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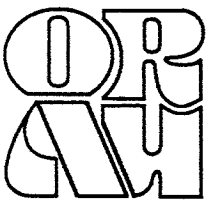

Prepared by
Oak Ridge Associated
Universities

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of Energy

VERIFICATION OF 1983 AND 1984 REMEDIAL ACTIONS NIAGARA FALLS STORAGE SITE VICINITY PROPERTIES LEWISTON, NEW YORK

S. A. WICAL, M. R. LANDIS, and A. J. BOERNER

Environmental Survey and Site Assessment Program
Energy/Environment Systems Division

FINAL REPORT
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FINAL REPORT

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INTRODUCTION

Beginning in 1944, the Manhattan Engineer District (MED) and its successor, the Atomic Energy Commission (AEC), used portions of the Lake Ontario Ordnance Works, presently referred to as the Niagara Falls Storage Site (NFSS) and vicinity properties, near Lewiston, New York (Figure 1), for storage of radioactive wastes. These wastes were primarily residues from uranium processing operations; however, they also included: contaminated rubble and scrap from decommissioning activities, biological and miscellaneous wastes from the University of Rochester, and low-level fission-product waste from contaminated-liquid evaporators at the Knolls Atomic Power Laboratory (KAPL). Receipt of radioactive waste was discontinued in 1954, and, following cleanup activities by Hooker Chemical Company, 525 hectares (approximately 1297 acres) of the original 612-hectare site were declared surplus. This property was eventually sold by the General Services Administration to various private, commercial, and governmental agencies.[1]

From 1970-1971 and again from 1981-1984, radiological surveys were conducted of the approximately 525 hectares comprising the vicinity (off-site) properties. The latter surveys, performed by Oak Ridge Associated Universities (ORAU), were in response to a Department of Energy (DOE) request to determine if any of these properties contained residual contamination above current DOE guidelines. During 1983 and 1984, Bechtel National, Inc. (BNI), the Project Management contractor for the Formerly Utilized Sites Remedial Action Program (FUSRAP), conducted additional characterization surveys, where appropriate, to more accurately define the boundaries of contamination on eleven properties identified by ORAU. These properties were designated as A, H', L, M, N/N' South, Q, R, S, U, V, and X. The locations of these properties, relative to the Niagara Falls Storage Site, are shown on Figure 2. In addition, surveys conducted by Battelle Columbus Laboratories in 1979 and 1980, identified extensive contamination in the West and Central Drainage Ditches - major

drainage pathways through the NFSS and vicinity properties (Figure 3). Information on the radiological survey findings is presented in ORAU and Battelle documents.[2-13]

During 1983 and 1984, BNI remediated the eleven properties and the two major drainage pathways described above. Cleanup consisted primarily of excavation of contaminated surface and subsurface soil and rock. However, remedial efforts also included backfilling and regrading of roads and restoration of water and sewer lines, fencing, and culverts. Upon completion of remedial actions, a follow-up survey was performed by BNI to demonstrate compliance with the cleanup guidelines. Remedial actions at each of the properties and results of the follow-up surveys are described in a post-remedial action report prepared by BNI.[14] Activities to identify and remove contamination on additional vicinity properties at NFSS were performed from 1985 to 1987 and are documented separately.

It is the policy of the DOE to perform independent (third party) verifications of the effectiveness of remedial actions conducted within FUSRAP. The Environmental Survey and Site Assessment Program (ESSAP) of ORAU was designated by the DOE as the organization responsible for this task at the NFSS vicinity properties. Beginning in April 1986 and continuing through October 1986, ORAU performed verification activities for the eleven vicinity properties and the West and Central Drainage Ditches where remedial actions were conducted in 1983 and 1984. This report describes the procedures and findings of that verification.

PROCEDURES

Objectives

The objectives of the verification were to confirm that the surveys, sampling, analyses and associated project documentation provided an accurate and complete description of remedial actions and the conditions of the vicinity properties at the NFSS and, thereby, confirm that remedial actions have been effective in meeting established criteria.

Procedures

1. Radiological characterization reports (References 2-13), engineering drawings for each of the areas undergoing remediation, and the post-remedial action report (Reference 14) were reviewed. Data were evaluated to assure that areas exceeding guidelines were identified and had undergone remedial action. Post-remedial action radionuclide concentrations in soil and exposure-rate data were compared to guidelines and the post-remedial action report was reviewed for general thoroughness and accuracy.

2. One hundred and sixteen (116) soil samples, collected during the post-remedial action survey, were obtained from BNI. Thirty-four (34) of these samples, representing eight of the eleven properties and the West and Central Drainage Ditches, were selected at random and analyzed for radionuclides of interest (Ra-226, U-238, and Th-232) by the ORAU laboratory to confirm the accuracy of BNI analyses.

3. Survey teams from ORAU visited the NFSS vicinity properties and performed visual inspections, gamma scans, direct measurements, and surface (0-15 cm) and subsurface sampling on representative portions of the excavated areas. Measurement and sampling locations were referenced to the New York State grid; reference grid lines are shown on Figure 4.

4. Sixteen soil samples were collected from the Lewiston area (but not on the NFSS or associated off-site properties) to provide baseline concentrations of radionuclides for comparison purposes. Background radiation levels were measured at locations where baseline soil samples were collected. The locations of the baseline samples and background measurements are shown on Figure 5.

5. Findings of the inspections and radiological surveys were compared with the post-remedial action report and the established NFSS vicinity

property criteria (Appendix A). Measurement and analytical equipment and procedures are described in further detail in Appendices B and C.

FINDINGS AND RESULTS

Document Reviews

Cleanup of the eleven properties and two major drainage pathways was appropriate, based on the characterization surveys performed by ORAU and Battelle Columbus Laboratories. Each of these properties and drainage ditches had contained isolated and/or general areas of Ra-226, U-238, and/or Th-232 contamination in excess of the guidelines established for the NFSS vicinity properties. Efforts were made in these reports to distinguish those locations and areas, where contamination was due to activities associated with the Manhattan Engineer District, from those areas with materials of other origin. For example, slags and crushed rock, containing elevated levels of naturally occurring uranium and thorium, have been used as construction fill at various locations throughout the Buffalo/Niagara Falls area. Analyses of samples provided information which was used by the cleanup contractor, BNI, to design remediation plans for such areas. Further characterization data collected by BNI more precisely defined those areas already designated for remediation and identified a few additional small areas warranting cleanup. The post-remedial action report accurately describes the remedial activities performed on these areas, and the data presented confirms that the guidelines have been met.

Confirmatory Sample Analyses

Table 1 presents the results of gamma spectrometry analyses performed independently by ORAU and BNI on thirty-four soil samples collected from the remediated Niagara Falls Storage Site vicinity properties. For the major radionuclide of concern, Ra-226, data are in agreement within their respective 95% confidence levels for 29 of the 34 samples and within 99% confidence levels for 31 of the 34 samples. Large differences were noted in Ra-226 levels measured in two of the samples. Sample 4 from Property M (S2260, E920) was

reported to contain 24.1 pCi/g by ORAU, but only 10.6 pCi/g by BNI. In addition, sample 128 collected from the West Ditch (N1600, W160), was reported to contain 78.7 pCi/g by ORAU, but less than the minimum detectable activity (MDA - no value stated) by BNI. Reasons for these differences in the ORAU and BNI analyses could not be identified; however, it should be noted that verification surveys of the areas from which these samples were obtained did not identify residual activity exceeding guidelines. With exception of seven samples, all results for U-238 analyses, reported by BNI, were less than the detection sensitivity of the procedure (i.e. <MDA). For the seven samples, having both ORAU and BNI values, six were in agreement within the 95% confidence intervals and all seven were within the 99% confidence intervals. Thorium-232 data pairs were within the 95% confidence levels for 32 of the 34 samples. For the two samples not within the 95% confidence levels, BNI reported less than the minimum detectable activity and, therefore, a direct comparison of the ORAU and BNI data could not be performed. These findings indicate, that with only a few isolated exceptions, the ORAU and BNI data are statistically indistinguishable; it is therefore, ORAU's opinion that the BNI data is accurate and should be accepted.

Background Levels and Baseline Concentrations

Background exposure rates and baseline radionuclide concentrations in soil, determined for 16 locations in the vicinity of the NFSS, are presented in Table 2. Exposure rates ranged from 7 to 9 μR/h (typical levels for this area of New York). Concentrations of radionuclides in soil were: Ra-226, <0.1 to 1.2 pCi/g (picocuries per gram); U-238, <4.2; Th-232, 0.3 to 1.2 pCi/g; and Cs-137, <0.1 to 1.1 pCi/g. These concentrations are typical of the radionuclide levels normally encountered in surface soils.

Verification Surveys

Property A

Gamma scans were conducted at locations originally identified by the ORAU characterization survey.[2] Remedial action was effective in removing isolated

locations of elevated activity along "H" Street (Figure 6). The small area on the shoulder of the road at the intersection of Marshall Street and "H" Street originally identified in the ORAU characterization report could not be located by BNI or during the ORAU verification survey. It is suspected that routine road maintenance activities resulted in removing or relocating the source of the slightly elevated direct radiation levels.

Exposure rates were in the range of background levels at remediated locations. The gamma scan did identify, however, several additional isolated areas of elevated activity remaining near the southwest property boundary. Pieces of slag-like material, removed from this area, contained up to 1830 pCi/g of Ra-226. Uranium-238 and Th-232 concentrations were 10% or less of the Ra-226 levels, indicating that this material was not of natural origin. Further cleanup was performed by BNI, and follow-up scans indicated that remediation had been effective. Radionuclide concentrations in verification soil samples, collected by ORAU from this area, are listed in Table 3. Levels of Ra-226, U-238, and Th-232 were in the range of baseline values. Exposure rates following remediation of this area ranged from 8 to 17 μR/h at contact and from 7 to 9 μR/h at 1 m above the surface.

Property H'

Surface exposure rates ranged from 7 to 14 μR/h for the major portion of the remediated area on Property H' (Figure 7). Three isolated areas with elevated direct radiation levels were identified. All three were within the area originally identified in the ORAU characterization report. An elevated gamma reading (40 μR/h) was noted at grid coordinate N2077, E1126; small chips of material were uncovered at this location. Removal of this material reduced contact exposure rates to near background levels (12 μR/h). Elevated gamma levels (27 μR/h) at N2066, E1189 were due to naturally occurring slag; no cleanup was therefore performed at this location. The third location of elevated activity was adjacent to a remediated area on "M" Street (N1940, E1125). Contact exposure rates at this location ranged up to 84 μR/h. Gamma activity was associated with a black cinder-like material; a sample of this material contained 220 pCi/g of Ra-226 and 37 pCi/g of U-238. Additional excavation was effective in removing this material.

Radionuclide concentrations in samples from the general remediated area and follow-up samples along "M" Street are listed in Tables 4 and 5, respectively. All concentrations are within the guidelines for vicinity properties at the Niagara Falls site.

Property L

Gamma scans were conducted along the west side of Campbell Street from the intersection with Pletcher Road to the DOE security fence (Figure 8). Contact exposure rates ranged from 7 to 32 μR/h. The highest level was found at grid coordinate S2180, E876. Table 6 presents radionuclide concentrations in soil samples collected from the west side of Campbell Street. Four surface soil samples contained Ra-226 concentrations ranging from 8.0 pCi/g to 31.5 pCi/g. Although these concentrations are individually in excess of the guideline values, these samples were collected from locations of isolated, elevated gamma activity, and application of the hot spot criteria results in meeting the DOE guidelines. Therefore, no additional remedial action was required at these locations. Three samples, collected at a depth of 15-30 cm (0.5 to 1 ft) between backfilled and undisturbed soil, contained baseline concentrations of radionuclides. All other sampling locations were within the guidelines.

Property M

Surface gamma scans were conducted along the east side of Campbell Street, from the intersection with Pletcher Road to the DOE security fence (Figure 8). Slightly elevated exposure rates (to 16 μR/h) were noted adjacent to the street. Radionuclide concentrations in verification samples collected from this area are listed in Table 7. Four of these samples were collected from the interface (30-45 cm [1.0 to 1.5 ft] depth) between backfilled and undisturbed soil. Six samples contained concentrations of Ra-226 greater than 5 pCi/g over background; the highest level (9.5 pCi/g) was noted at grid location S2533, E937. Application of the hot spot criteria results in these locations meeting the DOE guidelines.

Property N/N' South

Two areas of remedial action on N/N' South, were resurveyed by ORAU (Figure 9). The surface scan identified two isolated locations of elevated surface activity inside the western-most excavation along Track Street. Surface sampling reduced the direct radiation levels to background levels. Contact gamma exposure rates ranged from 8 to 12 μR/h. Radionuclide concentrations in verification soil samples are listed in Table 8. Five of these samples were collected at the interface between backfilled and undisturbed soil. The results indicate that baseline levels (approximately 1 pCi/g) of Ra-226 are present; levels of U-238 are elevated in three of the samples, ranging from 5.9 to 13.3 pCi/g. These levels of U-238, however, are well below the criteria of 45 pCi/g. Levels of Th-232 were also in the range of baseline values.

Property Q

Surface scans, conducted over several areas on Property Q (Figures 10-13), identified 3 regions of residual elevated direct radiation. One of these was near the former location of a warehouse (Figure 10). A sample collected from this area contained 8290 pCi/g of Ra-226. Following cleanup by BNI, exposure rates were reduced to near-background levels (8 to 13 μR/h). The results of follow-up samples are presented in Table 9; all radionuclide concentrations were below their respective guideline levels.

The gamma scan identified elevated levels (40 to 70 μR/h) adjacent to railroad tracks in the east-central portion of the property, identified as Section 2 in the post-remedial action report (Figure 11). Investigation of this area revealed cinder and ash-like materials, high in Ra-226 content; five soil samples, collected from the area, contained levels of Ra-226 up to 200 pCi/g (Table 10). Further remediation reduced contact exposure rates to near background levels (8 to 20 μR/h). Samples collected from within the remediated grid block, S5600 to S5650 and E2300 to E2350, after additional cleanup, contained concentrations of the radionuclides within the guidelines (see Table 10).

Elevated contact exposure rates (up to 500 μR/h) were noted on a dirt access road, north of the Highway Maintenance Garage, identified as Section 3 in the post-remedial action report (Figure 12). These gamma levels were associated with an ash-like material containing elevated Ra-226 (to 820 pCi/g) and U-238 (to 87.1 pCi/g). Further remedial action was effective in significantly reducing exposure rates (14 to 24 μR/h). Radionuclide concentrations in follow-up samples are listed in Table 11; levels of Ra-226, U-238 and Th-232 are within the applicable guidelines.

The fourth region surveyed was a rather large remediated area, south of the Highway Maintenance Garage near Swann Road (Figure 13). This area was identified as Section 5 in the post-remedial action report. No locations of elevated activity were identified by the gamma scan; exposure rates ranged from 5 to 10 μR/h. Sampling results, presented in Table 12, indicate radionuclide concentrations in the range of baseline levels.

In addition to the areas described above, two other small areas of contamination were identified at approximately S5570, E2342 and S5589, E2343. Samples collected from these locations after removal of 0.6 and 1.8 m^3 (21 and 64 ft^3) of soil, respectively, contained levels of Ra-226, U-238 and Th-232 in the range of baseline soil.

Property R

Gamma surface scans, performed in and near the remediated area (Figure 14) adjacent to Pletcher Road, identified slightly elevated contact exposure rates (12 to 14 μR/h); however, radionuclide concentrations in verification samples collected from this portion of Property R were generally in the range of baseline levels (see Table 13). Several samples did contain elevated Ra-226 levels (up to 5.3 pCi/g including background), but all were within the guidelines for vicinity properties. Samples from the excavation interface (to 0.45 m depth) contained radionuclide concentrations in the range of baseline samples.

At an isolated area of elevated activity, approximately 120 m (394 ft) north of Pletcher Road, exposure rates before sampling ranged from 29 to 34 μR/h. Levels of Ra-226 in samples collected from this area ranged up 255 pCi/g. Further remediation was performed. Results of follow-up sampling from the excavation are listed in Table 14. The maximum concentration in these samples was 13.3 pCi/g of Ra-226, which is below the 15 pCi/g guideline value for subsurface radium in soil (the excavation was backfilled), and contact exposure rates were reduced to 12 to 14 μR/h.

Property S

Gamma scanning was conducted over a small remediated area west of Campbell Street, the center of which is located at approximately N1304, E888 (Figure 15). Contact gamma exposure rates ranged from 10 to 14 μR/h; no verification soil samples were collected from this area because the direct measurement data indicated that remediation had been effective.

Properties U and V

Figure 16 indicates the major area of remediation along the boundary between properties U and V; this area is an extension of the remediation in the southwest corner of Property A. Initial verification gamma scans had identified residual activity, which was subsequently removed. Follow-up contact radiation levels in this area ranged from 8 to 12 μR/h. Radionuclide concentrations in verification samples, listed in Table 15, were within the guideline values; most were in the range of baseline soils.

Several additional small (<1 to 5 m^2 [10.8 to 54 ft^2]) surface areas which were remediated on these properties were gamma scanned. Some elevated residual levels were noted; these were associated with isolated individual pieces of slag-like material. Further remediation removed these materials, reducing the contact radiation levels to background values of 8 to 10 μR/h.

Property X

Surface scans identified two regions of residual elevated gamma levels. Both were in the area referred to as Section 1 in the BNI report. One of these had contact exposure rates which ranged from 17 to 40 μR/h. Samples from this area contained approximately equal concentrations of Ra-226 and U-238, which indicates that this is naturally occurring rock and slag material, commonly used in the Niagara area as a fill and paving base, and not of MED/AEC origin. Elevated gamma levels at the other location were associated with a black ash material; this material, which may have resulted from prior incinerator activities, had contact gamma levels ranging to 130 μR/h. A sample of this material contained 120 pCi/g of Ra-226. Additional cleanup reduced gamma exposure rates to 20 μR/h and a verification sample (N1364, W330) contained 1.3 pCi/g of Ra-226.

Gamma scans were also performed over a large remediated area on the south boundary of the property (Figure 17). No locations of elevated activity were noted, and contact exposure rates ranged from 7 to 12 μR/h. Verification samples collected from this area are listed in Table 16. Radionuclide concentrations were all below their respective guideline values.

West Drainage Ditch

The surface scan of the West Drainage Ditch identified several areas of elevated gamma levels, mainly along the lower banks. Contact exposure rates were in the range of 17 to 42 μR/h. These areas were small $<<1$ m^2 and isolated; and therefore, further remediation was not necessary. Verification soil samples were collected at 61 m (200 ft) intervals along the West Drainage Ditch, between the DOE property and its intersection with the Central Ditch (Figure 3). Radionuclide concentrations in these samples are presented in Table 17. No concentrations in excess of guidelines were noted in these samples.

Central Drainage Ditch

Surface scans and soil sampling were performed in the Central Drainage Ditch, beginning at the DOE property fenceline and continuing north to the end of remedial action. Initially samples were collected at 30.5 m (100 ft) intervals, alternating between the Center (C), West (W) and East (E) banks of the ditch. Based on negative scanning results, the sampling interval was increased to 100 m (330 ft) intervals, north of the intersection of the Central Ditch with Balmer Road (N4814, E390).

Contact and general area exposure rates determined during scanning and those measured at sampling points ranged from 7 to 16 μR/h. Radionuclide concentrations in soil samples collected from representative locations along the ditch are listed in Table 18. With the exception of the sampling point at the DOE fence line (N614, E490), all samples contained levels of Ra-226, U-238, and Th-232 below their respective guideline values. The location at the DOE fence line was isolated and small in area; application of the hot spot criteria results in satisfying the DOE guidelines.

SUMMARY

Between April 1986 and October 1986 Oak Ridge Associated Universities' Environmental Survey and Site Assessment Program performed activities to independently verify the adequacy of remedial actions on eleven of the NFSS vicinity properties and the West and Central Drainage Ditches. The verification activities included document reviews, confirmatory laboratory analyses, and independent measurements and sampling. Based on the results and findings of these activities, it is ORAU's opinion that the remedial action has been effective in satisfying the established DOE guidelines and that the documentation supporting the remedial action process is adequate and accurate. A verification letter, indicating these opinions, has been provided to DOE.

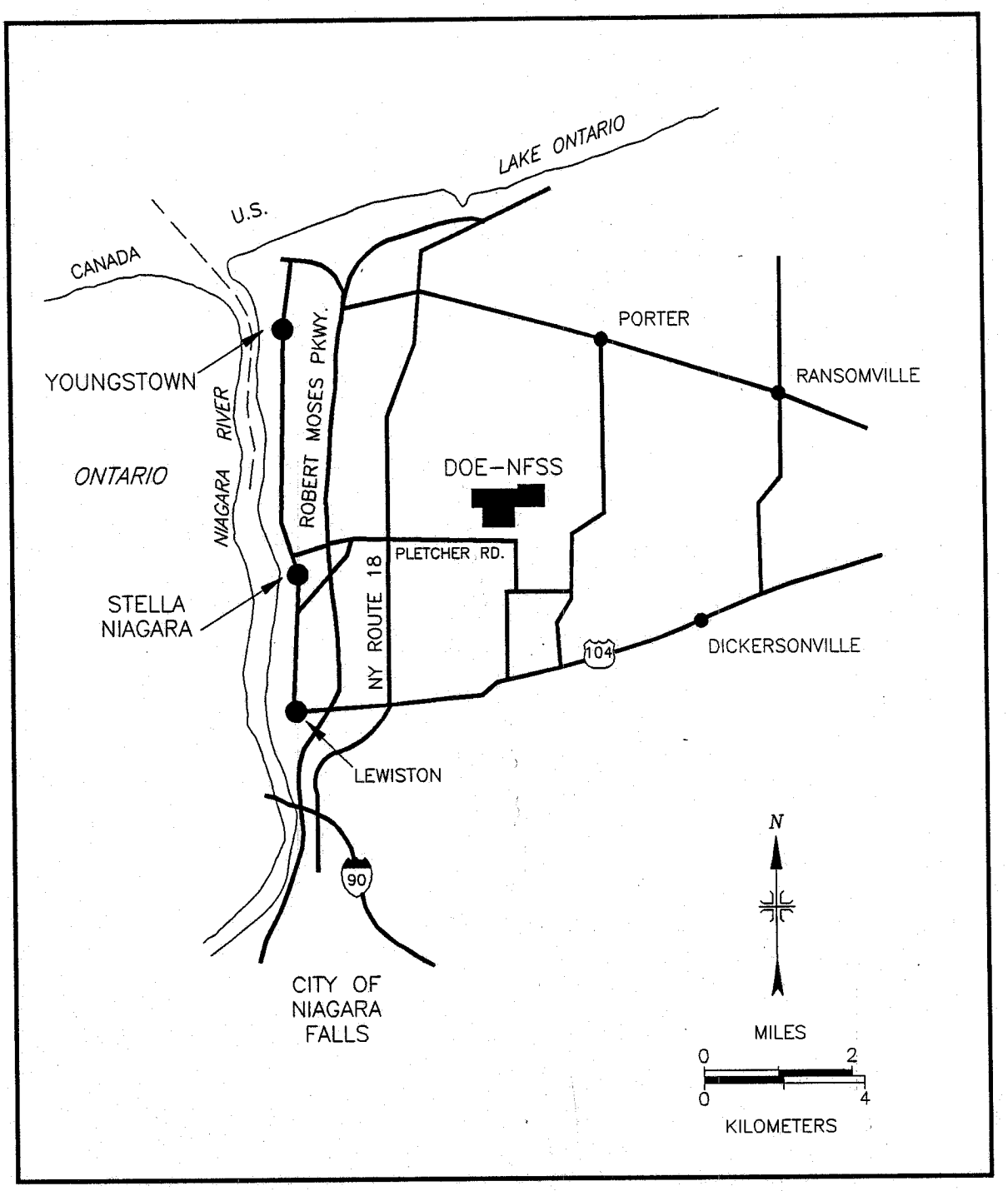


FIGURE 1: Map of Northern Niagara County, New York Indicating the Location of the Niagara Falls Storage Site

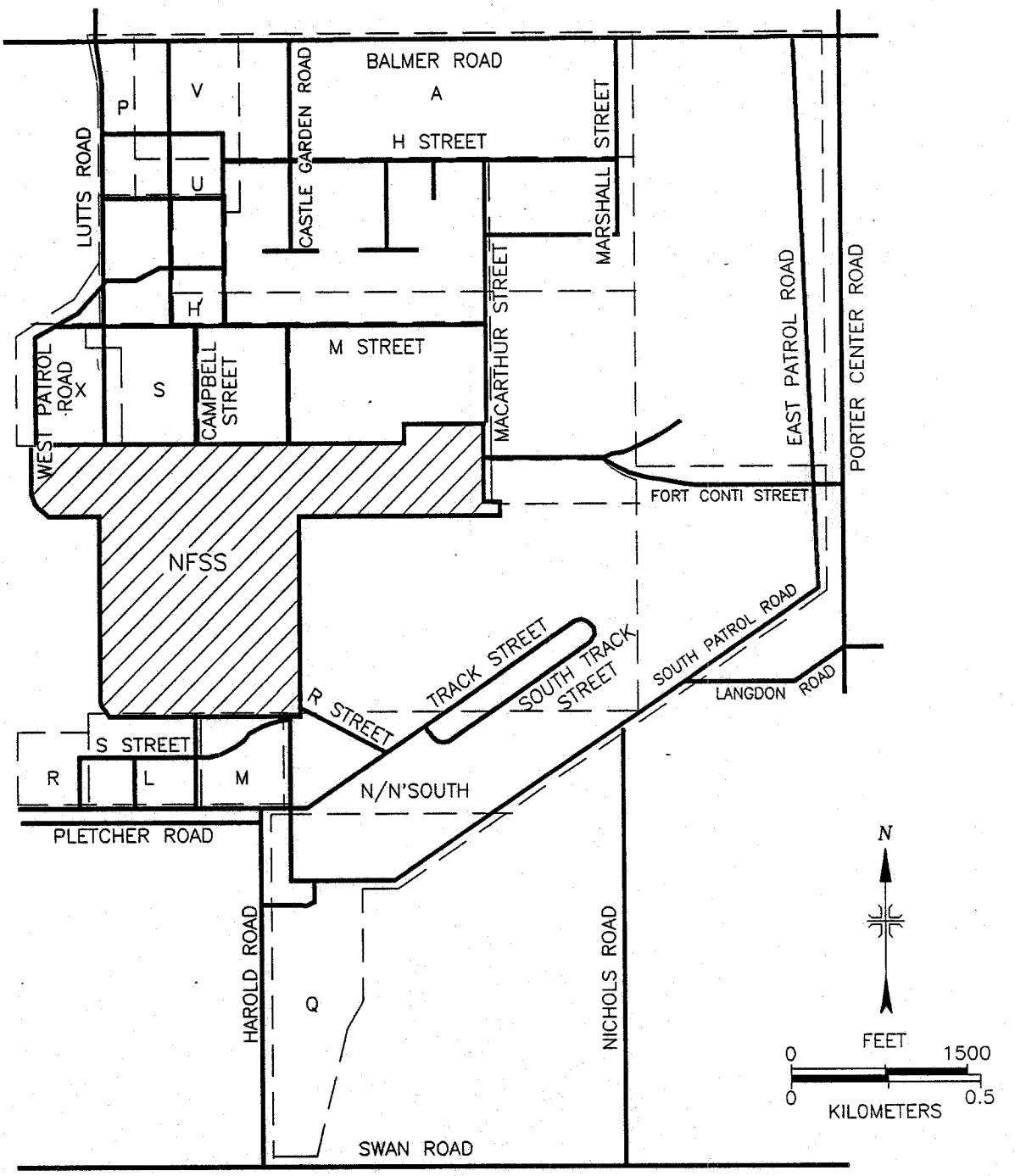


FIGURE 2: Plot Plan of NFSS Vicinity Properties Receiving Remedial Action in 1983 and 1984

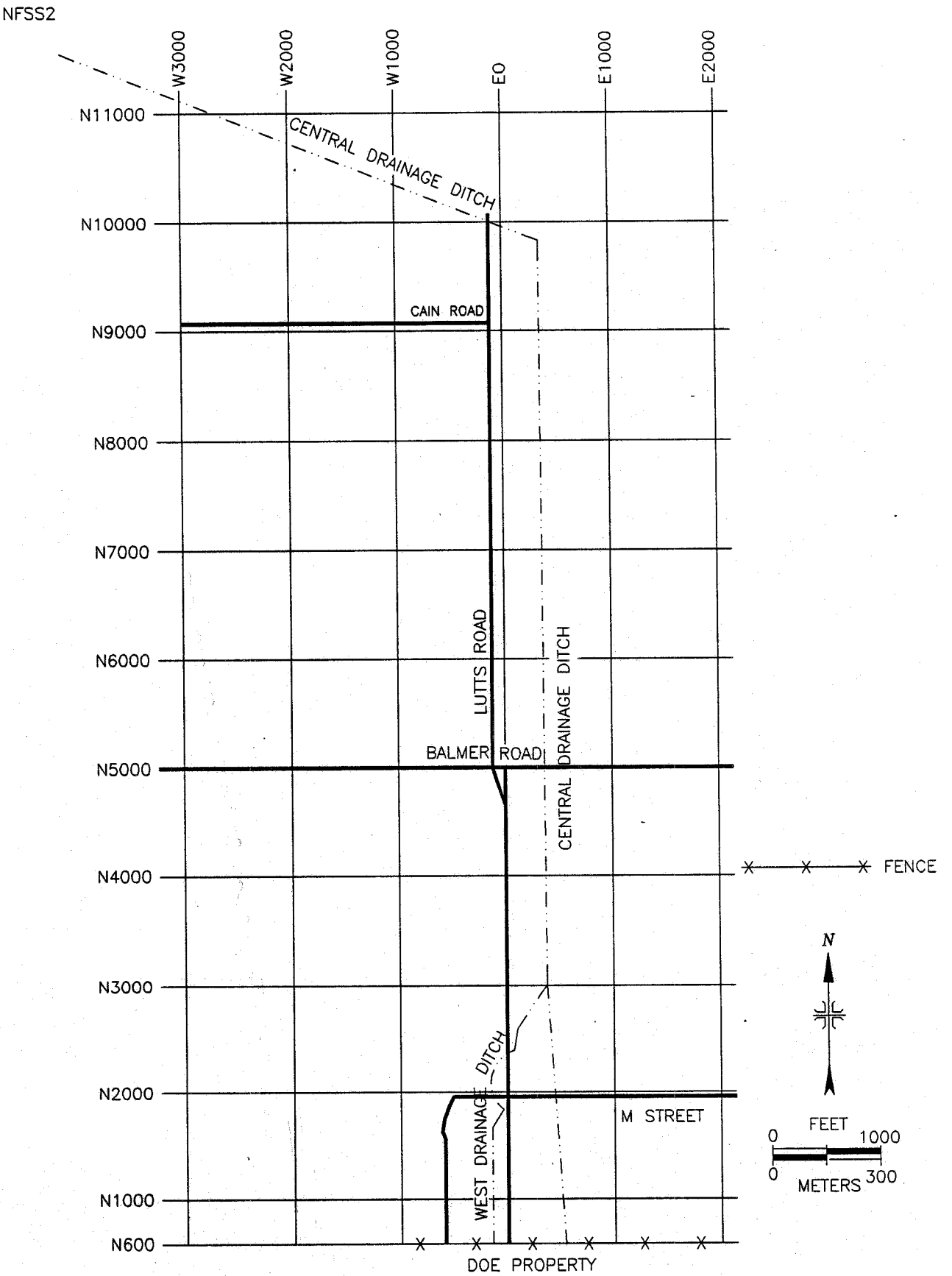


FIGURE 3: Plot Plan of the West and Central Drainage Ditches

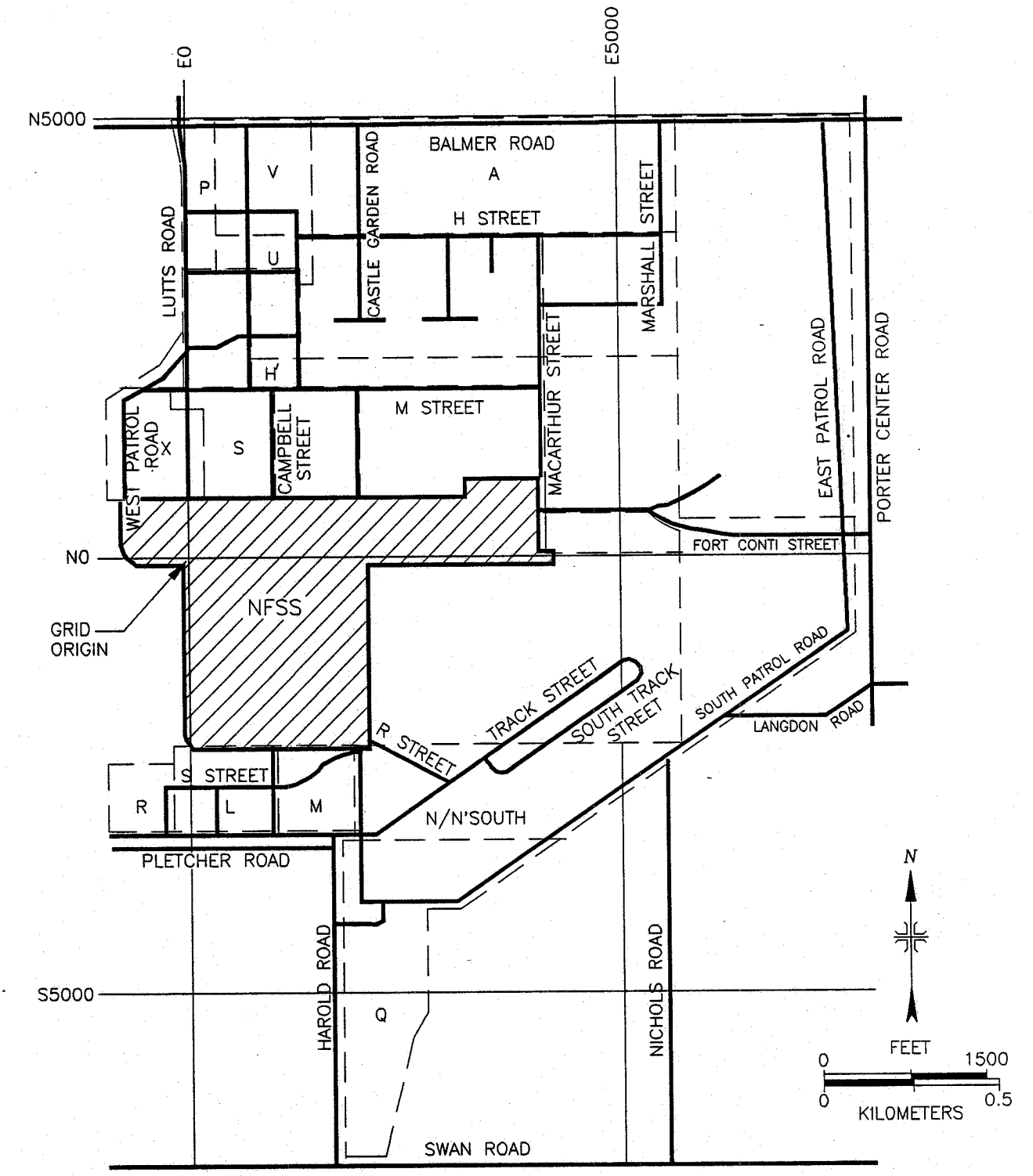


FIGURE 4: Plot Plan of NFSS Vicinity Properties Indicating Reference Grid Lines

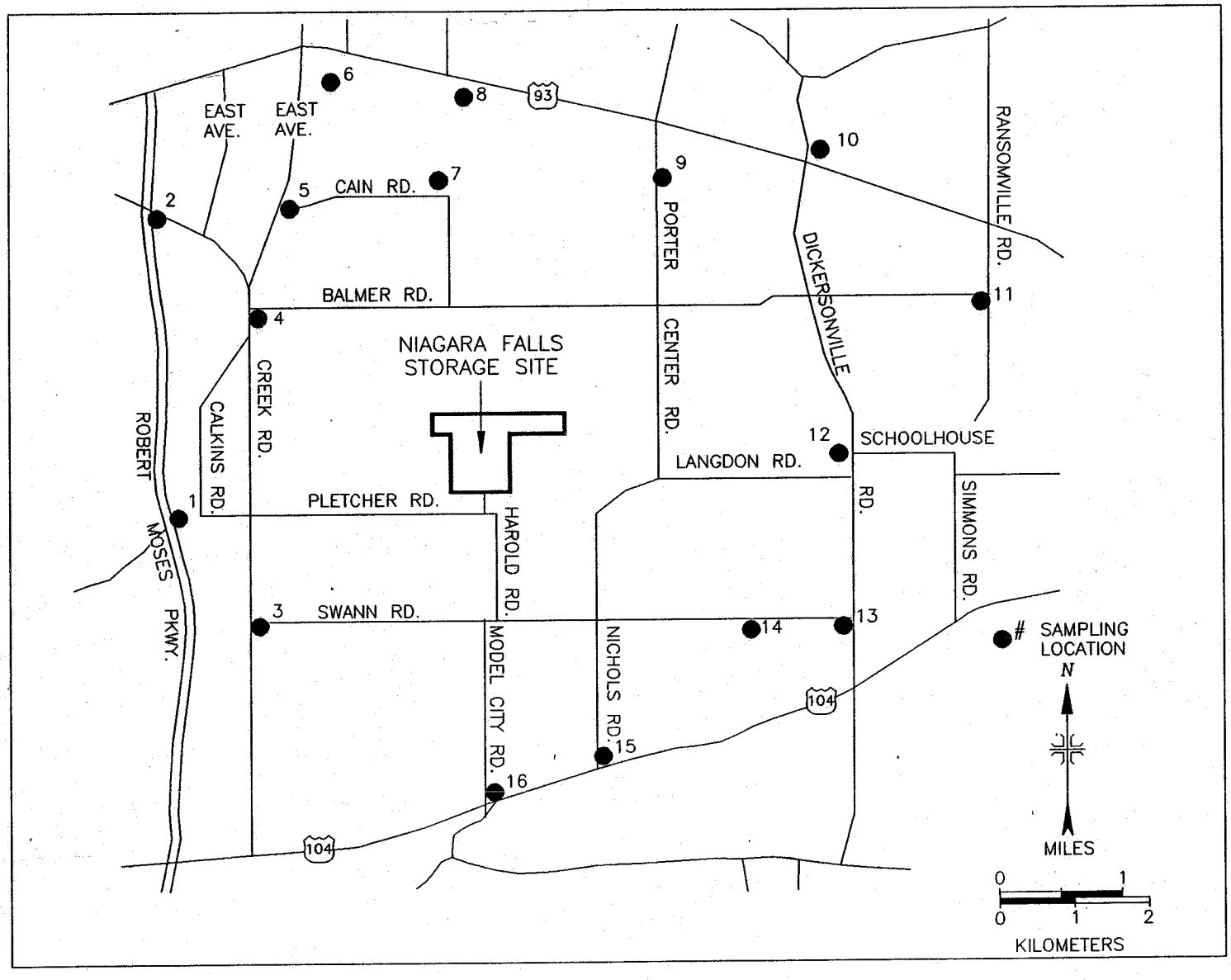


FIGURE 5: Map of Northern Niagara County, New York, Showing Locations of Background Measurements and Baseline Samples

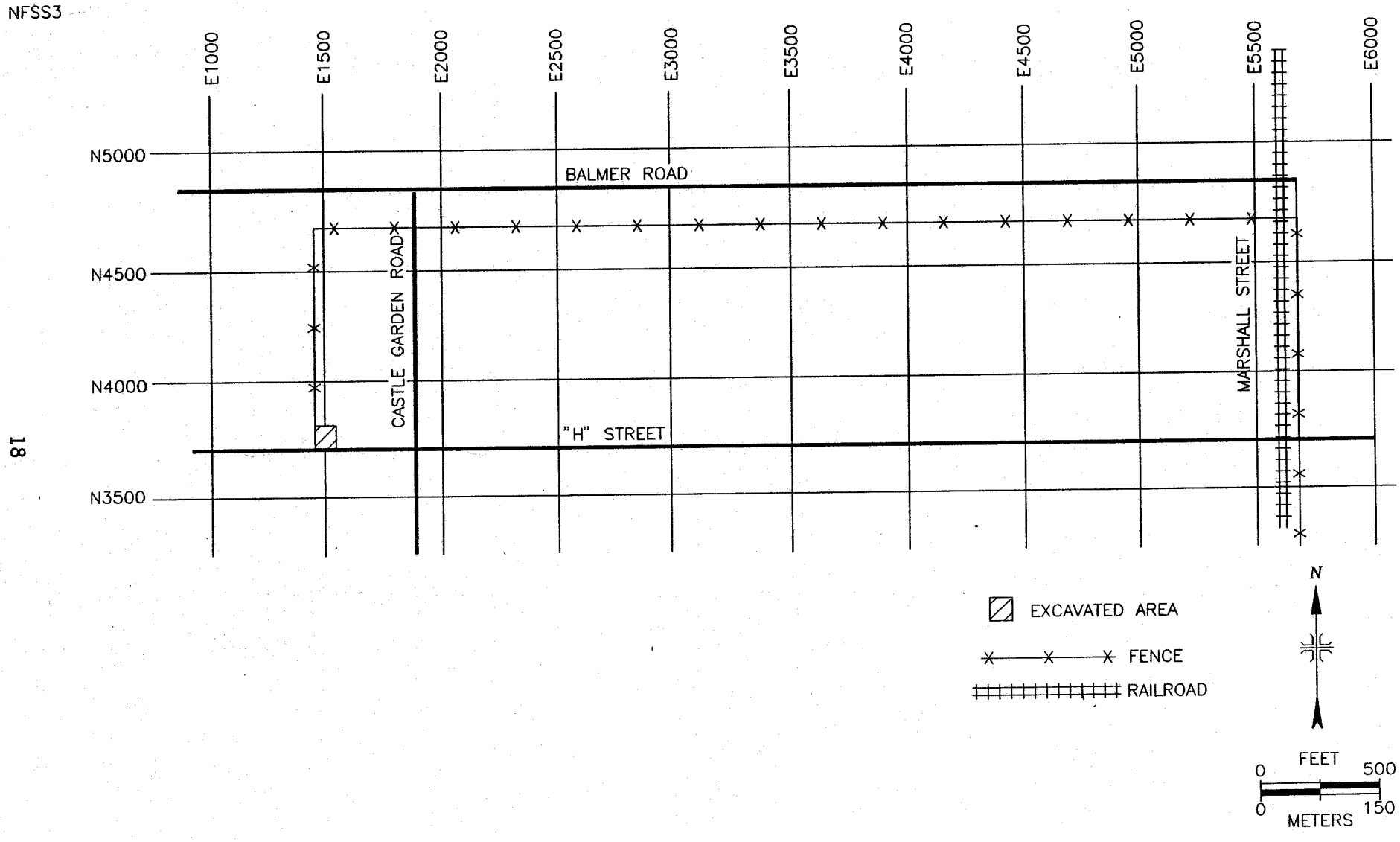


FIGURE 6: Plot Plan of Remediated Section of Vicinity Property A

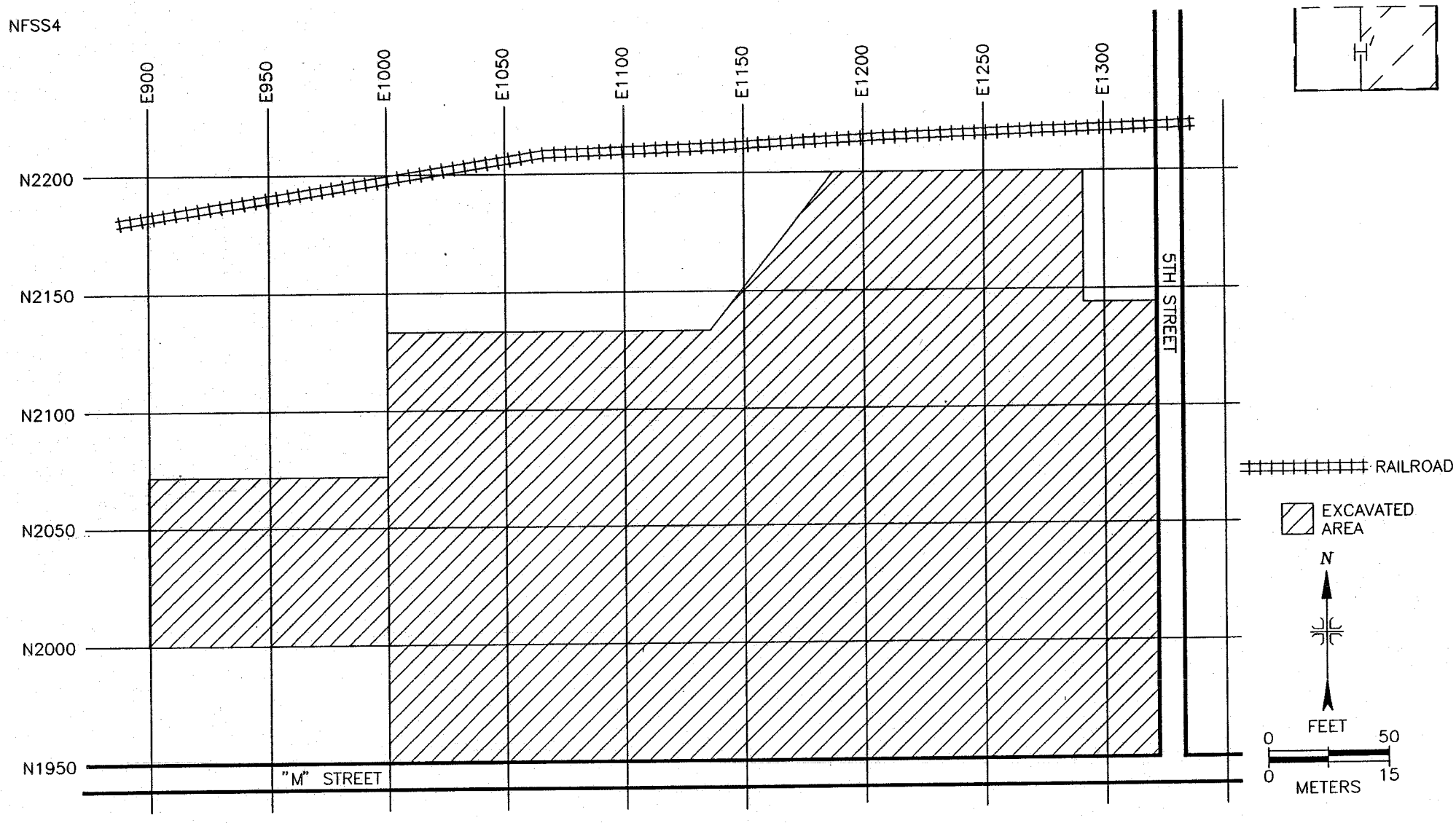
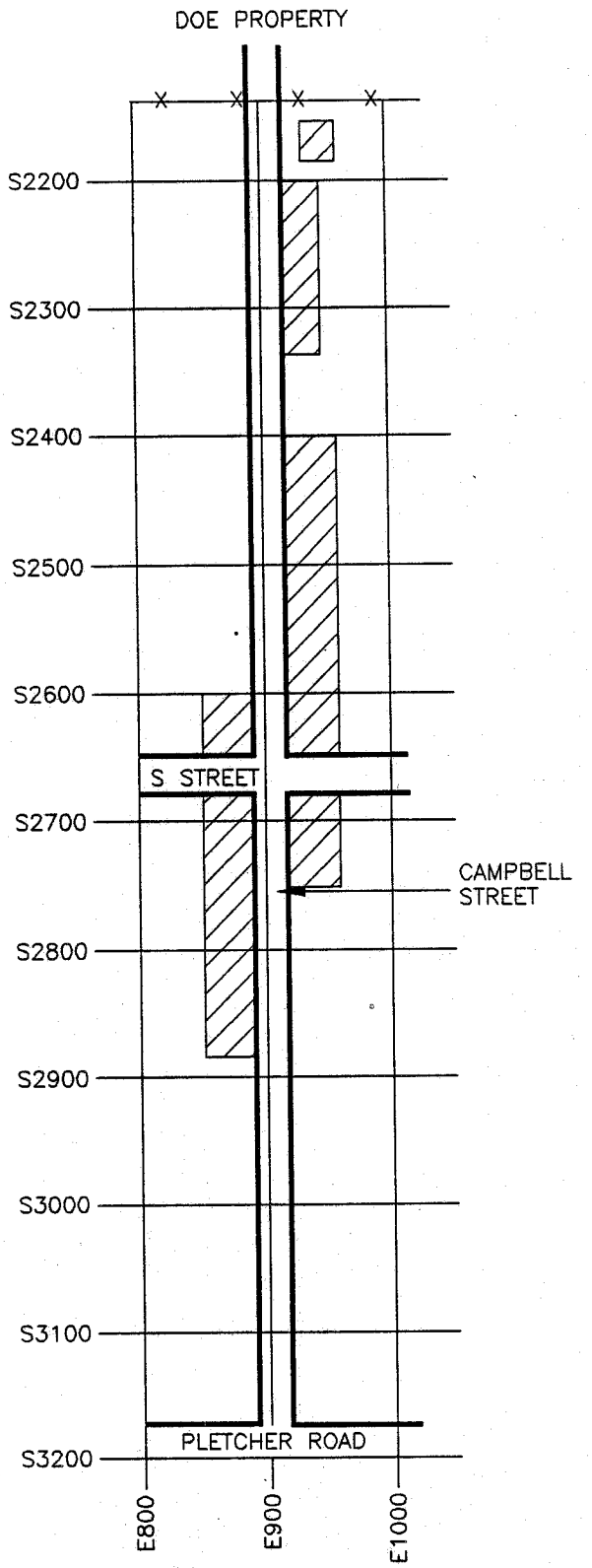
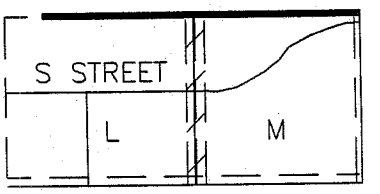


FIGURE 7: Plot Plan of Remediated Section of Vicinity Property H'





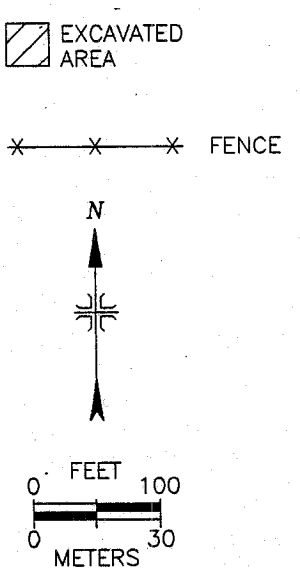


FIGURE 8: Plot Plan of Remediated Sections of Vicinity Properties L and M

NFSS6

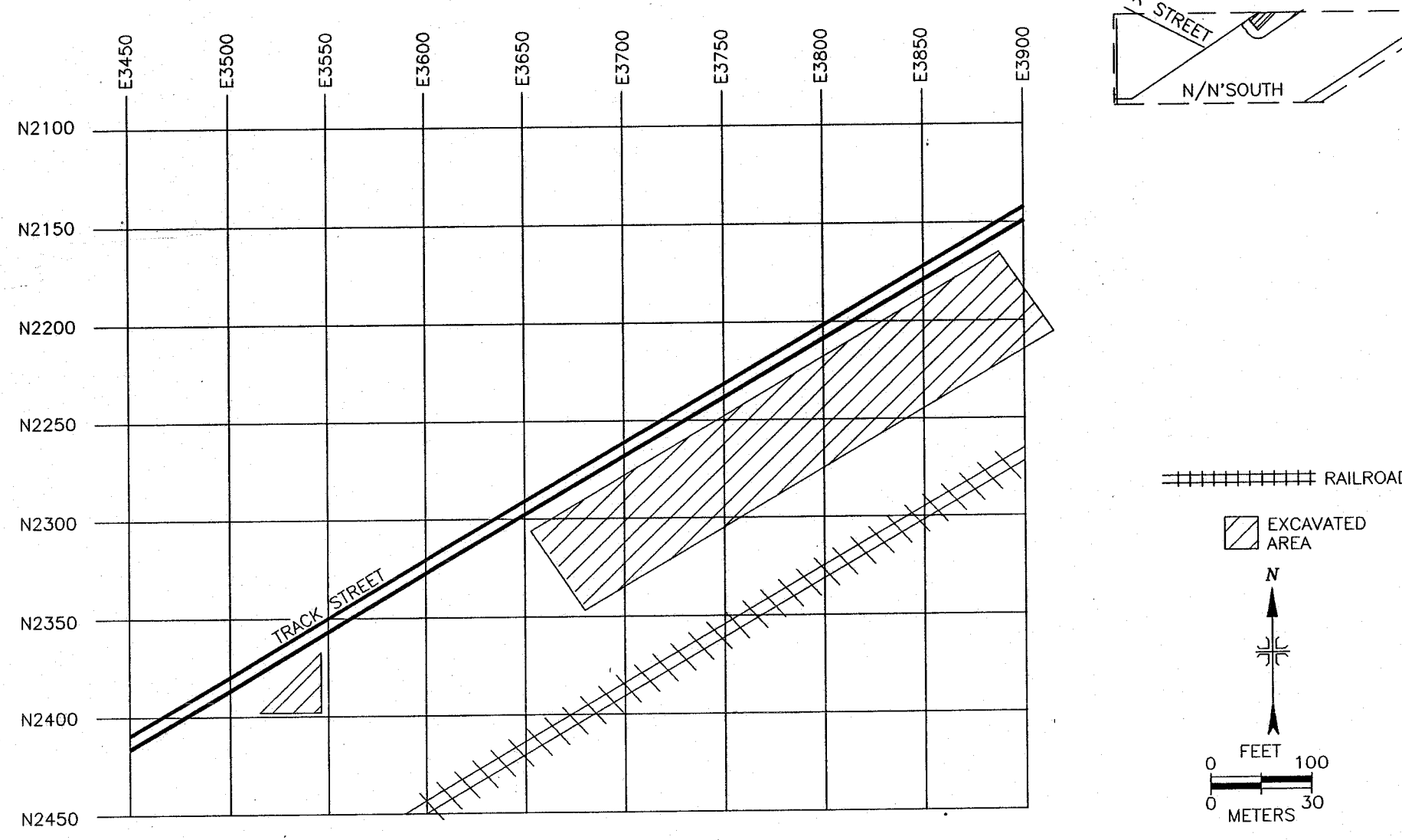


FIGURE 9: Plot Plan of Remediated Section of Vicinity Property N/N' South

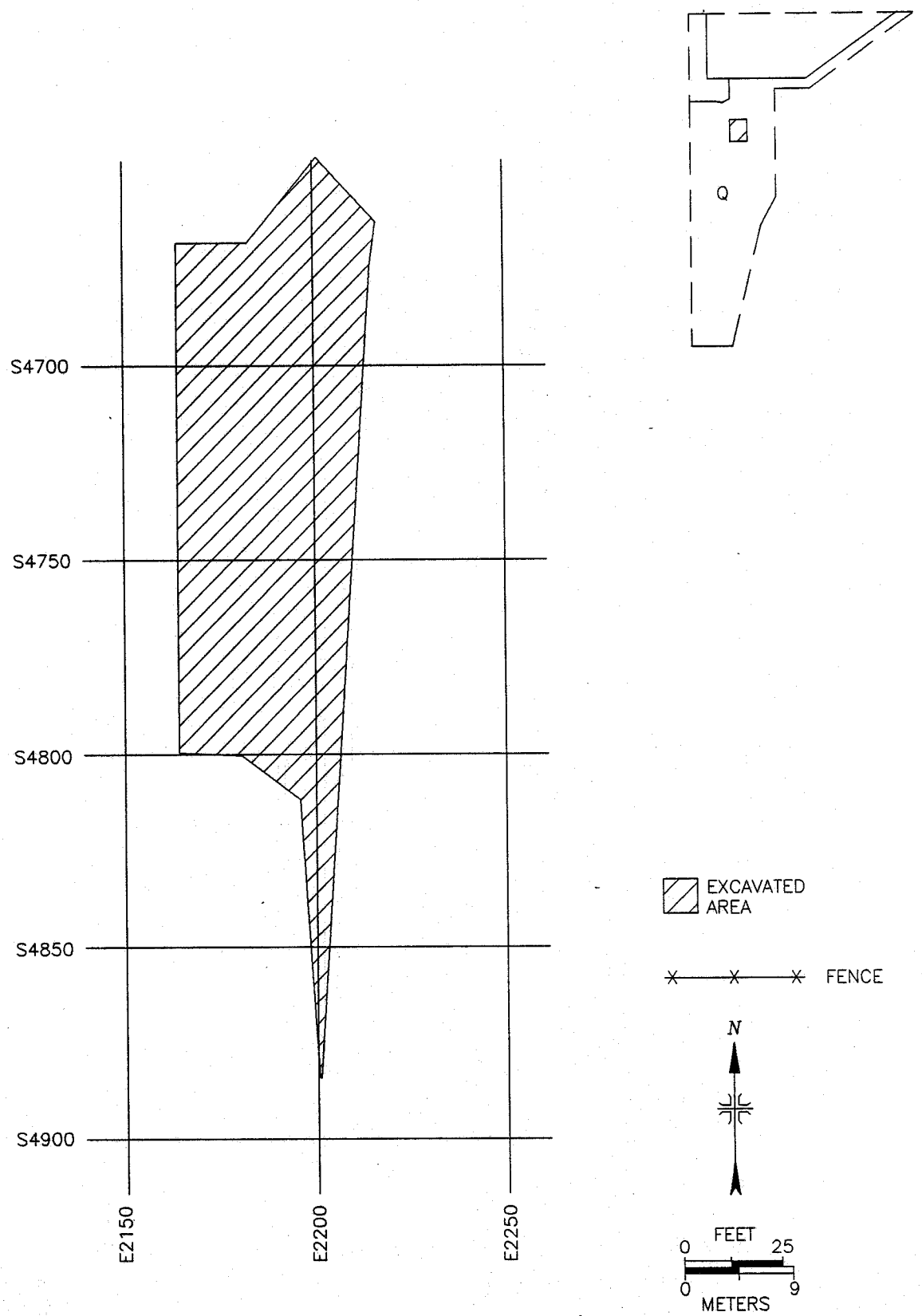
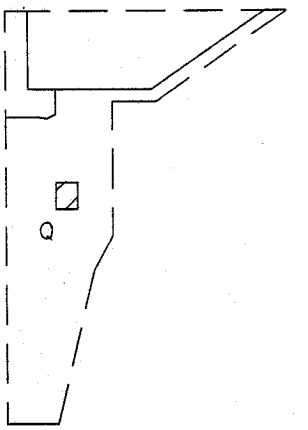
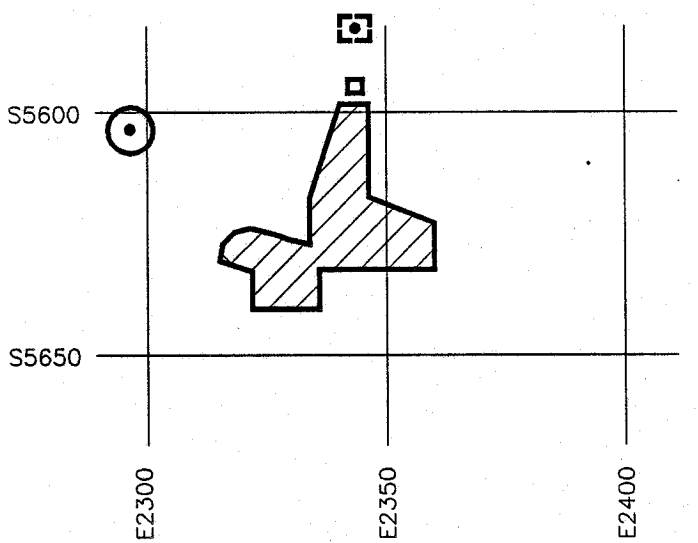


FIGURE 10: Plot Plan of Remediated Section 1 of Vicinity Property Q





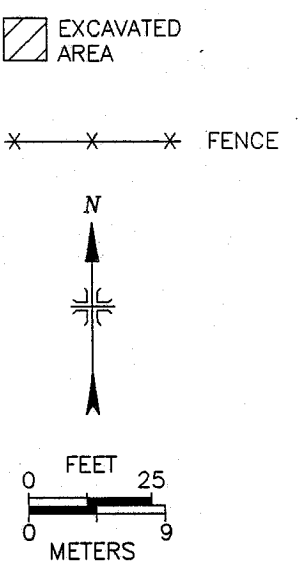


FIGURE 11: Plot Plan of Remediated Section 2 of Vicinity Property Q

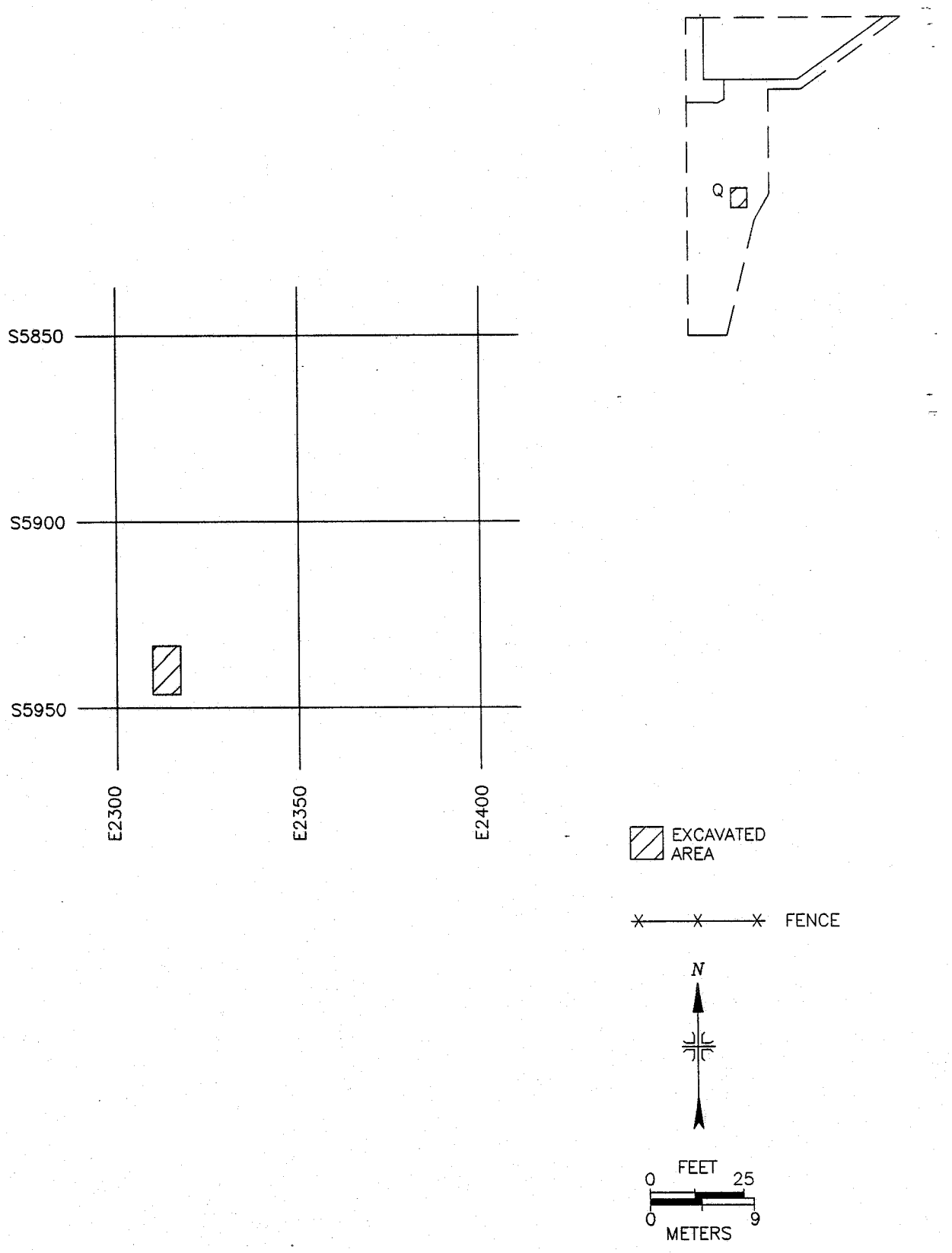


FIGURE 12: Plot Plan of Remediated Section 3 of Vicinity Property Q

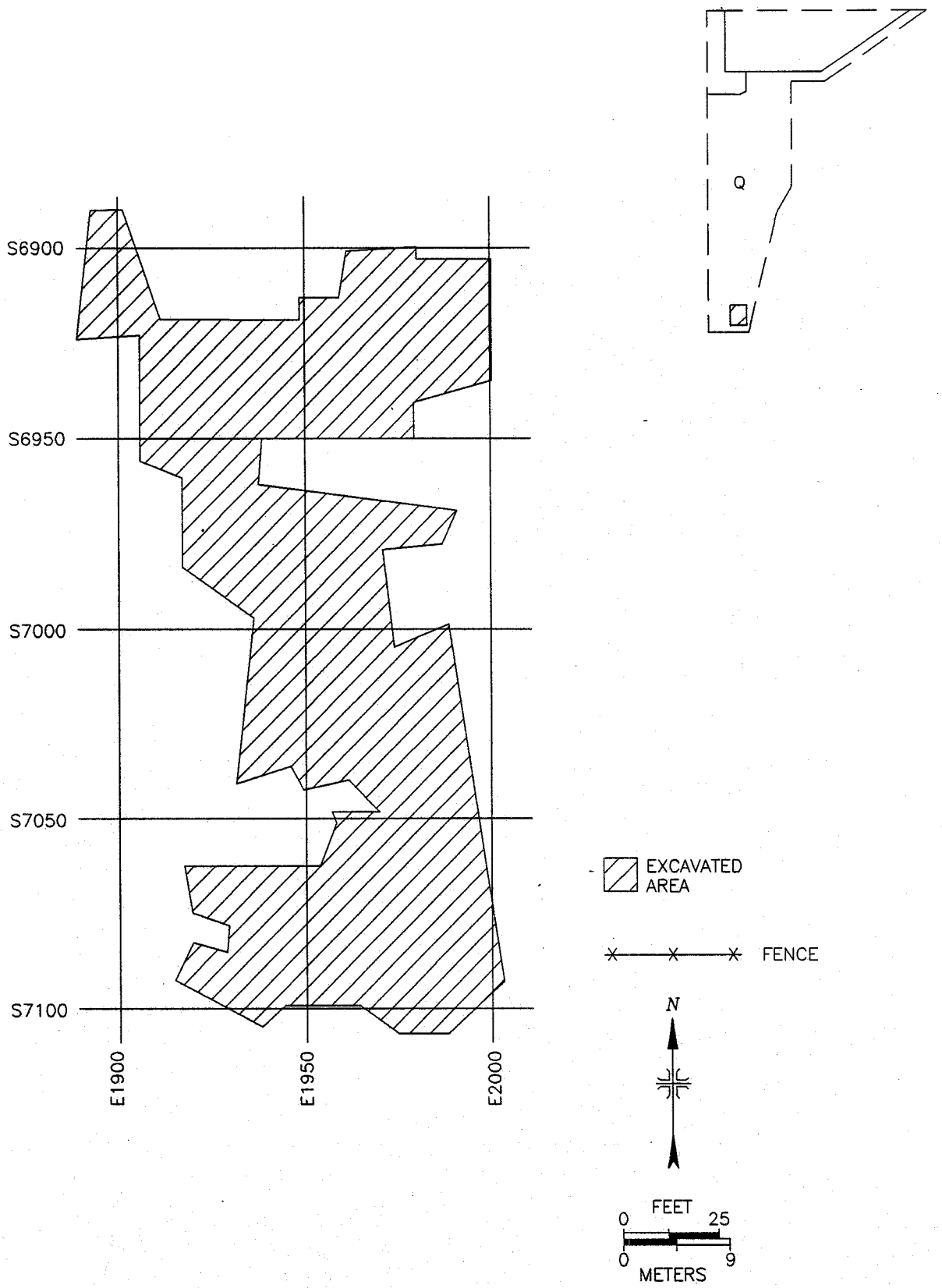


FIGURE 13: Plot Plan of Remediated Section 5 of Vicinity Property Q

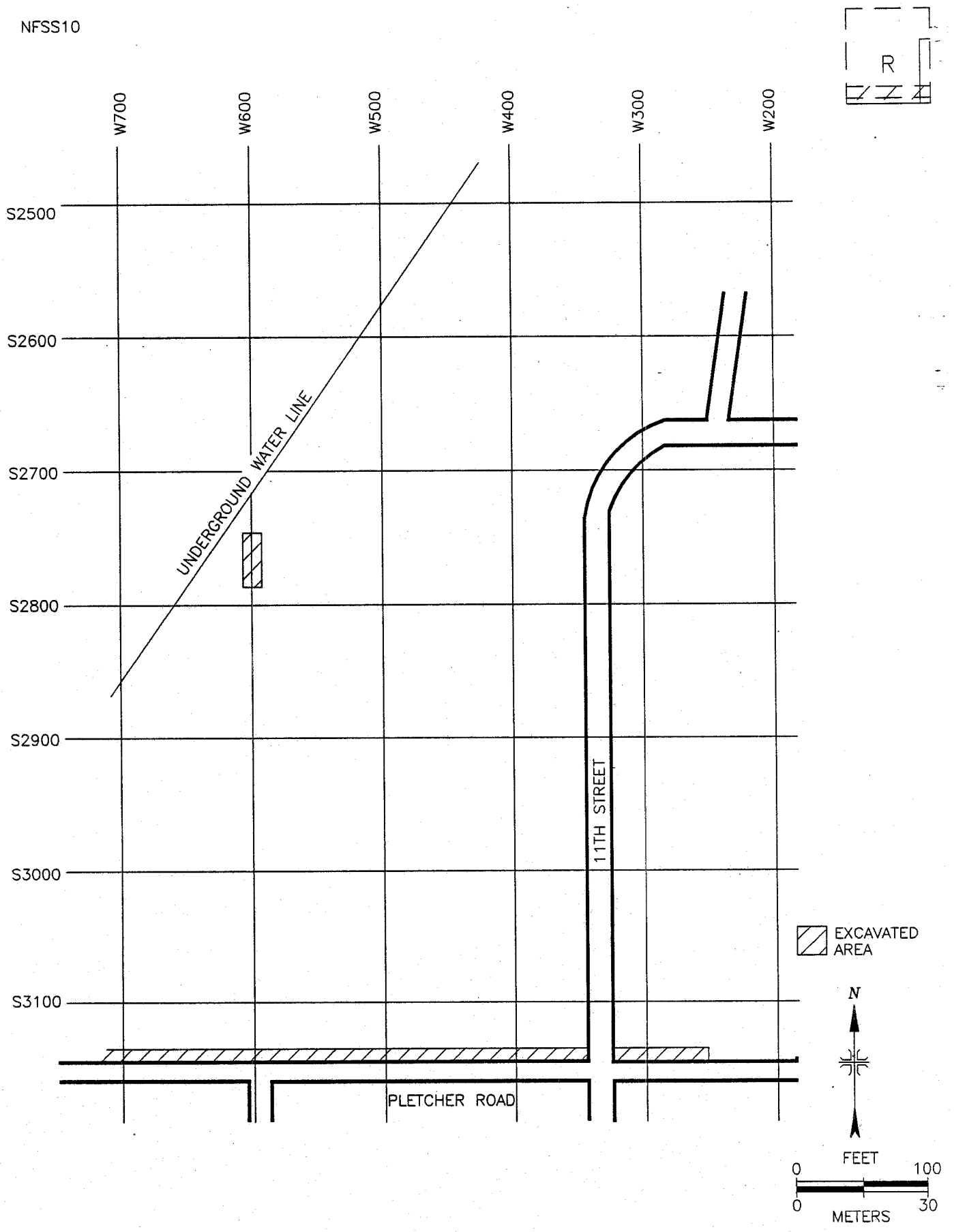


FIGURE 14: Plot Plan of Remediated Sections of Vicinity Property R

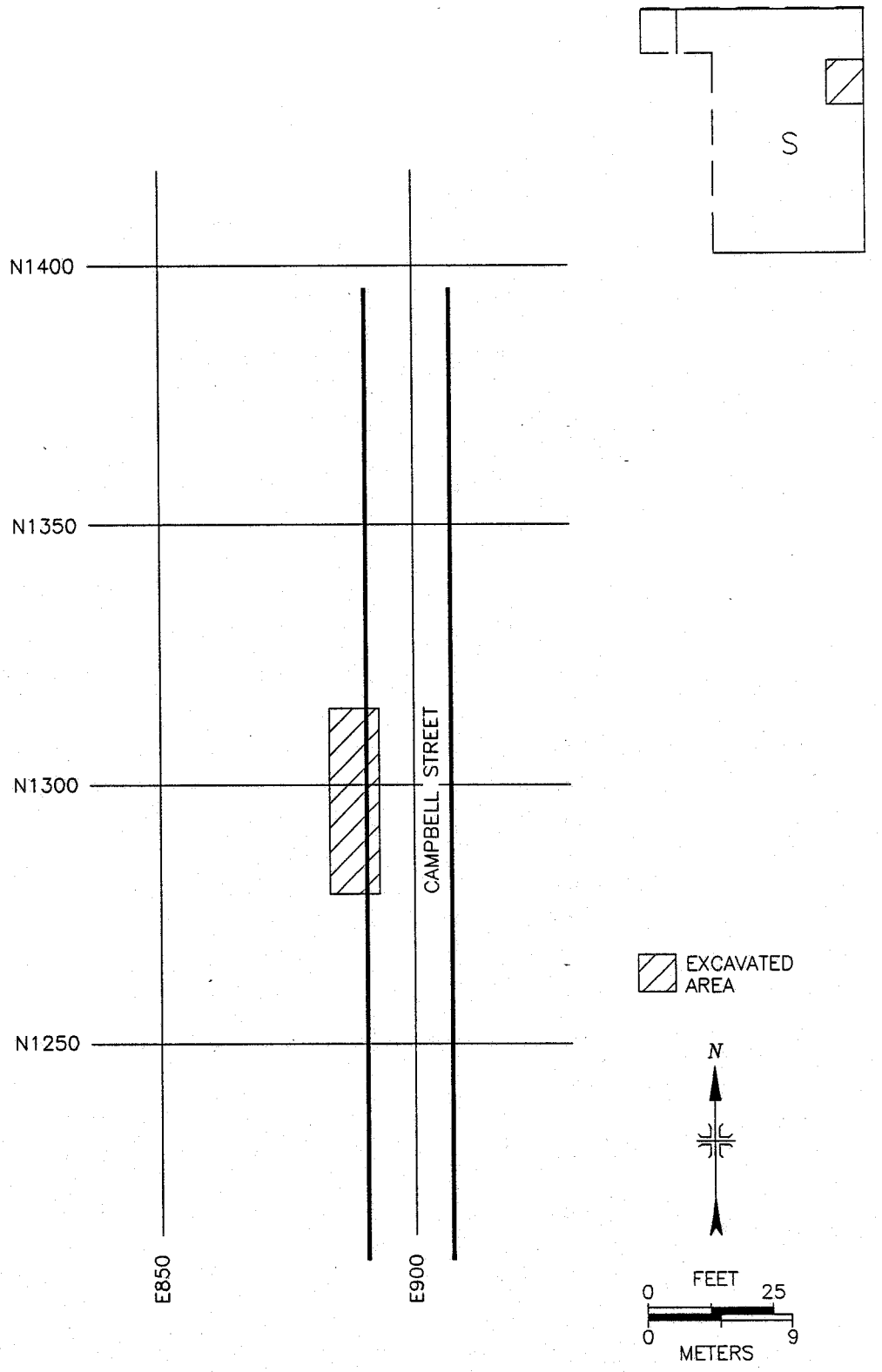
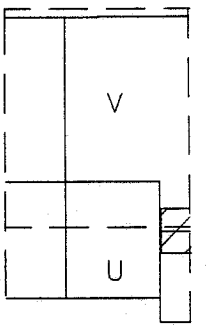


FIGURE 15: Plot Plan of Remediated Section of Vicinity Property S



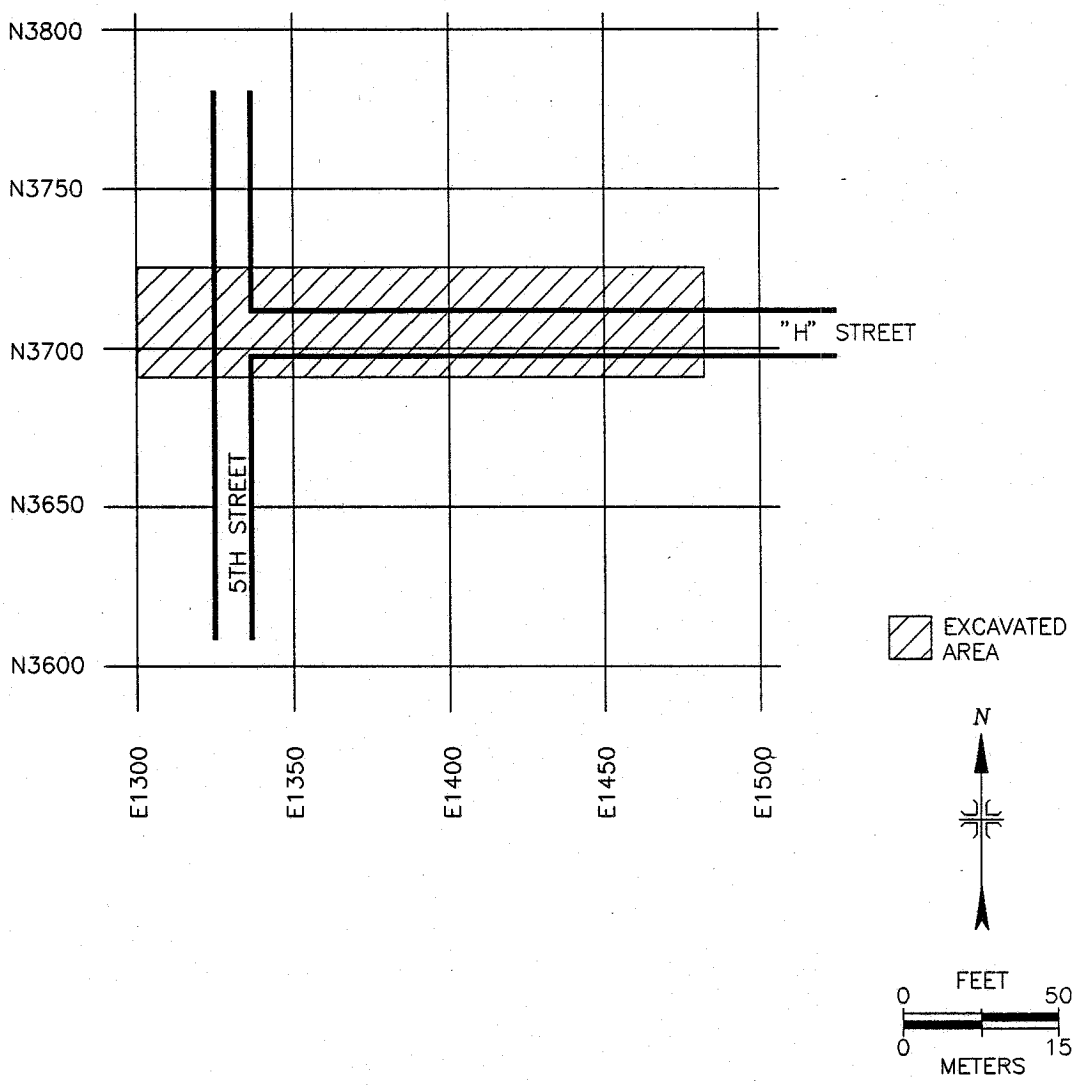


FIGURE 16: Plot Plan of Remediated Sections of Vicinity Properties U and V

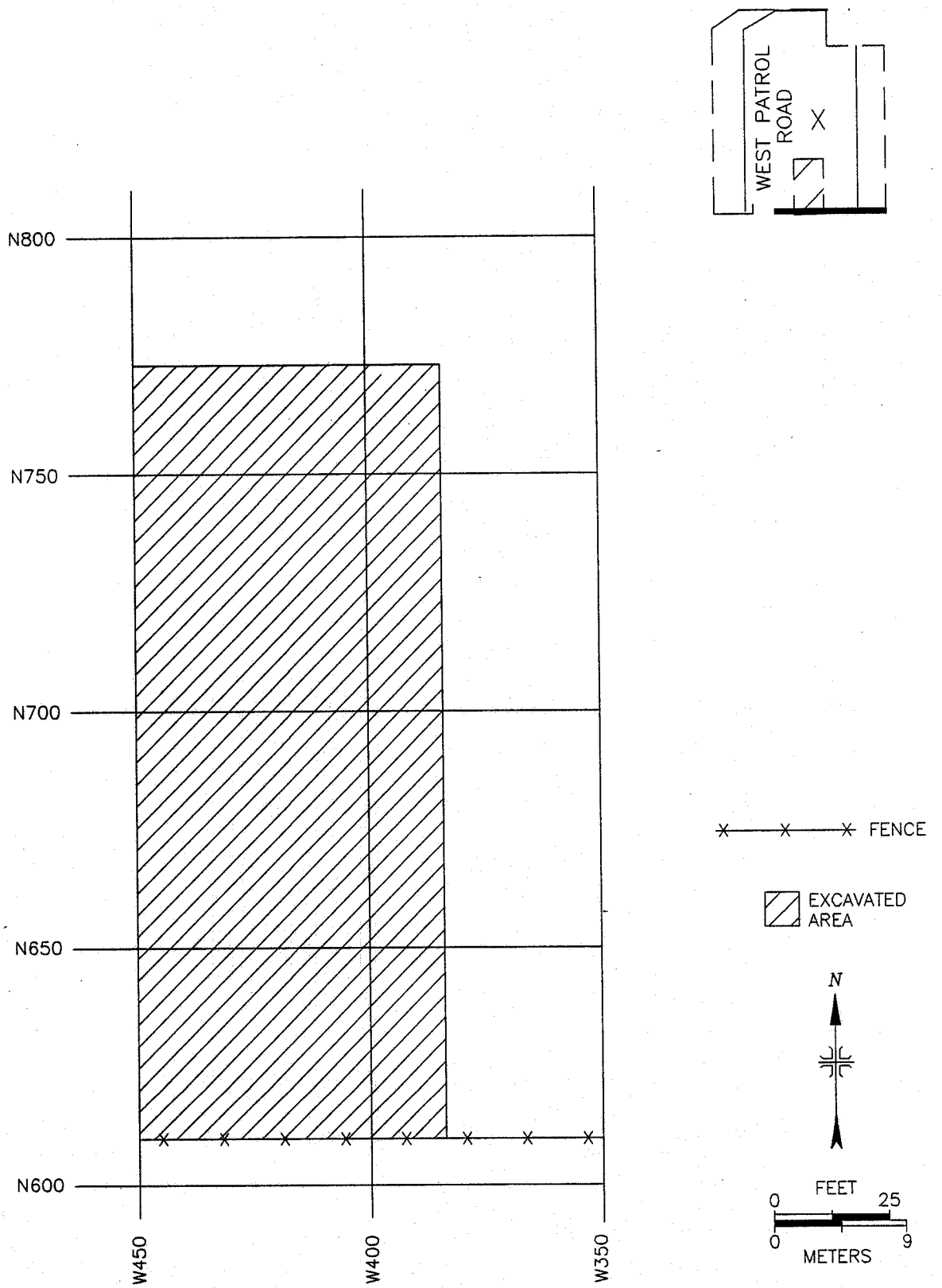


FIGURE 17: Plot Plan of Remediated Section of Vicinity Property X

TABLE 1

RESULTS OF CONFIRMATORY ANALYSES ON SOIL SAMPLES
NIAGARA FALLS STORAGE SITE VICINITY PROPERTIES
LEWISTON, NEW YORK

Property	Sample ID[a]	Grid Location	Analysis By	Radionuclide Concentration(pCi/g)[b] Ra-226	U-238	Th-232
H'	102	N2020, E1130	BNI	0.6 ± 0.2[c]	<MDA[d]	0.4 ± 0.4
			ORAU	1.4 ± 0.4	1.7 ± 1.3	1.2 ± 0.5
	105	N2020, 1200	BNI	1.1 ± 0.2	2.5 ± 2.2	1.6 ± 0.4
			ORAU	0.9 ± 0.3	2.1 ± 1.5	1.3 ± 0.6
	117	N2030, E1230	BNI	1.0 ± 0.2	<MDA	0.9 ± 0.4
			ORAU	0.9 ± 0.2	1.7 ± 1.4	1.1 ± 0.4
	146	N2070, E1050	BNI	1.1 ± 0.2	1.3 ± 1.8	1.0 ± 0.4
			ORAU	1.3 ± 0.2	1.8 ± 1.4	1.2 ± 0.5
	346	N2070, E1110	BNI	1.2 ± 0.4	<MDA	1.6 ± 0.4
			ORAU	2.1 ± 0.4	1.7 ± 2.8	1.1 ± 0.7
	325	N2130, E1010	BNI	0.7 ± 0.2	<MDA	0.6 ± 0.2
			ORAU	0.9 ± 0.3	1.9 ± 0.8	1.1 ± 0.3
	28	N2130, E1230	BNI	1.0 ± 0.2	3.2 ± 3.6	1.0 ± 0.4
			ORAU	0.9 ± 0.2	1.9 ± 0.8	1.1 ± 0.3
L	5	S2680, E 880	BNI	6.4 ± 0.4	4.8 ± 4.8	1.4 ± 0.4
			ORAU	6.2 ± 0.4	3.4 ± 1.8	1.2 ± 0.9
	10	S2780, E 880	BNI	0.8 ± 0.2	<MDA	0.8 ± 0.2
			ORAU	0.9 ± 0.2	1.0 ± 1.2	0.5 ± 0.3
M	4	S2260, E 920	BNI	10.6 ± 0.6	<MDA	<MDA
			ORAU	24.1 ± 1.1	8.7 ± 3.9	0.6 ± 0.5
	29	S2440, E 925	BNI	1.4 ± 0.2	<MDA	1.2 ± 0.4
			ORAU	1.7 ± 0.3	1.0 ± 1.5	0.9 ± 0.5
N/N'South	14	S2210, E3870	BNI	0.9 ± 0.2	<MDA	1.3 ± 0.4
			ORAU	0.9 ± 0.2	1.6 ± 2.5	0.9 ± 0.3
	2	S2240, E2160	BNI	1.2 ± 0.4	<MDA	1.0 ± 0.4
			ORAU	1.3 ± 0.2	0.9 ± 1.4	0.9 ± 0.4
	31	S2250, E3790	BNI	1.0 ± 0.2	<MDA	1.3 ± 0.4
			ORAU	0.9 ± 0.3	1.3 ± 1.7	1.0 ± 0.4

TABLE 1 (continued)

RESULTS OF CONFIRMATORY ANALYSES ON SOIL SAMPLES
NIAGARA FALLS STORAGE SITE VICINITY PROPERTIES
LEWISTON, NEW YORK

Property	Sample ID[a]	Grid Location	Analysis By	Radionuclide Concentration(pCi/g)[b] Ra-226	U-238	Th-232
	63	S2320, E3660	BNI	0.6 ± 0.2	<MDA	0.7 ± 0.2
			ORAU	0.6 ± 0.2	1.1 ± 0.6	0.7 ± 0.4
	69	S2330, E3690	BNI	0.6 ± 0.2	<MDA	0.7 ± 0.2
			ORAU	0.6 ± 0.2	1.1 ± 0.6	0.7 ± 0.4
R	2	S3140, W 607	BNI	4.0 ± 0.4	<MDA	1.1 ± 0.6
			ORAU	3.8 ± 0.5	<0.8	0.5 ± 0.3
	6	S3140, W 527	BNI	1.3 ± 0.2	<MDA	<MDA
			ORAU	1.2 ± 0.3	<0.7	1.6 ± 0.5
S	3	N1305, E 885	BNI	2.8 ± 0.6	<MDA	0.9 ± 0.4
			ORAU	2.1 ± 0.3	1.5 ± 0.9	1.0 ± 0.4
V	2	N3709, E1138	BNI	0.8 ± 0.2	<MDA	1.1 ± 0.4
			ORAU	0.9 ± 0.3	6.9 ± 1.3	1.0 ± 0.5
X	312	N 640, W 410	BNI	1.2 ± 0.2	1.3 ± 3.6	0.8 ± 0.4
			ORAU	1.0 ± 0.3	4.3 ± 2.0	1.4 ± 0.4
	4	N 690, W 420	BNI	1.0 ± 0.2	<MDA	0.7 ± 0.2
			ORAU	0.9 ± 0.3	2.9 ± 1.4	0.7 ± 0.3
	9	N 710, W 400	BNI	1.1 ± 0.2	<MDA	1.3 ± 0.4
			ORAU	0.8 ± 0.2	2.1 ± 2.2	1.3 ± 0.3
West Ditch	67	N 820, W 170.5	BNI	0.9 ± 0.2	<MDA	1.2 ± 0.6
			ORAU	1.0 ± 0.2	0.3 ± 1.1	0.9 ± 0.4
	125	N1560, W 170	BNI	1.3 ± 0.4	<MDA	1.2 ± 0.6
			ORAU	1.5 ± 0.3	1.5 ± 1.3	1.0 ± 0.3
	128	N1600, W 160	BNI	<MDA	<MDA	0.9 ± 1.2
			ORAU	78.7 ± 1.8	9.3 ± 12.5	0.9 ± 1.1
	200	N2220, W 110	BNI	1.3 ± 0.4	<MDA	0.6 ± 0.4
			ORAU	1.4 ± 0.3	1.3 ± 1.1	1.1 ± 0.4
	252	W2500, E 090	BNI	1.0 ± 0.2	<MDA	0.8 ± 0.4
			ORAU	1.0 ± 0.3	2.2 ± 1.4	1.2 ± 0.4

TABLE 1 (continued)

RESULTS OF CONFIRMATORY ANALYSES ON SOIL SAMPLES
NIAGARA FALLS STORAGE SITE VICINITY PROPERTIES
LEWISTON, NEW YORK

Property	Sample ID[a]	Grid Location	Analysis By	Radionuclide Concentration(pCi/g)[b] Ra-226	U-238	Th-232
Central Ditch	142	N 660, E 480	BNI	1.3 ± 0.6	<15	1.2 ± 0.6
			ORAU	1.4 ± 0.3	<0.9	0.4 ± 0.2
	248	N1020, E 490	BNI	1.1 ± 0.2	0.8 ± 0.4	0.6 ± 0.2
			ORAU	1.1 ± 0.2	2.2 ± 0.8	0.8 ± 0.3
	469	N2160, E 461	BNI	1.0 ± 0.2	<MDA	1.0 ± 0.4
			ORAU	1.0 ± 0.2	0.7 ± 0.9	1.0 ± 0.3
	33	N5330, E 415	BNI	1.0 ± 0.2	<MDA	0.6 ± 0.2
			ORAU	0.9 ± 0.2	< 0.5	0.8 ± 0.4
	1302	N7590, E 410	BNI	0.9 ± 0.2	<MDA	1.0 ± 0.4
			ORAU	0.8 ± 0.2	2.1 ± 1.2	1.1 ± 0.3
	1761	N10190, W 650	BNI	0.8 ± 0.2	<MDA	0.9 ± 0.4
			ORAU	3.8 ± 0.5	1.8 ± 1.9	1.7 ± 0.8

[a]Sample Identification as presented in the BNI post-remedial action report.[14]
[b]Reported data includes background contributions from naturally occurring materials in soil.
[c]Uncertainties represent the 95% confidence levels, based only on counting statistics: systematic ORAU laboratory uncertainties, estimated at ± 6 to 10%, are not included in the reported values for the ORAU analyses.
[d]Reported as less than the minimum detectable activity (no values given).

TABLE 2

BACKGROUND EXPOSURE RATES
AND
BASELINE RADIONUCLIDE CONCENTRATIONS IN SOIL
NIAGARA FALLS STORAGE SITE VICINITY PROPERTIES
LEWISTON, NEW YORK

Location[a]	Exposure Rate[b] (μR/h)	Radionuclide Concentrations (pCi/g)			
		Ra-226	U-238	Th-232	Cs-137
1	7	0.7 ± 0.7[c]	<2.9	0.7 ± 0.5	0.3 ± 0.1
2	7	0.8 ± 0.2	<3.4	0.8 ± 0.2	0.2 ± 0.1
3	8	0.7 ± 0.2	<4.1	1.2 ± 0.4	0.1 ± 0.1
4	8	0.5 ± 0.2	<2.3	0.5 ± 0.4	0.2 ± 0.1
5	8	0.6 ± 0.1	<2.7	0.8 ± 0.2	0.4 ± 0.1
6	8	0.6 ± 0.1	<2.2	0.5 ± 0.2	<0.1
7	7	0.6 ± 0.2	<4.2	0.8 ± 0.4	0.7 ± 0.1
8	7	0.7 ± 0.2	<3.0	0.6 ± 0.3	0.7 ± 0.1
9	7	<0.1	<2.8	0.5 ± 0.3	0.5 ± 0.1
10	7	0.5 ± 0.1	<2.8	0.7 ± 0.3	0.7 ± 0.1
11	7	0.7 ± 0.2	<3.2	0.7 ± 0.3	0.7 ± 0.1
12	8	0.7 ± 0.1	<3.2	0.7 ± 0.4	0.2 ± 0.1
13	7	0.9 ± 0.2	<3.6	0.8 ± 0.3	0.6 ± 0.1
14	7	0.5 ± 0.1	<2.7	0.3 ± 0.2	0.4 ± 0.1
15	9	1.2 ± 0.2	<3.8	1.1 ± 0.5	1.1 ± 0.1
16	9	0.8 ± 0.2	<3.0	0.8 ± 0.3	0.1 ± 0.1
Range	7 to 9	<0.1 to 1.2	<2.3 to <4.2	0.3 to 1.2	<0.1 to 1.1

[a]Refer to Figure 5.
[b]Measured at 1 m above the surface.
[c]Uncertainties represent the 95% confidence levels, based only on counting statistics; additional laboratory uncertainties of ± 6 to 10% have not been propagated in these data.

TABLE 3

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES
FROM PROPERTY A
NIAGARA FALLS STORAGE SITE VICINITY PROPERTIES
LEWISTON, NEW YORK

Location[a] N	E	Radionuclide Concentrations (pCi/g) Ra-226	U-238	Th-232
3689	1461	0.8 ± 0.3[b]	1.3 ± 1.8	<0.5
3694	1464	1.1 ± 0.2	<0.6	0.9 ± 0.4
3695	1457	0.6 ± 0.3	0.8 ± 1.0	1.0 ± 0.3
3700	1470	0.8 ± 0.2	1.1 ± 1.1	0.9 ± 0.4
3706	1459	0.9 ± 0.2	2.1 ± 1.0	0.9 ± 0.4
3715	1466	0.7 ± 0.2	<0.7	0.9 ± 0.3

[a]Refer to Figure 6.
[b]Uncertainties represent the 95% confidence levels, based only on counting statistics; additional laboratory uncertainties of ± 6 to 10% have not been propagated into these data.

TABLE 4

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES
FROM PROPERTY H'
NIAGARA FALLS STORAGE SITE VICINITY PROPERTIES
LEWISTON, NEW YORK

Location[a] N	Location[a] E	Depth (m)	Radionuclide Concentrations (pCi/g) Ra-226	U-238	Th-232
1937	1013	Surface	0.9 ± 0.3[b]	1.5 ± 1.9	1.1 ± 0.6
1943	1182	Surface	0.8 ± 0.4	<0.8	1.0 ± 0.5
1950	1304	Surface	1.0 ± 0.2	2.4 ± 1.6	1.2 ± 0.3
1986	1159	Surface	0.9 ± 0.3	<0.9	1.3 ± 0.4
		0.5 - 0.6	1.1 ± 0.3	0.9 ± 1.3	1.6 ± 0.4
2004	1220	Surface	0.9 ± 0.2	<3.0	1.1 ± 0.6
		0.3 - 0.5	0.6 ± 0.3	2.5 ± 1.3	1.1 ± 0.5
2031	900	Surface	0.9 ± 0.2	1.6 ± 1.1	1.2 ± 0.3
		0.3 - 0.5	0.9 ± 0.2	0.6 ± 1.8	1.3 ± 0.5
2034	1002	Surface	0.7 ± 0.2	1.1 ± 1.0	1.1 ± 0.4
		0.3 - 0.5	1.0 ± 0.2	3.4 ± 2.4	1.1 ± 0.4
2044	1315	Surface	0.8 ± 0.2	1.2 ± 1.3	0.9 ± 0.4
		0.3 - 0.5	0.8 ± 0.3	2.3 ± 1.2	1.4 ± 0.4
2061	1118	Surface	0.9 ± 0.2	2.5 ± 2.1	0.9 ± 0.8
		0.3 - 0.5	0.8 ± 0.2	1.1 ± 1.0	0.5 ± 0.6
2062	988	Surface	1.0 ± 0.3	1.9 ± 0.9	1.0 ± 0.5
		0.3 - 0.5	0.7 ± 0.2	1.4 ± 1.4	0.8 ± 0.4
2064	1234	Surface	1.1 ± 0.3	2.5 ± 2.0	1.1 ± 0.5
		0.5 - 0.6	0.8 ± 0.2	3.1 ± 1.0	0.7 ± 0.3
2117	1287	Surface	1.1 ± 0.3	1.3 ± 1.5	0.9 ± 0.5
		0.3 - 0.5	1.0 ± 0.2	2.1 ± 1.4	0.9 ± 0.3
2127	1089	Surface	1.0 ± 0.4	2.6 ± 2.0	1.0 ± 0.5
		0.3 - 0.5	0.8 ± 0.3	1.7 ± 1.7	1.1 ± 0.5
2149	1209	Surface	1.2 ± 0.2	2.4 ± 1.5	1.0 ± 0.4
		0.5 - 0.7	0.8 ± 0.2	1.7 ± 1.4	0.7 ± 0.3

TABLE 4 (continued)

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES
FROM PROPERTY H'
NIAGARA FALLS STORAGE SITE VICINITY PROPERTIES
LEWISTON, NEW YORK

Location[a] N	Location[a] E	Depth (m)	Radionuclide Concentrations (pCi/g) Ra-226	U-238	Th-232
2193	1293	Surface	0.8 ± 0.2	1.0 ± 1.4	0.9 ± 0.4
		0.3 - 0.5	1.0 ± 0.2	0.8 ± 1.3	0.7 ± 0.6
2198	1313	Surface	1.4 ± 0.2	1.1 ± 1.5	0.8 ± 0.4

[a]Refer to Figure 7.
[b]Uncertainties represent the 95% confidence levels, based only on counting statistics; additional laboratory uncertainties of ± 6 to 10% have not been propagated into these data.

TABLE 5

RADIONUCLIDE CONCENTRATIONS IN SURFACE SOIL SAMPLES
FOLLOWING REMOVAL OF CINDER MATERIAL - PROPERTY H'
NIAGARA FALLS STORAGE SITE VICINITY PROPERTIES
LEWISTON, NEW YORK

Location[a] N	E	Radionuclide Concentrations (pCi/g) Ra-226	U-238	Th-232
1937	1125	1.4 ± 0.3[b]	1.4 ± 1.6	0.7 ± 0.3
1940	1122	1.2 ± 0.2	1.6 ± 0.9	1.1 ± 0.4
1940	1128	1.1 ± 0.3	1.6 ± 1.2	1.2 ± 0.4
1943	1125	0.5 ± 0.3	0.6 ± 1.7	0.6 ± 0.3

[a]Refer to Figure 7.
[b]Uncertainties represent the 95% confidence levels, based only on counting statistics; additional laboratory uncertainties of ± 6 to 10% have not been propagated into these data.

TABLE 6

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES
FROM PROPERTY L
NIAGARA FALLS STORAGE SITE VICINITY PROPERTIES
LEWISTON, NEW YORK

Location[a] S	Location[a] E	Depth (m)	Radionuclide Concentrations (pCi/g) Ra-226	U-238	Th-232
2180	876	Surface	8.0 ± 0.6[b,c]	1.8 ± 1.8	1.4 ± 0.5
2334	866	Surface	1.4 ± 0.3	1.5 ± 0.9	1.0 ± 0.5
2337	876	0.15 - 0.3	1.0 ± 0.4	1.5 ± 2.5	1.2 ± 0.4
2346	878	Surface	2.8 ± 0.4	<1.0	1.3 ± 0.5
2523	878	Surface	16.6 ± 0.9[c]	<1.3	1.2 ± 0.5
2583	870	Surface	2.1 ± 0.5	<1.5	1.6 ± 0.6
2590	885	Surface	31.5 ± 1.4[c]	<1.8	1.3 ± 1.1
2632	879	0.15 - 0.3	1.2 ± 0.4	1.4 ± 2.5	1.2 ± 0.5
2756	880	0.15 - 0.3	1.2 ± 0.2	2.0 ± 1.3	1.0 ± 0.4
2773	887	Surface	1.5 ± 0.4	<1.2	1.2 ± 0.6
2778	869	Surface	2.9 ± 0.5	3.0 ± 2.1	0.9 ± 0.6
2879	880	Surface	3.8 ± 0.6	<1.4	1.5 ± 0.8
3143	871	Surface	12.0 ± 0.7[c]	5.4 ± 2.6	1.2 ± 0.8

[a]Refer to Figure 8.
[b]Uncertainties represent the 95% confidence levels, based only on counting statistics; additional laboratory uncertainties of ± 6 to 10% have not been propagated into these data.
[c]Application of hot spot criteria results in satisfying the DOE guidelines.

TABLE 7

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES
FROM PROPERTY M
NIAGARA FALLS STORAGE SITE VICINITY PROPERTIES
LEWISTON, NEW YORK

Location[a] S	Location[a] E	Depth (m)	Radionuclide Concentrations (pCi/g) Ra-226	U-238	Th-232
2159	923	Surface	1.3 ± 0.3[b]	<0.8	0.8 ± 0.6
2159	953	Surface	3.5 ± 0.8	<1.6	1.0 ± 0.7
2203	935	Surface	9.4 ± 0.6[c]	<1.0	1.0 ± 0.7
2203	936	0.3 - 0.45	0.7 ± 0.2	0.9 ± 0.6	0.9 ± 0.5
2265	938	Surface	0.9 ± 0.4	1.5 ± 2.0	1.1 ± 0.6
2273	918	Surface	1.3 ± 0.3	2.7 ± 2.0	1.0 ± 0.5
2281	925	0.3 - 0.45	1.3 ± 0.3	0.9 ± 1.8	1.2 ± 0.4
2320	923	Surface	6.6 ± 0.8[c]	<1.6	1.0 ± 0.5
2413	923	Surface	6.8 ± 0.8[c]	<1.2	1.3 ± 0.8
2432	935	Surface	4.1 ± 0.7	4.5 ± 4.5	1.6 ± 0.8
2474	918	Surface	7.6 ± 0.7[c]	<1.3	1.4 ± 0.9
2533	937	Surface	9.5 ± 0.8[c]	<1.3	0.6 ± 0.9
2604	918	Surface	2.8 ± 0.4	1.6 ± 1.8	1.1 ± 0.7
2604	933	Surface	6.4 ± 0.7[c]	<1.2	1.3 ± 0.7
2661	925	0.3 - 0.45	1.2 ± 0.4	4.1 ± 2.4	0.9 ± 0.4
2677	917	Surface	3.0 ± 0.4	2.7 ± 1.7	1.3 ± 0.6
2678	938	Surface	2.1 ± 0.6	1.5 ± 1.7	<0.3
2689	925	0.3 - 0.45	1.4 ± 0.3	2.1 ± 1.9	0.9 ± 0.5
2773	921	Surface	3.8 ± 0.4	<0.7	0.7 ± 0.3

[a]Refer to Figure 8.
[b]Uncertainties represent the 95% confidence levels, based only on counting statistics; additional laboratory uncertainties of ± 6 to 10% have not been propagated into these data.
[c]Application of hot spot criteria results in satisfying the DOE guidelines.

TABLE 8

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES
FROM PROPERTY N/N' SOUTH
NIAGARA FALLS STORAGE SITE VICINITY PROPERTIES
LEWISTON, NEW YORK

Location[a] S	Location[a] E	Depth (m)	Radionuclide Concentrations (pCi/g) Ra-226	U-238	Th-232
2188	3873	Surface	1.4 ± 0.3[b]	2.3 ± 1.8	1.5 ± 0.6
2215	3803	Surface	1.3 ± 0.4	3.5 ± 2.4	0.7 ± 0.5
2219	3844	0.3 - 0.45	1.0 ± 0.3	1.2 ± 1.1	1.2 ± 0.3
2235	3750	Surface	0.8 ± 0.2	0.6 ± 1.1	1.3 ± 0.4
2240	3845	Surface	1.0 ± 0.2	1.4 ± 1.5	0.8 ± 0.5
2275	3688	Surface	1.4 ± 0.3	1.6 ± 1.9	1.3 ± 0.4
2278	3763	0.3 - 0.45	0.9 ± 0.4	<1.0	1.2 ± 0.4
2293	3755	Surface	1.1 ± 0.3	1.3 ± 1.8	1.1 ± 0.5
2303	3683	0.3 - 0.45	0.9 ± 0.2	0.6 ± 1.2	1.3 ± 0.5
2315	3644	Surface	1.0 ± 0.2[b]	1.2 ± 1.4	1.0 ± 0.3
2315	3710	Surface	1.1 ± 0.2	1.2 ± 1.6	1.0 ± 0.5
2365	3503	0.6 - 0.75	0.9 ± 0.2	<0.6	0.9 ± 0.5
2369	3513	0.3 - 0.45	0.9 ± 0.3	12.4 ± 1.8	2.3 ± 0.6
2370	3531	Surface	1.8 ± 0.3	3.3 ± 1.1	1.3 ± 0.5
2381	3488	Surface	0.8 ± 0.4	5.9 ± 2.4	1.7 ± 0.9
2393	3495	Surface	1.2 ± 0.3	13.3 ± 3.1	2.3 ± 0.6

[a]Refer to Figure 9.
[b]Uncertainties represent the 95% confidence levels, based only on counting statistics; additional laboratory uncertainties of ± 6 to 10% have not been propagated into these data.

TABLE 9

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES
FROM THE VICINITY OF THE OLD WAREHOUSE - PROPERTY Q
NIAGARA FALLS STORAGE SITE VICINITY PROPERTIES
LEWISTON, NEW YORK

Location[a] S	Location[a] E	Depth (m)	Radionuclide Concentrations (pCi/g) Ra-226	U-238	Th-232
4646	2178	Surface	1.4 ± 0.2[b]	<0.8	0.5 ± 0.5
4665	2192	0.45 - 0.6	0.7 ± 0.2	0.6 ± 0.4	0.5 ± 0.2
4665	2211	Surface	4.0 ± 0.4	0.7 ± 1.3	0.8 ± 0.4
4708	2165	Surface	1.2 ± 0.3	4.5 ± 1.6	1.4 ± 0.5
4708	2177	0.45 - 0.6	1.1 ± 0.2	1.6 ± 1.3	1.8 ± 0.5
4736	2204	0.3 - 0.45	0.6 ± 0.2	0.8 ± 0.4	0.9 ± 0.3
4749	2167	Surface	0.9 ± 0.3	2.4 ± 1.7	0.7 ± 0.3
4749	2213	Surface	0.8 ± 0.2	1.3 ± 1.2	0.9 ± 0.3
4782	2199	0.45 - 0.6	1.0 ± 0.3	2.1 ± 1.4	1.3 ± 0.4
4798	2193	Surface	1.1 ± 0.2	0.9 ± 0.9	1.1 ± 0.3
4833	2213	Surface	0.9 ± 0.2	1.2 ± 1.9	2.1 ± 1.1
4840	2197	Surface	0.6 ± 0.2	<0.4	0.4 ± 0.3

[a]Refer to Figure 10.
[b]Uncertainties represent the 95% confidence levels, based only on counting statistics; additional laboratory uncertainties of ± 6 to 10% have not been propagated into these data.

TABLE 10

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES
FROM AREA ALONG RAILROAD TRACKS - PROPERTY Q
NIAGARA FALLS STORAGE SITE VICINITY PROPERTIES
LEWISTON, NEW YORK

Location[a] S	Location[a] E	Depth (m)	Radionuclide Concentrations (pCi/g) Ra-226	U-238	Th-232
Prior to Additional Remediation					
5612	2345	Surface	47.9 ± 1.5[b]	2.6 ± 3.6	1.5 ± 1.1
5620	2339	0.45 - 0.6	110 ± 3.0	<4.2	2.6 ± 1.8
		0.6 - 0.75	200 ± 3.0	27 ± 25	2.0 ± 2.0
5621	2352	1.2 - 1.4	7.2 ± 0.9	3.1 ± 3.6	1.1 ± 0.7
5632	2314	0.3 - 0.4	77.9 ± 2.1	<2.6	2.0 ± 1.5
Random Samples Collected Following Additional Remediation					
		Surface	1.1 ± 0.3	<0.9	1.2 ± 0.4
		Surface	1.9 ± 0.3	<0.7	0.9 ± 0.4
		0.6 - 0.75	2.0 ± 0.4	<1.1	1.6 ± 0.6
		0.6 - 0.75	4.4 ± 0.7	4.7 ± 3.4	2.5 ± 0.8
		Surface	1.1 ± 0.2	1.2 ± 1.4	1.0 ± 0.3
		Surface	0.8 ± 0.2	<0.7	0.9 ± 0.4

[a]Refer to Figure 11.
[b]Uncertainties represent the 95% confidence levels, based only on counting statistics; additional laboratory uncertainties of ± 6 to 10% have not been propagated into these data.

TABLE 11

RADIONCULIDE CONCENTRATIONS IN SOIL SAMPLES
FROM ACCESS ROAD FOLLOWING REMOVAL OF ASH MATERIAL - PROPERTY Q
NIAGARA FALLS STORAGE SITE VICINITY PROPERTIES
LEWISTON, NEW YORK

Location[a] S	Location[a] E	Depth (m)	Radionuclide Concentrations (pCi/g) Ra-226	U-238	Th-232
5938	2315	0.6	3.1 ± 0.5[b]	1.5 ± 2.4	1.7 ± 0.5
5944	2317	0.6	5.0 ± 0.7	1.9 ± 2.5	1.8 ± 0.7
5943	2315	0.9 - 1.1	4.5 ± 0.6	4.1 ± 2.4	1.8 ± 0.6
5948	2316	0.3	2.4 ± 0.5	1.9 ± 2.8	2.0 ± 0.6

[a]Refer to Figure 12.
[b]Uncertainties represent the 95% confidence levels, based only on counting statistics; additional laboratory uncertainties of ± 6 to 10% have not been propagated into these data.

TABLE 12

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES
FROM AREA SOUTH OF MAINTENANCE GARAGE - PROPERTY Q
NIAGARA FALLS STORAGE SITE VICINITY PROPERTIES
LEWISTON, NEW YORK

Location[a]		Radionuclide Concentrations (pCi/g)		
S	E	Ra-226	U-238	Th-232
6902	1988	1.2 ± 0.2[b]	1.0 ± 0.5	0.9 ± 0.3
6904	1894	1.5 ± 0.3	<1.1	1.5 ± 0.5
6918	1934	2.0 ± 0.4	2.9 ± 0.9	1.2 ± 0.7
6993	1922	1.2 ± 0.3	2.2 ± 2.3	0.9 ± 0.6
7044	1924	0.7 ± 0.2	1.7 ± 0.9	1.1 ± 0.4
7062	1992	1.0 ± 0.2	0.5 ± 1.8	0.9 ± 0.4
7065	1933	1.3 ± 0.3	1.7 ± 1.9	1.4 ± 0.6
7097	1955	0.7 ± 0.2	0.6 ± 0.8	0.6 ± 0.3
7099	1921	0.8 ± 0.2	1.0 ± 0.6	1.0 ± 0.4

[a]Refer to Figure 13.
[b]Uncertainties represent the 95% confidence levels, based only on counting statistics; additional laboratory uncertainties of ± 6 to 10% have not been propagated into these data.

TABLE 13

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES
FROM PROPERTY R
NIAGARA FALLS STORAGE SITE VICINITY PROPERTIES
LEWISTON, NEW YORK

Location[a] S	Location[a] W	Depth (m)	Radionuclide Concentrations (pCi/g) Ra-226	U-238	Th-232
3124	320	Surface	2.0 ± 0.4[b]	<0.9	1.1 ± 0.5
3128	388	Surface	1.4 ± 0.3	1.5 ± 3.7	0.8 ± 0.3
3130	548	Surface	2.0 ± 0.3	0.8 ± 0.3	1.0 ± 0.2
3135	260	Surface	0.8 ± 0.3	1.2 ± 1.3	1.0 ± 0.5
3138	650	Surface	1.0 ± 0.2	4.1 ± 1.2	1.3 ± 0.5
3142	268	Surface	0.2 ± 0.2	0.7 ± 1.7	0.8 ± 0.5
3142	460	Surface	5.3 ± 0.5	<1.1	0.9 ± 0.9
3142	550	Surface	2.9 ± 0.4	<1.0	0.9 ± 0.4
3132	320	0.15 - 0.3	1.1 ± 0.2	3.8 ± 1.3	1.6 ± 0.5
		0.3 - 0.45	0.1 ± 0.1	<0.5	0.2 ± 0.2
3134	416	0.15 - 0.3	1.3 ± 0.3	3.0 ± 1.7	0.9 ± 0.5
3136	592	0.15 - 0.3	1.4 ± 0.3	2.0 ± 1.4	0.9 ± 2.1

[a]Refer to Figure 14.
[b]Uncertainties represent the 95% confidence levels, based only on counting statistics; additional laboratory uncertainties of ± 6 to 10% have not been propagated into these data.

TABLE 14

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES
FROM AREAS NEAR UNDERGROUND
WATER LINE - PROPERTY R
NIAGARA FALLS STORAGE SITE VICINITY PROPERTIES
LEWISTON, NEW YORK

Location[a] S	Location[a] E	Depth (m)	Radionuclide Concentrations (pCi/g) Ra-226	U-238	Th-232
2741	590	Surface	13.3 ± 0.9[b,c]	8.8 ± 7.1	0.6 ± 0.6
2759	601	Surface	3.7 ± 0.4	<0.7	1.3 ± 0.5
2762	598	Surface	1.2 ± 0.3	<0.8	1.0 ± 0.5
2762	601	0.2 - 0.3	10.0 ± 0.8[c]	<1.6	1.3 ± 0.5
2762	604	Surface	1.5 ± 0.2	<0.5	1.1 ± 0.4
2765	601	Surface	1.2 ± 0.3	<0.8	0.6 ± 0.3

[a]Refer to Figure 14.
[b]Uncertainties represent the 95% confidence levels, based only on counting statistics; additional laboratory uncertainties of ± 6 to 10% have not been propagated into these data.
[c]Sample depths are relative to the exposed surface following excavation; after backfilling of the excavation, these locations were subsurface and therefore satisfy the guideline level of 15 pCi/g for Ra-226, below the 15 cm depth.

TABLE 15

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES
FROM PROPERTIES U AND V
NIAGARA FALLS STORAGE SITE VICINITY PROPERTIES
LEWISTON, NEW YORK

Location[a] N	Location[a] E	Depth (m)	Radionuclide Concentrations (pCi/g) Ra-226	U-238	Th-232
3678	1404	Surface	0.7 ± 0.3[b]	0.5 ± 1.3	1.1 ± 0.4
3684	1394	0.3	0.5 ± 0.3	<0.6	1.0 ± 0.6
3684	1434	0.6	0.8 ± 0.3	1.1 ± 1.5	0.9 ± 0.5
3687	1317	Surface	0.8 ± 0.3	<0.7	0.5 ± 0.4
3689	1336	0.3	0.8 ± 0.2	1.3 ± 1.1	1.0 ± 0.4
3689	1370	0.5	2.5 ± 0.4	<1.1	0.8 ± 0.6
3692	1363	Surface	1.0 ± 0.3	1.0 ± 1.7	0.9 ± 0.3
3700	1319	Surface	0.8 ± 0.5	1.1 ± 1.9	1.0 ± 0.7
3700	1408	0.9 - 1.1	0.5 ± 0.2	0.8 ± 1.1	0.7 ± 0.3
3700	1447	0.9 - 1.1	0.5 ± 0.2	<0.6	0.8 ± 0.3
3703	1348	0.9 - 1.1	0.9 ± 0.3	<0.8	1.9 ± 0.5
3712	1361	0.5	10.7 ± 0.2	0.8 ± 1.1	0.5 ± 0.4
3712	1388	0.6	0.7 ± 0.2	1.0 ± 1.5	1.1 ± 0.4
3712	1412	0.6	0.9 ± 0.3	1.0 ± 1.2	0.9 ± 0.5
3716	1311	Surface	0.7 ± 0.2	0.5 ± 1.4	0.8 ± 0.5
3716	1336	0.5	0.8 ± 0.3	1.1 ± 1.6	0.8 ± 0.6
3718	1399	Surface	0.5 ± 0.2	1.1 ± 1.0	0.9 ± 0.4
3721	1346	Surface	1.0 ± 0.3	<0.7	0.9 ± 0.4

[a]Refer to Figure 16.
[b]Uncertainties represent the 95% confidence levels, based only on counting statistics; additional laboratory uncertainties of ± 6 to 10% have not been propagated into these data.

TABLE 16

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES
FROM PROPERTY X
NIAGARA FALLS STORAGE SITE VICINITY PROPERTIES
LEWISTON, NEW YORK

Location[a] N	Location[a] W	Depth (m)	Radionuclide Concentrations (pCi/g) Ra-226	U-238	Th-232
610	432	Surface	1.5 ± 0.3[b]	1.0 ± 2.6	0.8 ± 0.9
631	344	Surface	0.9 ± 0.2	0.9 ± 1.4	1.0 ± 0.5
658	409	Surface	1.0 ± 0.3	1.7 ± 1.3	0.9 ± 0.3
		0.2 - 0.4	0.7 ± 0.2	3.8 ± 0.8	1.0 ± 0.3
699	375	Surface	0.6 ± 0.3	1.5 ± 2.1	1.0 ± 0.4
729	459	Surface	0.6 ± 0.2	2.1 ± 1.0	0.7 ± 0.3
735	395	Surface	1.3 ± 0.3	4.1 ± 2.1	1.2 ± 0.4
		0.2 - 0.4	0.9 ± 0.2	1.4 ± 0.5	0.9 ± 0.5
759	368	Surface	1.4 ± 0.5	2.6 ± 1.8	0.7 ± 0.3

[a]Refer to Figure 17.
[b]Uncertainties represent the 95% confidence levels, based only on counting statistics; additional laboratory uncertainties of ± 6 to 10% have not been propagated into these data.

TABLE 17

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES
FROM THE WEST DRAINAGE DITCH
NIAGARA FALLS STORAGE SITE VICINITY PROPERTIES
LEWISTON, NEW YORK

Location[a] N	Location[a] W	Radionuclide Concentrations (pCi/g) Ra-226	U-238	Th-232
614	145	3.1 ± 0.3[b]	2.3 ± 0.8	0.9 ± 0.5
814	145	1.0 ± 0.3	<0.6	1.0 ± 0.4
1014	145	1.4 ± 0.3	<0.8	1.3 ± 0.4
1214	145	0.8 ± 0.2	0.7 ± 0.5	0.9 ± 0.5
1414	145	1.0 ± 0.3	<0.6	0.9 ± 0.4
1614	145	3.1 ± 0.4	2.1 ± 1.7	0.7 ± 0.5
1814	60	1.2 ± 0.3	2.2 ± 1.8	1.0 ± 0.3
2024	115	0.7 ± 0.2	0.6 ± 1.4	0.8 ± 0.3
2214	127	1.7 ± 0.3	<0.9	1.0 ± 0.3
2404	-25	2.7 ± 0.3	1.1 ± 0.6	0.7 ± 0.3
2614	-120	1.3 ± 0.3	1.8 ± 1.5	1.1 ± 0.5
2814	-250	0.5 ± 0.2	1.3 ± 0.7	0.8 ± 0.3
3014	-390	0.9 ± 0.3	<0.8	1.3 ± 0.5

[a]Refer to Figure 3.
[b]Uncertainties represent the 95% confidence levels, based only on counting statistics; additional laboratory uncertainties of ± 6 to 10% have not been propagated into these data.

TABLE 18

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES
FROM THE CENTRAL DRAINAGE DITCH
NIAGARA FALLS STORAGE SITE VICINITY PROPERTIES
LEWISTON, NEW YORK

Location[a] N	E	Radionuclide Concentrations (pCi/g) Ra-226	U-238	Th-232
614	490	22.9 ± 1.0[b,c]	<1.8	0.5 ± 0.4
714	480	1.1 ± 0.2	0.6 ± 1.1	0.8 ± 0.4
814	490	1.6 ± 0.3	2.5 ± 0.6	0.8 ± 0.4
914	500	1.9 ± 0.3	<0.8	0.7 ± 0.3
1014	490	1.6 ± 0.2	0.5 ± 1.2	0.8 ± 0.2
1114	480	0.9 ± 0.2	0.8 ± 0.5	1.0 ± 0.5
1214	490	2.5 ± 0.5	<1.2	1.4 ± 0.7
1314	500	1.3 ± 0.4	<0.8	1.1 ± 0.7
1414	490	2.9 ± 0.4	1.3 ± 0.7	1.1 ± 0.5
1514	480	1.0 ± 0.2	<0.7	1.3 ± 0.5
1614	490	1.3 ± 0.3	0.9 ± 1.3	0.9 ± 0.4
1714	500	1.2 ± 0.2	1.6 ± 1.0	1.1 ± 0.3
1814	490	d	d	d
1904	480	1.2 ± 0.3	2.2 ± 1.5	0.9 ± 0.5
2014	480	0.8 ± 0.2	2.4 ± 1.2	0.9 ± 0.4
2114	460	1.0 ± 0.2	0.4 ± 0.5	1.1 ± 0.4
2214	460	1.0 ± 0.3	1.6 ± 1.5	0.9 ± 0.5
2314	460	0.9 ± 0.2	0.7 ± 1.1	1.1 ± 0.5
2414	440	0.9 ± 0.2	1.0 ± 0.6	1.2 ± 0.4
2514	420	0.9 ± 0.4	<0.8	1.2 ± 0.4
2614	420	0.9 ± 0.2	0.9 ± 0.9	0.7 ± 0.4

TABLE 18 (continued)

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES
FROM THE CENTRAL DRAINAGE DITCH
NIAGARA FALLS STORAGE SITE VICINITY PROPERTIES
LEWISTON, NEW YORK

Location[a] N	Location[a] E	Radionuclide Concentrations (pCi/g) Ra-226	U-238	Th-232
2714	420	1.6 ± 0.2	0.5 ± 0.9	0.9 ± 0.4
2814	400	1.2 ± 0.3	<0.8	1.1 ± 0.4
2914	380	1.5 ± 0.4	<0.5	0.8 ± 0.4
3014	390	0.8 ± 0.2	0.9 ± 0.8	1.1 ± 0.3
3114	400	1.2 ± 0.2	<0.7	1.1 ± 0.4
3214	390	1.0 ± 0.2	1.5 ± 1.3	1.1 ± 0.4
3304	380	0.9 ± 0.3	0.8 ± 0.8	1.0 ± 0.3
3414	390	0.9 ± 0.3	<0.7	0.8 ± 0.3
3514	400	0.8 ± 0.2	1.1 ± 1.2	0.6 ± 0.2
3614	390	1.1 ± 0.2	1.5 ± 0.8	0.9 ± 0.3
3714	380	4.2 ± 0.5	<1.0	1.0 ± 0.5
3814	390	1.1 ± 0.3	<0.8	1.0 ± 0.4
3914	400	0.7 ± 0.2	0.7 ± 1.5	0.8 ± 0.4
4014	390	1.0 ± 0.3	0.7 ± 0.7	0.8 ± 0.5
4114	380	2.3 ± 0.4	<0.9	1.1 ± 0.5
4214	390	1.0 ± 0.3	1.7 ± 3.3	1.1 ± 0.3
4314	400	0.8 ± 0.3	<0.8	1.1 ± 0.5
4414	390	1.3 ± 0.3	1.5 ± 0.6	1.1 ± 0.5
4514	380	1.3 ± 0.3	1.2 ± 1.1	0.7 ± 0.5
4614	390	1.1 ± 0.3	<0.8	1.4 ± 0.6
4714	400	0.8 ± 0.2	1.2 ± 0.8	0.9 ± 0.4

TABLE 18 (continued)

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES
FROM THE CENTRAL DRAINAGE DITCH
NIAGARA FALLS STORAGE SITE VICINITY PROPERTIES
LEWISTON, NEW YORK

Location[a] N	Location[a] E	Radionuclide Concentrations (pCi/g) Ra-226	U-238	Th-232
4814	390	1.3 ± 0.3	1.0 ± 1.7	1.1 ± 0.5
5138	380	0.9 ± 0.2	0.8 ± 1.1	1.0 ± 0.5
5466	390	0.9 ± 0.2	0.8 ± 1.0	0.8 ± 0.3
5794	400	1.2 ± 0.3	<0.8	1.0 ± 0.3
6122	390	1.3 ± 0.3	<0.5	0.7 ± 0.3
6450	380	0.6 ± 0.2	1.0 ± 0.4	0.8 ± 0.3
6778	390	1.3 ± 0.3	<0.7	0.7 ± 0.3
7106	400	0.8 ± 0.2	1.1 ± 1.0	0.9 ± 0.3
7434	390	1.4 ± 0.2	1.7 ± 1.6	1.2 ± 0.4
7762	380	0.6 ± 0.2	0.8 ± 1.3	0.8 ± 0.4
8090	390	4.3 ± 0.5	<0.7	0.7 ± 0.9
8418	400	1.2 ± 0.2	0.5 ± 0.4	0.9 ± 0.5
8746	390	2.6 ± 0.5	<1.4	0.7 ± 0.7
9074	380	2.0 ± 0.4	1.1 ± 2.0	1.3 ± 0.5
9402	390	0.9 ± 0.3	1.8 ± 0.7	1.1 ± 0.4
9730	400	1.0 ± 0.2	1.0 ± 0.9	0.7 ± 0.4
10058	390	4.0 ± 0.5	<1.0	1.0 ± 0.6
9905	275	1.7 ± 0.3	<0.6	0.7 ± 0.5
9950	80	1.8 ± 0.3	0.4 ± 0.6	1.1 ± 0.5

TABLE 18 (continued)

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES
FROM THE CENTRAL DRAINAGE DITCH
NIAGARA FALLS STORAGE SITE VICINITY PROPERTIES
LEWISTON, NEW YORK

Location[a] N	E	Radionuclide Concentrations (pCi/g) Ra-226	U-238	Th-232
10010	-85	3.3 ± 0.5	<1.0	1.0 ± 0.4
10030	-240	2.2 ± 0.3	3.4 ± 1.6	1.0 ± 0.7
10100	-400	0.9 ± 0.2	0.9 ± 0.9	1.0 ± 0.3
10140	-475	2.2 ± 0.3	<0.9	1.4 ± 0.5

[a]Refer to Figure 3.
[b]Uncertainties represent the 95% confidence levels, based only on counting statistics; additional laboratory uncertainties of ± 6 to 10% have not been propagated into these data.
[c]Application of the hot spot criteria results in meeting the DOE guidelines.
[d]No sampling due to high water level.

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APPENDIX A

SUMMARY OF RADIATION GUIDELINES APPLICABLE TO NIAGARA FALLS STORAGE SITE VICINITY PROPERTIES

APPENDIX A

SUMMARY OF RADIATION GUIDELINES APPLICABLE TO NIAGARA FALLS STORAGE SITE VICINITY PROPERTIES[1]

BASIC DOSE LIMITS

The basic limit for the annual radiation dose received by an individual member of the general public is 100 mrem/yr.

SOIL (LAND) GUIDELINES

Radionuclide	Soil Concentration (pCi/g above background)[a,b,c]
Radium-226 Radium-228 Thorium-232 Thorium-232	5 pCi/g, averaged over the first 15 cm of soil below the surface; 15 pCi/g when averaged over any 15-cm-thick soil layer below the surface layer.
Uranium (total)	90 pCi/g[2,3] (assume natural isotopic ratio for U-234, U-238, and U-235 of 1:1:0.046)
Other radionuclides	Soil guidelines will be calculated on a site-specific basis using the DOE manual developed for this use.

STRUCTURE GUIDELINES

Airborne Radon Decay Products

Generic guidelines for concentrations of airborne radon decay products shall apply to existing occupied or habitable structures on private property that are intended for unrestricted use; structures that will be demolished or buried are excluded. The applicable generic guidelines (40 CFR 192) is: In any occupied or habitable building, the objective of remedial action shall be, a reasonable effort shall be made to achieve an annual average (or equivalent) radon decay product concentration (including background) not to exceed 0.02 WL.[d] In any case, the radon decay product concentration (including background) shall not exceed 0.03 WL. Remedial actions are not required in order to comply with this guideline when there is reasonable assurance that residual radioactive materials are not the cause.

External Gamma Radiation

The average level of gamma radiation inside a building or habitable structure on a site to be released for unrestricted use shall not exceed the background level by more than 20 μR/h and shall comply with the basic dose limit when an appropriate-use scenario is considered.

INDOOR/OUTDOOR STRUCTURE SURFACE ACTIVITY

Radionuclide[e]	Allowable Residual Surface Activity (dpm/100 cm^2)[d] Average[f,g]	Maximum[g,h]	Removable[g,i]
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	100	300	20
Th-Natural, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1,000	3,000	200
U-Natural, U-235, U-238, and associated decay products	5,000 α	15,000 α	1,000 α
Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above	5,000 β - γ	15,000 β - γ	1,000 β - γ

Applicable guidelines within various ARC buildings will vary, depending upon the primary contaminant. For the majority of building surfaces, the major contaminant is Th-232. Guidelines associated with radionuclide decay series are 1000 dpm/100 cm^2, average; 3000 dpm/100 cm^2, maximum; and 200 dpm/100 cm^2, removable. For areas where uranium is the primary contaminant, the guidelines are 5000 dpm/100 cm^2, average; 15000 dpm/100 cm^2, maximum; and 1000 dpm/100 cm^2, removable.

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[a]These guidelines take into account ingrowth of radium-226 from thorium-230 and of radium-228 from thorium-232, and assume secular equilibrium. If either thorum-230 and radium-226 or thorium-232 and radium-228 are both present, not in secular equilibrium, the guidelines apply to the higher concentrations. If other mixtures of radionuclides occur, the concentrations of individual radionuclides shall be reduced so that the dose of the mixtures will not exceed the basic dose limit.

[b]These guidelines represent unrestricted-use residual concentrations above background averaged across any 15-cm-thick layer at any depth and over any contiguous 100-m^2 surface area.

[c]Localized concentrations in excess of these limits are allowable provided that the average concentration over a 100-m^2 area does not exceed these limits. For areas of less than 25 m^2 localized concentrations ("hot spots") may exceed the guideline limits by a factor of (100/A)1/2, where A is the area of the elevated region in square meters. In addition, every reasonable effort shall be made to remove any source of radionuclide that exceeds 30 times the appropriate soil limit, irrespective of the average concentration in the soil.

[d]As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

[e]Where surface contamination by both alpha-and beta-gamma-emitting radionuclides exists, the limits established for alpha-and-beta-gamma-emitting radionuclides should apply independently.

[f]Measurements of average contamination should not be averaged over more than 1 m^2. Of objects of less surface area. The average shall be derived for each such object.

[g]The average and maximum radiation levels associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h and 1.0 mrad/h, respectively, at 1 cm.

[h]The maximum contamination level applies to an area of not more than 100 cm^2.

[i]The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and measuring the amount of radioactive material on the wipe with an appropriate instrument of know efficiency. When removable contamination on objects of surface area less than 100 cm^2 is determined, the activity per unit area should be based on the actual area and the neither surface should be wiped. The numbers in this column are maximum amounts.

[1]U.S. Department of Energy, U.S. Department of Energy Guidelines for Residual Radioactivity at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management Program Sites, Revision 2, March 1987.

[2]Argonne National Laboratory, Derivation of a Uranium and Cesium-137 Residual Radioactive Material Guidelines for the Niagara Falls Storage Site, Chicago, IL, August 1988.

[3]Memorandum for P.J. Gross, Technical Services Division, Department of Energy, Oak Ridge Operations, to J. Fiore (GTN-HQ 2), August 1988.

APPENDIX B

MAJOR SAMPLING AND ANALYTICAL EQUIPMENT

APPENDIX B

MAJOR SAMPLING AND ANALYTICAL EQUIPMENT

The display or description of a specific product is not to be construed as an endorsement of that product or its manufacturer by the authors or their employer.

A. Direct Radiation Measurements

Eberline PRM-6
Portable Ratemeter
(Eberline, Santa Fe, NM)

Victoreen NaI Gamma Scintillation Probe
Model 489-55
(Victoreen, Inc., Cleveland, OH)

Reuter-Stokes Pressurized Ionization Chamber
Model RSS-111
(Reuter-Stokes, Cleveland OH)

B. Laboratory Analysis

Ge (Li) Detector
Model LGCC2220SD, 23% efficiency
(Princeton Gamma-Tech, Princeton, NJ)

Used in conjunction with:
Lead Shield, SPG-16
(Applied Physical Technology, Smyrna, GA)

High Purity Germanium
Model GMX-23195-S, 23% efficiency
(EG&G ORTEC, Oak Ridge, TN)

Used in conjunction with:
Lead Shield, G-16
(Gamma Products Inc., Palos Hills, IL)

High Purity Germanium Detector
Model IGC25, 25% efficiency
(Princeton, Gamma-Tech, Princeton, NJ)

Used in conjunction with:
Lead Shield
(Nuclear Data, Schaumburg, IL)

High Purity Germanium Coaxial Well Detector
Model GWL-110210-PWS-S, 23% efficiency
(EG&G ORTEC, Oak Ridge, TN)

Used in conjunction with:
Lead Shield Model G-16
(Applied Physical Technology, Atlanta, GA)

Multi-channel analyzer
ND-66/ND-680 System
(Nuclear Data, Inc., Schaumburg, IL)

APPENDIX C

MEASUREMENT AND ANALYTICAL PROCEDURES

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MEASUREMENT AND ANALYTICAL PROCEDURES

Gamma Surface Scans

Walkover surface scans were performed using Eberline Model PRM-6 portable ratemeters with Victoreen Model 489-55 gamma scintillation probes, containing 3.2 cm (1.25 M) x 3.8 cm (1.50 M) NaI(Tl) scintillation crystals. Relative count rates were monitored using earphones, and increased rates above the ambient background levels were noted.

Exposure Rate Measurements

Measurements of gamma exposure rates were performed using Eberline PRM-6 portable ratemeters with Victoreen Model 489-55 gamma scintillation probes. Count rates were converted to exposure rates (μR/h) by cross-calibrating with a Reuter Stokes Model RSS-111 pressurized ionization chamber.

Soil and Sediment Sample Analysis

Soil and sediment samples were dried, mixed, and a portion placed in a 0.5 l (0.53 qt) Marinelli beaker. The quantity placed in each beaker was chosen to reproduce the calibrated counting geometry and ranged from 600 to 900 g (1.3 to 2.0 lb) of soil. Net soils weights were determined and the samples counted using germanium detectors coupled to a Nuclear Data Model ND-680 pulse height analyzer system. Background and Compton stripping, peak search, peak identification, and concentration calculations were performed using the computer capabilities inherent in the analyzer system. Energy peaks reviewed for determination of radionuclides of concern were:

Ra-226 - 0.609 MeV from Bi-214*
U-238 - 0.094 MeV or 0.063 MeV from Th-234 or 1.001 MeV from Pa-234m*
Th-232 - 0.911 MeV from Ac 228*

*Secular Equilibrium Assumed

Errors and Detection Limits

The uncertainties associated with the analytical data presented in the tables of this report represent the 95% confidence levels based only on counting statistics. Other sources of error associated with the sampling and analyses introduce an additional uncertainty of ± 6 to 10% in the results. When the net sample count was less than the statistical deviation of the background count, the sample concentration was reported as less than the detection capabilities of the procedure. Because of variations in background levels, sample weights, detector efficiencies, and the effects of the Compton continuum, caused by other constituents in the samples, the detection sensitivities for specific radionuclides differ from sample to sample and from instrument to instrument.

Calibration and Quality Assurance

Laboratory and field survey procedures are documented in manuals developed specifically for the Oak Ridge Associated Universities' Environmental Survey and Site Assessment Program. Instruments were calibrated with NIST-traceable standards. Quality control procedures on all instruments included daily background and check-source measurements to confirm equipment operation within acceptable statistical fluctuations. The ORAU laboratory participates in the EPA and EML Quality Assurance programs. All samples collected by ORAU as part of this verification have been archived.