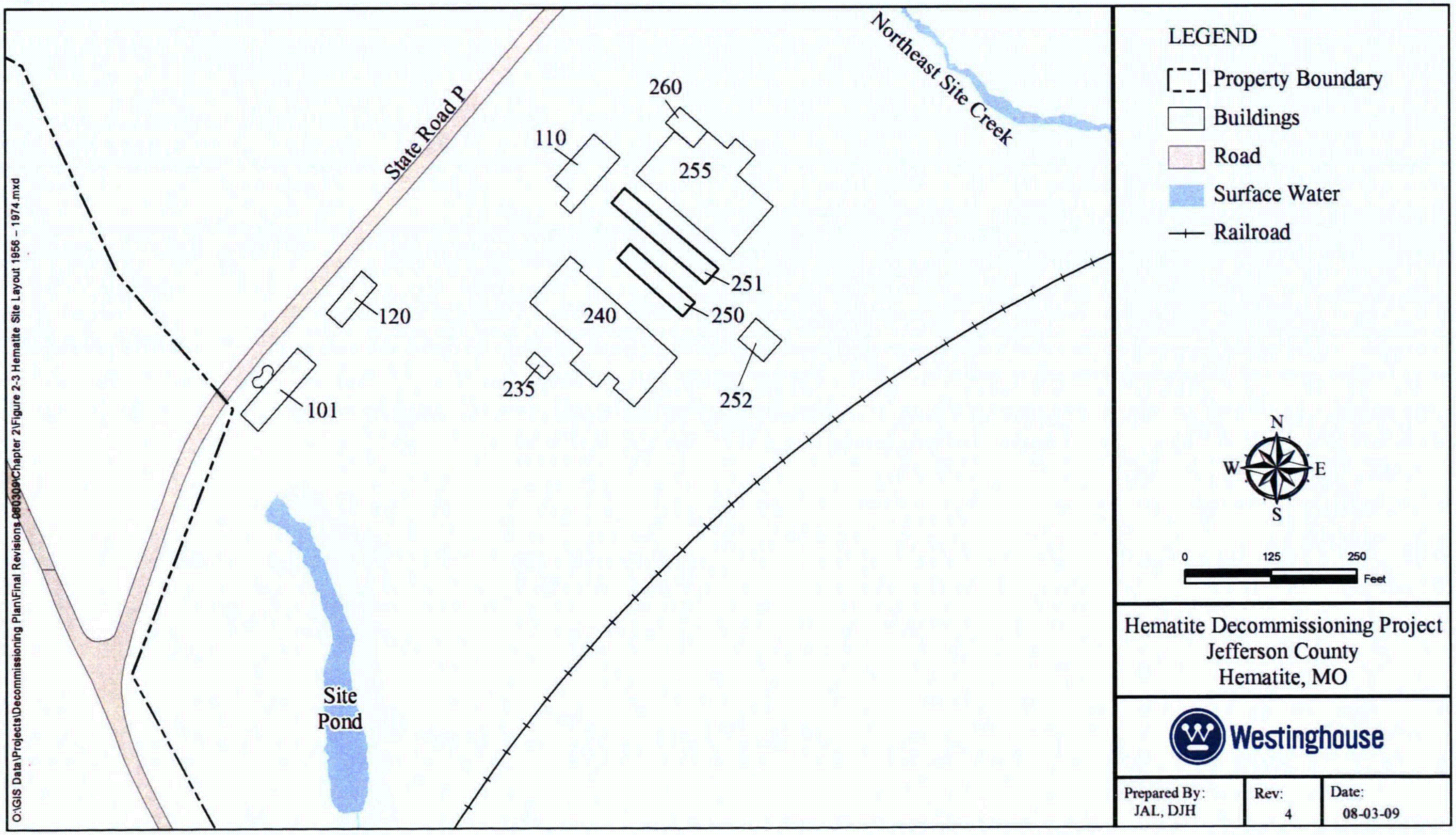


Figure 2-4

Hematite Site Layout 1974 – 2001

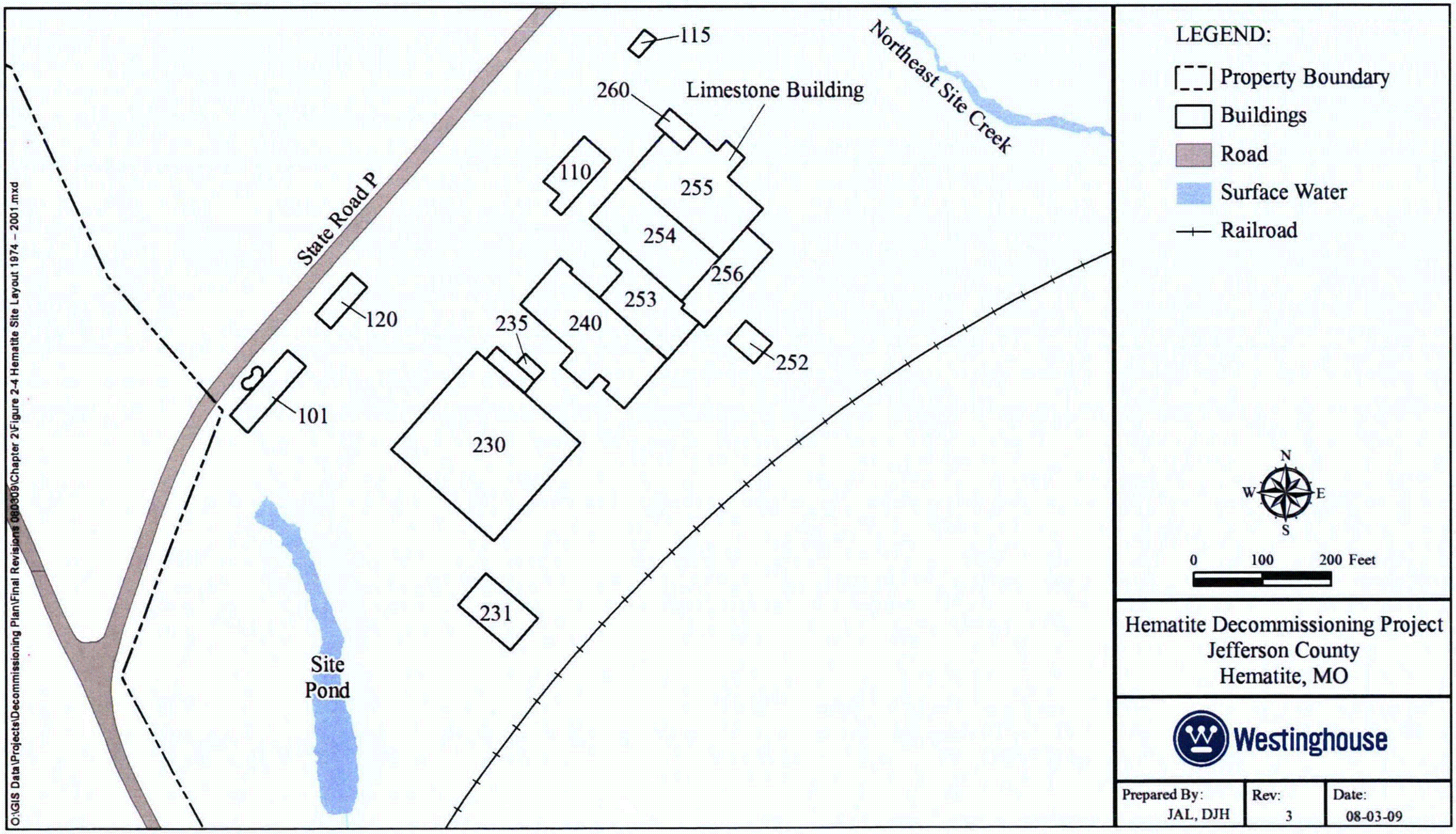


Figure 2-5

Hematite Historical Remediation Areas And Areas Of Concern

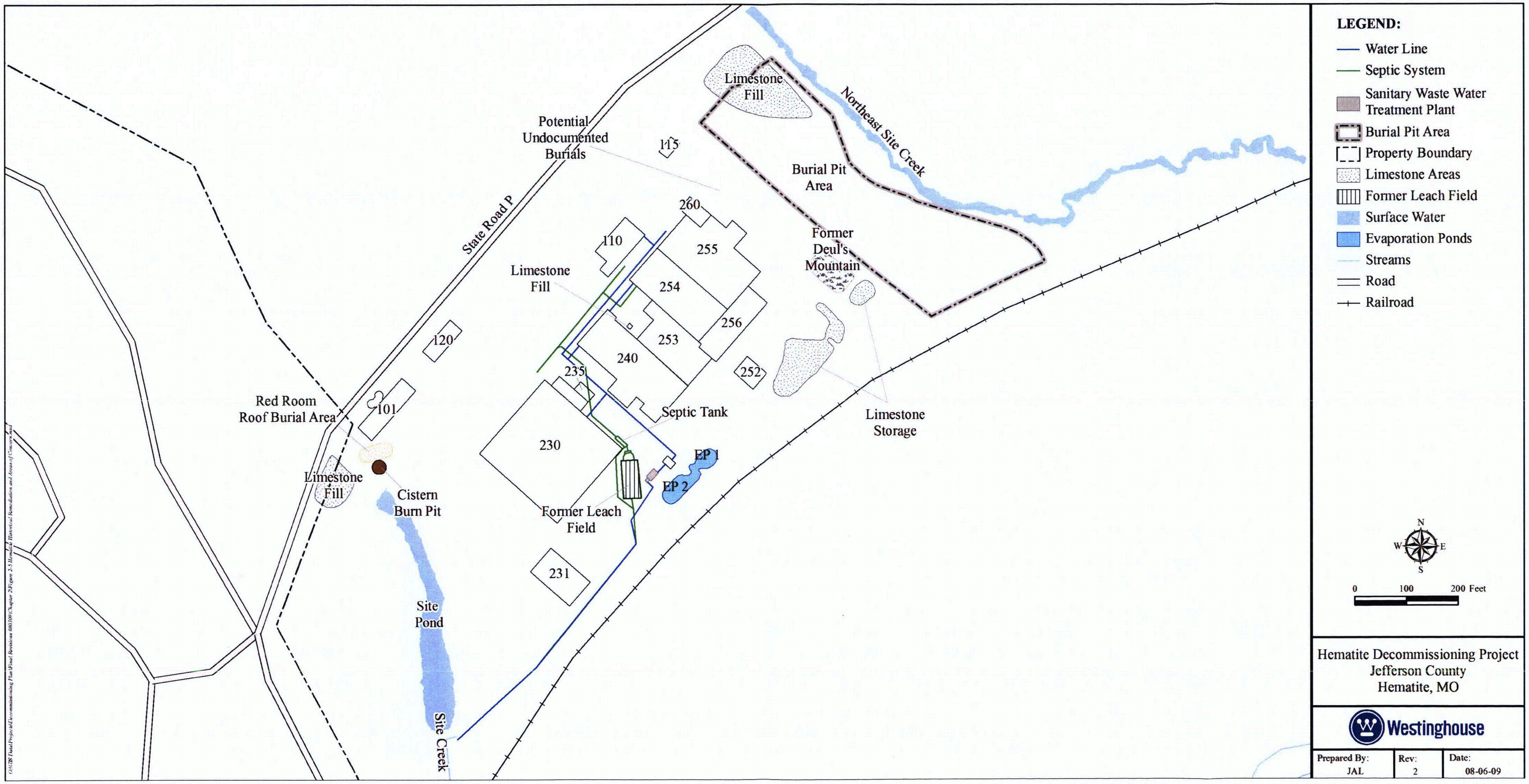


Figure 2-6

Hematite Storm Drains And Outfall Piping

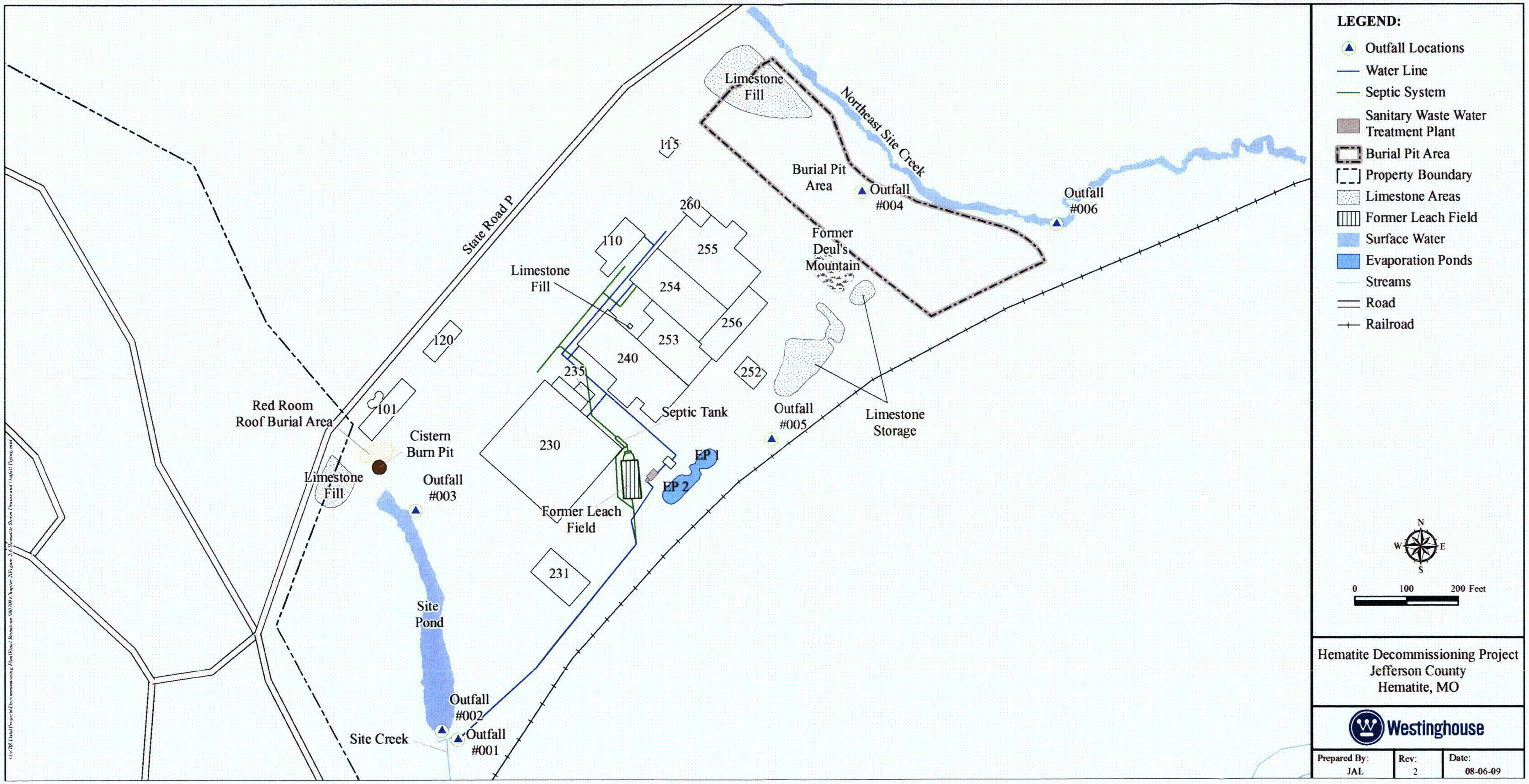


TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES
(Continued)

ACRONYMS AND ABBREVIATIONS

AMSL	above mean sea level
AOC	Area of Concern
AQCR	Air Quality Control Regions
bgs	below ground surface
DP	Decommissioning Plan
DPT	direct-push technology
DSCC	deeper silty clay/clay
EPA	U.S. Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FS	Feasibility Study
gpd	gallons per day
gpm	gallons per minute
HSUs	hydrostratigraphic units
JC	Jefferson City
K_h	Hydraulic Conductivity
LBG	Leggette, Brashears and Graham, Inc.
MDNR	Missouri Department of Natural Resources
MMS	Modified Mercalli Scale
NAAQS	National Ambient Air Quality Standards
NPDES	National Pollutant Discharge Elimination System
NSSSC	near surface silt/silty clay
PVC	polyvinyl chloride
PWSD	Public Water Supply District
RB	Roubidoux
RI	Remedial Investigation
USDA	U.S. Department of Agriculture
USGS	U. S. Geological Survey
WIMS	Well Information Management System

3.0 SITE DESCRIPTION

3.1 SITE LOCATION AND DESCRIPTION

The 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 3-1. The area within a 5-mile radius of the site is presented in Figure 3-2.

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. Activities with special nuclear materials (SNM) were conducted within an approximately 10-acre Central Tract adjacent to the site access road, State Road P. The Central Tract is developed with buildings, infrastructure, and maintained landscaping. The remaining property is woods and farmland, with no documented evidence of historic operations by Westinghouse or previous owners. The current site boundaries and the Central Tract are depicted in Figure 3-3, and a site map with building locations and other infrastructure features is included as Figure 3-4.

Three private residences are located on the site property. The nearest on-site residence is located approximately 0.4 mi. northeast of the Hematite Facility on the south side of State Route P. This residence is currently occupied. The two other residences are located adjacent to each other on the same piece of property, approximately 0.5 mi. from the site on the north side of State Route P. Only one of these two residences is currently occupied. The residences are leased to family members of the original owner of this residential property.

An active railroad line runs across the site southeast of the Central Tract. The highest elevation on the site is approximately 560 ft above mean sea level (AMSL). The site topography drops to approximately 412 ft AMSL along the banks of Joachim Creek. Topographic contours around the site are shown in Figure 3-5.

Figure 3-3 illustrates several surface water features present on or in close proximity to the site. These features are described in Section 3.6 of this Decommissioning Plan (DP).

The area immediately surrounding the site is primarily woods, farmland, and suburban residential. Groundwater is widely used within four miles of the site as the primary source of household water. According to "Water Resources of the St. Louis Area: Missouri Geological Survey and Water Resources," WR30, 1974 (Reference 3-1), domestic and industrial water wells in the vicinity produce water from the Powell-Gasconade aquifer group, which includes the Jefferson City Dolomite, the uppermost bedrock unit at the site. Wells in the area might penetrate the Jefferson City Dolomite if it is present, but presumably do not derive significant quantities of water from it due to its poor storability. According to the Missouri Department of Natural Resources (MDNR) "Wellhead Protection Section, Well Information Management System (WIMS)" (Reference 3-2), as of April 2004, there were 763 wells within a 5-mile radius of the Hematite Site. There are 721 private drinking wells, 38 public wells, 4 industrial wells, and no irrigation wells. There were 29 wells within 0 to 1 mile of the site, 111 wells within 1 to 2 miles,112 wells within 2 to 3 miles, 231wells within 3 to 4 miles, and 280 wells within 4 to 5 miles. Not all wells in Missouri are registered with the State. There might be wells in existence near the site that are not documented by the State.

The current on-site private residence located on the south side of State Road P has been supplied by the Public Water Supply District (PWSD) No. 5 since November 2005. The two on-site residences on the north side of State Road P obtain drinking water from a single private well. As part of a previous removal action related to migration of groundwater contaminated with volatile organic compounds, twenty-three private residences situated southeast of the site were connected to PWSD No. 5 in 2003 and 2004 and the associated private drinking water wells were abandoned in accordance with "Action Memorandum for Off-Site Groundwater," (Reference 3-3).

According to a U.S. Environmental Protection Agency (EPA) field investigation report, "Preliminary Assessment, Hematite Radioactive Site, Hematite, Jefferson County, Missouri," 1990 (Reference 3-4), most of the residents in the community of Hematite and nearby Lake Virginia receive their drinking water from PWSD No. 5. Previous reports also state that surface water is not used for drinking within a 4-mile radius of the Hematite Site (Reference 3-5). PWSD No. 5 operates five public wells located in the Desoto and Festus quadrangles. Residents in Mapaville receive their public drinking water supply from PWSD No. 7. Eight public wells service customers in Mapaville, Festus, Hillsboro, and Pevely (approximately 9 miles northeast of the site). The wells are located in the Festus and DeSoto quadrangles. The nearest active public well (Well #3) to the Hematite Site is located approximately 2 miles south/southeast of the site on Carron Road. There is a standby public well (Well #5) located approximately ¼ mile from the site in the Lake Virginia subdivision.

There is a Head Start pre-school in the community of Hematite. A county school for handicapped children is located in Mapaville. There is a high school/middle school/elementary school complex in Festus. Additional information on site description is provided in the Environmental Report (Reference 3-6).

3.2 POPULATION DISTRIBUTION

Several towns and unincorporated settlements are wholly or partly within a 5-mile radius of the Hematite Site. Hematite is the closest settlement and is a bedroom community of about 125 people. Festus and Crystal City, located 3.5 miles east of the site and having a combined population of about 13,900 people, are the nearest towns of significant size. They are the county's second largest incorporated community and include a substantial number of commercial and retail businesses. The locations of nearby communities are shown in Figure 3-2, and information on these communities is provided in Table 3-1.

The county's average population density is 301 people per square mile based on the total estimated 2000 census population of 198,099 persons and an area of 657 square miles. Most of the population is Caucasian (193,102), followed by African American (1,354), Asian American (708), or Native American (577), and other races. The median annual income is approximately $46,000. Owner-occupied housing units outnumber renter-occupied units by a ratio of approximately 6 to 1. The average size of an owner-occupied household is 2.81 people, and the average size of a renter-occupied household is 2.42 people.

Estimates provided by the Missouri Census Data Center indicate the population of Jefferson County is projected to increase by approximately 31% between 2000 and 2025.

3.2 CURRENT AND FUTURE LAND USE

The current land use in the surrounding area is a mixture of farming, commercial industry, and suburban residential. Current land use within the site boundary consists of characterization and decommissioning activities, primarily in the Central Tract. Part of the site property outside the Central Tract area is leased to residents and to farmers.

It is anticipated that future uses of the land in and around the site will remain roughly consistent with its current use, i.e., residential, agricultural, and light industrial. Additional information on site current and future land use is provided in the Environmental Report (Reference 3-6).

3.3 METEOROLOGY AND CLIMATOLOGY

The *Missouri Water Atlas*, 1986 (Reference 3-7) was referenced to determine local precipitation. The area receives an average of 38 inches of precipitation per year, with 12 inches of average annual runoff. The maximum 10-day event expected precipitation is 9 inches in a given 25-year period. Snowfall has averaged less than 20 inches per winter season since 1930. The three winter months are the driest, the spring months are normally the wettest, and it is not unusual to have extended periods (1 to 2 weeks or more) without appreciable rainfall from the middle of the summer into the fall. Thunderstorms occur on average between 40 to 50 days per year. The U.S Department of Commerce's National Climate Date Center website (www.ncdc.noaa.gov/oa/climate/severeweather/tornadoes.html) reports an average annual frequency of about 8 tornadoes per year on data for a 30 year period in the state of Missouri. The probability of a tornado striking the site location is computed as 7.51 x 10E-4, and the recurrence interval is 1,331 years.

General climatological characteristics of the site area can be approximated by those of St. Louis, the location of the nearest U.S. Weather Bureau recording station. The region experiences a modified continental climate without prolonged periods of extreme cold, extreme heat, or high humidity. To the south, the warm, moist air comes off the Gulf of Mexico, and to the north, Canada is a source of cold air masses. The alternate invasion of the region by air masses from these sources produces a variety of weather conditions, none of which is likely to persist for any length of time. Winters are brisk but seldom severe. Minimum temperatures remain as cold as 32°F or lower, fewer than 20 to 25 days in most years. Summers are warm with a maximum temperature of 90°F or higher an average of 35 to 40 days per year.

The Clean Air Act was established to protect the public safety, health, and welfare from the effects of a variety of air pollutants. National Ambient Air Quality Standards (NAAQS) were established for sulfur dioxide, particulate matter, carbon monoxide, ozone, nitrogen dioxide, and lead. Missouri has adopted the federal NAAQS and added hydrogen sulfide and sulfuric acid emission standards. In order to monitor the attainment of the NAAQS, the EPA has designated Air Quality Control Regions (AQCR) across the United States. The Hematite Site is located in the Metropolitan St. Louis Interstate AQCR as defined in Section 302(f) of the Clean Air Act, 42 U.S.C. 7401 (Reference 3-8) and in 40 CFR 81.18 "Protection of the Environment, Metropolitan St. Louis Interstate Air Quality Control Region" (Reference 3-9). This AQCR has been designated by the EPA as an ozone non-attainment area, and a portion of Jefferson County, particularly the city of Herculaneum, has been designated as a lead non-attainment area.

3.4 GEOLOGY AND SEISMOLOGY

The regional geology and physiography are described in Sections 3.5.1, 3.5.2, and 3.5.3, while the site-specific geology is presented in Section 3.5.4. Additional geological information is provided in the Environmental Report (Reference 3-6) and "Supplemental Analysis of Hydrogeologic Conditions in Bedrock and Overburden at Westinghouse Hematite Facility, Hematite, Missouri" (Reference 3-10).

3.5.1 REGIONAL GEOLOGY AND PHYSIOGRAPHY

The Hematite Site is located within the Ozarks Plateaus Physiographic Province (Figure 3-6). The Ozark Plateaus province is a geologic uplift, covering approximately 50,000 square miles and is bounded to the north by the Missouri River, to the east by the Mississippi River, to the south by the Arkansas River, and to the west by the Grand and Neosho Rivers. Precambrian igneous and metamorphic rocks that outcrop at the Saint Francois Mountains (Figure 3-6) form the basal crust of the entire region and are overlain by Paleozoic sedimentary rocks that range in thickness from 0 around the periphery of the Saint Francois Mountains to 6,000 ft "Geohydrology of the Ozark Plateaus Aquifer System in Parts of Missouri, Arkansas, Oklahoma, and Kansas"(Reference 3-11).

The Ozark Plateaus consist of three sections: the Springfield Plateau, the Salem Plateau, and the Boston Mountains. Topography is mostly gently rolling except in the Boston Mountains, along the escarpments separating the Springfield and Salem Plateaus, and the Saint Francois Range where it is rugged. Karst features, such as springs, sinkholes, and caves, are common in the limestone of the Springfield Plateau and abundant in the dolomite bedrock of the Salem Plateau and Boston Mountains. The Missouri Environmental Geology Atlas (Reference 3-12) did not indicate a significant number of Karst features in the vicinity of the Hematite Site.

The Hematite Site is within the Salem Plateau (Figure 3-6), which is underlain by flat-lying to gentle northeasterly dipping Cambrian to Lower Ordovician strata that are mostly dolomite. The Paleozoic rocks are overlain by unconsolidated surficial deposits of Tertiary to Quaternary age. Within the Festus quadrangle where Hematite is located ("Bedrock Geologic Map of the Festus 7.5' Quadrangle, Jefferson County, Missouri" [Reference 3-13]), Ordovician-age Cotter Dolomite outcrops almost entirely throughout the region (Figure 3-7). The Ordovician- and Cambrian-age strata graphic units underlying the Salem Plateau in the vicinity of the Hematite Site include from youngest to oldest (Reference 3-11):

- The Cotter Dolomite; the Jefferson City Dolomite; the Roubidoux Formation; the Gasconade Dolomite, which contains a well-defined basal sandstone member called the Gunter Sandstone member; the Eminence Dolomite; and the Potosi Dolomite

- The Doe Run Dolomite, the Derby Dolomite, the Davis Formation, the Bonneterre Dolomite, the Reagan Sandstone, and the Lamotte Sandstone (These units make up the St. Francois confining unit and the St. Francois aquifer.)

Numerous fault and fracture zones that exhibit preferential orientations to the northwest-southeast and northeast-southwest have been mapped in the Ozark Plateaus (Reference 3-11 and Reference 3-12). The northwest-southeast-trending Eureka-House Springs Fault Complex and the Ste. Genevieve fault zones intersect the northeast and southwest tips of Jefferson County, respectively ("Structural Features of Missouri" [Reference 3-14]). However, these fault zones are several miles away from the Hematite Site and do not appear to have any influence on the geology or hydrogeology of the area.

The southeastern area of Missouri is quite active seismically and also contains a portion of the New Madrid Fault that caused the "great earthquakes" of 1811 and 1812. There were three quakes of Epicenter Intensity XII Modified Mercalli Scale (MMS) that took place on December 6, 1811 and January 23 and February 7, 1812 near New Madrid. In 1962, a quake measuring V (MMS) was recorded in the New Madrid area. A quake with a magnitude of 4.5 was recorded in the New Madrid area in 1963. A quake reported as "the strongest in years" occurred near Caruthersville, Missouri, 150 miles southeast of Hematite, on December 3, 1980. Figure 3-8 shows the location of mapped faults and folds in the Hematite, Missouri area. Figure 3-9 illustrates measured earthquakes in and near southeast Missouri from roughly 1900 to present. The closest earthquake to the Hematite Site of 3.0 magnitude or greater was centered roughly 10 miles south/southeast of the site.

Several north-northwesterly trending monoclines are mapped on the Festus and DeSoto quadrangles (Reference 3-13) but nothing in the immediate vicinity of the Hematite Site. The first geologic map prepared for the " Geologic map of the Crystal City, Missouri 15 minute quadrangle" (Reference 3-15) identified a northeast-southwest-trending structural feature parallel to Joachim Creek (offset slightly to the south of the creek) that was termed the Crystal City Anticline. Later mapping by Schmitz ("Geologic map of the Festus 7.5 minute quadrangle, State of Missouri Geological Survey and Water Resources" [Reference 3-16]) also shows this anticline but more nearly coincident with the creek. McCracken (Reference 3-14) includes the Crystal City Anticline in her survey of Missouri's structural features. Whitfield and Middendorf (Reference 3-13) do not include the anticline on their map of the area, although the feature is still identified in Missouri's recently published geographic information systems-based geologic atlas (Reference 3-12).

3.5.2 BEDROCK

The Jefferson City Formation and the Cotter Formation are described by Martin et al. in a journal published by the Missouri Department of Resources ("The Stratigraphic Succession in Missouri (Revised – 1995)," Missouri Department of Natural Resources, Division of Geology and Land

Survey "[Reference 3-17]), as referenced in the Remedial Investigation/Feasibility Study (RI/FS) Work Plan (Reference 3-5), as mostly light-brown to medium-brown, medium to finely crystalline dolomite, and argillaceous dolomite. Chert, which is not abundant, typically is oolitic, banded, mottled, or sandy. Lithologic succession within the formation is complex and varies among locations. Because the two formations are difficult to differentiate without the aid of insoluble residue testing, they are often designated as a combined unit, the Jefferson City-Cotter Dolomite. These two dolomite units average 400 ft thick statewide and are bounded beneath by the Roubidoux Formation. Imes and Emmett (Reference 3-11) describe the Roubidoux Formation within the Ozark aquifer system as "...a loosely to well-cemented sandstone or a sandy to cherty dolostone containing several distinct sandstone bodies." The sedimentary rocks in this area dip gently and uniformly to the northeast.

The monitoring wells discussed in this section have alpha-numeric designations. The first two letters designate the type of well (e.g., bedrock well) or, for temporary wells installed in the overburden, the location by Area of Concern (AOC). This is followed by the individual well number, while the last two letters indicate the unit or bedrock formation monitored. For example, BR-3-JC indicates a bedrock well, number 3, installed in the Jefferson City-Cotter formation. Letter designations are as follows:

- Well type designations or designations specific to AOC locations (temporary overburden wells)

  - BR Bedrock
  - PZ Piezometer
  - WS Water Sample
  - PW Private Well
  - BP Burial Pits
  - EP Evaporation Ponds
  - LF Leach Field
  - BD Beneath Buildings
  - OA Outdoor & Shallow Surface Areas
  - GS Former Gas Station
  - PL Natural Gas Pipeline
  - DM Deul's Mountain
  - CB Cistern Burn Pit Area
  - NB Exploration of Nature & Extent
  - RR Red Room Roof Burial Area
  - SW Surface Water

- Designation for unit or Formation
  - OB Overburden
  - JC Jefferson City-Cotter Formation
  - RB Roubidoux Formation.

3.5.3 UNCONSOLIDATED DEPOSITS

The Festus quadrangle geologic map (Reference 3-13) shows Quaternary (Holocene) alluvium and terrace deposits to be closely associated with Joachim Creek and its tributaries in the vicinity of Joachim Creek (Figure 3-7). The map also shows that the extent of alluvium and terrace deposits across Joachim Creek are very limited.

The Holocene alluvium as clay, silt, sand, and gravel chiefly derived from local loess and colluvium (Reference 3-13). Colluvium is described as a mixture of residuum, from fines to cobbles, and loess that is moving down slope as a result of slope wash and gravity. Colluvium accumulates at the base of valley slopes and in large valleys washes onto the flood plain, blending with the alluvium. Terraces typically contain lenticular beds of sand and gravel interbedded with silt and clay (Reference 3-5).

The soil survey for Jefferson County conducted by the U.S. Department of Agriculture (USDA) indicates the presence of seven soil types within the Hematite Site area: (1) the Horsecreek silt loam directly under the site and monitoring well BR-11 area, (2) the Haymond silt loam comprising the terrace deposits between the site and Joachim Creek, (3) the Kaintuck fine sandy loam along the immediate flood plain of Joachim Creek (monitoring wells BR-06, BR-08, and BR-10), (4) the Moko-Rock outcrop complex in the vicinity of the Tile Barn, (5) the Freeburg silt loam in the pasture area of monitoring well BR-05, (6) the Bloomsdale silt loam in the areas of monitoring wells BR-09 and BR-12, and (7) the Useful silt loam in the area of monitoring well BR-07 (Reference 3-18). Figure 3-10 and Figure 3-11 depict the locations of these monitoring wells.

3.5.4 SITE-SPECIFIC GEOLOGY

As noted in Section 3.5.1, the Hematite Site lies in the northeastern portion of the Salem Plateau. The Ozark uplift took place in the early Paleozoic during a time associated with deposition of a thick sequence of strata that included the Roubidoux Formation and Jefferson City-Cotter Dolomite. As a result of the uplift (locally associated with the St. Francois Mountains to the south-southwest of the Hematite Site, Figure 3-6) and subsequent erosion, these sedimentary formations both dip gently and thicken in a northeasterly direction. The approximate strike and dip of the Jefferson City-Cotter strata are N45W and 2 to 5 degrees northeast, respectively, at points closest to the Hematite Site, as indicated on field copies of the Festus quadrangle used by Whitfield and Middendorf (Reference 3-13) to prepare the most recent geologic map of the area.

However, notations on this map indicate that both the strike and dip of these strata are somewhat variable in the region.

The topography in the region of the Hematite Site is relatively deeply dissected by streams (refer to Figure 3-5 for a topographic map). Downward cutting of Joachim Creek and other streams in the area (or their predecessors) was in response to the Ozark uplift. In the immediate vicinity of the Hematite Site, Joachim Creek is at an elevation of approximately 412 ft AMSL and occupies a relatively narrow valley (approximately 2,000 ft wide) that generally trends east-northeastward. The valley is bounded both to the north and south by uplands that reach elevations in excess of 600 ft AMSL. A number of intermittent streams are tributaries to Joachim Creek in the area and also are incised resulting in the distinctive dissected topography characteristic of this region. These tributaries flow generally southeastward or northwestward from the highlands to their points of confluence with Joachim Creek.

Figure 3-7 is a portion of the geologic map encompassing the Hematite Site (Reference 3-13). The shallowest and most relevant components of the bedrock geology in the vicinity of the site are dominated by (in descending stratigraphic order) the Cotter Dolomite, Jefferson City Dolomite, and Roubidoux Formations. Figure 3-7 shows that the upland regions to the north and south of Joachim Creek are underlain by the Cotter Dolomite. The Jefferson City Dolomite is exposed in the valley walls of the tributaries to Joachim Creek. The nearest outcropping of the Roubidoux Formation is in the city of Desoto, Missouri, approximately 6 miles to the southwest of the Hematite Site.

The regional characteristics of the bedrock units are described in Section 3.5.2. Lithologic descriptions provided in Whitfield and Middendorf (Reference 3-13) and examination of core materials and core logs obtained during the RI and previous investigations indicate that, in the vicinity of the Hematite Site, the Jefferson City-Cotter Dolomite is composed of dolostone and sandy dolostone with minor interbedded sandstone and cherty intervals. The Roubidoux Formation is composed of dolostone with chert intervals and relatively common sandstone interbeds. The Jefferson City Dolomite-Roubidoux Formation contact reportedly occurs approximately 10 ft to 15 ft above a recognizable sandstone layer in the upper Roubidoux Formation. Although this sandstone is not always present, many of the bedrock logs from the Hematite Site appear to confirm its presence. Therefore, this sandstone will be used as a basis for recognizing the Jefferson City-Roubidoux contact.

The stream valleys in this region are characterized by deposits of alluvium that have their origin through local erosion in the upland regions and subsequent deposition in the relatively gently sloping valleys. The valley occupied by Joachim Creek has a zone of alluvium as much as 40 ft to 45 ft thick underlying and immediately adjacent to the creek that rests on top of the Jefferson City-Cotter bedrock surface. The soil cover in the upland regions is much thinner, and observations made at BR-07 (borehole drilled in the upland region southeast of Joachim Creek, Figure 3-10) indicate a thickness of only several feet.

It is apparent that Joachim Creek has responded to several episodes of uplift in the region evidenced by several different phases of alluvial deposition. For example, Whitfield and Middendorf (Reference 3-13) mapped a terrace deposit in the valley of Joachim Creek that is found in discontinuous, narrow strips near the margins of the valley or as small, isolated pockets within the valley. The Hematite Site lies on terrace deposits that extend along the northern boundary of the Joachim Creek valley.

3.5.4.1 Overburden

A detailed review of the hydrogeology of the site, including the overburden and bedrock HSUs, and an analysis of the well screen depths and monitoring results is provided in SAIC Report, "Supplemental Analysis of Hydrogeologic Conditions in Overburden at Westinghouse Hematite Facility" (Reference 3-10) and SAIC Report, "Radionuclide Activity in Bedrock Groundwater at Westinghouse Hematite Facility" (Reference 3-26). A summary is provided below.

The overall thickness of alluvium/terrace deposits underlying the Joachim Creek valley near the Hematite Site varies from approximately 17 to 45 ft and is comprised primarily of upper fine-grain silts and clay that overlie coarser-grain material (sands and gravels with some cobbles) near the bedrock surface. The thickness of the coarse-grain units is highly variable in this region and ranges from 0 ft to greater than 20 ft. The resulting unit is variably distributed with thickness increasing toward Joachim Creek. There are five HSUs underlying the Hematite facility as listed below:

- Near surface silty clay,
- Discontinuous "fat" clay layer,
- Deeper silty clay,
- Clayey, silty sand and gravel, and
- Bedrock.

The overburden consists of a surficial aquitard with three, predominantly clay, HSUs including the near surface silty clay, the discontinuous "fat" clay layer with high plasticity, and the deeper silty clay. Sand and silt are present as discontinuous thin layers, lenses, inclusions, or seams that are capable of transmitting water laterally over limited distances within the aquitard.

Precipitation and recharge interaction with the contaminated soil and buried waste materials results in the generation of leachate that migrates downward under prevailing seepage conditions in the aquitard and subsequently flows laterally within the sand/gravel aquifer.

North of the Union Pacific railroad line which includes the central tract, the clay ranges from 20 ft to 38 ft thick with an average thickness of 30 ft. Total porosity in the clay ranged from 0.41 feet to 0.48 feet. Saturation in the clay aquitard is variable and dependent on precipitation events and recharge. The calculated vertical hydraulic gradient through the clay is downward-directed with a range from 0.035 feet/foot to 1.049 feet/foot and an average of 0.574 feet/foot. The calculated hydraulic gradients are consistent with the clay aquitard lithology.

The sand and gravel deposits thicken from less than 5 ft in the terrace deposits at the northern facility boundary to approximately 20 ft in the vicinity of Joachim Creek. The average sand thickness in the facility area is 6.5 ft. Field (slug) testing in the sand and gravel deposits indicated hydraulic conductivity ranging from 3.38 x 10-4 cm/sec to 6.91 x 10-2 cm/sec with a geometric mean of 7.987 x 10-3 cm/sec.

The development of a sustainable water supply from the aquitard for the purposes of domestic supply or irrigation is considered impractical and infeasible based on the mean hydraulic conductivity of the aquitard (2.85 x 10-5 cm/sec), the low mean matrix permeability (3.48 x 10-8 cm/sec) of the clay, and the apparent lack of interconnected flow pathways in the clay. In addition, a survey of 721 private drinking wells, 38 public wells, and 4 industrial wells within a 5-mile radius of the site provided no documentation to indicate that any of the wells are completed in overburden or more specifically a clay resource. Domestic and industrial water wells in the region produce water predominantly from the Powell-Gasconade bedrock aquifer group of the Ozark Aquifer, which includes the Jefferson City and the Roubidoux Formations.

Although the Hematite area well survey did not identify any domestic or industrial wells completed in the overburden, the sand/gravel aquifer is conservatively assumed to be a potential source of potable water. Development of a water supply from the sand/gravel would be challenging on the site property because of the limited overall thickness of the aquifer. However, the sand and gravel deposits on the facility remain an effective under-drain for the clay overburden and provide a viable water resource immediately down-gradient of the plant area boundary south of the facility. The thickness of sand in this area was estimated from an isopach (thickness) contour map to be approximately 8 ft. The thickest accumulation of sand (25 ft) is encountered farther down-gradient on the Joachim Creek floodplain. While the thicker sand would be more suitable for a well, the sand thickness adjacent to the facility (8 ft), at the down-gradient edge of the contaminated zone, could provide sufficient resource for the development of a domestic water supply.

Based on the above discussion, water samples collected from wells screened in the aquitard overburden is considered leachate from surrounding contaminated soil, not potable groundwater. Only water collected from wells screened in the sand/gravel aquifer or the bedrock aquifer is considered to represent potable groundwater. HDP has planned to install additional wells to in order to continue monitoring the absence of contamination in the sand/gravel aquifer. HDP groundwater well locations are shown in Figure 3-10. Well sample frequencies and analysis parameters are described in Chapter 11. Post-remediation groundwater well locations are shown in Figure 3-41.

The details of the local subsurface geology can be described by a series of geologic cross-sections based on drilling logs obtained from cores derived from the implementation of the RI, as well as from a number of logs from earlier investigations ("Hydrogeologic Investigation and Groundwater, Soil and Stream Characterization"[Reference 3-19] and "Interim Hydrogeologic Investigation to Support the Engineering Evaluation and Cost Analysis for Response Actions for Off-Site Ground-Water Quality"[Reference 3-20]). Figure 3-10 and Figure 3-11 are maps showing the location of borings in the overburden obtained during the RI investigation. Boring logs were compiled for these locations, and a complete inventory of these logs is included in the RI report ("Remedial Investigation Report for the Westinghouse Hematite Site [Reference 3-21]).

Three cross-sections were assembled to examine the overburden underlying and proximal to the Hematite Site. The layout of these cross-sections is provided in Figure 3-12. Cross-sections B-B' and C-C' are oriented approximately parallel to Joachim Creek. Cross-section A-A' is roughly perpendicular to both B-B' and C-C'. Figure 3-13 is the legend for the geologic units encountered in both the overburden and bedrock in this investigation.

Cross-section A-A' (Figure 3-14) reveals a bedrock surface that is relatively flat, but slopes gently toward Joachim Creek. The bedrock surface illustrated in cross-sections B-B' and C-C' (Figure 3-15 and Figure 3-16, respectively) also is relatively flat with no indication of significant relief. The density of the borings represented in Figure 3-11 supports this inference.

The correlation of lithologic units in Figure 3-14, Figure 3-15, and Figure 3-16 focuses on the distinction between fine-grain and coarse-grain units. Alluvial depositional environments tend to be rather complex and heterogeneous with numerous examples of abrupt variations in lithologies from coarse to fine representing the complicated interplay between episodes of erosion and deposition as the stream channel migrates laterally within its flood plain. Detailed lithologic correlations can be difficult to make, but the interpretations illustrated in these cross-sections honor the boring logs and are realistic of what might be found in an alluvial depositional setting.

One notable feature revealed by cross-section A-A' (Figure 3-14) is the change that occurs at the terrace-alluvium boundary that is manifested by a thickening of coarse-grain lithologies from less than 5 ft in the terrace deposits to more than 15 ft in the vicinity of Joachim Creek. The sediment in this area is associated with the most recent episodes of deposition from the stream. Underlying the terrace, there is evidence of a variable thickness of coarse-grain materials, but nowhere are these zones as thick as those found in the alluvium. Examination of core material indicates that the pebbles and cobbles of the coarse-grain unit are angular to sub-rounded, suggestive of a local origin and little transportation prior to deposition.

The common occurrence of the coarse-grain material in the lower part of the overburden is significant because it is relatively permeable and appears to be a principal pathway for contaminant migration by groundwater in the overburden. The thickness of this zone has been mapped in the vicinity of the Hematite Site based on the core logs available in Reference 3-21 and from earlier studies (Reference 3-19 and Reference 3-20) by focusing on the subset of logs that demonstrably intersected the overburden-bedrock interface. These logs yield a reliable estimate of thickness for the coarse-grain units.

Figure 3-17 is an isopach map for the coarse-grain material in this area. Although some interpretation is required in constructing this map, the general configuration of the coarse deposits appears to define several thick, lenticular zones parallel to the stream that might represent old channel lag deposits.

Consistent with information in cross-section A-A' (Figure 3-14), the subsurface interface between the terrace and alluvial deposits appears to be the zone where significant thickening of sands and gravels occurs near Joachim Creek. In the vicinity of borehole BR-02 (Figure 3-10), the thickness of the coarse alluvial zone is much less. This area corresponds to the outside of a meander loop of Joachim Creek, which represents a zone of northward, lateral migration and erosion. Recent erosion activity associated with Joachim Creek might have removed much of the coarse-grain material that had been present in this region.

3.5.4.2 Bedrock

Figure 3-18 illustrates the location of three cross-sections that focus on the bedrock underlying the Hematite Site. The cross-sections are presented in Figure 3-19, Figure 3-20, and Figure 3-21. Overburden detail is purposely omitted, as it is not relevant to a discussion of bedrock. Cross-sections D-D' and E-E' are oriented approximately normal to the regional strike (N45W). Cross-section F-F' is oriented approximately strike-parallel.

The bedrock core logs obtained during the RI contain few distinctive marker beds that can be used as an indication of location within the stratigraphic section. However, a thin (5 to 10 ft thick) and apparently laterally continuous sandstone interbed mentioned previously (Section 3.5.4) appears to represent a unit that has been described as occurring approximately 10 to 15 ft below the top of the Roubidoux Formation. Cross-section D-D' (Figure 3-19) shows a correlation based on this marker bed. Because of the strike-normal orientation of the cross-section, this bed yields information about the dip of these strata. The dip represented by this sandstone bed ranges from 1.4 to 2.9 degrees in this cross-section, a value consistent with results from field mapping of surface outcrops (Reference 3-13) and from regional studies of these strata. Note that boreholes BR-01-RB and BR-04-RB were drilled by Leggette, Brashears and Graham, Inc. (LBG) (Reference 3-20) and contain the interpreted contact between the Jefferson City Dolomite and the Roubidoux Formation.

Stratigraphic correlation on what is believed to be the same sandstone bed also is illustrated in cross-section E-E’ for boreholes BR-06, BR-03, and BR-10 (Figure 3-10). The location of the marker bed in BR-03 is based on an evaluation of the core from BR-06 and the conclusion that the interpreted contact between the Jefferson City Dolomite and Roubidoux Formation in BR-03-RB (Reference 3-20) appears to be too deep by approximately 50 ft. The original location of the contact might have been based on the incorrect sandstone bed. Shifting the contact upward by this amount puts it in association with the sandstone bed illustrated in the cross-section.

The projection of the sandstone marker bed to BR-02 is problematic because the core log for this borehole shows the presence of only several very thin (~ 1 ft thick) sandstone interbeds within 20 ft of the Jefferson City-Roubidoux contact. Assuming that the contact is properly identified, these thin interbeds are interpreted to be correlative with the more prominent sandstone marker bed observed in the other boreholes. Therefore, the marker bed is projected to a position approximately 15 to 20 ft below this contact in BR-02. The resultant apparent dip of the marker bed in this cross-section is about 3 degrees, comparable to that observed in Figure 3-19 and within the range of measured values provided by Whitfield and Middendorf (Reference 3-13).

3.5.4.3 Local Structural Features

Cross-section F-F’ is shown in Figure 3-21. Based on a correlation of the same sandstone marker bed observed in D-D’ and E-E’, this bed appears to define a subtle warp in the strata, the axis of which is located close to Joachim Creek. This might be a depositional feature but probably is not tectonic in origin. The limbs of this warp have an apparent dip on the order of 1 to 2 degrees. As mentioned in Section 3.5.1, older geologic maps showed the Crystal City Anticline (Reference 3-14, Reference 3-15, and Reference 3-16) passing through this area. More recent maps do not have this feature (Reference 3-13).

The structural interpretation of bedrock for the Hematite Site based on cross-sections D-D’, E-E’ and F-F’ and discussed above can be integrated into a consistent geologic framework for the area. Figure 3-22 is a cross-section that is coincident with cross-section E-E’ and is oriented approximately perpendicular to the regional geologic strike. In this cross section; however, boreholes associated with the RI and earlier studies (Reference 3-20) that penetrated the sandstone marker bed (and, by inference, the Jefferson City-Roubidoux contact) have been included. Each borehole has been projected into the plane of the cross-section by correcting for the dip associated with the anticlinal-like structure (cross-section F-F’ in Figure 3-21). Therefore, the logs for boreholes located distant from the cross-section must be moved upward an amount equal to the distance from the plane multiplied by the tangent of the dip angle of the strata obtained from Figure 3-21. This process has the effect of unfolding the structure into a planar feature, while faithfully retaining information about the regional northeasterly dip of bedding (Figure 3-18 and Figure 3-19). Because of the vertical adjustment of boreholes not lying in the plane of the cross-section, the vertical scale represents relative elevation.

The results of applying these corrections to the vertical orientation of boreholes (Figure 3-22) demonstrates that the relative location of the sandstone marker bed identified in the cores defines an inclined plane dipping to the northeast at approximately 2.7 degrees.

Information regarding the identification of prominent bedrock fracture sets in outcrop or cores is limited, although the logs that describe core material obtained during the RI do mention the presence of fractures when observed. The LBG (Reference 3-20) investigation included construction of boreholes BR-01, BR-02, BR-03, and BR-04. Detailed core descriptions and a number of geophysical and hydrologic logging studies were associated with borehole construction. LBG (Reference 3-20) reports that the fracture densities for the Jefferson City-Cotter Dolomite and Roubidoux Formation lie within the ranges of 0.5 to 3.4 and 0.7 to 4 fractures per foot, respectively. Furthermore, they indicate that fractures, joints, and bedding planes in the Roubidoux core appear to be widened by dissolution; whereas, it is less apparent in the Jefferson City-Cotter core material. If such observations are generally true for the Hematite Site, they can have an impact on groundwater flow and contaminant transport. However, data obtained during the RI do not provide definitive information related to these earlier observations.

3.6 SURFACE WATER HYDROLOGY

The "Missouri Water Atlas," 1986, was referenced to determine local stream characteristics. The atlas shows that Joachim Creek, located along the southeast site boundary, is a permanent flowing stream. There are several other surface water features present on or near the site, including a spring, intermittent perennial and ephemeral streams, a lake, and ponds (See Figure 3-3). These features are listed as follows:

- Site Spring flows an estimated 1 to 10 gallons per year (gpm) most of the year. The spring is likely a result of fracture flow in the Jefferson City/Cotter Formation, which receives its source water from the hills northwest of the site.
- Site Pond is a small concrete dam impoundment southwest of the site. It receives flow from the Site Spring. It also receives sanitary discharge and storm water runoff from the facility area in accordance with the National Pollutant Discharge Elimination System (NPDES) permit.
- Site Creek is the effluent from below the dam of the Site Pond that receives discharge from the sanitary and storm water system. It flows through a culvert beneath the railroad track and joins the effluent from the Lake Virginia drainage basin.
- Virginia tributary flows from Lake Virginia and through two sewage treatment lagoons prior to combining with Site Creek tributary.
- Northeast Site Creek flows southeast to the east of the Burial Pit Area and then east to its confluence with the effluent of East Lake tributary and then to the Joachim Creek.
- East Lake east of the site is an earth impoundment lake used as a water supply for cattle. It is reported to never have been used in conjunction with site operations.
- North Lake is located just outside the northeast site boundary. It is an earth impoundment lake used as a water supply for cattle. It is reported to never have been used in conjunction with site operations.
- North Lake Tributary is the effluent drainage from North Lake and North Tributary. This tributary crosses the terrace, west of East Lake.
- North Tributary is an intermittent stream west of North Lake.

Quantitative data regarding flow quantity, duration, peak discharge, etc. are not available for all of these features. However, some observations can be made.

- The Site Spring flows continually.
- The ponds and lake on the site hold water year round. (Flow is measured at the Site Pond dam and reported quarterly to the MDNR Water Pollution Control Program.)
- Other than Site Creek, the site streams flow intermittently.
- Joachim Creek is perennial. Based on flow gauge information from the U.S. Geological Survey, the annual mean flow is approximately 132 cubic feet per second (cfs). The seasonal mean flows are: 330 cfs (spring), 12 cfs (summer), 16 cfs (fall), and 169 cfs (winter). Joachim Creek flows into the Mississippi River near Herculaneum, Missouri.

MDNR ("Base-Flow Recession Characteristics and Seasonal Low-Flow Frequency Characteristics for Missouri Streams" [Reference 3-22]) estimated the base flow recession, which is the amount of water that will flow in a stream after a 30-day rainless period. The base flow recession from 1961 through 1965 on Joachim Creek is 0.2 ft^3/second. These data indicate that Joachim Creek is a gaining stream, and therefore, a recipient of shallow groundwater discharge (Reference 3-19). This observation is consistent with the discussion in Section 3.7.2 that indicates that groundwater in the overburden at the Hematite Site migrates from the vicinity of the Hematite Site toward Joachim Creek where it discharges.

Water levels at surface water gauging stations in Joachim Creek, Site Pond, Site Creek, Northeast Site Creek, and East Lake were measured monthly from June 2004 through January 2005. Average, minimum, and maximum water levels for this measurement period are shown in Table 3-2.

The water levels at all the surface water gauging stations exhibited similar seasonal trends, with water levels decreasing in the summer (July through September 2004) and increasing in the winter (November 2004 through January 2005). Immediately before the measurement event in January 2005, significant precipitation occurred that resulted in elevated water levels at all the surface water gauging stations (Joachim Creek was flooded). The surface water data also shows that the Northeast Site Creek is an intermittent stream, based on observed dry bed conditions in July, September and October 2004.

Surface water levels were also measured through survey methods at points along Joachim Creek downstream of the bridge and closer to the Hematite Site. These surface water measurements were made in conjunction with water level measurements at nearby wells to determine whether groundwater discharges into Joachim Creek. These surveyed surface water measurements are presented and discussed in Section 3.7.2.

There are no public water supply intakes on Joachim Creek. As noted in Section 3.1, most of the residents in the community of Hematite receive their drinking water from a public water supply well (in PWSD No. 5) located approximately 2.5 miles south-southeast of the town (near the intersection of Sunnyside and Carron roads).

There are two water control structures on the site—the Site Pond dam and the East Lake dam. The Site Pond dam is made of concrete and is approximately 32 ft long, 16 in. wide, and 40 in. from the footing to the top of the dam. The East Lake has an earthen dam, which is approximately 175 ft long. There are two lakes within a one mile radius of the site that have water control structures. North Lake is located northeast of the site and has an earthen dam of approximately 200 ft in length. Lake Virginia is located southwest of the site and has an earthen dam structure. With the exception of Lake Virginia (actually a small pond), there are no known water obstructing barriers within 5 miles upstream of the Hematite Site. The drainage channels for the above structures cross through the site boundaries and empty into Joachim Creek.

Floods that might occur at the site will produce different flood levels depending upon the flow rate of Joachim Creek. While historical records (maximum observed level of 431 ft above mean sea level) and analysis by the Federal Emergency Management Agency (FEMA) show that a site flood is not likely, it is still considered remotely possible. If a flood of larger magnitude (greater than 432 ft above mean sea level) were to occur, water at the site would rise, but there is not expected to be any significant water velocity associated with the flooding. The reason for the minimal water velocity is that the railroad track, which is located between Joachim Creek and the site, would serve to isolate the facility area from the main stream flow. Figure 3-23 shows the 100- and 500-year flood boundaries for Joachim Creek.

3.7 GROUNDWATER HYDROLOGY

The components of the hydrogeologic system near the Hematite Site that are relevant to this DP include the following:

- Overburden—see Section 3.5.4.1
- Jefferson City-Cotter Formation—see Section 3.5.4.2
- Roubidoux Formation—see Section 3.5.4.2

Flow within the overburden generally is from areas of high elevation toward lower elevation, with local streams being the zone of discharge. Within this general framework, the principal groundwater flow paths in overburden are dictated by the occurrence of porous and permeable lithologies such as sands and gravels. For this reason, the basal coarse-grain unit in the overburden (occurring in both the terrace and alluvial zones, refer to Figure 3-14) is expected to be an important pathway for groundwater flow and transport of dissolved contaminants.

Surface topography also appears to be a strong driver that influences groundwater flow directions in the shallow bedrock on the Salem Plateau (see Section 3.5.1). The impact of topography on flow direction tends to decrease with increasing depth where the influence of regional flow patterns dominated by major rivers to the north and east is the controlling factor. In this region of the Salem Plateau, deep groundwater in these formations generally flows to the northeast (Reference 3-11). Additional hydrogeologic information is provided in the Environmental Report (Reference 3-6) and the supplemental analysis report (Reference 3-10).

Groundwater elevation maps for the Jefferson City-Cotter HSU for September 2008 (Figure 3-39) and March 2009 (Figure 3-40) indicate that groundwater flow in the upper bedrock aquifer is radial reflecting the surface topography surrounding the site area. An area of groundwater convergence in the Jefferson City bedrock is located southeast of the Hematite Facility.

3.7.1 IDENTIFICATION OF HYDROSTRATIGRAPHIC UNITS IN BEDROCK

Before proceeding with construction of potentiometric maps for bedrock or an assessment of groundwater flow directions, it is important to determine how the screened intervals in the bedrock wells are related to one another. The goal is to identify the hydrostratigraphic units (HSUs) present at the site and those wells that intercept each one. The cross-sections illustrated in Figures 3-12 through 3-16 form the basis for this analysis.

Figure 3-24 is an expansion of Figure 3-22 that includes all bedrock boreholes at the Hematite Site and illustrates the screened intervals in each (or the open intervals for the private wells, portrayed by dashed lines). Although the wells were labeled as either "Jefferson City (JC)" or "Roubidoux (RB)," it is apparent that some completion zones probably were not in the designated formation. The patterned zones delineate three tentatively identified HSUs: Jefferson

City-Cotter, Jefferson City-Roubidoux contact zone, and Roubidoux Formation. These HSUs were selected based on geology, i.e., they are strata-bound and parallel to the regional dip. The identification of these HSUs is based on historical and RI data and should be considered as a working conceptual model that relies on available data.

Additional insight into the hydrologic properties of these HSUs is available through estimates of hydraulic conductivity from slug testing conducted during previous investigations ("Investigation to Determine the Source of Technetium-99 in Groundwater Monitoring Wells 17 and 17B, Combustion Engineering Hematite Facility" [Reference 3-23] and Reference 3-20) and as part of the RI. A description of the test method is provided below, and analyses of the slug test data are in Reference 3-21. In addition, injection tests were conducted by LBG (Reference 3-20), which provided estimates of relative transmissivity.

In situ hydraulic conductivity tests (slug tests) were performed on selected overburden wells (BR-06 OB, BR-08-OB, BR-10-OB, NB-73 and NB-84), and on bedrock wells (BR-07-JC, BR-08-JC, BR-10-JC, BR-11-JC, BR-12-JC, PW-06-JC, PW-19-JC, PZ-03, PZ-04, WS-30, WS-31, BR-01-RB, BR-02-RB, BR-06-RB, BR-07-RB, BR-08-RB, BR-10-RB, BR-12-RB and PW-06-RB) to supplement data from previous investigations. Testing was performed in accordance with SAIC FTP-376, Aquifer Analysis by Slug Test Method (Reference 3-24), and other approved industry standards. The overburden locations were chosen to provide representative hydraulic conductivities of the overburden near the site (terrace deposits) and near Joachim Creek (flood plain deposits). The bedrock locations were selected to provide representative hydraulic conductivities of the Jefferson City–Cotter Formation and Roubidoux Formation across the entire Hematite Site.

The slug tests were performed using a standard technique of pressurizing the well casing with air (a pneumatic slug), which displaces water out of the well thus releasing the pressure, then monitoring the recovery of the water level in the well. During the slug tests, water levels were measured using a pressure transducer that was connected to a data logger capable of recording data every 1 second. The pneumatic slug assembly was positioned on top of the well casing, gauges zeroed, and relief valves closed. Prior to insertion into the well, the pressure transducer was programmed with specific well information, and the static water level and total depth were manually recorded. The transducer was then lowered into the well through the pneumatic slug assembly to a position approximately 10 to 15 ft below the static water level, and an airtight fitting was tightened around the transducer cable to seal the connection. Air was introduced into the well via a small portable air compressor until the desired displacement was achieved. At that point, the relief valve was opened and the test performed as a "rising head" test. A data logger was used to record pressure transducer response from the beginning of pressurization through complete recovery to the static water level. Due to the need to set recording times at such a short interval (every 1 second), direct observation of the data was not possible in some of the wells tested. After a period of approximately 5 minutes, the transducer was stopped and the data reviewed to ensure static conditions had been achieved. Additional tests were run routinely to provide replicate recovery data for a given well.

Due to the low conductivities experienced in BR-07-JC, a sufficient water displacement using a pneumatic slug in the well was difficult to achieve. Thus, a traditional "slug" constructed of polyvinyl chloride (PVC) pipe was used to create displacement and a "falling head" conductivity test was performed. Direct reading of the pressure transducer allowed for the correction of an error common to pneumatic slug testing in aquifers with lower conductivities. In these instances, the transducer reads the pressure inside the well and not the displacement of the water column. By using the direct-read function of the transducer, air was continually applied, thus resulting in a "rise" in the water level. This was monitored until the level had returned to static. At this time, the relief valve was opened and a subsequent lowering of the water level occurred, and the levels were routinely monitored until true static conditions were achieved.

Table 3-3 gives the results of the slug tests. As seen, the hydraulic conductivity (K_h) values are variable in each formation but are generally higher in the overburden (3.8 to >155 ft/day) and the Jefferson City-Cotter (<0.2 to 103.9 ft/day) than in the Roubidoux Formation (0.8 to >15 ft/day).

LBG (Reference 3-20) also reported some additional borehole testing information that is referred to as "Permeability Test" data. This information is related to the maximum rate of water injection that could be achieved from isolated 20-ft intervals in boreholes BR-01, BR-02, BR-03 and BR-04 along most of their length. The results are reported in units of "gpm" and are assumed to represent a qualitative measure of permeability.

Figure 3-25 presents the K_h results on cross-section G-G' (refer to Figure 3-18 for the cross-section location). The injection test results are presented in Figure 3-26, in which each borehole is represented in its proper orientation relative to the sandstone below the Jefferson City-Roubidoux contact identified in lithologic cross-sections, (i.e., Figure 3-19, Figure 3-20, Figure 3-21, Figure 3-22 and Figure 3-24). The vertical blue line segments in Figure 3-26 represent the location in each borehole of those zones with high injection rates, i.e., apparent transmissivity. These boreholes were originally drilled into the Gasconade Formation that underlies the Roubidoux Formation. The injection tests were performed before these boreholes were grouted back to their current completion depths, which accounts for the length of the test records.

The hydraulic conductivity results in Figure 3-25 and Figure 3-26 are combined in Figure 3-27. The patterned areas identify those zones with relatively high conductivity and/or transmissivity. By comparing Figure 3-27 with Figure 3-24, where three HSUs have tentatively been identified, the following conclusions can be reached:

- There is an upper transmissive zone that lies within the Jefferson City-Cotter HSU and appears to be most closely associated with those boreholes completed within about 50 ft of the overburden-Jefferson City-Cotter interface, e.g., PZ-03, PZ-04, WS-31, BR-08-JC and BR-10-JC.
- The Jefferson City-Roubidoux contact zone is a region of variable, but typically low, transmissivity.
- There is a deeper, second zone of high transmissivity (Roubidoux HSU), defined by the injection test results of LBG (Reference 3-20), that lies immediately below the relatively low transmissivity Jefferson City Roubidoux contact zone.

3.7.2 POTENTIOMETRIC SURFACE

Figure 3-28, Figure 3-29, Figure 3-30, Figure 3-31, and Figure 3-32 illustrate the potentiometric surfaces for the major HSUs defined in the RI based on water level measurements made during December 2004. Figure 3-28 shows a number of wells in the immediate vicinity of the Hematite Site that are completed in the fine-grain sediments in the shallow overburden. These wells typically are screened from 5 to 15 ft below ground surface (bgs), approximately 10 to 15 ft above the overburden-bedrock interface. Although the number of data points is not large, it is apparent that under the main part of the Hematite Site, head elevations are greater than 430 ft AMSL; whereas, heads are 4 to 10 ft lower further to the east, and all are less than 430 ft AMSL.

The cause of this lateral decline in heads might reflect a shallow flow pathway leading to discharge into the Northeast Site Creek that flows intermittently through this region. Alternatively, it is possible that the Burial Pit Area on the eastern side of the Hematite Site (Figure 3-3) influence groundwater flow in the overburden. The Burial Pits extend to a depth of about 12 ft (Reference 3-19) and are expected to contain relatively more permeable fill material than the native sediments. It is possible that a hydraulic connection exists between the Burial Pits and the permeable lower sands and gravels such that water contained in the vadose zone entering the pit area is able to migrate downward to the deep overburden. Figure 3-28 is similar to the potentiometric surface for the near surface silt/silty clay (NSSSC) reported by LBG (Reference 3-19), which suggests that hydrologic conditions in this shallow unit have not changed significantly since 1999.

Figure 3-29 is a potentiometric surface map based on those wells completed in the lower part of the overburden. Many of these wells were installed by direct-push technology (DPT) to the depth of refusal, and some of them might not have fully penetrated the overburden if large cobbles were encountered in the coarse material. Nearly all of these wells are screened at a depth that includes some of the coarse-grain material, but many also incorporate some finer-grain units in the screened interval. However, the wells appear to be hydraulically connected to the coarse-grain basal layer. The potentiometric surface defined by these wells in Figure 3-29 clearly defines a southeasterly groundwater flow direction with the trend of the contours roughly paralleling Joachim Creek. The region of highest hydraulic heads on this map corresponds to the location of the Hematite Site.

LBG (Reference 3-19) also presented a potentiometric map for the deeper silty clay/clay (DSCC), a unit that lies below the NSSSC and above the coarse-grain material at the base of the overburden. The map was limited in extent to the immediate vicinity of the Hematite Site. During fieldwork for the RI, geologists were unable to distinguish this sub-unit in core material. As a consequence, water level and contaminant data for the DSCC wells of LBG (Reference 3-19) and the deep overburden wells of the RI have been combined. The water level results illustrated in Figure 3-29 suggest that this approach is valid.

In Section 3.6, it is noted that Joachim Creek is a gaining stream in the vicinity of the Hematite Site. Additional information is available that supports this interpretation.

As part of the RI, water levels were measured for Joachim Creek at several points near the site in association with water level determinations in neighboring overburden monitoring wells in February 2005. The results are summarized in Table 3-4 (refer to Figure 3-29 for well locations).

These measurements, coupled with the observed hydraulic gradient in the direction of Joachim Creek as illustrated in Figure 3-29, suggest discharge from the overburden into the stream. During periods of flooding of the stream, there might be temporary reversal of flow proximal to Joachim Creek, but this condition will not persist once the stream water level returns to normal.

Comparison of the hydraulic heads in shallow (Figure 3-28) and deep (Figure 3-29) overburden underlying the Hematite Site illustrates a downward vertical gradient (details are discussed in Section 3.7.3). Head differences of 10 ft or more are common in this region. This fact suggests that the shallow groundwater represents a perched water table. The fact that the hydraulic heads are highest in the vicinity of the Hematite Site could result from several different mechanisms. For example, a possible source of increased recharge in this area might be related to operation of the site. Leaks in storm water, domestic and process water, and waste transfer piping could be a factor in these observations. Alternatively, shallow subsurface groundwater flow from the topographically elevated region northwest of the site might be important. Likewise, storm runoff from the adjacent State Road P could contribute to this observation.

The potentiometric surface maps for bedrock are presented as a sequence of separate illustrations based on the three HSUs previously defined. Figure 3-30 represents the potentiometric surface for the Jefferson City-Cotter HSU. In general, the potentiometric surface in Figure 3-30 appears to define a zone of high heads in bedrock under the Hematite Site. The region of high heads roughly corresponds to similar regions observed in both the shallow and deep overburden wells

(Figure 3-28 and Figure 3-29, respectively) and suggests that the overburden and shallow Jefferson City-Cotter Dolomite might be hydraulically interconnected.

There is evidence for declining heads in the direction of Joachim Creek, as defined by wells close to the Hematite Site, i.e., PZ-04, PZ-03, WS-30, and WS-31, and those located further toward the southeast, i.e., BR-08, BR-10, and BR-03. These wells are screened in a shallow zone within approximately 50 ft of the overburden-bedrock interface. Evidence based on contaminant distributions in the Jefferson City-Cotter Dolomite supports an interpretation of flow and transport toward the southeast. Other wells to the north of Joachim Creek and lying on its flood plain, i.e., BR-04, BR-05, BR-09, BR-11, and BR-02, appear to define a potentiometric flat surface, suggesting little potential for lateral flow except in close proximity to the Hematite Site.

The cluster of wells on the topographically elevated region to the south of Joachim Creek also appears to define a region of high heads, and contours have been drawn in a way that might reflect a topographic influence, with heads declining northwestward in the direction of Joachim Creek. This gradient suggests a zone of groundwater convergence or discharge from the Jefferson City-Cotter HSU to the overburden near to the location of the creek. This inference is consistent with the vertical groundwater gradients observed between the overburden and Jefferson City-Cotter in this area (Section 3.7). However, the water levels measured in PW-19 and PW-06 on December 3, 2004 (Figure 3-30) appear to be low in comparison to their nearest neighbors and relative to another set of water levels that were obtained less than 2 weeks later. This latter data set was obtained in association with site-wide groundwater sample collection that occurred in late December 2004 and early January 2005. The differences between these two data sets might be associated with slow re-equilibration of water levels in the Jefferson City-Cotter HSU following conversion of PW-06, PW-16 and PW-19 from open holes to dual completion wells in mid-November 2004.

There also is uncertainty in attributing water levels observed in PW-05, PW-10, and both Menke private wells to the Jefferson City-Cotter HSU. These private wells are completed as open holes (refer to Figure 3-30 for well locations and Figure 3-24 for open depth intervals). The Menke wells are completed in the Jefferson City-Cotter Dolomite, and the others reach the Jefferson City-Roubidoux contact zone. It is not possible, given existing information regarding these private wells, to identify which hydrologic zone intersected by these open boreholes has a controlling influence on the observed heads. Thus, it is questionable that they are representative of the Jefferson City-Cotter HSU, as defined by other wells that are isolated within this zone, e.g., PW-06-JC, PW-16-JC and PW-19-JC. For that reason, water levels for these wells are not incorporated into the potentiometric map in Figure 3-30.

Figure 3-31 shows a potentiometric surface for the Jefferson City-Roubidoux contact zone HSU that differs significantly from that for the Jefferson City-Cotter HSU in Figure 3-30. Borehole BR-12-JC has a head value that is elevated with respect to the others, but the more dominant feature is the indication of a significant northeasterly component to the gradient (and to groundwater flow). As already noted, the regional potentiometric gradient declines towards the northeast and Figure 3-31 appears to be part of this regional hydraulic regime. As for Figure 3-30, water levels for the open boreholes/private wells to the south of Joachim Creek have not been included in drawing the potentiometric surface shown in Figure 3-31, because it is not possible to determine what HSU controls the water levels.

Water levels for wells in the Roubidoux HSU (Figure 3-32) define a potentiometric surface roughly similar to that observed in Figure 3-31 and appear to reflect the regional influences, i.e., a northeasterly trending gradient. Artesian conditions in BR-03-RB prevented an accurate determination of the head on December 3, 2004, and an additional riser was added to the well before December 9, 2004. The water level in BR-03-RB was re-measured on December 9 as part of groundwater sampling, and an elevation of 423.1 ft AMSL was obtained. It is possible to combine information from potentiometric surface maps (Figure 3-28, Figure 3-29, Figure 3-30, Figure 3-31 and Figure 3-32) and slug test results (Table 3-3) to compute estimates of groundwater flow velocities based on Darcy's Law:

$$\text{Linear Velocity} = -K_h\left(\frac{d_h / d_l}{\rho}\right) \quad \textbf{(3-1)}$$

where:

K_h = Hydraulic Conductivity

d_h = difference in head

d_l = change in length

ρ = porosity

However, one must assume that the two points used to calculate velocity actually lie on a flow path. Estimates have been made of Darcy flow velocities for a variety of potential flow paths. The lateral velocity results obtained for overburden range between approximately 20 ft/yr and 300 ft/yr. Estimated lateral velocity values in bedrock range from 2 to >300 ft/yr. Table 3-5 provides estimated lateral and vertical velocity results for selected well pairs on the Hematite Site. The method used to determine velocity is also identified. The locations of wells listed in this table can be found in Figure 3-10 and Figure 3-11.

In unconsolidated porous media such as the overburden, there is a reasonable level of confidence that the potentiometric surface provides a good indication of the direction of groundwater flow and contaminant transport. In contrast, the relationship between groundwater flow and contaminant transport and the configuration of the potentiometric surface for bedrock formations is more difficult to interpret. Groundwater flow directions in fractured media are dependent on the orientation of transmissive fracture sets. The transmissivity of individual fractures depends on the interconnectivity of a network of fractures. Lithologic features, such as the presence of transmissive interbeds, also will influence flow directions.

Both the Jefferson City-Cotter Dolomite and the Roubidoux Formation are dominated by dolostone, although sandstone interbeds are known to occur in the geologic section underlying this area (see Figure 3-19, Figure 3-20, and Figure 3-21). Groundwater flow in the dolostone primarily should follow laterally continuous, permeable interbeds, such as sandstone and fractures, some of which might have been widened by dissolution. The core logs reveal the presence of the interbeds. The drilling log entries also note that fractures were occasionally encountered in recovered core, but details about the role of fractures in groundwater flow in the vicinity of the Hematite Site are not available because comprehensive information on fracture frequency, orientation, and apertures are not available. As noted in Section 3.5.4.2, there is no information on the dominant fracture sets and their orientation in this region.

Preferential flow in bedrock also might be associated with zones of weathering that widen fractures and increase permeability. Some parts of the Jefferson City-Cotter Dolomite near the overburden-bedrock interface in the valley of Joachim Creek might be an example of this process. Consequently, the potentiometric surfaces for the Jefferson City-Cotter Dolomite and Roubidoux Formation should be regarded only as providing information on the potential directions of groundwater flow.

3.7.3 VERTICAL HEAD GRADIENTS

Whereas the previous discussion examines the potential for lateral groundwater flow (and contaminant transport), it is also important to understand the evidence relating to the potential for vertical groundwater flow at the Hematite Site Figure 3-33, Figure 3-34, and Figure 3-35 present vertical gradient results between the shallow and deep overburden, the deep overburden and Jefferson City-Cotter Dolomite, and the Jefferson City-Cotter Dolomite and Roubidoux Formation, respectively. Note that these gradients were calculated based on water level measurements made in December 2004. The vertical gradient is defined as follows:

$$\text{Vertical Gradient} = -\left(\frac{d_h}{dZ}\right) \qquad \textbf{(3-2a)}$$

where:

d_h = difference in head

dZ = vertical separation of monitored zones

$$\text{Vertical Gradient} = \frac{-\text{(shallow head – deep head)}}{\text{(vertical separation of monitored zones)}} \quad \textbf{(3-2b)}$$

[Note: negative values indicate a downward potential]

Figure 3-33 shows that the vertical gradient between the shallow and deep overburden layers underlying the Hematite Site is strongly downward, except at WS-26/WS-27 next to Northeast Site Creek where an upward gradient is observed. The general observation of a downward head gradient in this area is consistent with the earlier discussion related to Figure 3-28 and Figure 3-29. A region of downward gradients under the Hematite Site also is observed when water levels in the deep overburden are compared to the Jefferson City-Cotter Dolomite, as illustrated in Figure 3-34. However, the magnitude of the gradient is less than that in Figure 3-33. The overburden-Jefferson City-Cotter gradient near Joachim Creek is upward, which coincides with the interpretation of this region as a zone of groundwater convergence (i.e., discharge), as seen on Figure 3-30. As illustrated in Figure 3-35, the gradient between the Jefferson City and Roubidoux Formation is upward throughout most of the area, except to the east for wells BR-02 and BR-05 where the gradient is slightly downward.

3.7.4 INTERCONNECTIVITY OF GEOLOGIC UNITS

It is important to assess the degree of interconnectivity of the main hydrologic units in this area, because this information will help explain the vertical distribution of contaminants. Figure 3-36, Figure 3-37 and Figure 3-38 are time-series plots of water levels in selected wells with at least quarterly measurements that extend over a period of from one to several years. Comparison of these water level results focuses on the relative shapes of the time-series patterns and not on absolute values of water level elevations. The data show that for the common period of water level records (March to December 2004) the overburden and shallow Jefferson City-Cotter HSU (Figure 3-36) well hydrographs appear to be very similar. In addition, from August 2004 to August 2005 the hydrographs for BR-04-JC (Jefferson City-Cotter HSU) and BR-08-RB (Jefferson City-Roubidoux Contact Zone HSU) also mimic one another (Figure 3-37). One possible explanation for these observations is that these geologic units are hydraulically interconnected. Alternatively, the similar hydrographs might reflect the fact that the Jefferson City-Cotter Dolomite outcrops in the vicinity of the Hematite Site, and water levels are responding independently to seasonal changes in precipitation and recharge, i.e., elevated water levels in winter-spring and lower during the drier summer months. The Jefferson City-Cotter well shown in Figure 3-37 is BR-04-JC, which is located northeast of the site and completed at a depth of 100 ft bgs. BR-08-RB is located southeast of the site and screened at a depth of approximately 110-150 ft bgs.

Water level data for Roubidoux wells Figure 3-38 (this figure has the same vertical scale as Figure 3-37) suggest a somewhat different response over time. The most significant difference is that these wells experienced an overall rapid rise in water levels that appears to have begun in 2003. Head increases of 30 to 40 ft took place by the end of 2004. The magnitude of the increase appears to increase with increasing distance from the Hematite Site, such that BR-02 has the greatest head rise and BR-01 the least over the same period of time. There are two events that most likely contributed either individually or in concert with one another to cause this dramatic rise.

First, in late summer 2003, the City of Festus, located approximately 5 miles to the east of the Hematite Site, brought online a new water-production site located approximately 1 mile from the Mississippi River. This "collector" well draws water from the sediments marginal to and underlying the Mississippi River and now provides nearly all of the water needs for the area. Startup of this well permitted the City to place its four production wells located on the west side of Festus, i.e., closer to the Hematite Site, on standby. These wells had been pumping approximately 1 million gallons per day (gpd) from the lower Roubidoux Formation. Currently, they are used only during periods of peak demand in mid- to late summer or when the collector well is off-line. When supplementing production from the collector well, the pumping rate on these wells is much less than before August 2003.

Secondly, once contamination was discovered in private wells located southeast of the Hematite Site across Joachim Creek, the local public water supply system was extended to the residents and wells in this area were shut down (between November 2003 and March 2004). The U. S. Geological Survey (USGS) reports that in Missouri, self-supplied water usage is approximately 65 gpd/person (http://water.usgs.gov/pubs/circ/2004/circ1268/htdocs/table06.html). Therefore, the total daily withdrawal of groundwater by the more than 20 families in this area probably was on the order of 5,000 gpd. Although this amount is much less than for the City of Festus, there might have been a local impact on drawdown in the Roubidoux Formation until these wells were shutdown.

Both of these events relieved a source of hydraulic stress to the Roubidoux Formation. The magnitude of the shutdown of the Festus production wells is regional in scale, while the impact of the shutdown of the private wells was probably only of local extent.
Further support for the magnitude of regional impact of the Festus production wells comes from a well located within 1 mile of one of the original Festus production wells that is monitored by USGS and has continuous water level data over the time period of interest (Reference 3-25). This USGS well is located approximately 3 miles northeast of the Hematite Site, is 1,048 ft deep, and is completed in the lower Roubidoux/Potosi Formation. Since mid-2003, this well has experienced a rise in water level of approximately 150 ft.

On July 6, 2005, the City of Festus temporarily resumed pumping three of its deep production wells. Coincident with this event, the water levels in the USGS monitoring well and wells BR-02-RB and BR-03-RB began to decline rapidly. This result adds support to the proposed cause and effect relationship between large-scale pumping (or shutdown) of the Festus wells and observed changes in water levels in monitoring wells penetrating into the Roubidoux HSU on the Hematite Site.

In addition to the overall rise in water levels throughout 2004 in Roubidoux HSU wells located near the Hematite Site, comparison of the shapes of the hydrograph trends for Roubidoux, Jefferson City-Cotter, and overburden wells (Figure 3-36, Figure 3-37, and Figure 3-38) shows general similarity during the period of 2002 to 2005. However, the amplitude of changes in the Roubidoux water level data appears to be damped in comparison to the other wells. The fine structure to the water level curves in Figure 3-36, Figure 3-37, and Figure 3-38 appears to be persistent among wells completed in the three geologic units and, as noted above, probably represents a response to seasonal changes in the amount of precipitation and recharge. The water level records are too short to provide a detailed comparison to local precipitation records.

Whereas information discussed earlier in this section suggests hydraulic interconnection between overburden and at least parts of the Jefferson City-Cotter HSU, deeper bedrock units appear to be more isolated from one another. The contrast between hydrographs for the Jefferson City-Cotter and Roubidoux wells since mid-2002 (Figure 3-37 and Figure 3-38) suggests that significant hydraulic interconnections do not occur between these two geologic units. This observation supports an interpretation that contamination of the Roubidoux Formation by downward migration of groundwater is unlikely. Rebound of water levels of 20 to 40 ft in the Roubidoux wells (especially BR-04-RB) during this period of time is not reflected to any significant degree in the hydrograph of BR-04-JC. It is more likely that the superficial similarities of the fine structure of these hydrographs are related to their response to seasonal precipitation and recharge factors transmitted to the formations from areas of surface outcrops on a regional scale.

Another example of information supporting the lack of hydraulic interconnectivity between the Jefferson City-Cotter Dolomite and Roubidoux Formation is illustrated by the results of integrity testing in wells PW-06, PW-16, and PW-19. Following their shutdown, these private wells were reconfigured as dual-completion monitoring wells with deep and shallow screened intervals isolated by a thick grouted zone. In November 2004, the lower intervals in these wells were pumped at a sustained rate of 2 to 4 gpm for 1 hour, as water levels in the upper zones were monitored. The purpose of the testing was to confirm the integrity of the grout seal. The shallow zones in PW-06 and PW-19 showed no changes in water level during the test. Not only do these results establish that the grout seal is intact, but they also show that the lower and upper screened intervals of bedrock are not significant in hydraulic communication. Water levels in the upper zone at PW-16 rose slightly (1.09 ft) during the pumping of the deep zone, an observation that is difficult to reconcile with the nature of the testing.

The rebound in water levels observed in the Roubidoux wells in Figure 3-38 is significant for another important reason. Prior to the shut down of the Festus production wells in 2003 and the private wells near the Hematite Site in 2004, water levels within these Roubidoux wells were 30 to 40 ft lower than results from the most recent measurements made in December 2004. The potentiometric surface for the Roubidoux Formation (Figure 3-32) and the vertical gradients between this formation and the Jefferson City-Cotter Dolomite (Figure 3-35) were measured after a significant period of recovery had occurred and apparently are approaching a new, higher, static potentiometric level. Had similar data been obtained prior to 2003 for the new wells shown in these figures, the resultant patterns of head distributions would have been dramatically different. Specifically, there would have been a strong easterly gradient in the Roubidoux Formation, i.e., greater drawdown for wells closer to the City of Festus production wells, and the vertical gradients between the Jefferson City-Cotter Dolomite and Roubidoux Formation would have been consistently downward rather than upward.

This observation is critically important because groundwater flow and contaminant migration in the vicinity of the Hematite Site probably occurred over a period of years prior to 2003 during which hydraulic conditions (at least for the Roubidoux Formation) were very different than today. The distribution of contamination currently observed in the Roubidoux Formation in the private wells southeast of the site appears to be related to the lower heads prevailing in that formation prior to 2003.

A detailed review of the hydrogeology of the site, including the overburden and bedrock HSUs, water levels, hydraulic gradients and an analysis of the well screen depths and monitoring results is provided in SAIC Report, "Supplemental Analysis of Hydrogeologic Conditions in Overburden at Westinghouse Hematite Facility" (Reference 3-10) and SAIC Report, "Radionuclide Activity in Bedrock Groundwater at Westinghouse Hematite Facility" (Reference 3-26). Updated time series plots of water levels from selected wells for 2007 thru 2009 are provided in Figures 3-36, 3-37, and 3-38.

3.8 NATURAL RESOURCES

The primary natural resources occurring at or near the site are agricultural lands, surface water ponds and streams, and groundwater. There are some wooded areas on and surrounding the site, but the low quality of the timber makes any major harvesting unlikely.

The surface water features on and near the site are described in Section 3.6. These surface water features are not used for drinking water, but some are used for watering livestock. Groundwater is widely used as the primary source of household water.

There are 33 surface mines within 5 miles of the Hematite Site. The closest are two limestone quarries, less than two acres in size, that are approximately 1 mile southwest of the site. The other mines consist of 1 copper, 11 lead, 2 other limestone, and 17 sandstone quarries. Most of these lie outside of a 2-mile radius from the site.

3.9 REFERENCES FOR CHAPTER 3.0

3-1 Miller, D.E., et al., "Water Resources of the St. Louis Area: Missouri Geological Survey and Water Resources," WR30, 1974.

3-2 Missouri Department of Natural Resources, Wellhead Protection Section, Well Information Management System (WIMS).

3-3 Westinghouse Electric Co. LLC, "Action Memorandum for Off-Site Groundwater," June 2002.

3-4 Mearns, S.L., Ph.D., Preliminary Assessment, Hematite Radioactive Site, Hematite, Jefferson County, Missouri: Ecology and Environment, Inc., Field Investigation Team (E & E/Fit) Zone II, Contract No. 68-01-7347, for Region VII EPA, 1990.

3-5 Leggette, Brashears and Graham, Inc., "Remedial Investigation/Feasibility Study Work Plan," Rev. 0, Westinghouse Report, May 9, 2003.

3-6 Westinghouse Electric Co. Report No. DO-08-009, "Environmental Report."

3-7 Missouri Water Atlas, 1986.

3-8 Clean Air Act, 42 U.S.C. 7401.

3-9 U.S. EPA, 40 CFR 81.18, Protection of the Environment, Metropolitan St. Louis Interstate Air Quality Control Region.

3-10 Westinghouse Electric Company LLC, "Supplemental Analysis of Hydrogeologic Conditions in Bedrock and Overburden at Westinghouse Hematite Facility, Hematite, Missouri."

3-11 Imes, J.L. and Emmett, L.F., "Geohydrology of the Ozark Plateaus Aquifer System in Parts of Missouri, Arkansas, Oklahoma, and Kansas," U. S. Geological Survey Professional Paper 1414-D, 1994.

3-12 Missouri Department of Natural Resources, Missouri Environmental Geology Atlas (MEGA), Ver. 2003.1, Sesquicentennial Edition, NAD83 Datum, Zone 15, 2004.

3-13 Whitfield, J. and Middendorf, M., "Bedrock Geologic Map of the Festus 7.5' Quadrangle, Jefferson County, Missouri," IFM 92-296-GMR, MDNR, 1979.

3-14 McCracken, M., "Structural Features of Missouri," Missouri Geological Survey & Water Resources, 1966.

3-15 Pike, R.W., Geologic map of the Crystal City, Missouri 15 minute quadrangle, M.S. thesis, University of Chicago, 1929.

3-16 Schmitz, R.J., Geologic map of the Festus 7.5 minute quadrangle, State of Missouri Geological Survey and Water Resources, 1965.

3-17 Thompson, T. L., "The Stratigraphic Succession in Missouri (Revised – 1995)," Missouri Department of Natural Resources, Division of Geology and Land Survey," V. 40 (2nd Series).

3-18 U.S. Department of Agriculture, Soil Survey of Jefferson County, Missouri, 2003.

3-19 Leggette, Brashears and Graham, Inc., "Hydrogeologic Investigation and Groundwater, Soil and Stream Characterization," Combustion Engineering Report, March 1999.

3-20 Leggette, Brashears and Graham, Inc., "Interim Hydrogeologic Investigation to Support the Engineering Evaluation and Cost Analysis for Response Actions for Off-Site Ground-Water Quality," Rev 0, Westinghouse Report, November 2002.

3-21 Science Applications International Corporation, "Remedial Investigation Report for the Westinghouse Hematite Site," EO-05-002.

3-22 Missouri Department of Natural Resources, WR-25, "Base-Flow Recession Characteristics and Seasonal Low-Flow Frequency Characteristics for Missouri Streams," 1970.

3-23 Gateway Environmental Associates, Inc., "Investigation to Determine the Source of Technetium-99 in Groundwater Monitoring Wells 17 and 17B, Combustion Engineering Hematite Facility," ABB Combustion Engineering, September 1996.

3-24 Science Applications International Corporation, "Aquifer Analysis by Slug Test Method," FTP-376.

3-25 U.S. Geological Survey, Archived and real time data for USGS 381405090260301 Festus, MO, 2005. http://waterdata.usgs.gov/mo/nwis/dv/?site_no=381405090260301&agency_cd=USGS

3-26 SAIC Report, "Radionuclide Activity in Bedrock Groundwater at Westinghouse Hematite Facility, Hematite, Missouri," Revision 0, July 2009.