For Public Comment Only

LMS/NFS/S06246

Formerly Utilized Sites Remedial Action Program

Niagara Falls Storage Site Vicinity Properties, New York: Review of Radiological Conditions at Six Vicinity Properties and Two Drainage Ditches

March 2010

For Public Comment Only

U.S. DEPARTMENT OF ENERGY | Legacy Management

This page intentionally left blank

For Public Comment Only

LMS/NFS/S06246

Formerly Utilized Sites Remedial Action Program
Niagara Falls Storage Site Vicinity Properties, New York: Review of Radiological Conditions at Six Vicinity Properties and Two Drainage Ditches

March 2010

This page intentionally left blank

Contents

Abbreviations iii
Executive Summary v
1.0 Introduction 1–1
1.1 Objective 1–3
1.2 Review Scope 1–3
2.0 Roles on FUSRAP NFSS Vicinity Properties 2–1
2.1 U.S. Department of Energy 2–1
2.2 U.S. Army Corps of Engineers 2–1
2.3 State and Federal Regulatory Agencies 2–2
2.4 Stakeholders 2–2
3.0 Site History 3–1
3.1 Operations 3–1
3.2 Cleanup Activities 3–1
3.2.1 Early Decontamination Activities 3–1
3.2.2 Vicinity Property FUSRAP Activities 3–2
4.0 DOE Vicinity Property Cleanup Process 4–1
4.1 Definition of FUSRAP Waste 4–1
4.2 Other Radiological Materials 4–1
4.3 FUSRAP Cleanup Guidelines 4–2
4.4 Assessment Process 4–4
4.5 Remediation Process 4–5
4.6 Verification Process 4–6
5.0 Results of DOE Investigations 5–1
5.1 Vicinity Property Q 5–1
5.1.1 Current Land Use 5–1
5.1.2 Review Findings 5–1
5.2 Vicinity Property R 5–10
5.2.1 Current Land Use 5–10
5.2.2 Review Findings 5–10
5.3 Vicinity Property S 5–13
5.3.1 Current Land Use 5–14
5.3.2 Review Findings 5–14
5.4 Vicinity Property T 5–14
5.4.1 Current Land Use 5–14
5.4.2 Review Findings 5–14
5.5 Vicinity Property W 5–17
5.5.1 Current Land Use 5–17
5.5.2 Review Findings 5–17
5.6 Vicinity Property X 5–17
5.6.1 Current Land Use 5–18
5.6.2 Review Findings 5–18
5.7 Drainages 5–20
5.7.1 Current Land Use 5–20
5.7.2 Review Findings 5–22
5.7.2.1 USACE RI/BRA Findings 5–22
6.0 Conclusions 6–1
6.1 Stakeholder/Outstanding Issues 6–1

7.0 Bibliography 7–1

Figures

Figure 1–1. NFSS Vicinity Map 1–2
Figure 1–2. NFSS Vicinity Properties Addressed by the Review 1–4
Figure 5–1. 2008 Aerial Photo of Vicinity Property Q 5–7
Figure 5–2. 1951 Aerial Photo of Vicinity Property Q 5–8
Figure 5–3. VP-Q: Fenceline Separating Modern Landfill and Small-Arms Range (East from Harold Road) 5–9
Figure 5–4. VP-Q: Entrance to Small-Arms Firing Range (Central to the Property, East of Harold Road, and North of Town of Lewiston Maintenance Shops) 5–9
Figure 5–5. VP-Q: View Northeast up Harold Road (Town of Lewiston Shops) 5–10
Figure 5–6. 2008 Aerial Photo of Vicinity Property R 5–11
Figure 5–7. 1951 Aerial Photo of Vicinity Property R 5–12
Figure 5–8. VP-R: View of Access Road that Parallels the West Drainage Ditch (December 2009) 5–13
Figure 5–9. VP-R: View North of West Drainage Ditch that Flows Through the VP 5–13
Figure 5–10. 2008 Aerial Photo of Vicinity Properties S, T, W, and X 5–15
Figure 5–11. 1951 Aerial Photo of Vicinity Properties S, T, W, and X 5–16
Figure 5–12. VP-X: View Northeast from IMHOFF Tank to Remains of Pump House 5–18
Figure 5–13. VP-X: IMHOFF Tank 5–19
Figure 5–14. VP-X: View West from IMHOFF Tank at Access from the Holding Ponds Off-site 5–19
Figure 5–15. VP-X: West Drainage Ditch within VP-X (West of the Sewage Treatment Plant) 5–20
Figure 5–16. Central and West Drainage Ditches (Niagara Falls Storage Site) 5–21
Figure 5–17. Central Drainage Ditch South from Balmer Road (September 2009) 5–23
Figure 5–18. Central Drainage Ditch View North Toward IWCS (September 2009) 5–23

Tables

Table 4–1. Standards for Remediation of FUSRAP Residual Radioactive Contamination at the NFSS VPs 4–3
Table 4–2. Background Radionuclide Concentrations at the NFSS VPs 4–4
Table 5–1. Summary of Radiological Conditions at the NFSS Vicinity Properties 5–2

Appendixes

Appendix A NFSS Vicinity Property Q
Appendix B NFSS Vicinity Property R
Appendix C NFSS Vicinity Property S
Appendix D NFSS Vicinity Property T
Appendix E NFSS Vicinity Property W
Appendix F NFSS Vicinity Property X
Appendix G Drainages

Abbreviations

AEC	U.S. Atomic Energy Commission
ALARA	as low as reasonably achievable
BNI	Bechtel National, Inc.
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm	centimeter
CWM	Chemical Waste Management
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ft	foot/feet
FUSRAP	Formerly Utilized Sites Remedial Action Program
IWCS	Interim Waste Containment Structure
KAPL	Knolls Atomic Power Lab
LOOW	Lake Ontario Ordnance Works
m	meter(s)
m^2	square meter
MAP	Management Action Plan
MED	Manhattan Engineer District
µR/h	microroentgen(s) per hour (radioactivity measurement)
mrem	millirem (dose measurement)
NFSS	Niagara Falls Storage Site
NRC	U.S. Nuclear Regulatory Commission
NYDOH	New York State Department of Health
NYSDEC	New York State Department of Environmental Conservation
ORAU	Oak Ridge Associated Universities
ORNL	Oak Ridge National Laboratory
pCi/g	picocurie(s) per gram (contamination measurement)
SPRU	Separations Process Research Unit
SFMP	Surplus Facilities Management Program
TEDE	total effective dose equivalent
TNT	trinitrotoluene
USACE	U.S. Army Corps of Engineers
VP	vicinity property

This page intentionally left blank

Executive Summary

Stakeholder concerns about final conditions at certain Niagara Falls Storage Site (NFSS) Vicinity Properties (VP) prompted the U. S. Department of Energy (DOE) to respond to the community with a desktop review of remediation documentation and land use of all VPs for which DOE has completed remediation activities under the Formerly Utilized Sites Remedial Action Program (FUSRAP). A more detailed data review was conducted for selected VPs (VP-Q, VP-R, VP-S, VP-T, VP-W, and VP-X) and associated drainages. DOE has determined that its assessment, remediation, and verification processes were thorough, and that FUSRAP wastes from the VPs have been remediated in accordance with DOE guidelines for unrestricted use.

The NFSS proper and associated VPs occupy approximately 1,500 acres of the original 7,500 acre Lake Ontario Ordnance Works (LOOW), a former trinitrotoluene manufacturing facility built during the 1940s. In 1944, the LOOW was reassigned to the Manhattan Engineer District (MED) and began to be used as a storage location for radioactive residues that resulted from the processing of uranium ore during the development of the atomic bomb and other radioactive material. By 1948, 6,000 acres of the original 7,500 acres were sold by the federal government, leaving the remaining 1,500 acres in the control of the newly formed U.S. Atomic Energy Commission (AEC), the agency that succeeded the MED.

In 1974, DOE began to address sites formerly used for MED and early AEC operations not addressed by other programs under FUSRAP, DOE completed remediation of 23 of the 26 designated VPs before transfer of FUSRAP to the U.S. Army Corps of Engineers (USACE). The USACE Buffalo, NY, District is responsible for remediating the remaining three VPs and the NFSS proper under FUSRAP.[1]

The documentation in the DOE records collection was found to adequately describe final radiological conditions at the completed VPs. All FUSRAP wastes at the completed sites were cleaned up to meet DOE guidelines for unrestricted use. However, it was determined that certain other radiological materials remain on some of the VPs. These include wastes from other types of activities and types of slag that have been used for railroad ballast, road base, and structural fill throughout the Niagara Falls area. Remediation of these materials will need to be investigated further by regulators, USACE, and DOE.

If previously undiscovered contamination is found that is eligible for remediation under FUSRAP, DOE will refer the property to USACE for investigation and remediation in accordance with the Memorandum of Understanding between the two federal agencies (DOE and USACE 1999).

[1] NFSS proper refers to the 191-acre parcel owned by DOE and containing the Interim Waste Containment Structure. The NFSS VPs are nearby properties that were found to contain MED/AEC radiological contamination and are owned by other entities.

This page intentionally left blank

1.0 Introduction

The Niagara Falls Storage Site (NFSS) is a small parcel (191 acres) within a much larger defense site—the former Lake Ontario Ordnance Works (LOOW), which is located 10 miles north of Niagara Falls, NY (Figure 1−1). The LOOW was constructed in 1942 and encompassed approximately 7,500 acres. During World War II, the U.S. Army built and operated a trinitrotoluene (TNT) plant on approximately 2,500 acres of the site known as the "developed zone." The remaining 5,000 acres were used as a "buffer zone" around the TNT plant. The plant manufactured bulk TNT for approximately nine months and was decommissioned in 1943 (USACE 2009).

In 1944, the Manhattan Engineer District (MED) started storing uranium ore processing residues on approximately 1,650 acres of the former developed zone of the LOOW. Between 1947 and about 1952, the U.S. Atomic Energy Commission (AEC) continued to import, store, and dispose of radioactive wastes on the NFSS through 1952 and used the site for transshipment of processed uranium and other radioactive materials. In the 1950s, AEC relocated most of the stored material to the NFSS proper.

The residues and waste came from multiple sources. Most of the radioactive material stored at LOOW was from uranium ore processing. This material, known as residues, consisted of finely crushed rock from which the uranium was removed, but still contained the uranium decay products. Much of the residues contained only low levels or radioactivity and came from the Linde site in Tonawanda, NY, and other sources. However, MED also stored residues left from processing ore from the Belgian Congo, some of which contained as much as 65 percent uranium (the "K-65" residues). These were actually owned by the mining company and MED acquired only the uranium portion of the ore, but the U.S. Government acquired title to these residues and placed them in the Interim Waste Containment Structure (IWCS) on NFSS proper.

Other sources of radioactive material included the Knolls Atomic Power Laboratory, the University of Rochester, and material used for the construction of road and railways (slag). The slag contains low levels of radioactivity and was brought onto the LOOW during construction of the TNT facility.

If the radioactive material encountered at LOOW did not come from MED or early AEC operations or if it was managed under a different program, that waste may not be eligible for remediation under the Formerly Utilized Sites Remedial Action Program (FUSRAP). DOE generally left these material in place.

In the 1950s work was performed to consolidate the storage of radioactive materials and reduce the footprint of the AEC operation. Excess property surrounding the operations areas was subdivided and sold to the public or transferred to U.S. Department of Defense (DOD) ownership. Of the original AEC acreage, only the 191-acre NFSS remains under DOE ownership.

The NFSS and the NFSS VPs were included in FUSRAP by DOE. In the 1980s DOE remediated 23 of the VPs and consolidated the wastes into the 10-acre IWCS located on the NFSS. The VPs were certified to meet DOE guidelines for unrestricted use by DOE in 1990.

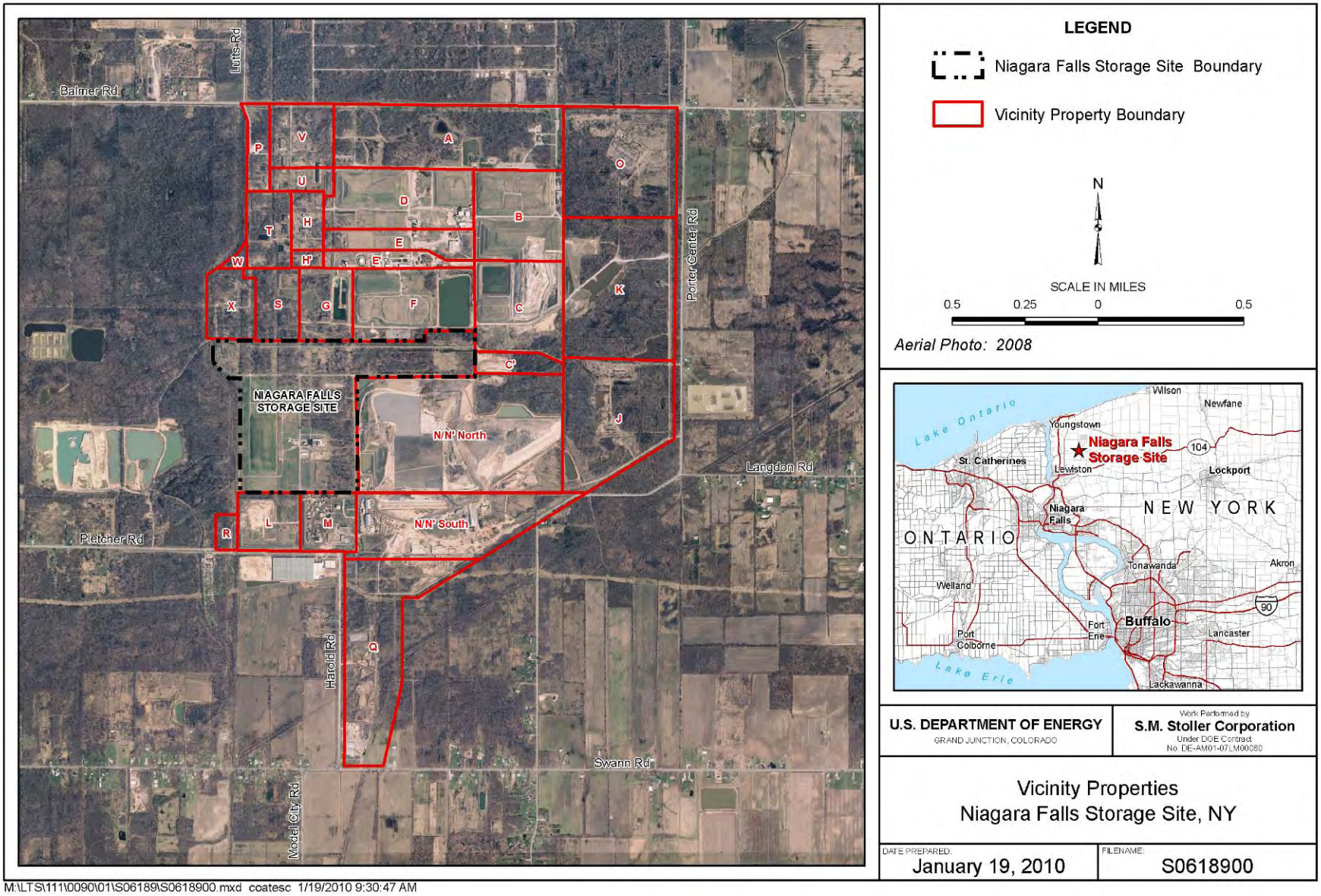

Figure 1–1. NFSS Vicinity Map

Responsibility for cleanup of FUSRAP sites was transferred from DOE to the U.S. Army Corps of Engineers (USACE) in 1997. USACE is responsible for conducting remediation activities at the NFSS and the NFSS VPs for which remediation was not complete at the time of transfer from DOE. USACE is also responsible for remediation of other DOD-related contamination at the LOOW, including contamination that may be identified on completed FUSRAP VPs.

The VPs are currently either vacant or used for industrial, local government, or commercial purposes. The majority of completed VPs were found to have restricted access and are used for either hazardous materials or municipal landfills.

1.1 Objective

This desktop review included (1) current land use and final radiological conditions for all of the completed VPs and (2) a more detailed records review of six VPs (VP-Q, VP-R, VP-S, VP-T, VP-W, and VP-X) and associated drainages (Figure 1−2). These six areas were selected by DOE based on specific stakeholder inquiries, the accessibility of the properties, and proximity to former operations on the NFSS.

The objectives were as follows:

- Ensure that DOE records of FUSRAP activities at NFSS and NFSS VPs is complete;
- Review documentation of the assessment, remediation, and verification of the completed VPs to confirm that those properties meet cleanup standards; and
- Determine if new information indicates the need to refer a completed VP to USACE for assessment.

1.2 Review Scope

This review concentrated on site records located within DOE's Considered Sites Library as well as the USACE Buffalo District's holdings. Most of the summary reports and correspondence were located. Some field records and planning documents could not be located, and DOE will continue to the search for them.

DOE interviewed members of the team that conducted the original verification surveys, and coordinated with the New York State Department of Health (NYDOH), the New York State Department of Environmental Conservation (NYSDEC), and the U.S. Environmental Protection Agency (EPA) as well as the USACE in gathering additional information.

The majority of completed VPs were found to have restricted access and currently are being used for either hazardous materials or municipal landfills.

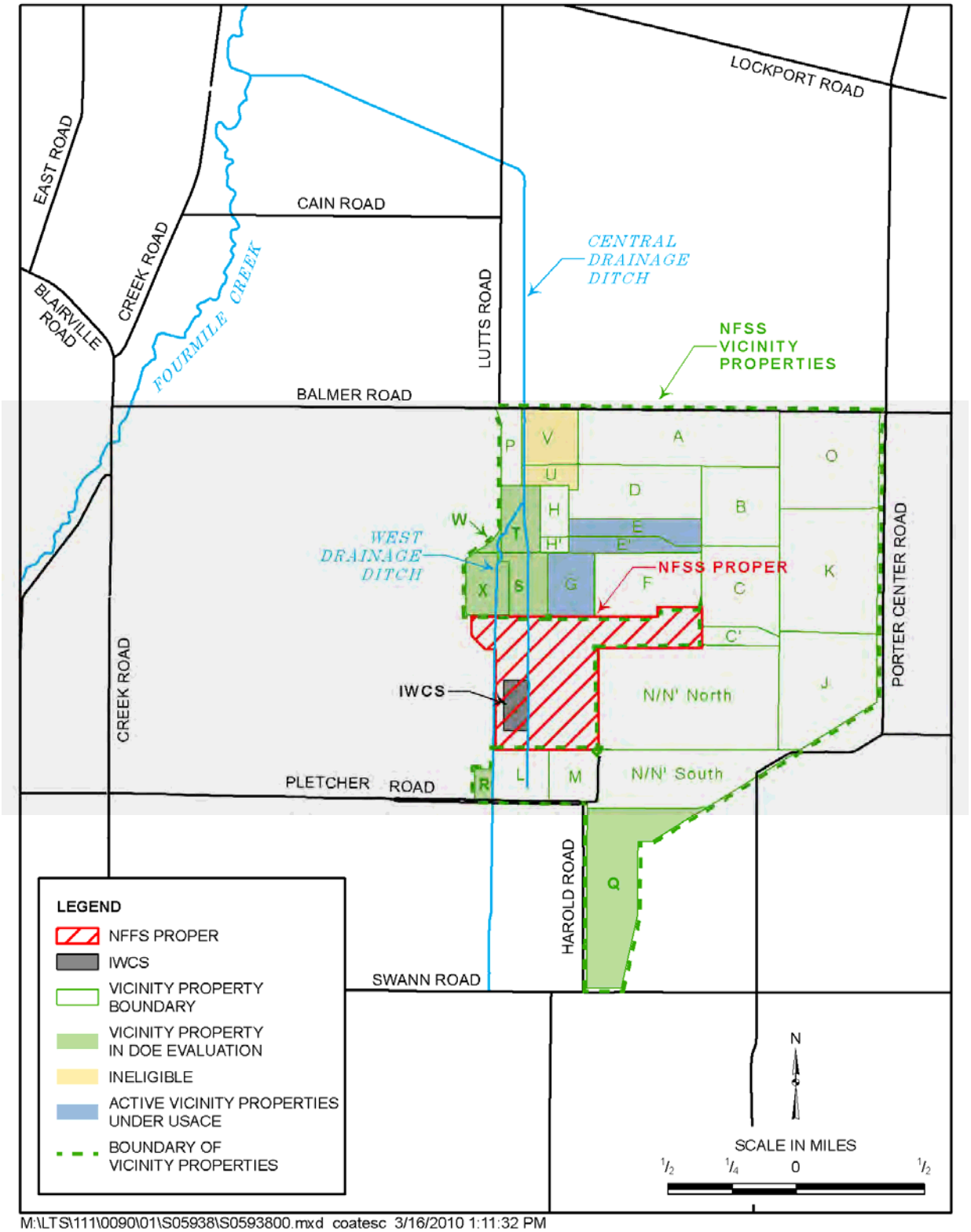

Figure 1–2. NFSS Vicinity Properties Addressed by the Review

2.0 Roles on FUSRAP NFSS Vicinity Properties

The following sections outline the roles and responsibilities of DOE, USACE, state and federal agencies, and stakeholders involved with the NFSS proper and its VPs.

2.1 U.S. Department of Energy

FUSRAP was created in 1974. Cleanup of eligible FUSRAP sites was the responsibility of the AEC and its successor agency, DOE, until 1997. AEC/DOE was self-regulated under the Atomic Energy Act and established cleanup criteria and remediation processes for FUSRAP sites (see additional discussion in Section 4.2). Under FUSRAP, DOE was responsible for the cleanup of only radiological contamination. For remediation of the NFSS VPs, correspondence records indicate that NYSDEC, NYDOH, and EPA were kept informed and consulted during the decontamination, assessment, and remediation.

During review of the NFSS and surrounding areas, conducted in the 1970s and 1980s under the authority of DOE, properties adjacent to the NFSS that were known or suspected of having been used for storage of radioactive materials were designated as VPs for environmental response and were assigned letter designations (Figure 1−2). As of March 1997, DOE had completed remediation of all but three VPs. DOE has responsibility for long-term surveillance of the completed VPs. The NFSS and the three partially remediated VPs (VP-E, VP-E′, and VP-G) are still active FUSRAP sites under the authority of USACE.

In addition to long-term surveillance and maintenance activities for the completed VPs, DOE is responsible for determining if new information or changed site conditions warrant the referral of a completed site to USACE for additional assessment and, if necessary, remediation, and for determining if a new site is eligible for remediation under FUSRAP.

DOE uses the following criteria to determine if a site should be referred to USACE for further assessment:

- A third-party characterization or survey reveals existing MED- or AEC-related contamination that was not previously identified;
- A review of historical records indicates the potential for existing MED/AEC contamination that was not previously identified; or
- An individual with credible institutional knowledge provides information that additional MED/AEC contamination might exist that was not identified in previous assessments.

2.2 U.S. Army Corps of Engineers

Congress transferred responsibility for assessing and remediating FUSRAP sites from DOE to USACE in 1997. In March 1999, DOE and USACE entered into a Memorandum of Understanding for the purpose of delineation, administration, and execution of responsibilities for FUSRAP (DOE and USACE 1999). It was agreed that USACE has the authority to administer and execute cleanup activities at eligible FUSRAP sites pursuant to the provisions of the Energy and Water Development Appropriations Act of 1998, the Energy and Water Development Appropriations Act of 1999, the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), and the National Oil and Hazardous Substances

Pollution Contingency Plan. In addition, it was agreed that DOE does not have regulatory responsibility or control over the FUSRAP activities of USACE. Except as noted in the Memorandum of Understanding, USACE is responsible for all environmental response activities at a FUSRAP site until two years after remedial action is complete, at which time DOE assumes responsibility for long-term surveillance and maintenance of the site.

USACE is responsible for the cleanup of FUSRAP wastes from the NFSS and the three VPs that were still "active" when the program was transferred in 1997. Additionally, USACE is responsible for cleanup of DOD-related wastes from approximately 6,500 acres of the LOOW, which includes the NFSS and VPs. This cleanup is being conducted under the Defense Environmental Restoration Program for Formerly Used Defense Sites.

2.3 State and Federal Regulatory Agencies

NYSDEC provides input and oversight of the USACE Buffalo District's ongoing FUSRAP cleanup, as well as regulatory oversight of the Modern Municipal Companies municipal waste landfill and Chemical Waste Management (CWM) hazardous waste landfill. These landfills occupy the majority of the VPs and access is restricted to the VPs that lie within their properties. NYSDEC has established guidelines for the cleanup of soils contaminated with radioactive materials (DSHM-RAD-05-01). NYSDEC policy states that the total effective dose equivalent (TEDE) to the maximally exposed individual of the general public from radioactive material remaining after site cleanup shall be as low as reasonably achievable (ALARA) and less than 10 millirem (mrem) above that received from background levels of radiation in any one year.

NYDOH maintains land use controls over portions of the NFSS and VPs. These were first imposed in 1972 after initial AEC activities indicated that dose rates from stored radioactive materials were potentially hazardous to the public. These controls, in the form of use restrictions, are still in effect for several of the completed VPs and prevent the properties from development or disturbance of the surface without an acceptable plan approved by the Commissioner of Health (Wallo 1980 and DOE 1980). Under these restrictions, the owner or future owner of a restricted property is responsible for performing the necessary due diligence in the case of sale of the property or a change in surface conditions or land use to ensure compliance with the restrictions.

EPA Region 2 provides regulatory oversight of the USACE operations and assists NYSDEC in its oversight of the municipal and hazardous waste landfill operations.

2.4 Stakeholders

USACE currently has a public outreach program for the LOOW and NFSS that is highlighted in the *Public Involvement Plan for the Former Lake Ontario Ordnance Works Site (Defense Environmental Restoration Program for Formerly Used Defense Sites) and Niagara Falls Storage Site (Formerly Utilized Sites Remedial Action Program)* for Lewiston and Porter, New York for 2009-2010 http://www.lrb.usace.army.mil/derpfuds/loow-nfss/loow-nfss-publicinvolvplan-2009-05.pdf (May 2009).

USACE has allowed DOE to present information to stakeholders at USACE public meetings. DOE has provided contact information to stakeholders and DOE will respond to stakeholder inquiries.

Stakeholders may contact DOE through Bob Darr, S.M. Stoller Public Affairs, at 720-377-9672 or bob.darr@lm.doe.gov.

This page intentionally left blank

3.0 Site History

This section provides a chronological history of operations, investigations, and remedial actions performed on the VPs, including the properties that are the focus of this review.

3.1 Operations

The LOOW was initially established on 7,500 acres of land as a TNT facility and operated from 1942 until 1944, when the site was reassigned from the Army to MED. The majority of the activities were conducted on 1,500 acres of the site as the "Developed Area" (USACE 2009). The "Undeveloped Area" was approximately 6,000 acres that surrounded the active process areas and served as a buffer for the site.

Between 1944 and 1954, MED/AEC stored low-level wastes on the Developed Area. These wastes consisted primarily of residues from uranium processing operations, but also included contaminated rubble and scrap from decommissioning activities, other biological and miscellaneous wastes from the University of Rochester, and low-level fission-product wastes from contaminated-liquid evaporators at the Knolls Atomic Power Lab (KAPL).

From 1955 to 1975, more than 1,300 acres of the Developed Area were transferred or sold to private concerns, leaving the current interior 191 acres that the NFSS comprises. The surrounding acreage that had been sold or transferred became known as the NFSS Vicinity Properties (AEC 1973).

3.2 Cleanup Activities

3.2.1 Early Decontamination Activities

During October 1970 and June 1971, radiological surveys of the approximately 1,300 acres formerly held by AEC indicated that about 6.5 acres exceeded the AEC exposure criterion of 50 microroentgens per hour (µR/h). As a result of this survey, 15,000 to 20,000 cubic yards of contaminated soil and debris were removed and transported to the NFSS during 1972 (AEC 1973).

In 1971, EG&G conducted an aerial survey of the greater Niagara Falls area (EG&G 1978). This survey identified several areas of elevated gamma radiation. Most of these areas were later shown to contain a slag-type material similar to wollastonite ($CaSiO_3$); this material was referred to in various reports as pseuowollastonite or cyclowollastonite. This material was reported to be of natural origin, probably the byproduct of a local metal processing or phosphorous extraction process.

In April 1972, following a review of AEC's survey data, NYDOH placed land-use restrictions on all the excessed properties (Town of Lewiston 1980 and Wallo 1980).

In October 1978 DOE conducted another follow-up aerial survey using a helicopter for more sensitive readings (EG&G 1978). The survey did not indicate the presence of any significant gamma radiation off site except for in the drainage ditches. A mobile ground scanning was also performed to confirm the areas identified by the aerial survey (DOE NY.17-7 1979).

In 1979 and 1980, Battelle Columbus Laboratories conducted a comprehensive radiological characterization of the NFSS, including the West and Central Drainage Ditches, both on site and off site (Battelle Columbus Laboratories 1981). This survey identified contamination that exceeded DOE guidelines along the entire length of the West Drainage Ditch and the upstream portion of the Central Drainage Ditch. This initiated a resurvey of the off-site areas to determine whether any residual contamination existed in other areas. DOE began a systematic review of the VPs, as summarized in Section 3.2.2.

3.2.2 Vicinity Property FUSRAP Activities

The following is a chronology of the FUSRAP-related activities undertaken by DOE for the NFSS VPs:

- **1981:** Bechtel of Oak Ridge, Tennessee, replaced National Lead Company as the manager of the NFSS.
- **1982:** A Background and Resurvey Recommendations investigation was performed on the AEC portion of the LOOW (VPs) (Aerospace Corp 1982).
- **1981–1985:** Oak Ridge Associated Universities (ORAU) and Oak Ridge National Laboratory (ORNL) performed individual vicinity-property comprehensive radiological surveys of the 1,300 acres that were formerly part of the AEC-owned portion of the LOOW and lie outside the boundaries of the NFSS proper (ORAU 1983a through 1983e and ORAU 1984a through 1984s). Gamma exposure rates on 21 of the 26 properties exceeded DOE guidelines. (See Appendixes A through G for results associated with the six NFSS VPs and associated drainages addressed in this report.)
- **1983–1986:** Bechtel National, Inc., (BNI) performed remedial/post-remedial actions for DOE Oak Ridge Operations Office on the individual VPs based on the comprehensive radiological assessments by ORAU and ORNL.
- **1983–1984:** Supplemental Residual Contamination Guidelines were developed, as part of the remedial/post-remedial action being performed on the Central Drainage Ditch (BNI 1986).
- **1983–1989:** ORAU, under contract to DOE for FUSRAP, performed independent verification surveys and sampling on each of the VPs. Three of the properties could not be surveyed due to an inability to access the ground surface because of existing wet areas or ponds and paved areas. These VPs (VP-E, and VP-E′ and G) continue to be classified as active VPs to be evaluated and remediated in the future by USACE.

The radiological surveys conducted by DOE between 1979 and 1985 indicated that the majority of contamination was located on the NFSS proper and associated drainages. Remedial activities were completed in 1986 by DOE which removed approximately 50,000 cubic yards of low-level radiologically contaminated soil. The contaminated soil and the uranium residues are stored in the IWCS that is located on the NFSS proper. The USACE is actively performing a Remedial Investigation/Feasibility Study under CERCLA on the NFSS proper. The remaining VPs are completed and are in a records-only status as the Niagara Falls Vicinity Properties, New York Site with the exception of three VPs that will remain open until assessment/remediation can be performed by USACE.

4.0 DOE Vicinity Property Cleanup Process

4.1 Definition of FUSRAP Waste

For wastes to be eligible for cleanup under FUSRAP, the following requirements must be satisfied:

- The wastes must have been generated by MED/AEC activity, which occurred from approximately the 1940s to the early 1960s (requires historical and process knowledge).
- The wastes have radioactive contaminants.
- The wastes must not be addressed under another program (e.g., CERCLA, U.S. Nuclear Regulatory Commission [NRC] license).

FUSRAP wastes primarily consist of low levels of uranium or thorium, along with their associated decay products. Wastes include ores and residues or similar materials derived from processing the ores (similar in character to uranium mill residues), as well as radioactive scrap and other process wastes.

DOE was not authorized to remediate waste under FUSRAP that resulted from non-FUSRAP eligible activities. Indicators that waste not eligible under FUSRAP included the following:

- The waste was brought or used at site before or after the 1940s to 1960s time frame.
- The waste was not related to MED/AEC activity (e.g., activities conducted by DOD).
- The waste has characteristics unlike known FUSRAP wastes for a given site (based on site-specific knowledge of MED/AEC activities).

Based on these criteria, wastes described in Section 4.2 that would not be eligible for remediation under FUSRAP wastes are the pseudowollastonite and metal separation slag. Other materials to be evaluated for eligibility under FUSRAP are related to the University of Rochester and Knolls Atomic Power Lab/ Separations Process Research Unit (KAPL/SPRU). Based on process knowledge typically when other radiological materials were encountered during assessment, remediation, and verification DOE contractors generally left them in place and documented their occurrence.

4.2 Other Radiological Materials

Other radiological materials were identified during the FUSRAP cleanup activities described in Section 3.2.2 and are described in the following:

- **Knolls Atomic Power Lab/Separations Process Research Unit (KAPL/SPRU) wastes:** These wastes consist of semisolid neutralized radioactive waste, fission products from evaporator bottoms of a pilot plant fuel reprocessing operations. This was a federal research and development project to extract plutonium and uranium from canisters in support of the development of the PUREX process. The federal research was conducted on a laboratory scale and never production plant size (Aerospace Corp 1982). KAPL/SPRU is currently being addressed at the Schenectady NY facility under a separate program by DOE Office of Environmental Management. If KAPL wastes exceeding current guidelines are determined

to exist on the NFSS or any of the completed VPs the USACE and DOE will coordinate to determine the necessary path forward.

- **Metal separation slag:** Prior assessment surveys identified numerous pieces of slag-like rock in the base material beneath an asphalt parking lot north of a two-story structure on VP-P. These pieces of slag-like material were determined to contain elevated radionuclide concentrations as high as 940 picocuries per gram (pCi/g) of the Th-232 decay series and as high as 190 pCi/g of the U-238 series. Both of these naturally occurring decay series appeared to be in secular equilibrium (that is, generally found in concentrations that indicate the material was not processed to remove a particular radionuclide). The slag-like material was therefore considered to be non FUSRAP eligible and was not removed as part of the remediation of this property. (Berger 2009).
- **Pseudowollastonite slag:** Pseudowollastonite slag was commonly used mostly as construction material for road base and railroad grades in Niagara County during the time of LOOW construction. Pseudowollastonite slag was identified at numerous locations, both on the NFSS VPs (for example, VP-H) and at other locations in the Lewiston and Niagara Falls area. The slag was described as typically very hard and exhibiting a glass-like blue/green/gray coloring. The pieces were typically 1 to 2 inches in size and had generally flat sides with distinct edges. The individual pieces did not appear to be weathered or worn, suggesting that the slag was mechanically fractured into these small pieces. This type of slag contains equal activities of uranium and radium, in the range of approximately 5 to 50 pCi/g. It is not regarded as a FUSRAP waste originating from AEC/MED operations but instead as part of the construction materials brought in by contractors constructing the LOOW in the early 1940s. ORNL attributed it to early elemental phosphorus operations by Niagara Falls electrochemical plants (Berger 2009).
- **University of Rochester:** Radiation safety research was performed by the University during the MED era on VP-G, an active FUSRAP Site not addressed under this project. Burial of contaminated carcasses and waste from laboratory animals occurred on VP-G, an active FUSRAP Site. Ignitors for nuclear Model 1 (strontium 90) and Model 3 gaps (cesium-137) were sent to LOOW for storage or burial. One gap reading 11 μR/h on contact was removed from the University of Rochester burial area (Aerospace Corp 1982). VP-G remains active due to areas that could not be adequately surveyed during the comprehensive assessments (surface structures or ponds) and therefore was not remediated. Future RI work will need to be performed prior to determining whether the site can be closed or will require remediation. If during the RI work any of the University of Rochester waste is determined to be FUSRAP related, then DOE will evaluate with the USACE a path forward.

4.3 FUSRAP Cleanup Guidelines

Under FUSRAP, DOE cleanups did not fall under the authority of any separate regulatory agency. There were no formal cleanup criteria established by statute. FUSRAP guidelines for residual radioactive materials (DOE 1987) were developed for the protection of public health and the environment based on radiation protection dose standards consistent with recommendations of the International Commission on Radiological Protection; guidelines established for other remedial programs (e.g., Title 40 *Code of Federal Regulations* Part 192); and guidelines established in DOE Orders (Orders 5480.1A & B, superseded by Order 5400.5). Guidelines for radiation protection and for residual radioactive contamination that are currently in DOE Order 5400.5, “Radiation Protection of the Public and the Environment” are identical to and

supersede the FUSRAP Guidelines (DOE 1987) and are generally referred to in this document as the "DOE guidelines."

DOE guidelines include a basic dose limit for the general public for exposure to radiation from DOE activities (including remedial actions) of 100 mrem/yr above normal background. This basic dose limit, which is based on International Commission on Radiological Protection recommendations, was used to establish generic soil guidelines that apply to "worst-case plausible-use" scenarios (DOE Order 5400.5). The basic dose limit can also be used to calculate site-specific soils cleanup levels for radionuclides that do not have numerical limits or for site-specific exposure scenarios. (Numerical limits have also been developed for surface contamination of structures. Those are not discussed here because, with the exception of an old warehouse located on Property B, the remedial action at NFSSA involved removal of contaminated soil, therefore, the soil guidelines are most relevant to the data review summarized in this report).

The generic soil guidelines are based on average radionuclide concentrations over an area of 100 square meters (m^2). The generic guidelines for radium-226, radium-228, thorium-230, and thorium-232 are 5 pCi/g above background averaged over 100 m^2 in the first (surface) 15-centimeter- (cm-) thick soil layer and 15 pCi/g above background averaged over 100 m^2 within any subsequent 15-cm-thick soil layer below the surface layer (Table 4−1).

Table 4–1. Standards for Remediation of FUSRAP Residual Radioactive Contamination at the NFSS VPs

Type of Occurrence	Standard
Contamination in Soil	FUSRAP/SFMP Guidelines[a] DOE Order 5400.5[b] Derived limits for total uranium and cesium-137[c]
Surface Activity (structural surfaces)	FUSRAP/SFMP Guidelines[a] DOE Order 5400.5[b]
Gamma Exposure Rate (interior areas only)	FUSRAP/SFMP Guidelines[a] DOE Order 5400.5[b]
Radon Decay-Product Concentration (interior areas only)	FUSRAP/SFMP Guidelines[a] DOE Order 5400.5[b]
Total Effective Dose Equivalent	FUSRAP/SFMP Guidelines[a]

[a]DOE (U.S. Department of Energy), 1987. *Guidelines for Residual Radioactive Material at Formerly Utilized Sites Remedial Action Program (FUSRAP) and Remote Surplus Facilities Management Program Sites*.
[b]DOE Order 5400.5, *Radiation Protection of the Public and the Environment.*
[c]DOE (U.S. Department of Energy), 1988. *Derivation of a Uranium and Cesium-137 Residual Radioactive Material Guidelines for the Niagara Falls Storage Site,* Argonne National Laboratory, Chicago, IL, August.

DOE guidelines also establish criteria for evaluating "hot spots" based on the areal extent and maximum concentration of contamination, and a mixture rule for occurrences where more than one radionuclide is present.

During the assessment and cleanup process discussed in Sections 4.4 through 4.6, assessment and verification data were compared not only to DOE guidelines but also to background or baseline measurements collected throughout the Lewiston area. Background measurements used during verification activities for radium-226 and thorium-232 ranged up to 1.2 pCi/g. Background surface exposure rates (at 1 meter [m] above ground surface) ranged from 7 to 9 μR/h (Table 4−2).

Table 4–2. Background Radionuclide Concentrations at the NFSS VPs

Radionuclide	Background[a]
Radium-226	<0.9 to 1.22 pCi/g
Thorium-232	0.32 to 1.18 pCi/g
Uranium-235	<0.14 to 0.46 pCi/g
Uranium-238	< 2.20 to 6.26 pCi/g
Cesium-137	<0.02 to 1.05 pCi/g
Dose Rate at 1 m	6.7 to 8.6 μR/h

[a]DOE ** to DOE
Key: m = meter(s); pCi/g = picocurie(s) per gram; μR/h = microroentgens per hour

DOE conducted remediation activities to result in contamination levels that were "as low as reasonably achievable" (DOE Order 5400.5). This concept refers to an approach to radiation protection to control or manage (1) exposures (both individual and collective, to the workforce and the general public) and (2) releases of radioactive material to the environment as low as social, technical, economic, practical, and public policy considerations permit. The objective of the DOE guidelines is to attain dose levels as far below the applicable limits as is reasonably achievable.

4.4 Assessment Process

For each of the properties included as a VP, a comprehensive radiological survey was conducted by ORAU or ORNL. The technical approaches as well as the results of these surveys are summarized in separate reports for each property (ORAU 1983a through 1983e and ORAU 1984a through 1984s). The surveys employed a systematic approach to characterizing radiological contamination at each site as follows:

- Brush and weeds were cleared as necessary to provide access for gridding and surveying.
- A grid system was established for each property. Grids ranged in size from 10 m to 80 m, depending on the known history of the site and whether contamination was likely to be present. Previous survey data (for example, the Battelle Columbus Laboratories survey), if available, were also used to make this determination.
- Gamma exposure rates were measured at the surface and 1 m above the surface for each grid interval.
- Beta-gamma rates were measured 1 cm above the surface at each grid interval.
- Surface soil samples were collected at grid intervals, and from within each gridded area in a systematic, non biased, uniform sampling procedure.
- Additional, biased samples were collected from those areas of known contamination and at locations where more detail was required.
- Walkover surface scans were conducted over accessible areas of each property.
- Where walkover scans detected elevated surface radiation, beta-gamma dose rates and exposure rates at 1 m above the surface were measured. Surface soil samples were collected,

and surface exposure rates were re-measured to determine the effectiveness of sampling on source removal.

- Analysis of soil samples included Th-232, U-238, Th-230, Cs-137, and Ra-226.
- Ground penetrating radar surveys were performed at selected properties where known burial areas existed.
- Boreholes were drilled and logged at selected locations. Borehole locations were placed at locations of known previous burials, at selected locations of surface contamination, and at locations of surface targets identified by ground penetrating radar. Samples were collected from the borings included grab water samples and soils. Downhole gamma logging was performed on the borings prior to completion. Additional locations were also distributed throughout the accessible portions of the properties to provide more representative data.

The survey reports compared sample results to cleanup guidelines and identified areas where radionuclide concentrations exceeded the guidelines. Volumes of material requiring remediation were estimated. The survey reports included maps showing the sampling grids, borehole locations, other sampling locations, and areas where radionuclide concentrations in soil exceeded criteria. Results of all grid sampling were also included (analytical results, gamma, and beta-gamma) in the summary reports. However, the field documentation supporting the summary reports were not included (walkover survey data).[2]

4.5 Remediation Process

Based on the radiological survey results, engineering drawings were prepared to guide remediation activities. These delineated the identified areas exceeding the remediation guidelines. Remediation activities consisted of the following:

- Contaminated areas were resurveyed and marked for excavation.
- Contaminated soils were removed from marked areas to the depth specified.
- After excavation, a gamma scan of the excavated area was performed to ensure that no significant areas of contamination remained. Additional contamination was removed, if necessary, until average concentrations met DOE guidelines.
- A 10 foot (ft) grid was established in the excavated areas, and soil samples were collected from alternate grid intersections (every 20 ft) for confirmatory analysis.
- Gamma count rates were obtained for each grid intersection point.
- Excavated areas were backfilled with clean fill material.

Two post-remedial-action reports were prepared: one for remediation activities conducted in 1983 and 1984 (BNI 1986) and one for remediation activities conducted in 1985 and 1986 (BNI 1989). These reports summarized the remediation activities and the post-remediation status for each property. Maps were included showing the extent of excavations and the locations of post-remediation samples. Laboratory data for post-remediation sampling was also provided in these reports.

[2] DOE may have found the gamma walkover survey data in ORAU records. Confirmation and acquisition of the data for the DOE FUSRAP collection is pending.

4.6 Verification Process

Following the post-remedial-action sampling, ORAU performed an independent verification of the cleanup work for the VPs. The verification process included the following:

- A review of characterization reports, engineering drawings, and post-remedial-action reports.
- Laboratory analysis of selected samples (sample splits) collected by the remediation contractor to confirm the accuracy of the post-remedial-action sampling results.
- A survey of the excavated areas, including visual inspections, gamma scans, direct measurements, and surface and subsurface sampling, on representative portions of the excavated areas.

Results of the verification work were compared with background exposure rates and soil concentrations for the Lewiston area. Results of verification sampling were included in the two verification reports (ORAU 1989 and ORAU 1990).

Statements of certification were prepared that addressed all of the completed sites and were signed by the director of DOE Oak Ridge Operations Office. The statements indicated that the properties were determined to be in compliance with DOE decontamination criteria and standards (DOE Order 5400.5 and FUSRAP Guidelines). Letters of certification were sent to property owners. After remediation of all VPs was completed (except those that were transferred to the USACE), DOE-HQ published a *Federal Register* notice of certification for the NFSS VPs site and made the certification docket available for public review (DOE 1992).

5.0 Results of DOE Investigations

Table 5−1 summarizes information from the comprehensive radiological assessments, the post-remedial-action reports, and the verification reports for all of the VPs that were certified as "completed" at the time the remainder of the project was transferred to USACE.

Current land use was evaluated by representatives of DOE Office of Legacy Management on two occasions, in September and December 2009. Aerial photos were reviewed to determine current site land use. The following sections describe conditions observed during the 2009 site visits and from the review of 2008 aerial photography. A 1951 aerial photograph of these sites is also provided for comparison with the 2008 aerial photographs. On-site photographs could not be obtained from VP-S, VP-T, and VP-W, because the areas were fenced and secured by the owner, CWM.

Specific information for the six VPs and the associated drainages is provided in the following sections.

5.1 Vicinity Property Q

VP-Q covers approximately 89 acres (36 hectares). It is the southernmost VP, bounded on the west by Harold Road and on the south by Swan Road. The northern boundary is a fence dividing Town of Lewiston property and that owned by the operator of a municipal landfill. South Patrol Road forms the northeast boundary and the eastern boundary is not delineated by a feature. Three structures were located on the property during the MED/AEC operations; these structures have since been demolished or destroyed by fire.

A former railroad grade can be observed in aerial photographs (2008 and 1951) running from southwest to northeast and also north and south across the property. The central portion of the property is accessible to the public.

5.1.1 Current Land Use

Current land use can be described as a mixture of municipal landfill (north), a small-arms firing range (central), composting/materials-storage-area (central), and Town of Lewiston maintenance shops on the southernmost tip (Figure 5−1).

5.1.2 Review Findings

Assessment data tables, a survey grid, and the remedial action survey information is located in Appendix A. Table 5−1 summarizes the pre-remediation assessment, remediation action, post-remedial action, and verification results.

Surface scans during verification identified three regions of elevated radioactivity. The area near former warehouse location was cleaned up to background levels. Areas adjacent to railroad tracks had cinder and ash-like materials that were cleaned up to near-background levels. Elevated gamma levels near a dirt access road were associated with ash-like material. This area was cleaned up, and remediation resulted in reduced exposure rates (14–24 μR/h); samples met DOE guidelines. A large remediated area had gamma scans within range of background. Soil was removed from two small areas of contamination, and subsequent sampling was within the baseline range.

Table 5–1. Summary of Radiological Conditions at the NFSS Vicinity Properties

VP-ID	Ownership/ Access	Pre-remediation Assessment Status	Remediation Performed	Post-remedial Action Status	Verification Status	Current Land Use/Site Conditions
A	CWM/ Perimeter Fence and security	80 m grid samples <5 pCi/g; numerous areas isolated; contamination identified on walkover scans; mainly small rock chips, crushed rock; likely would meet 100 m^2 guideline	4 areas decontaminated; backfilled	All samples < 5 pCi/g	Remediated areas at background; isolated elevated areas identified, removed, and rescanned.	Hazardous waste landfill operations
B	CWM/ Perimeter Fence and security	40 m grid samples <5 pCi/g; 100 m^2 guideline exceeded in areas around warehouse; warehouse exceeds surface criteria for buildings; incomplete scan of warehouse interior due to stored waste containers	7 areas decontaminated; backfilled	4 samples exceed 5 pCi/g; met average of 4.1 pCi/g (excluding background)	Cleanup to remove polychlorinated biphenyls (PCBs) will address residual radiological contamination	Hazardous waste landfill operations
C	CWM/ Perimeter Fence and security	40 m and 20 m grid samples all <5 pCi/g; no areas of surface contamination identified in walkover survey	Remediation not required	Not applicable	Not applicable	Hazardous waste landfill operations
C′	CWM/ Perimeter Fence and security	Samples collected sitewide on 20 m grid; one area subdivided into 10 m grid; elevated naturally occurring and MED/AEC materials identified ; hot spots identified on south-central portion of property	4 areas decontaminated; not backfilled because below water	2 samples exceed 5 pCi/g (excluding background); meet average of 1.9 pCi/g (including background)	Additional cleanup performed based on elevated readings; following cleanup, 2 locations exceeded 15 pCi/g but met hot spot criteria for 1 m^2 and DOE criteria for 100 m^2	Hazardous waste landfill operations
D	CWM/ Perimeter Fence and security	All 40 m grid samples <5 pCi/g; walkover surveys identified small pieces of elevated materials; rock samples with elevated uranium and thorium; numerous areas with small isolated pieces of contaminated materials (not dispersed in soil)	8 areas decontaminated	1 sample exceeds 5 pCi/g; average 1.3 pCi/g above background	Residual pieces of material removed; no elevated readings following removal	Hazardous waste landfill operations
F	CWM/ Perimeter Fence and security	40 m and 20 m grid samples all <5 pCi/g; small isolated areas of elevated concentration identified by walkover scan, and sampling removed most of this; many isolated areas of contamination located adjacent to main roads, suggesting minor spills	1 area decontaminated and backfilled	Sample meets 5 pCi/g	1 elevated area removed; remaining soil <5 pCi/g	Hazardous waste landfill operations

Table 5−1 (continued). Summary of Radiological Conditions at the NFSS Vicinity Properties

VP-ID	Ownership/ Access	Pre-remediation Assessment Status	Remediation Performed	Post-remedial Action Status	Verification Status	Current Land Use/Site Conditions
H	CWM/ Perimeter Fence and security	<3% of 20 m grid locations exceeded 5 pCi/g; met 100 m^2 guideline; areas of slag material used in the Niagara Falls area	Remediation not required	Not applicable	Not applicable	Currently undeveloped by CWM
H′	CWM/ Perimeter Fence and security	Large area of property (6,000 m^2 in eastern portion); down to 50 cm in depth	1 large area decontaminated and backfilled	5 samples exceed 15 pCi/g; average for 100 m^2 meets 15 pCi/g	Small chips removed at elevated areas; black cinder-like material removed; only remaining elevated areas were naturally occurring slag	Currently undeveloped by CWM
J	Modern Affiliated Companies/ Perimeter Fence and security	All 80 m grid samples at background levels; no elevated surface readings	Remediation not required	Not applicable	Not applicable	Undeveloped
K	Modern Affiliated Companies/ Perimeter Fence and security	All 80 m grid samples at background levels; no elevated surface readings	Remediation not required	Not applicable	Not applicable	Undeveloped
L	Modern Affiliated Companies/ Perimeter Fence and security	Isolated areas of surface soil exceeding guidelines along streets on east and south sides of property based on walkover sampling; few 20 m grid samples exceeded 5 pCi/g	2 areas decontaminated and backfilled	2 samples exceed 5 pCi/g; average concentration = 1.7 pCi/g above background	4 individual samples above 5 pCi/g; areas meet 5 pCi/g when averaged over 100m^2	Undeveloped
M	Modern Affiliated Companies/ Perimeter Fence and security	All 20 m grid samples < 5 pCi/g; elevated areas noted in walkover survey, most not removed by sampling; soil exceeds criteria at two areas along Campbell Street and few other isolated areas	3 areas decontaminated and backfilled	5 samples exceed 5 pCi/g; average per 100 m^2 is 5.6 pCi/g excluding background	Slightly elevated measurements; 6 samples exceed 5 pCi/g over background; average over 100 m^2 meets guidelines	Municipal landfill operations

Table 5−1 (continued). Summary of Radiological Conditions at the NFSS Vicinity Properties

VP-ID	Ownership/ Access	Pre-remediation Assessment Status	Remediation Performed	Post-remedial Action Status	Verification Status	Current Land Use/Site Conditions
N/N′ North	Modern Affiliated Companies/ Perimeter Fence and security	**N′ North**: 10 m grid; walkover survey identified several general and numerous isolated elevated areas; 13% of grid samples exceeded 5 pCi/g; small white chips with highly elevated Ra-226 and U-238 **N North**: 80 m grid; walkover survey identified 2 general and several isolated elevated areas; highest Ra-226 levels were ballast; yellowcake identified	Property decontaminated per agreement with Modern Landfill	1 location exceeded 15 pCi/g, but 100 m^2 average was 6.6 pCi/g; 1 location with 44 pCi/g U-238 met hot spot criteria	Small isolated elevated levels removed; further remediation done in other areas; surveys show 100 m^2 guideline met; gamma rates slightly higher than other VPs due to railroad ballast with naturally occurring uranium	Municipal landfill operations
N/N′ South	Modern Affiliated Companies/ Perimeter Fence and security	80 m grid; 10 m grid in incinerator and Track Street areas; 80 m grid samples all <5 pCi/g; elevated concentrations in incinerator and Track Street areas; 2 areas where 100 m^2 average exceeds 5 pCi/g	11 areas decontaminated and backfilled	Average on property 1.3 pCi/g above background; 2 samples >15 pCi/g, but these areas meet 15 pCi/g criteria averaged over 100 m^2	2 isolated elevated areas reduced by surface sampling to background levels; verification samples met baseline levels or cleanup criteria	Municipal landfill operations
O	Southport Rail Transfer LLC./ Fence only	All 20 m grid samples at background levels; no elevated surface measurements; natural slag-like materials present; indoor measurements determined radioactive contaminants not present	Remediation not required	Not applicable	Not applicable	Currently undeveloped
P	CWM/ Perimeter Fence and security	All 20 m grid samples <5pCi/g; several elevated locations identified in walkover survey (all but 1 in paved parking lot); paving material assumed to be natural slag	1 area decontaminated and backfilled	Sample meets 5 pCi/g	No elevated measurements; 1 sample at baseline levels	Currently undeveloped by CWM
Q	North Modern Affiliated Companies/ Fenced South Town of Lewiston/ Accessible	Elevated contaminants identified in samples from 20 m grid samples and samples from elevated walkover areas; 2 general areas exceeded the 100 m^2 guideline for Ra-226; other isolated areas of contamination could be eliminated by removing small amounts of material	20 areas decontaminated and backfilled	2 samples exceed 15 pCi/g; average over 100 m^2 meets 15 pCi/g	4 regions and 2 small areas with elevated measurements; additional cleanup and small removals performed; subsequent sampling met 5 pCi/g	North: Municipal Landfill Middle: Small-arms firing range South: Town of Lewiston Maintenance Building

Table 5−1 (continued). Summary of Radiological Conditions at the NFSS Vicinity Properties

VP-ID	Ownership/ Access	Pre-remediation Assessment Status	Remediation Performed	Post-remedial Action Status	Verification Status	Current Land Use/Site Conditions
R	Niagara Mohawk National Grid/ Accessible	Several 20 m grid samples exceeded 5 pCi/g; general area of contamination identified along Pletcher Road.; 2 other isolated areas identified	3 areas decontaminated and backfilled	1 location >5 pCi/g but <15 pCi/g; average excluding background was 1.1 pCi/g	1 elevated area required further remediation; subsequent sampling met 15 pCi/g guideline before backfilling; other locations <5 pCi/g	Undeveloped. West Drainage borders the east side of the property between R and L. South of EU9(USACE 2009)
S	CWM/ Perimeter Fence and security	All 40 m grid locations <5 pCi/g; several samples from 5 m grid in vicinity of concrete pad >5 pCi/g and exceeded 100 m^2 guideline, but attributed to natural slag; other area with elevated Ra-226 is site-related but meets 100 m^2 guideline	1 area decontaminated and backfilled	All samples <5 pCi/g excluding background	No elevated readings	Currently undeveloped by CWM
T	CWM/ Perimeter Fence and security	Numerous elevated areas identified in 20 m grid survey and sampling; 3 types of material identified—only 1 of MED/AEC origin (rock-like material and sediment dredged from West Ditch)	37 small areas decontaminated and backfilled	6 locations > 5 pCi/g above background; all < 15 pCi/g; average 1.5 pCi/g above background	Elevated concentrations by Central Drainage Ditch and haul road and additional remediation performed; small areas > 15 pCi/g; hot spot and average guidelines met	Currently undeveloped by CWM
U & V	Somerset Group/	Samples from the 20 m grid and biased samples based on walkover survey exceeded 5 pCi/g; many of these were determined to be natural slag-like material with comparable Ra-226 and U-238 levels and not from MED/AEC activities; rock-like material with Ra-226 elevated above U-238 was likely MED/AEC	8 areas decontaminated and backfilled	All samples <5 pCi/g above background	Additional small areas remediated based on elevated levels; additional sampling met guidelines; scans at baseline levels	Currently undeveloped. All future federal liability on these properties has been resolved and is now ineligible from investigation under FUSRAP.
W	CWM/ Perimeter Fence and security	Samples from 40 m grid survey all at baseline; elevated areas identified from walkover survey near West Drainage Ditch; Ra-226 concentrations up to 102 pCi/g	2 areas decontaminated and backfilled	All samples <5 pCi/g	No elevated readings; samples <5 pCi/g above background	Currently undeveloped by CWM

Table 5−1 (continued). Summary of Radiological Conditions at the NFSS Vicinity Properties

VP-ID	Ownership/ Access	Pre-remediation Assessment Status	Remediation Performed	Post-remedial Action Status	Verification Status	Current Land Use/Site Conditions
X	Town of Lewiston/ Accessible	40 m grid samples <5 pCi/g; 2 general areas exceeding criterion along with biased samples based on walkover survey; small areas meet 100 m^2 guideline	14 areas decontaminated and backfilled	All samples <5 pCi/g	Elevated gamma scans identified ash material for removal; additional scans not elevated; verification samples <5pCi/g; some naturally occurring material may remain at site (rock and slag used for fill in the area)	Abandoned structures / fall hazards Evidence of trespassing
Pletcher Road	Accessible	No specific assessment report	26 areas decontaminated and backfilled	Average overall was 4.2 pCi/g above background; 3 samples exceeded 15 pCi/g but averages in those areas over 100 m^2 were < 15 pCi/g	Gamma scans identified several small elevated areas; further remediation performed; 2 locations exceeded 15 pCi/g but met hot spot criteria	Active roadway for access to municipal landfill, residences, greenhouse industry and KOA campground
West Drainage Ditch	Accessible	Composite sample (each bank plus midpoint) collected every 30 m to its confluence with Central Drainage Ditch; highest concentration = 75 pCi/g	Ditch was decontaminated but not backfilled	7 individual samples exceed 5 pCi/g but meet 100 m^2 guideline; average overall for ditch is 0.5 pCi/g above background	Several areas elevated along lower banks but areas were small and not remediated; verification samples met 5 pCi/g criterion	Overgrown and undeveloped. USACE EU9 identified some elevated levels which will be addressed during the FS
Central Drainage Ditch	Northern portion/ Accessible	Composite sample (each bank plus midpoint) collected every 30 m to its confluence with Fourmile Creek; concentrations up to 1,900 pCi/g	Portions of ditch were decontaminated but not backfilled; farthest downgradient portion not remediated and supplemental limits applied	Average remediated ditch concentration of 1.2 pCi/g above background; 7 areas exceed 5 pCi/g averaged over 100 m^2 but are less than 15 pCi/g	Verification samples indicated all but one met 5 pCi/g for excavated portion of ditch; ditch met 100 m^2 guideline	Overgrown and undeveloped to the North of the NFSS VPs and CWM and WETS Military facility

References: Comprehensive Radiological Surveys, ORNL 1983–1986.
Post Remedial Action Reports for 1983–1984, BNI 1986
Post Remedial Action Reports for 1985–1986, BNI 1989
Verification of 1983–1984 Remedial Actions, ORAU 1989
Verification of 1985–1986 Remedial Actions, ORAU 1990
USACE Management Action Plan, USACE 2009

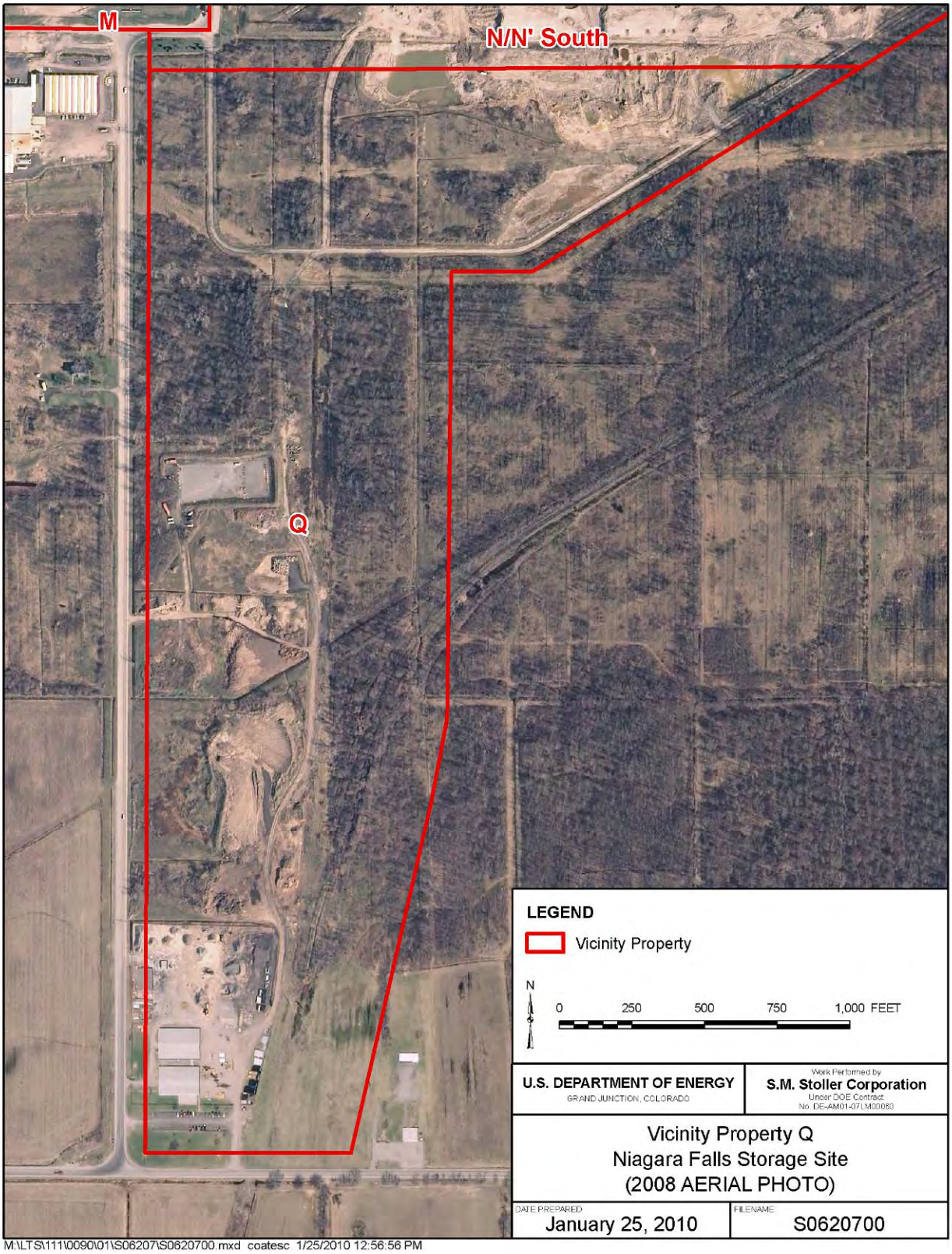

Figure 5–1. 2008 Aerial Photo of Vicinity Property Q

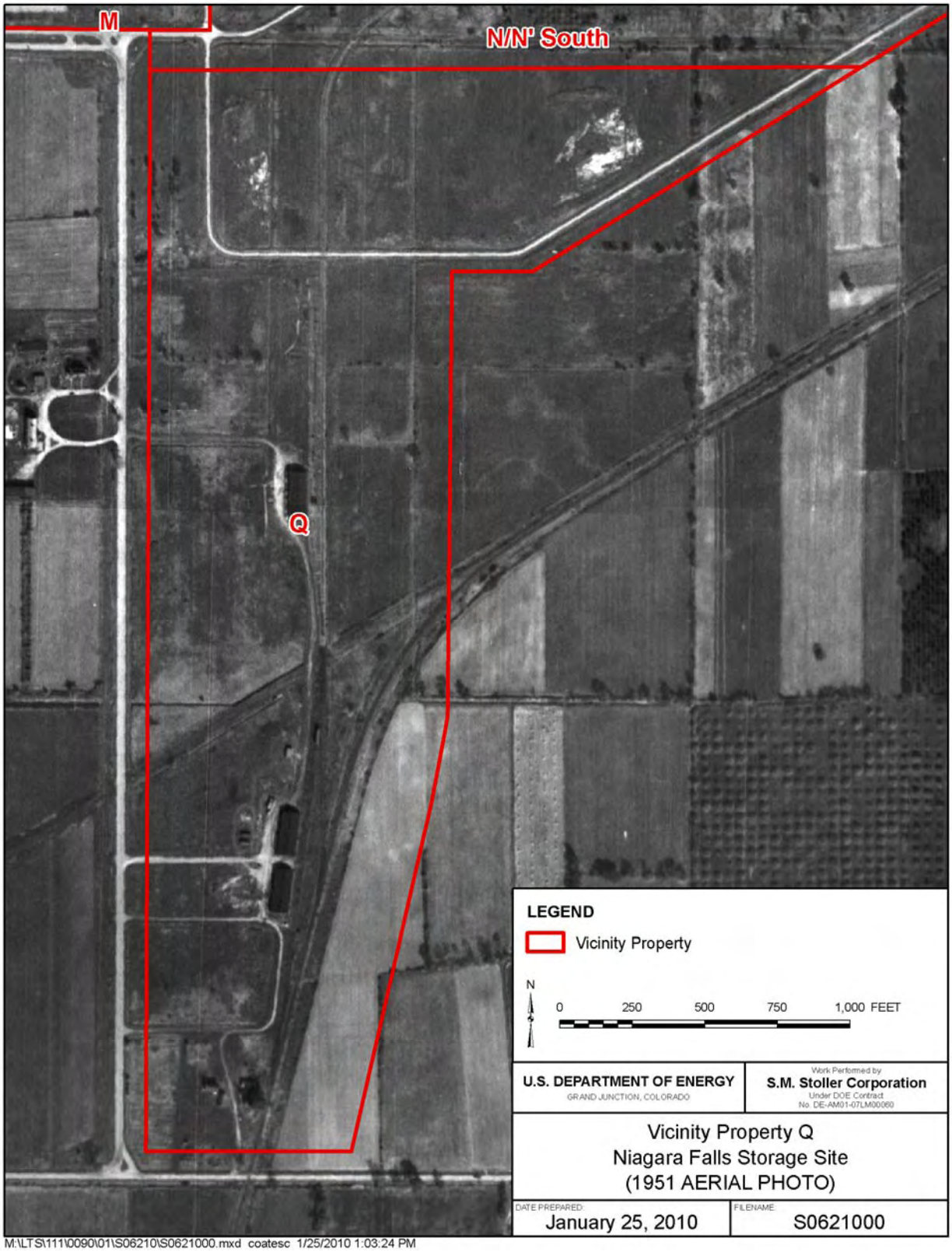

Figure 5–2. 1951 Aerial Photo of Vicinity Property Q

Figure 5–3. VP-Q: Fenceline Separating Modern Landfill and Small-Arms Range (East from Harold Road)

Figure 5–4. VP-Q: Entrance to Small-Arms Firing Range (Central to the Property, East of Harold Road, and North of Town of Lewiston Maintenance Shops)

Figure 5–5. VP-Q: View Northeast up Harold Road (Town of Lewiston Shops)

5.2 Vicinity Property R

VP-R is rectangular and measures approximately 190 m × 120 m (623 ft × 394 ft). The site borders Pletcher Road, which forms the southern boundary of the property. The West Drainage Ditch is located along the eastern boundary between VP-R and VP-L. The property is south of the EU9 currently being investigated by the USACE in its RIR/BRA. Power transmission lines cross the property in a north-south direction, and a paved road provides access to the power lines. There are no structures located on the property and it is accessible to the general public as evidenced by dumping along the access road.

5.2.1 Current Land Use

VP-R is currently owned by Mohawk Power Grid. The land is vegetated and undeveloped with the exception of the access road and power lines. The West Drainage Ditch bounds the eastern boundary of the site where it is adjacent to VP-L. Farther east from the drainage are industrial greenhouses, and residences and a KOA campground are to the south and east.

5.2.2 Review Findings

Assessment data tables and survey grid as well as the remedial action survey information is located in Appendix B. Table 5−1 summarizes the pre-remediation assessment, remediation action, post-remedial action, and verification results.

Gamma exposure rates in and near the remediated area were slightly elevated (12–14 μR/h), but soils samples were generally within baseline levels. All samples met DOE guidelines.

Further remediation was performed at areas of isolated elevated gamma exposure rates (29−34 μR/h). Follow-up samples were less than 15 pCi/g, and exposure rates were 13–14 μR/h before the area was backfilled.

Figure 5–6. 2008 Aerial Photo of Vicinity Property R

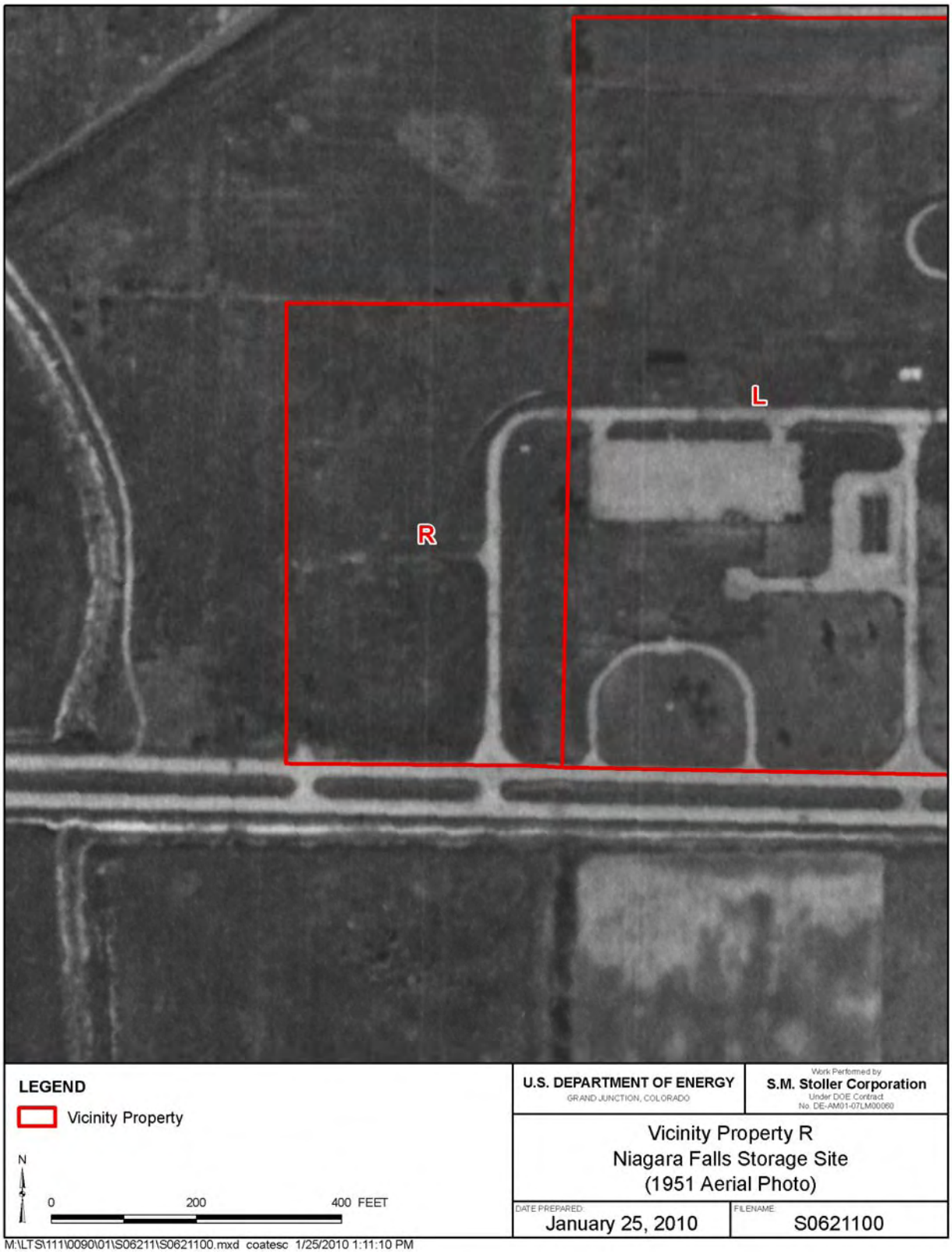

Figure 5–7. 1951 Aerial Photo of Vicinity Property R

Figure 5–8. VP-R: View of Access Road that Parallels the West Drainage Ditch (December 2009)

Figure 5–9. VP-R: View North of West Drainage Ditch that Flows Through the VP

5.3 Vicinity Property S

VP-S is bounded by M Street on the north and by Campbell Street on the east. NFSS is located directly south of the property. The Town of Lewiston owns the section of VP-X immediately bordering VP-S on the west. There are no structures associated with the property; however, there

is a concrete pad adjacent to M Street. The Central Drainage Ditch passes through VP-S in a north-south direction. The property is fenced and monitored by security.

5.3.1 Current Land Use

VP-S is currently owned by Chemical Waste Management as part of their hazardous waste landfill operations. The property is well vegetated and undeveloped. Figure 5−10 and Figure 5−11 show the property in 2008 and 1951.

5.3.2 Review Findings

Assessment data tables and survey grid as well as the remedial action survey information are in Appendix C. Table 5−1 summarizes the pre-remediation assessment, remediation action, post-remedial action, and verification results.

Gamma exposure rates were 10–14 μR/h in the small area that was remediated. It was determined that the cleanup met DOE Order 5400.5 and FUSRAP Guidelines for Unrestricted Use.

5.4 Vicinity Property T

VP-T measures 420 m × 235 m (1,378 ft × 771 ft). The property is bounded by I Street on the north, M Street on the south, Wesson Road on the east, and Lutts Road on the west. Sections of the West and Central Drainage Ditches pass through the property. Out-of-service railroad tracks are also located on the western side of VP-T. All the structures on this property were constructed for the Mathieson rocket fuel operations during the 1950s but the majority of the buildings were demolished as of the 1960s aerial photography (Aerospace Corp 1982). Concrete pads and foundations remain at various locations on the property, indicating additional structures were present at one time. VP-T is located just northeast of VP-X.

5.4.1 Current Land Use

Currently VP-T is undeveloped. It is inaccessible to the public due to a perimeter fence and security provided as part of the Chemical Waste Management operations.

The property is well vegetated and undeveloped. Figure 5−10 and Figure 5−11 show the property in 2008 and 1951.

5.4.2 Review Findings

Gamma scans identified regions of elevated contact radiation along the banks of the Central Drainage Ditch and the haul road areas adjacent to the Central Drainage Ditch. There areas were remediated further by BNI and follow-up direct monitoring and sampling confirmed that efforts were effective in reducing residual activity to acceptable levels. Final gamma exposure rates at 1 m above the surface ranged from 7 to 17 μR/h. Results of the verification sampling (Table 11 in Verification section of Appendix D) identified small areas of residual Ra-226 activity in excess of the 15 pCi/g guideline levels for subsurface soil at grid coordinates N2516,E76; N2814,E273; N2475,E495; N2720,E365; N2795,E435; N2905,E355; N2905,E395; and N2910,E430. Maximum Ra-226 level in samples from these locations was 103 pCi/g. Direct

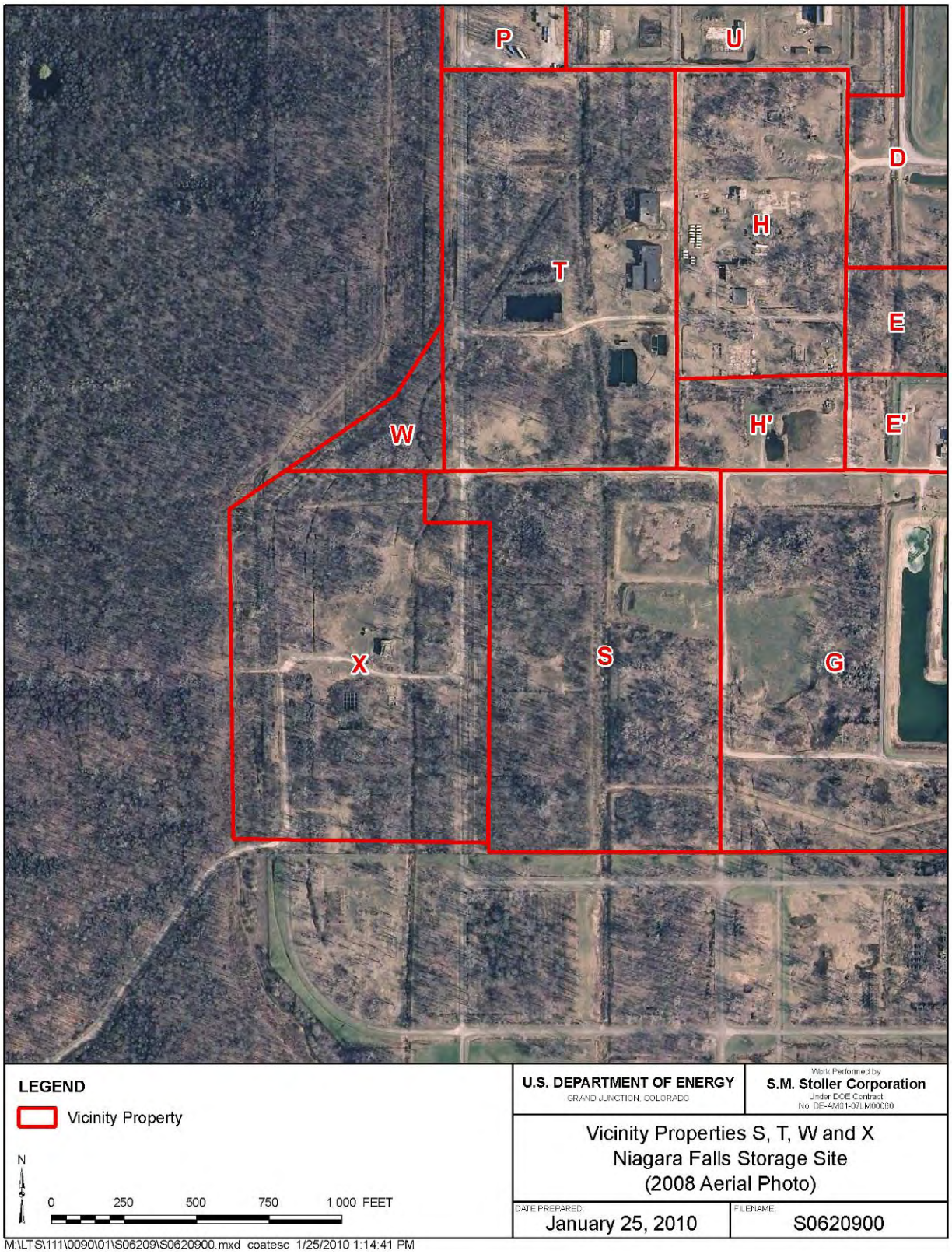

Figure 5–10. 2008 Aerial Photo of Vicinity Properties S, T, W, and X

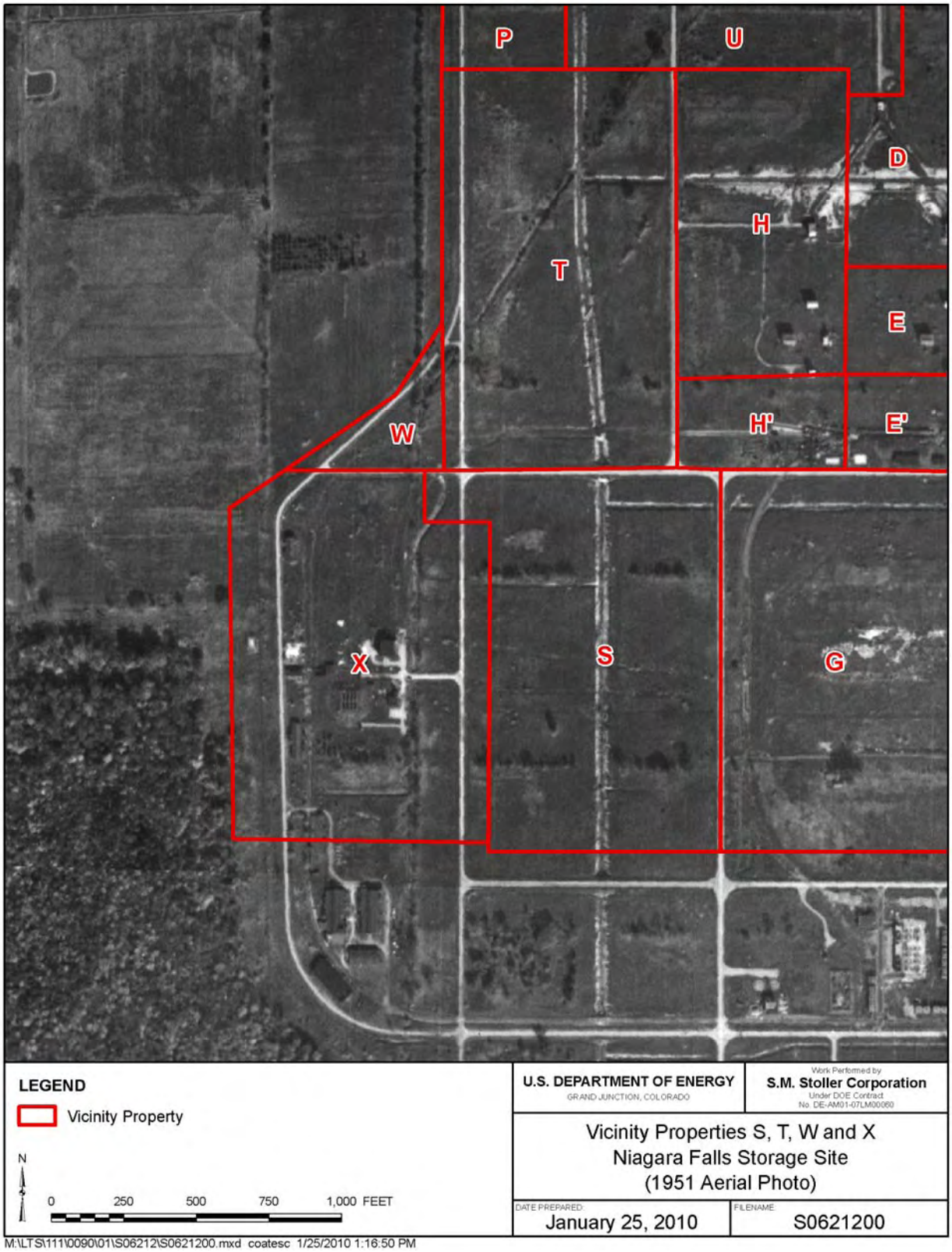

Figure 5–11. 1951 Aerial Photo of Vicinity Properties S, T, W, and X

monitoring and additional samples from contiguous 100 m^2 areas at these locations demonstrated that the residual contamination was confined to small (<1 m^2) isolated areas and that satisfied the Hot-Spot criterion and average guideline numerical standard.

Assessment data tables and survey grid as well as the remedial action survey information are in Appendix D. Table 5−1 summarizes the pre-remediation assessment, remedial action, post-remedial action, and verification results.

5.5 Vicinity Property W

VP-W is the smallest of the NFSS VPs. It is triangle-shaped, and its southern boundary is VP-X along M Street. A chain-link security fence forms the boundary along the northwest perimeter. There are no structures on VP-W. The West Drainage Ditch passes through the eastern section of the property.

5.5.1 Current Land Use

The property is currently well vegetated and undeveloped. The property is owned by CWM and therefore is inaccessible.

5.5.2 Review Findings

Assessment data tables and survey grid as well as the remedial action survey information are in Appendix E. Table 5−1 summarizes the pre-remediation assessment, remedial action, post-remedial action, and verification results.

Gamma scans identified elevated contamination along the banks of the Central Drainage Ditch and haul-road areas adjacent to the Central Drainage Ditch within the boundary of VP-W. These areas were remediated further during the Post Remedial Action and Verification surveys. Final gamma exposure rates were 7 to 17 µR/h. Verification sampling identified small areas exceeding the 15 pCi/g guideline (maximum 103 pCi/g Ra-226). Additional exposure rate measurements and sampling over a 100 m^2 area indicated contamination was limited to less that 1 m^2. The area met the hot-spot criterion (150 pCi/g) and the 100 m^2 guideline prior to backfilling.

5.6 Vicinity Property X

VP-X is roughly rectangular and measures approximately 223 m × 404 m (732 ft × 1,325 ft). M Street forms the northern property boundary. The NFSS forms the south boundary of VP-X. West Patrol Road and Lutts Road cross the property in a north-south direction along the western and eastern perimeters, respectively. Located near the center of VP-X are abandoned facilities that were part of the former wastewater treatment plant for the LOOW. Operation of the sewage plant ceased in the mid-1970s, and all that remains are the concrete structures of the plant. A chain-link fence separates the property from the NFSS but the site is still accessible by the public from the west. Railroad loading platforms straddle the border between VP-X and the NFSS Proper. The vicinity shops are located on the NFSS proper.

5.6.1 Current Land Use

The property is currently derelict and in disrepair but a four-wheeler access road allows the area to be monitored for trespassing. VP-X is currently owned by the Town of Lewiston, which is planning to construct a fence surrounding the property to deter trespassing and to prevent injury from animals or humans falling into the open tanks or foundations.

5.6.2 Review Findings

Assessment data tables and survey grid as well as the remedial action survey information is located in Appendix F. Table 5−1 summarizes the pre-remediation assessment, remedial action, post-remedial action, and verification results.

Two regions of elevated gamma exposure rates were identified (17–40 µR/h). At one area, these measurements were associated with materials that had approximately equal concentrations of Ra-226 and U-238, indicating naturally occurring rock and slag. This was commonly used as fill and paving base in the Niagara Falls area and is considered non-FUSRAP eligible materials and, therefore, this area was not remediated. At the other location, elevated gamma levels were associated with a black ash, possibly from incineration activities. Gamma exposure rates were as high as 130 µR/h. This material was cleaned up to 20 µR/h. Gamma scans over a large remediated area on the south property boundary were 7 to 12 µR/h in the vicinity of the rail loading platforms. Verification samples met DOE guidelines.

Figure 5–12. VP-X: View Northeast from IMHOFF Tank to Remains of Pump House

Figure 5–13. VP-X: IMHOFF Tank

Figure 5–14. VP-X: View West from IMHOFF Tank at Access from the Holding Ponds Off-site

Figure 5–15. VP-X: West Drainage Ditch within VP-X (West of the Sewage Treatment Plant)

5.7 Drainages

The West Drainage Ditch is one of the two major drainage ditches that flow on and off of the NFSS proper. The West and Central Drainage Ditches are shown in Figure 5−16. The West Drainage Ditch became radioactively contaminated as a result of surface erosion over the years. It begins at a point to the south of NFSS and flows northward for approximately 1,372 m (4,501 ft) where it intersects with the Central Drainage Ditch just north of the NFSS boundary in the vicinity of VP-X, VP-W, and VP-S.

The Central Drainage Ditch, which is the largest of the drainage ditches, originates on VP-L on the NFSS. It flows approximately 5.63 kilometers (3.5 miles) to its confluence with Fourmile Creek north and west of the NFSS and the VPs.

5.7.1 Current Land Use

The ditches continue to drain the NFSS and VPs and are heavily vegetated. No change in land use is anticipated.

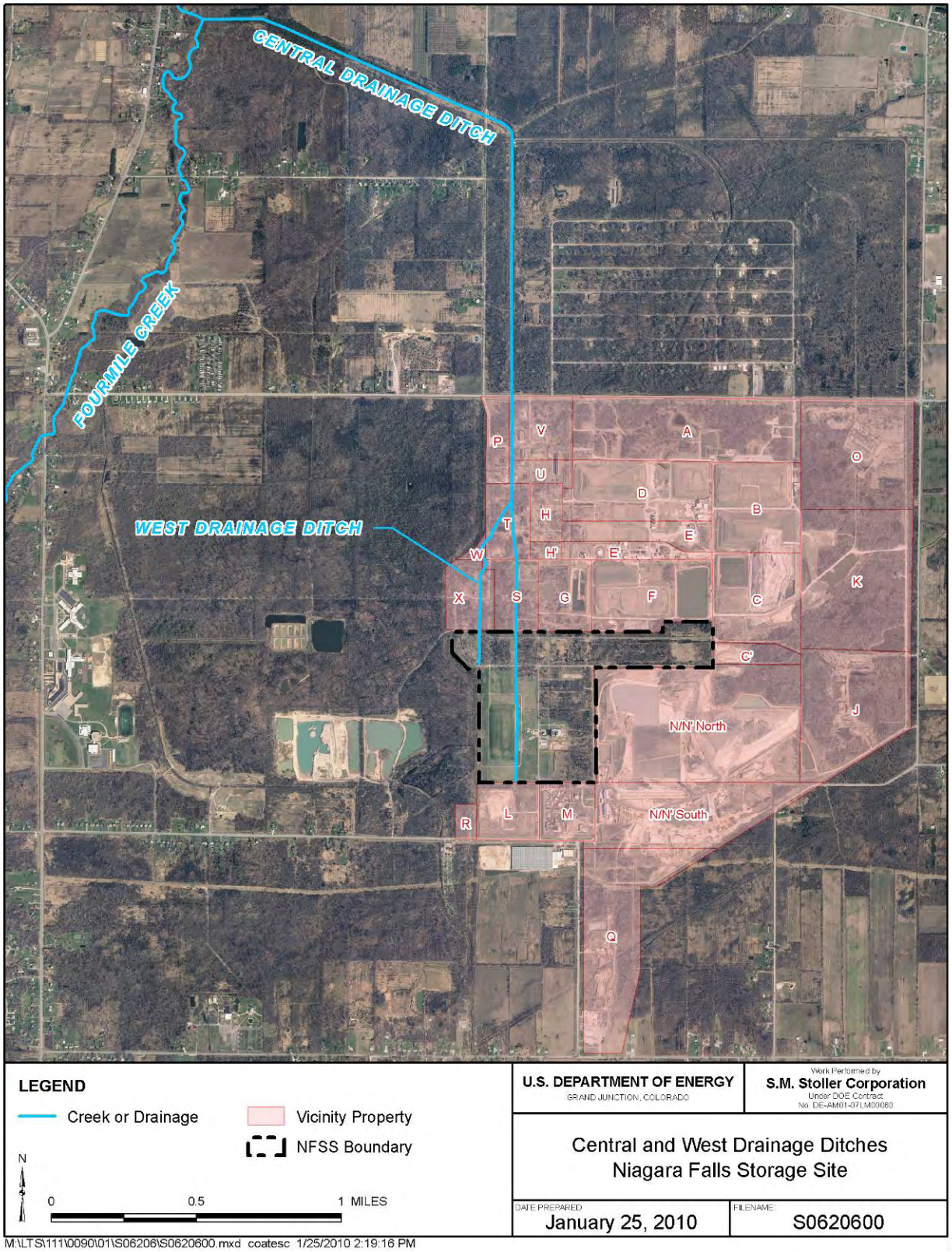

Figure 5–16. Central and West Drainage Ditches (Niagara Falls Storage Site)

5.7.2 Review Findings

Assessment data tables and survey grid as well as the remedial action survey information is located in Appendix G. Table 5−1 summarizes the pre-remediation assessment, remediation action, post-remedial action, and verification results.

Contact exposure rates in the West Drainage Ditch were 17–42 μR/h. These areas were located mainly along the lower banks and were < 1 m^2, isolated occurrences, therefore it was determined that no further remediation was necessary. Verification soil samples were collected at 200 ft intervals along the ditch between DOE property and its intersection with the Central Drainage Ditch and were found to meet the DOE guidelines (Oct 1989; 1983 and 1984 Verification Survey). No further remediation was performed.

Contact and general exposure rates in the remediated portion of the Central Drainage Ditch were 7–16 μR/h. All but one sample location met DOE guidelines. The location that was above guidelines was isolated and was therefore averaged over 100 m^2 according to DOE guidelines. (Note that the initial characterization of the Central Drainage Ditch did not identify elevated gamma readings based on surface scans of the unexcavated portion of the ditch.)

Exposure rates in the unexcavated portion were only slightly above DOE guidelines and, based on sampling and risk analysis, it was determined that supplemental standards be applied to this portion of the ditch in accordance with the FUSRAP Guidelines. Subsequent sample results from USACE during their annual environmental surveillance program indicated no levels above background in the sediment or the surface water exiting the Central Drainage Ditch (USACE 2008).

5.7.2.1 USACE RI/BRA Findings

During the 2001 site-wide gamma walkover survey of the NFSS property, gamma radiation in surface soil above background was detected on the western border of the NFSS property adjacent to the National Grid property within EU9 north of the VP-R. The Corps continued the gamma walkover survey from the NFSS fenceline westerly into the west ditch on National Grid property. A strip of ground, including the ditch, approximately 60 ft × 820 ft was surveyed. Several isolated spots in this area displayed elevated radioactivity two to three times the natural background level of approximately 9,000 to 13,000 counts per minute (USACE 2008).

Figure 5–17. Central Drainage Ditch South from Balmer Road (September 2009)

Figure 5–18. Central Drainage Ditch View North Toward IWCS (September 2009)

This page intentionally left blank

6.0 Conclusions

DOE has determined that the records collection was found to adequately describe final radiological conditions at the completed VPs. All FUSRAP wastes at the completed sites were cleaned up to meet DOE guidelines for unrestricted use.

In the future, if previously undiscovered contamination is found that is eligible for remediation under FUSRAP, DOE will refer the property to USACE for investigation and remediation in accordance with the Memorandum of Understanding between the two federal agencies (DOE and USACE 1999).

6.1 Stakeholder/Outstanding Issues

The review of the documentation from the completed VPs included consideration of outstanding issues associated with NFSS and the VPs as understood from stakeholder meetings. The stakeholder issues centered on responsibilities for the removal of certain residual radioactive materials remaining on the completed NFSS VPs. The following were determined to be included in that category:

- KAPL/SPRU: A portion of these materials were temporarily stored at the waste water treatment plant (VP-X); however, no evidence of contamination from these materials was found during the assessment, remediation or verification of this completed property. DOE will review available information to determine an appropriate response.
- Metal separation slag: This material was commonly used in the surrounding Niagara Falls area for road base and construction. Path forward will need to be addressed internally with regulators.
- Pseudowollastonite slag: This material was commonly used in the surrounding Niagara Falls area for road base and construction.
- University of Rochester: On open VP-G; USACE will address this material when they remediate this property.

A review of the origin and content of the above mentioned materials which were not removed during the assessment, remediation, and verification of the completed VPs determined that the materials did not meet FUSRAP criteria for remediation.

This page intentionally left blank

7.0 Bibliography

40 CFR 300. U.S. Environmental Protection Agency, "National Oil and Hazardous Substances Pollution Contingency Plan," *Code of Federal Regulations*, July 1, 2009.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). Title 42 *United States Code* § 9601 et seq.

DOE Order 5400.5 Chg 2. U.S. Department of Energy, *Radiation Protection of the Public and the Environment,* January 7, 1993.

Energy and Water Development Appropriations Act, 1999. Public Law 105-245, October 7, 1998.

Argonne National Laboratory, 1985. *Analysis of the Radiological Contamination of the Central Ditch near the Niagara Falls Storage Site*, April 26.

AEC (U.S. Atomic Energy Commission), 1972. *Meeting with EPA Personnel-AEC's Cleanup Criteria for the Former Lake Ontario Ordnance Property—March 20, 1972 Meeting Minutes*, March 23.

AEC (U.S. Atomic Energy Commission), 1973. *Radiation Survey and Decontamination Report of the Lake Ontario Ordnance Works Site,* January 18.

Aerospace Corp, 1982. *Background and Resurvey Recommendations for the Atomic Energy Commission Portion of the Lake Ontario Ordnance Works*, November.

Battelle Columbus Laboratories, 1981. *A Comprehensive Characterization and Hazard Assessment of the Niagara Falls Storage Site*, BMI-2074 (revised), UC-11, June.

BNI (Bechtel National Incorporated), 1986. *Post-Remedial Action Report for the Niagara Falls Storage Site Vicinity Properties—1983 and 1984, Lewiston, New York,* DOE/RO/20722-84, December.

BNI (Bechtel National Incorporated), 1989. *Post-Remedial Action Report for the Niagara Falls Storage Site Vicinity Properties—1985 and 1986, Lewiston, New York,* DOE/RO/20722-133.

Berger, J.D., 2009. *Summary Information Regarding Radiological Conditions of NFSS Vicinity Properties*, Denuke Contracting Services, Inc., Oak Ridge, Tennessee, December 2.

DOE Reports: ORNL/TM-7004, *Results of Ground Level Radiation Measurements in Support of the 1978 Aerial Survey of the Lake Ontario Ordnance Works, Lewiston, New York*, September 1979, NY.17-7.

ORNL/RASA-85/1, *Results of the Mobile Gamma Scanning Activities in Niagara Falls, New York Area*, August 1985, NY.17-9.

WAMD-006, *Summary Report, Aerial Radiological Survey Lake Ontario Ordnance Works, Lewiston, New York*, Date of Survey: October 1978, February 15, 1979, NY.17-5.

WAMD-010, *Summary Report, Aerial Radiological Survey Niagara Falls Area Niagara Falls, New York*, Date of Survey: September 1979, November 30, 1979 NY.17-6.

DOE (U.S. Department of Energy), 1980. Correspondence from William E. Mott, DOE, to Ms. Mary Beth Brado, Town of Lewiston, concerning NYDOH land use restrictions on 1,511 acres of former LOOW, May 29.

DOE (U.S. Department of Energy), 1986a. *Development of a Supplemental Residual Contamination Guideline for the NFSS Central Drainage Ditch*, Bechtel National Inc. (BNI), December.

DOE (U.S. Department of Energy), 1986b. *Formerly Utilized Sites Remedial Action Program: Summary Protocol: Identification, Characterization, Designation, Remedial Action, Certification*, January.

DOE (U.S. Department of Energy), 1986c. *Formerly Utilized Sites Remedial Action Program: Supplement No. 1 to the FUSRAP Summary Protocol - Designation/Elimination Protocol*, January.

DOE (U.S. Department of Energy), 1987. *U.S. Department of Energy Guidelines For Residual Radioactive Material at Formerly Utilized Sites Remedial Action Program (FUSRAP) and Remote Surplus Facilities Management Program Sites,* Revision 2, March.

DOE (U.S. Department of Energy), 1992. *Certification Docket for the Remedial Action Performed at the Niagara Falls Storage Site Vicinity Properties in Lewiston, New York, from 1983 through 1986*, DOE Oak Ridge Field Office, July. NY.17-8.

DOE (U.S. Department of Energy), 2005. *KAPL Radioactive Waste Information Related to the Lake Ontario Ordnance Works*, correspondence with eight attachments from J. Hughes Robillard, Dir. Radiological /Environmental Controls and Safety Division (DOE) to Steven Gavitt Assistant Bureau Director (NYDOH), August 10. NY.17-21.

DOE (U.S. Department of Energy) and USACE (U.S. Army Corps of Engineers), 1999. *Memorandum of Understanding Between U.S. Department of Energy and U.S. Army Corps of Engineers Regarding Program Administration and Execution of the Formerly Utilized Sites Remedial Action Program (FUSRAP)*, Energy and Water Development Appropriations Act, 1999, (Title I, Public Law 105-245, 112 Stat. 1838, 1843).

DSHM-RAD-05-01. New York State Department of Environmental Conservation, "Cleanup Guidelines for Soils Contaminated with Radioactive Materials," available on the Internet at http://www.dec.ny.gov/regulations/23472.html, accessed February 18, 2010.

EG&G Energy Measurements Group, 1978. *Summary Report Aerial Radiological Survey Lake Ontario Ordnance Works, Lewiston, New York*, October.

LaFalce, 1980. John J. LaFalce, Congressman, 36th Congressional District, NY, letter report to Douglas L. Turner, Executive Editor, *Buffalo Courier-Express*, Buffalo, NY, discussing risks to human health at the Lake Ontario Ordnance Works site, May 15.

LOOW RAB (Lake Ontario Ordnance Works Restoration Advisory Board), 2009. *LOOW RAB FACT SHEET*, *LOOW Risk Assessments Fail to Address Radiological Contamination*, September 16.

NYDOH (New York State Department of Health), 2004a. *A Summary of "Commissioners Orders" for Surplus Properties Formerly Part of the Lake Ontario Ordnance Works*, email correspondence from S.M. Gavitt, NYDOH, November 19.

NYDOH (New York State Department of Health), 2004b. Correspondence from J.A. Knickerbocker, Chemical Waste Management, December 14.

Oak Ridge National Laboratory, 1986. *Results of Radiological Measurements Taken in the Niagara Falls, New York Area (NF002)*, November.

ORAU (Oak Ridge Associated Universities), 1982. *Post Remedial Action Survey, Property of Modern Landfill, Inc., Former LOOW Site, Lewiston, New York*, January.

ORAU (Oak Ridge Associated Universities), 1983a. *Comprehensive Radiological Survey, Off-Site Property H', Niagara Falls Storage Site, Lewiston, New York*, January.

ORAU (Oak Ridge Associated Universities), 1983b. *Comprehensive Radiological Survey, Off-Site Property L, Niagara Falls Storage Site, Lewiston, New York*, May.

ORAU (Oak Ridge Associated Universities), 1983c. *Comprehensive Radiological Survey, Off-Site Property M, Niagara Falls Storage Site, Lewiston, New York*, May.

ORAU (Oak Ridge Associated Universities), 1983d. *Comprehensive Radiological Survey, Off-Site Property N/N' South, Niagara Falls Storage Site, Lewiston, New York*, August.

ORAU (Oak Ridge Associated Universities), 1983e. *Comprehensive Radiological Survey, Off-Site Property O, Niagara Falls Storage Site, Lewiston, New York*, August.

ORAU (Oak Ridge Associated Universities), 1983f. *Preliminary Radiological Survey, Of Pletcher Road, Lewiston, New York*, September 13.

ORAU (Oak Ridge Associated Universities), 1984a. *Comprehensive Radiological Survey, Off-Site Property A, Niagara Falls Storage Site, Lewiston, New York*, March.

ORAU (Oak Ridge Associated Universities), 1984b. *Comprehensive Radiological Survey, Off-Site Property B, Niagara Falls Storage Site, Lewiston, New York,* May.

ORAU (Oak Ridge Associated Universities), 1984c. *Comprehensive Radiological Survey, Off-Site Property C, Niagara Falls Storage Site, Lewiston, New York,* March.

ORAU (Oak Ridge Associated Universities), 1984d. *Comprehensive Radiological Survey, Off-Site Property C', Niagara Falls Storage Site, Lewiston, New York,* March.

ORAU (Oak Ridge Associated Universities), 1984e. *Comprehensive Radiological Survey, Off-Site Property D, Niagara Falls Storage Site, Lewiston, New York,* March.

ORAU (Oak Ridge Associated Universities), 1984f. *Comprehensive Radiological Survey, Off-Site Property F, Niagara Falls Storage Site, Lewiston, New York,* February.

ORAU (Oak Ridge Associated Universities), 1984g. *Comprehensive Radiological Survey, Off-Site Property H', Niagara Falls Storage Site, Lewiston, New York,* January.

ORAU (Oak Ridge Associated Universities), 1984h. *Comprehensive Radiological Survey, Off-Site Property J, Niagara Falls Storage Site, Lewiston, New York,* March.

ORAU (Oak Ridge Associated Universities), 1984i. *Comprehensive Radiological Survey, Off-Site Property K, Niagara Falls Storage Site, Lewiston, New York,* March.

ORAU (Oak Ridge Associated Universities), 1984j. *Comprehensive Radiological Survey, Off-Site Property N North, Niagara Falls Storage Site, Lewiston, New York,* May.

ORAU (Oak Ridge Associated Universities), 1984k. *Comprehensive Radiological Survey, Off-Site Property N' North, Niagara Falls Storage Site, Lewiston, New York,* May.

ORAU (Oak Ridge Associated Universities), 1984l. *Comprehensive Radiological Survey, Off-Site Property P, Niagara Falls Storage Site, Lewiston, New York,* March.

ORAU (Oak Ridge Associated Universities), 1984m. *Comprehensive Radiological Survey, Off-Site Property R, Niagara Falls Storage Site, Lewiston, New York,* February.

ORAU (Oak Ridge Associated Universities), 1984n. *Comprehensive Radiological Survey, Off-Site Property S, Niagara Falls Storage Site, Lewiston, New York,* February.

ORAU (Oak Ridge Associated Universities), 1984o. *Comprehensive Radiological Survey, Off-Site Property T, Niagara Falls Storage Site, Lewiston, New York,* March.

ORAU (Oak Ridge Associated Universities), 1984p. *Comprehensive Radiological Survey, Off-Site Property U, Niagara Falls Storage Site, Lewiston, New York,* March.

ORAU (Oak Ridge Associated Universities), 1984q. *Comprehensive Radiological Survey, Off-Site Property V, Niagara Falls Storage Site, Lewiston, New York,* April.

ORAU (Oak Ridge Associated Universities), 1984r. *Comprehensive Radiological Survey, Off-Site Property W, Niagara Falls Storage Site, Lewiston, New York,* February.

ORAU (Oak Ridge Associated Universities), 1984s. *Comprehensive Radiological Survey, Off-Site Property X, Niagara Falls Storage Site, Lewiston, New York,* May.

ORAU (Oak Ridge Associated Universities), 1988. *Radiological Survey of the Niagara Falls Storage Site, Lewiston, New York,* ORAU, December 1988.

ORAU (Oak Ridge Associated Universities), 1989. *Verification of 1983 and 1984 Remedial Actions, Niagara Falls Storage Site Vicinity Properties, Lewiston, New York,* December.

ORAU (Oak Ridge Associated Universities), 1990. *Verification of 1985 and 1986 Remedial Actions, Niagara Falls Storage Site Vicinity Properties, Lewiston, New York,* July.

State of New York Atomic Energy Council, 1972. *Memorandum: Decontamination of the Lake Ontario Ordnance Works (LOOW) Site*, response to comments draft letter concerning preliminary results of the recent radiological survey, October 25.

Town of Lewiston, 1980. Correspondence from Mary Beth Brado, Town of Lewiston, to William E. Mott, DOE, concerning NYDOH land use restrictions on 1,511 acres of former LOOW, January 29.

USACE (U.S. Army Corps of Engineers), 1999. *Report for Phase I Remedial Investigation at the Former Lake Ontario Ordnance Works (LOOW), Niagara County, New York*, prepared by EA Engineering, Science, and Technology for USACE, Baltimore District, July.

USACE (U.S. Army Corps of Engineers), 2002. *Report of Results for the Phase II Remedial Investigation at the Former Lake Ontario Ordnance Works (LOOW), Niagara County, New York,* prepared by EA Engineering, Science, and Technology, Inc., for USACE, Baltimore District, February.

USACE (U.S. Army Corps of Engineers), 2008. *Phase IV Remedial Investigation and Feasibility Studies at the Former Lake Ontario Ordnance Works (LOOW), NY* (Fact Sheet), July, available on the Internet at http://www.lrb.usace.army.mil/derpfuds/loow/loow-fs-phase4ri-2008-07.pdf, accessed February 18, 2010.

USACE (U.S. Army Corp of Engineers Buffalo District), 2009. *Lake Ontario Ordnance Works Management Action Plan*, September.

U.SA. War Department, Office of the Area Engineer, 1943. *Construction Completion Report Lake Ontario Ordnance Works,* vols. 1 and 2, Youngstown, New York, April.

Wallo, A., 1980. Correspondence from Andrew Wallo, The Aerospace Corporation, to William E. Mott, DOE, attached April 1972 NYDOH Commissioner's land use restrictions on 1,511 acres of former LOOW, August 11.

This page intentionally left blank