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Data Analysis of the 1984 and 1986 Soil Sampling Programs at Materials Disposal Area T in the Los Alamos National Laboratory

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DATA ANALYSIS OF THE 1984 AND 1986 SOIL SAMPLING PROGRAMS AT MATERIALS DISPOSAL AREA T IN THE LOS ALAMOS NATIONAL LABORATORY

by

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ABSTRACT

An environmental surveillance program for Materials Disposal Area T (MDA-T) at Los Alamos, New Mexico is described. The waste-use history of this disposal site is described, followed by a description of the materials and methods used to analyze data from two surface soil radionuclide sampling programs performed at this disposal site. The disposal site's physical features are related to the spatial distribution of radionuclide concentration contours in an attempt to evaluate radionuclide migration mechanisms in and around the site. The usefulness of the data analysis efforts is evaluated and recommendations are made for future studies.

I. INTRODUCTION

In the late 1970s the Department of Energy (DOE) issued interim operational criteria for radioactive waste areas owned or operated by DOE and its contractors (1-3). As a first response to the surveillance requirements listed in these criteria, personnel from the Environmental Surveillance Group at the Los Alamos Scientific Laboratory (LASL) developed an interim surveillance plan for the site's radioactive waste areas (4). More specifically, the stated objectives of this plan were to:

"(1) provide information to evaluate whether radioactive waste sites at LASL are being managed and maintained in an environmentally acceptable manner; and whether applicable criteria, such as the DOE Interim Criteria for Waste Management are met;

(2) identify and document possible changes over time for each area;

(3) provide data for the Annual Environmental Surveillance Report; and

(4) provide other environmental documentation that might be required prior to changes or additions to activities at LASL."

The original plan (4) called for a brief annual survey of each waste site starting at the end of FY-1981, involving portable radiation detector surveys and sampling programs for soils, vegetation, air, and small mammals. An additional detailed survey was to be performed on each waste area at least once every five years, with two or three waste areas being subject to this type of survey within any given year. The detailed surveys were meant to encompass more sampling locations, techniques with lower detection limits, and extensive sampling of surface soils (three depths in the top 30 cm of soil) and subsurface soils (depths below 30 cm).

Concurrent with the initial annual survey at each waste disposal area, a sampling grid was to be established by civil engineering surveys (4). The grid origin was to be randomly chosen to mitigate against bias in placement of grid points across the grid. Key points, coordinate axes

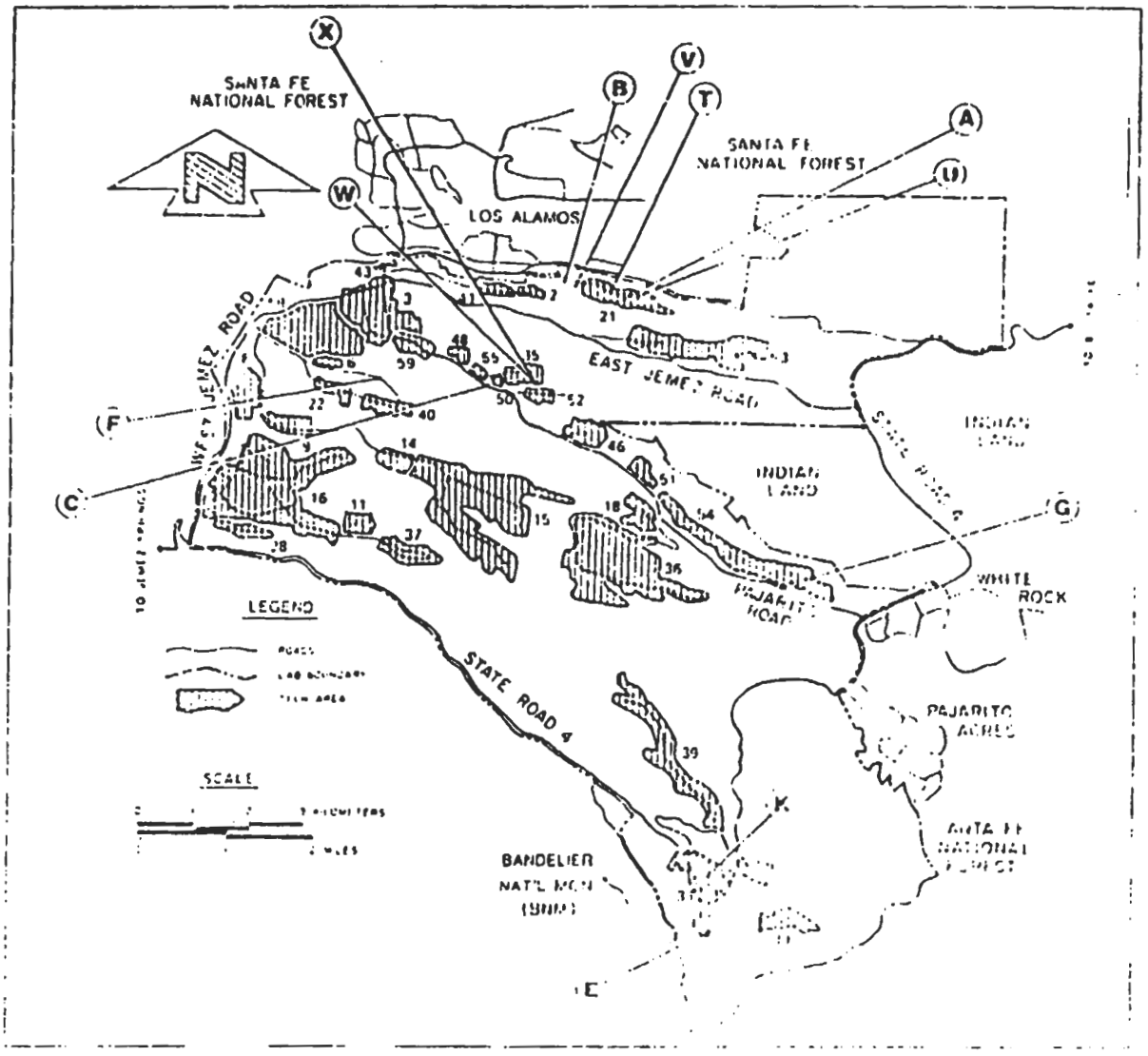

Fig. 1. Locations of technical areas and materials disposal areas at Los Alamos National Laboratory.

CMPs. Sixty-nine of these CMPs contained low-level radioactive wastes with a total inventory (8) of 0.77 Ci (0.044 g) ^{235}Pu, 1.18 Ci (19.2 g) ^{239}Pu, 15.3 Ci (4.7 g) ^{241}Am, and 0.16 Ci of mixed fission products. All 69 CMPs were relocated to MDA-G in 1984. An additional 158 CMPs contained transuranic wastes with a total inventory (8) of 30.97 Ci (1.8 g) ^{238}Pu, 59.4 Ci (966.9 g) ^{239}Pu, 10385.4 Ci (3205.4 g) ^{241}Am, and 0.4 Ci of mixed fission products. These 158 CMPs were relocated to MDA-G in 1986.

III. MATERIALS AND METHODS

A. Soil Sampling, Surveying, and Radionuclide Assay Techniques

Soil sampling techniques were initially outlined in the interim environmental surveillance plan for this ongoing DOE program (4). The details of how the samples were actually collected and processed for radiochemical analysis were never fully documented. This information will be presented here as the result of interviewing

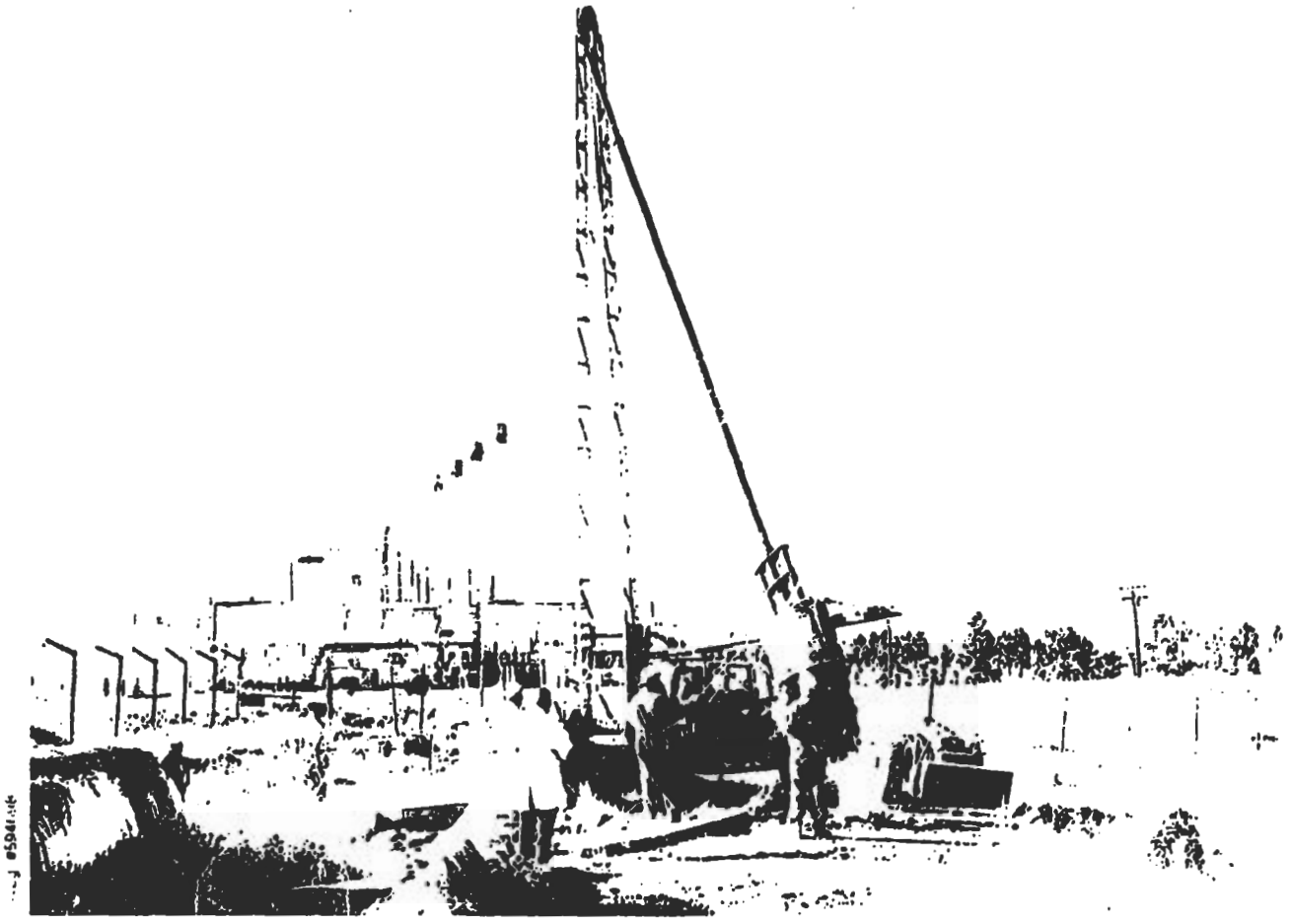

Fig. 3. Bucket auger being used to drill disposal shafts between Absorption Beds 2 and 4 at MDA-T. Absorption Beds 1 and 3 are behind the drill rig and represent the low areas to each side of the drill rig.

locations were marked with flagged spikes flush with the ground surface by the Laboratory's surveyors (10).

In 1986 Environmental Science Group personnel laid out a grid of sampling locations across MDA-T on 10 m centers (5). This coordinate system was laid out with respect to two reference points, which were surveyed in February 1990 (Engineering Drawing ENG-21-61, February 15, 1990). The two reference points were: (1) a point near the northwest corner of Building DP-257, and (2) a point near a sewer manhole, identified in Engineering Drawing ENG-21-61 as sample points CA-1 and CA-2, respectively. More details about this grid system will be presented in the Results and Discussion section of this report.

The radiochemical procedures for processing the soil samples through 1985 are summarized in Los Alamos National Laboratory report LA-8810-ENG (11). The analogous procedures for the assays on the 1986 samples are described in Los Alamos National Laboratory report LA-10992-ENV (12). Plutonium is chemically isolated from a 10-g aliquot of soil, electrodeposited and counted on an alpha spectrometer. Notice that the ^{239}Pu values mentioned in this report actually represent the sum of ^{239}Pu and ^{240}Pu, because both have identical alpha energies.

B. Conversions to New Mexico State Plane Coordinate System

Microcomputer programs were developed to convert all field location values to one common rectangular grid system, the NMSP coordinate system.

One program allowed us to take LASL coordinates and adjacent brass cap data to calculate NMSP coordinates. This program was used to calculate the NMSP coordinates for the absorption beds and disposal shafts at

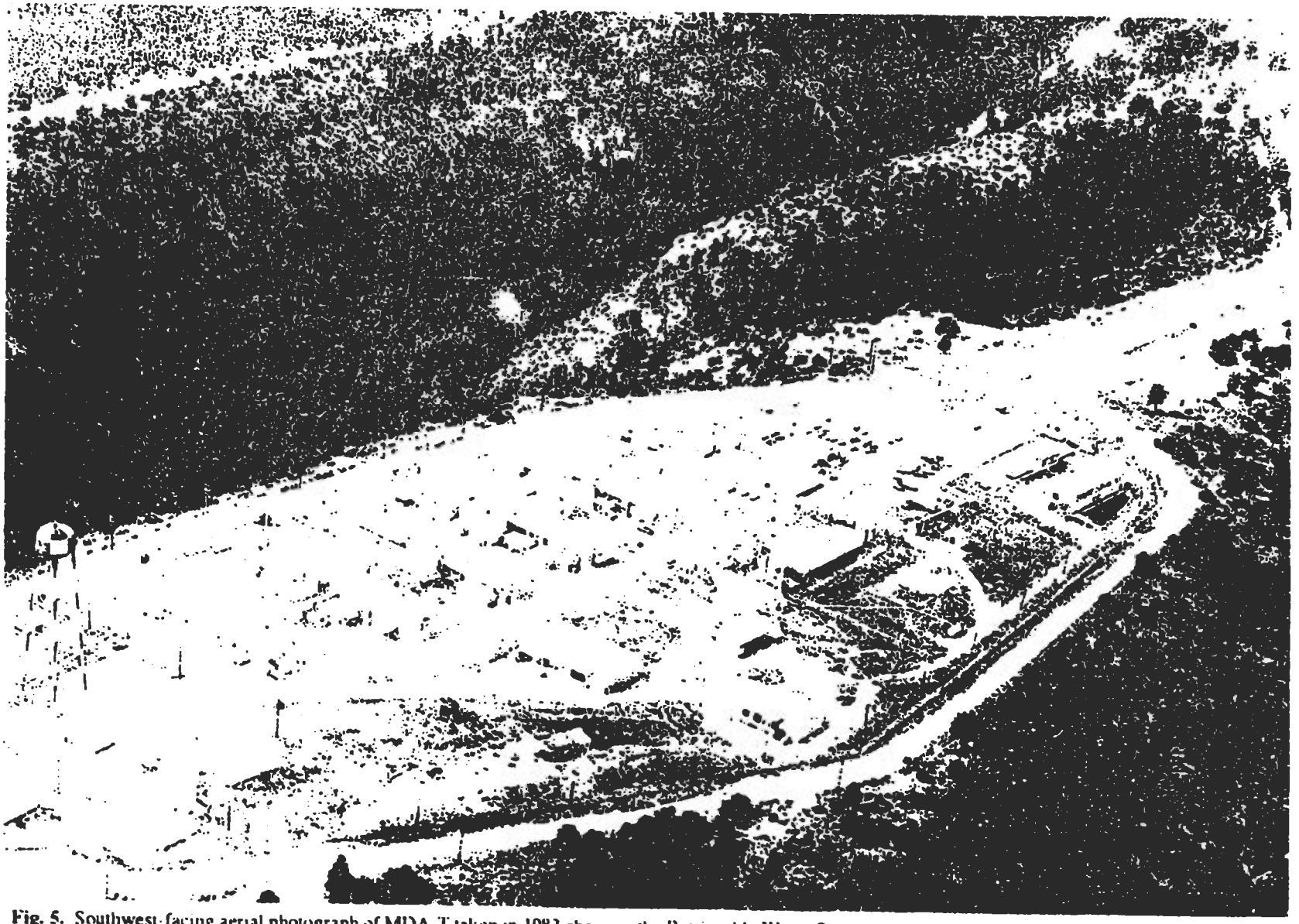

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Fig. 5. Southwest-facing aerial photograph of MDA-T taken in 1983 showing the Retrievable Waste Storage Area which contained the corrugated metal pipes

IV. RESULTS AND DISCUSSION

The locations of important waste site physical features (such as fence lines, absorption beds and disposal shafts) and sampling grids will be presented first in this section, because this data was needed before an analysis of the soil radionuclide data could be accomplished. The final subsection includes an analysis of the soil radionuclide data using a series of concentration contour plots.

A. Survey results for waste site physical features and soil sampling grids

Using the two computer programs described previously, NMSP coordinates were calculated for the four absorption beds at MDA-T (Table 1), as well as for the two types of disposal shafts (Table 2). This data is presented in Figure 7, which also shows the old runway to the area occupied by the CMPs, as well as the fence around the disposal area.

Table 1. Survey information for absorption beds at MDA-T.

Absorption Bed Number	Corner of Bed	Northing/Easting Values* LASL Grid System	Northing/Easting Values* New Mexico State Plane System
1	NW	89+31.25	1774510.94
		157+48.44	492368.34
	SW	89+14.38	1774494.57
		157+37.50	492356.67
	NE	88+52.81	1774427.45
		158+65.00	492481.34
	SE	88+36.25	1774411.38
		158+54.06	492469.68
2	NW	88+47.50	1774421.84
		158+71.91	492488.01
	SW	88+30.94	1774405.78
		158+60.97	492476.35
	NE	87+65.63	1774334.66
		159+94.38	492606.76
	SE	87+48.75	1774318.28
		159+83.44	492595.08
3	NW	89+97.50	1774575.15
		157+93.44	492416.21
	SW	89+60.63	1774538.79
		157+82.50	492403.66
	NE	89+37.50	1774510.98
		158+89.38	492509.42
	SE	89+00.94	1774474.94
		158+78.44	492496.88
4	NW	89+13.13	1774485.37
		159+18.16	492537.10
	SW	88+96.25	1774469.90
		158+86.59	492504.82
	NE	88+25.63	1774392.25
		160+47.81	492662.77
	SE	88+08.75	1774375.88
		160+36.56	492650.79

*Survey data estimated from Engineering Drawing ENG-C-2217 and data from Brass Caps 503 and 753 (entered in that order in the computer program)

Table 2. Survey information for disposal shafts at MDA-T (estimated from Engineering Drawing ENG-C-2217 and data from Brass Caps 503 and 753). (Cont.)

Disposal Shaft Number	New Mexico State Plane Survey Data (Easting, Northing)
6-ft diam Disposal Shafts	
70	492590.85,1774367.89
75	492581.16,1774375.20
76	492571.46,1774382.19
78	492585.93,1774401.57
80	492569.24,1774399.18
82	492552.07,1774396.50
83	492559.54,1774406.18
84	492566.54,1774415.88
87	492542.37,1774403.49
91	492537.45,1774437.18
92	492530.45,1774427.48
94	492520.76,1774434.79
95	492527.76,1774444.49
98	492501.37,1774449.06

The calculated NMSP coordinates for the 1984 survey of MDA-T are presented in Table 3. The unpublished original sample grid coordinates are presented for each soil sample collected at each sample location. The sample identification number assigned to each soil sample which underwent radionuclide analysis by the Laboratory's Health and Environmental Chemistry Group is listed in the last column in this table.

The original two reference points for the 1986 sampling grid were surveyed in 1990 (see discussion in Materials and Methods section) and an origin for the grid was derived, all in NMSP units (Table 4). The sampling grid was reconstructed from these original reference points (Fig. 8), but it incorrectly portrayed where the samples were actually collected (5). We discovered that both the origin and the other two reference points had to be adjusted as shown in Table 4 to get the sample grid locations to appear in their correct positions (5), as shown in Figure 9. Based on these adjusted NMSP coordinates for each sampling location, we then were able to reconstruct information for the 1986 survey (Table 5). All further references to the 1986 survey in this report will use the NMSP coordinates listed in Table 5 and shown in Figure 9.

Two-foot elevation contours data were collected from a 1986 elevation survey of the Laboratory, accessed through the Laboratory's Engineering Division (MOSS system). This elevation information is presented in conjunction with the 30 sampling locations in the 1984 survey (Fig. 10) and with the 71 sampling locations in the 1986 survey (Fig. 11). These two figures show that the southeastern portion of MDA-T has an elevation of about 7144 ft, proceeding to an elevation of 7130 ft close to the northwestern fence boundary. It is important to notice that the sample locations for both surveys were all collected above an elevation of about 7100 ft. As both Figures 10 and 11 show, the severe drop-off into DP Canyon starts at about 7100 ft to an elevation of about 7060 ft to the northwest. Elevations of about 7050 ft and lower are more typical of the regional bottom of this major canyon system.

Two other major elevation features should be noticed (Figs. 10 and 11). A large mound of excavated tuff was placed over the southern absorption beds, just south of the 7140 ft contour line, and extended to a total elevation of about 7160 ft. This tuff was excavated from the CMP runway area (see Figs. 5 and 6), which exhibited a major depression between absorption beds 1 and 3 to a minimum elevation of about 7122 ft.

Table 3. Sampling grid coordinates, New Mexico State Plane coordinates and radionuclide sample numbers for the 1984 survey of MDA-T.

Sample Grid System		NMSP System		Sample
Easting	Northing	Easting	Northing	Number
-60.00	-20.00	492843.18	1774262.06	84.04146
-160.00	-40.00	492624.47	1774515.26	84.04147
-120.00	-40.00	492689.11	1774401.05	84.04148
-100.00	-40.00	492721.43	1774343.95	84.04149
-60.00	-40.00	492786.07	1774229.74	84.04150
-160.00	-60.00	492567.37	1774482.94	84.04151
-140.00	-60.00	492599.69	1774425.84	84.04152
-120.00	-60.00	492632.01	1774368.73	84.04153
-100.00	-60.00	492664.33	1774311.63	84.04154
-200.00	-80.00	492445.62	1774564.84	84.04155
-180.00	-80.00	492477.94	1774507.73	84.04156
-160.00	-80.00	492510.26	1774450.63	84.04157
-140.00	-80.00	492542.58	1774393.52	84.04158
-100.00	-80.00	492607.22	1774279.31	84.04159
-80.00	-80.00	492639.54	1774222.20	84.04160
-100.00	-100.00	492550.12	1774246.99	84.04161
-60.00	-100.00	492614.76	1774132.78	84.04162
-120.00	-10.00	492774.77	1774449.53	84.04175
-80.00	-20.00	492810.86	1774319.16	84.04176
-60.00	-20.00	492843.18	1774262.06	84.04177
-160.00	-40.00	492624.47	1774515.26	84.04178
-120.00	-40.00	492689.11	1774401.05	84.04179
-100.00	-40.00	492721.43	1774343.95	84.04180
-60.00	-40.00	492786.07	1774229.74	84.04181
-160.00	-60.00	492567.37	1774482.94	84.04182
-140.00	-60.00	492599.69	1774425.84	84.04183
-120.00	-60.00	492632.01	1774368.73	84.04184
-100.00	-60.00	492664.33	1774311.63	84.04185
-200.00	-80.00	492445.62	1774564.84	84.04186
-180.00	-80.00	492477.94	1774507.73	84.04187
-160.00	-80.00	492510.26	1774450.63	84.04188
-140.00	-80.00	492542.58	1774393.52	84.04189
-100.00	-80.00	492607.22	1774279.31	84.04190
-80.00	-80.00	492639.54	1774222.20	84.04191
-60.00	-100.00	492614.76	1774132.78	84.04192
-80.00	-20.00	492810.86	1774319.16	84.04206
-60.00	-20.00	492843.18	1774262.06	84.04207
-160.00	-40.00	492624.47	1774515.26	84.04208
-120.00	-40.00	492689.11	1774401.05	84.04209
-100.00	-40.00	492721.43	1774343.95	84.04210
-60.00	-40.00	492786.07	1774229.74	84.04211
-160.00	-60.00	492567.37	1774482.94	84.04212
-140.00	-60.00	492599.69	1774425.84	84.04213
-120.00	-60.00	492632.01	1774368.73	84.04214
-100.00	-60.00	492664.33	1774311.63	84.04215
-200.00	-80.00	492445.62	1774364.84	84.04216
-180.00	-80.00	492477.94	1774507.73	84.04217
-140.00	-80.00	492542.58	1774393.52	84.04218
-100.00	-80.00	492607.22	1774279.31	84.04219

Table 4. Original and adjusted reference points for 1986 survey of MDA-T.

Sample grid system (Easting, northing)	NMSP Coordinates Easting	Northing
Original survey reference points:		
0,0	492815.76	1774166.10
-70,10	492607.15	1774253.84
-40,30	492715.08	1774295.63
Adjusted survey reference points:		
0,0	492825.76	1774156.10
-70,10	492607.15	1774227.34
-40,30	492725.08	1774285.63

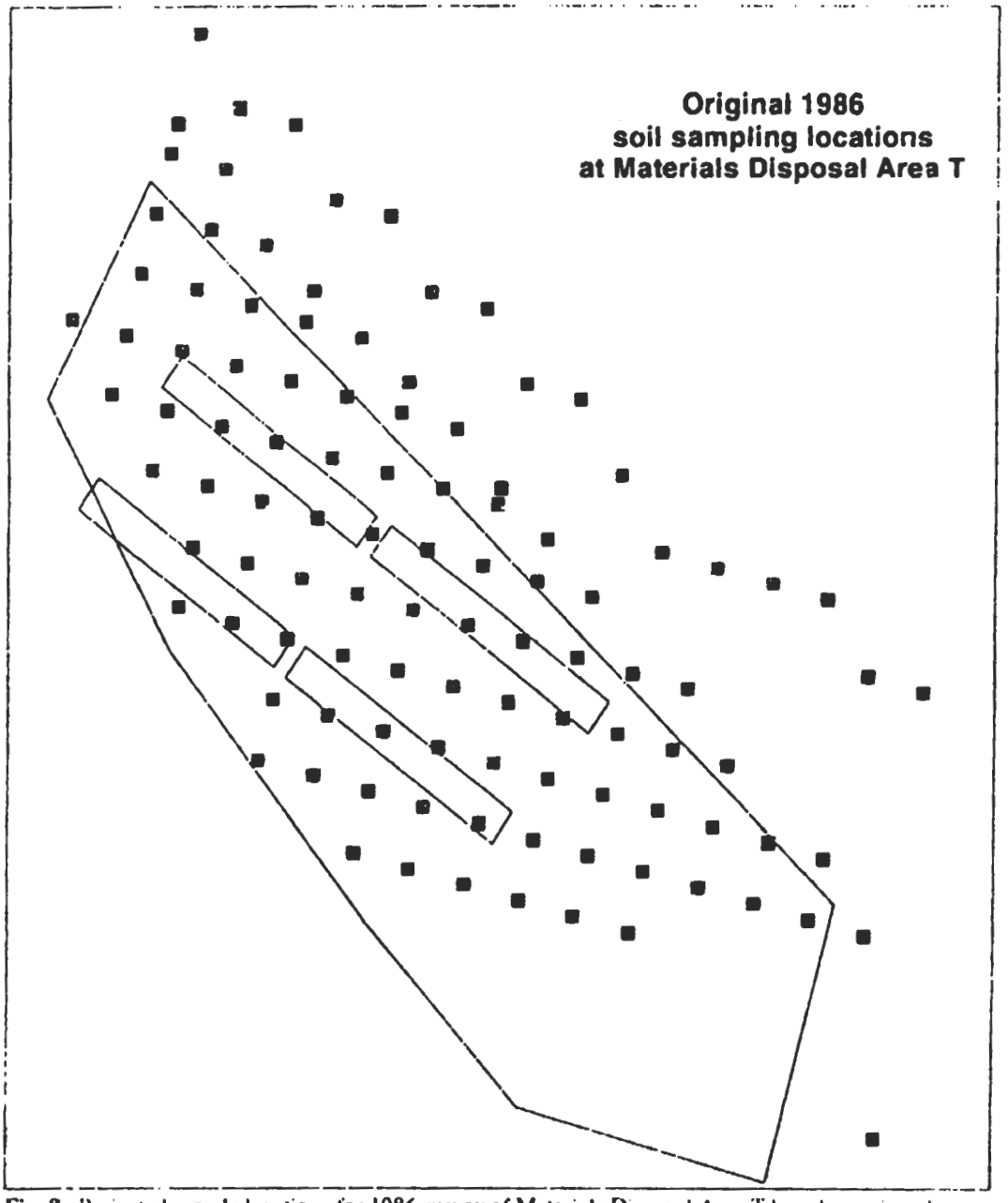

Fig. 8. Projected sample locations for 1986 survey of Materials Disposal Area T based on original survey reference points (Table 4)

Table 5. Sampling grid coordinates, New Mexico State Plane adjusted coordinates and radionuclide sample numbers for the 1986 surveys of MDA-T.

Sample Grid System		NMSP System		Sample
Easting	Northing	Easting	Northing	Number
-50.00	50.00	492701.44	1774351.97	86 11867
-60.00	50.00	492669.42	1774359.12	86 11868
-70.00	50.00	492637.40	1774366.28	86 11869
-70.00	60.00	492644.56	1774398.30	86 11870
-80.00	60.00	492612.54	1774405.45	86 11871
-90.00	60.00	492580.52	1774412.61	86 11872
-100.00	60.00	492548.50	1774419.76	86 11873
-110.00	60.00	492516.48	1774426.92	86 11874
-120.00	60.00	492484.46	1774434.07	86 11875
-130.00	60.00	492452.45	1774441.23	86 11876
-140.00	60.00	492420.43	1774448.38	86 11877
-80.00	70.00	492619.69	1774437.47	86 11878
-90.00	70.00	492587.68	1774444.63	86 11879
-100.00	70.00	492555.66	1774451.78	86 11880
-110.00	70.00	492523.64	1774458.93	86 11881
-120.00	70.00	492491.62	1774466.09	86 11882
-130.00	70.00	492459.60	1774473.24	86 11883
-140.00	70.00	492427.58	1774480.40	86 11884
-150.00	70.00	492395.56	1774487.55	86 11885
-100.00	80.00	492562.81	1774483.80	86 11886
-110.00	80.00	492530.79	1774490.95	86 11887
-120.00	80.00	492498.77	1774498.11	86 11888
-130.00	80.00	492466.76	1774505.26	86 11889
-140.00	80.00	492434.74	1774512.42	86 11890
-150.00	80.00	492402.72	1774519.57	86 11891
-160.00	80.00	492370.70	1774526.73	86 11892
-110.00	90.00	492537.95	1774522.97	86 11893
-120.00	90.00	492505.93	1774530.13	86 11894
-130.00	90.00	492473.91	1774537.28	86 11895
-140.00	90.00	492441.89	1774544.44	86 11896
-150.00	90.00	492409.87	1774551.59	86 11897
-160.00	90.00	492377.85	1774558.75	86 11898
-170.00	90.00	492345.84	1774565.90	86 11899
-130.00	100.00	492481.07	1774569.30	86 11900
-140.00	100.00	492449.05	1774576.46	86 11901
-150.00	100.00	492417.03	1774583.61	86 11902
-160.00	100.00	492385.01	1774590.77	86 11903
-150.00	110.00	492424.18	1774615.63	86 11904
-160.00	110.00	492392.16	1774622.78	86 11905
-160.00	110.00	492399.32	1774654.80	86 11906
-10.00	30.00	492815.21	1774259.31	86 11907
-20.00	40.00	492790.34	1774298.48	86 11908
-40.00	50.00	492733.46	1774344.61	86 11909
-50.00	60.00	492708.60	1774383.99	86 11910
-60.00	60.00	492676.58	1774391.14	86 11911
-70.00	70.00	492651.71	1774430.32	86 11912
-80.00	80.00	492626.85	1774469.49	86 11913
-90.00	80.00	492594.83	1774476.64	86 11914
-90.00	90.00	492601.99	1774508.66	86 11915
-100.00	90.00	492569.97	1774515.82	86 11916
-110.00	100.00	492545.10	1774554.99	86 11917
-120.00	100.00	492513.08	1774562.15	86 11918
-130.00	110.00	492488.22	1774601.32	86 11919
-140.00	110.00	492456.20	1774608.47	86 11920
-150.00	120.00	492431.34	1774647.65	86 11921
-160.00	130.00	492406.47	1774686.82	86 11922
-10.00	70.00	492843.83	1774387.39	86 11923
-20.00	70.00	492811.81	1774394.54	86 11924
-30.00	80.00	492786.94	1774433.71	86 11925
-40.00	80.00	492754.92	1774440.87	86 11926
-50.00	80.00	492722.91	1774448.02	86 11927
-60.00	80.00	492690.89	1774455.18	86 11928
-70.00	90.00	492666.02	1774494.35	86 11929
-80.00	100.00	492641.16	1774533.53	86 11930
-90.00	100.00	492609.14	1774540.68	86 11931
-100.00	110.00	492584.28	1774579.85	86 11932
-110.00	110.00	492552.26	1774587.01	86 11933
-120.00	120.00	492527.39	1774626.18	86 11935
-130.00	120.00	492495.38	1774633.34	86 11936
-140.00	130.00	492470.51	1774672.51	86 11937
-150.00	130.00	492438.49	1774679.67	86 11938
-160.00	140.00	492413.63	1774718.84	86 11939

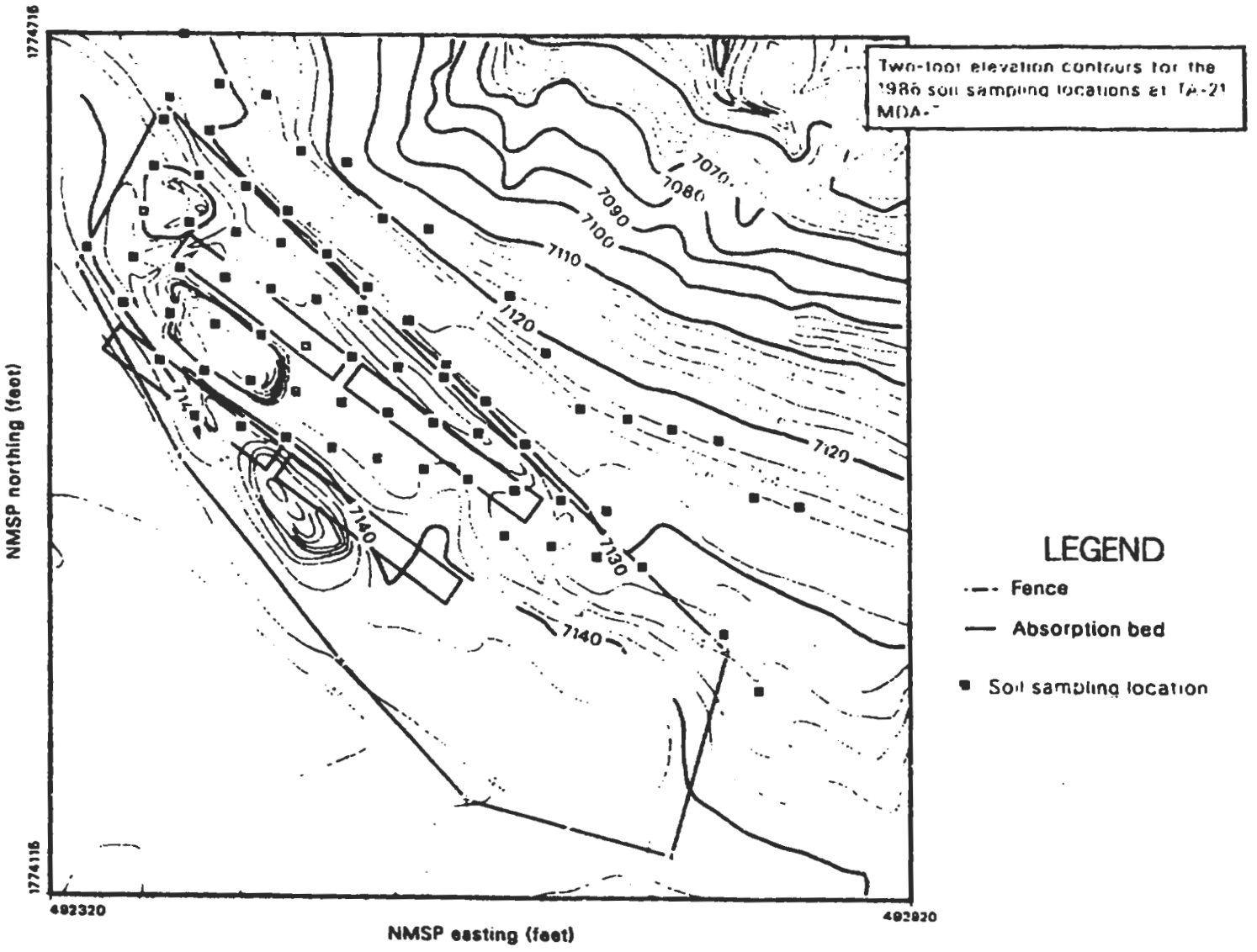

Fig. 11. Two-foot elevation contours and soil sampling locations for 1986 survey of Materials Disposal Area T.

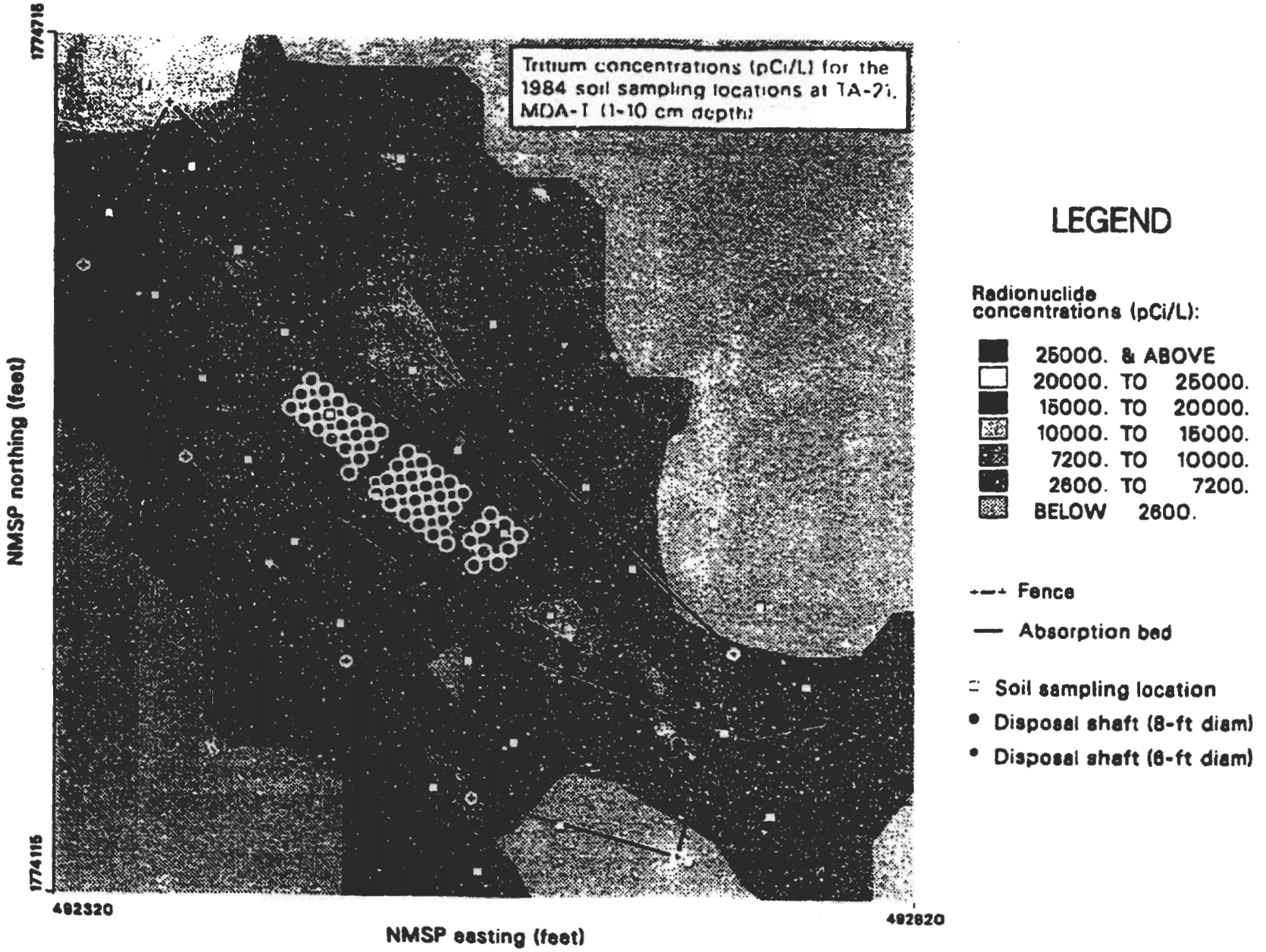

Fig. 12. Soil tritium concentration contours for the 1984 sampling grid at Materials Disposal Area T (1–10 cm depth).

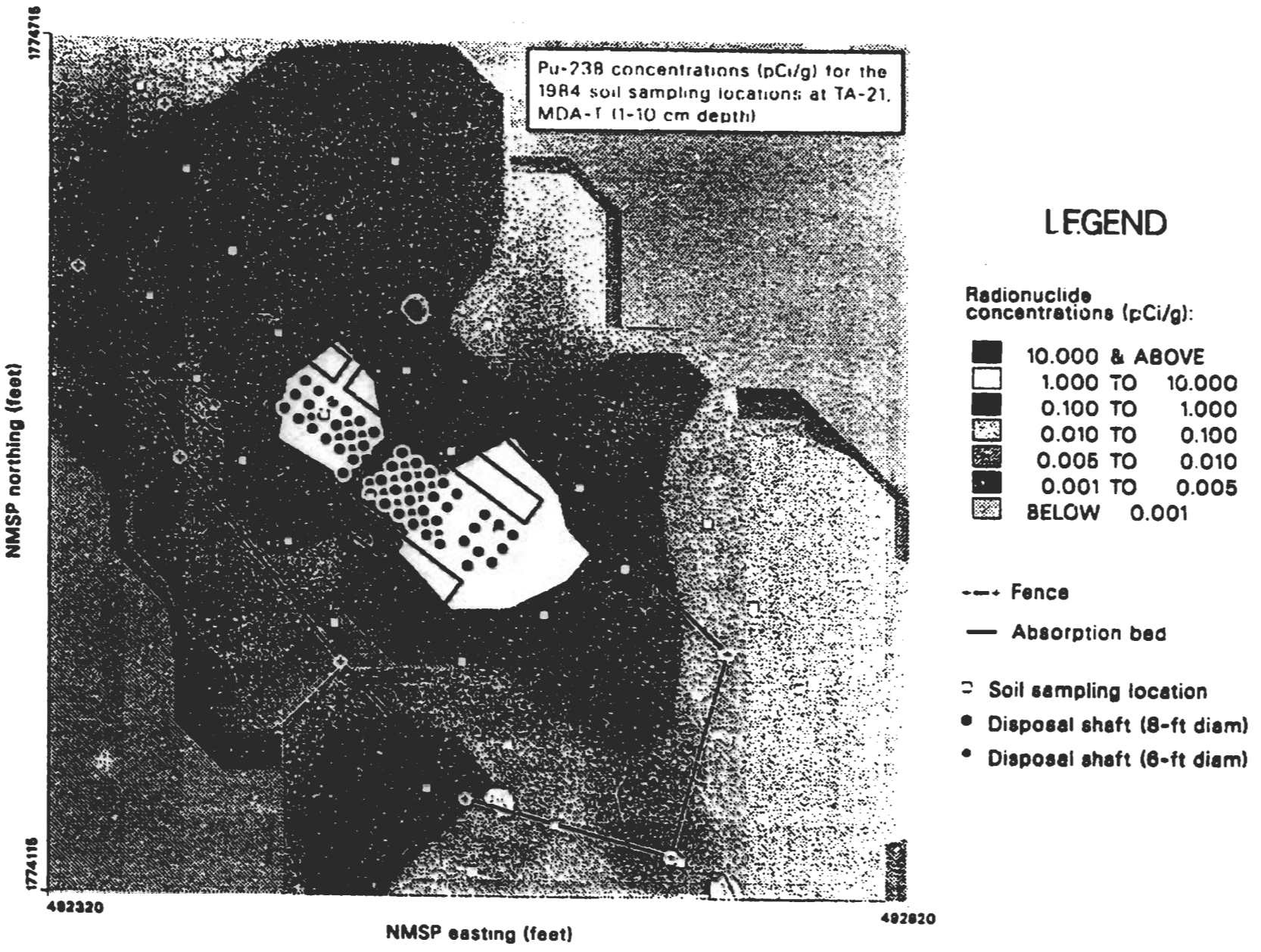

Fig. 14. Soil ^{238}Pu concentration contours for the 1984 sampling grid at Materials Disposal Area T (1–10 cm depth).

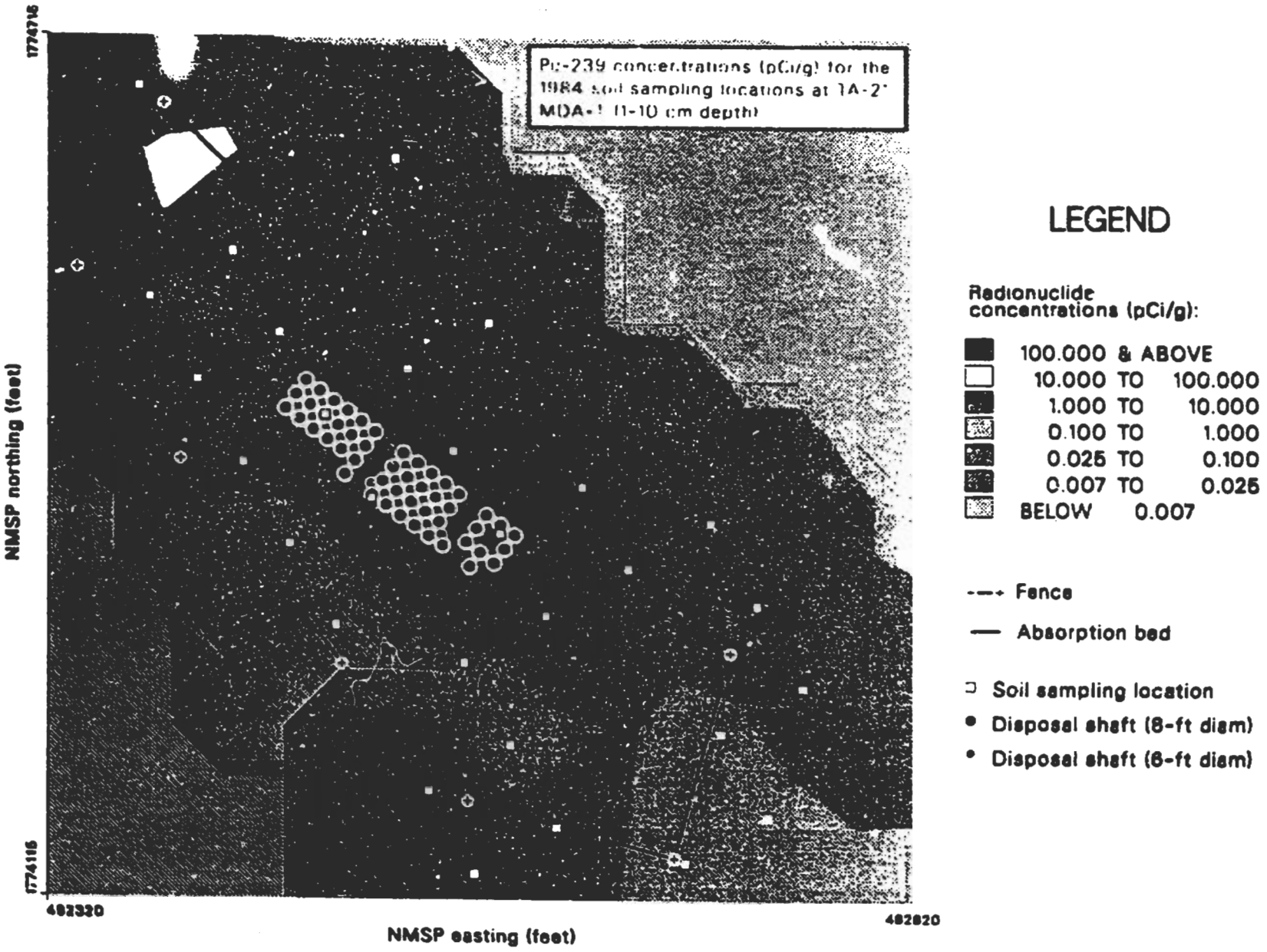

Fig. 16. Soil ^{239}Pu concentration contours for the 1984 sampling grid at Materials Disposal Area T (1–10 cm depth).

The highest concentrations of ^{239}Pu were found above the old CMP runway, in the western portion of MDA-T (Figs. 16 and 17). These are represented by ^{239}Pu concentration in these surface soil samples ranging from 10 to 100 pCi/g, designated as the yellow contours in Figures 16 and 17. Soil samples with 40- to 100-fold increased ^{239}Pu over the upper limit for background concentrations (contour with the dark green color in Figs. 16 and 17) seemed to be more dominant over the disposal site than corresponding contours for ^{238}Pu (Figs. 14 and 15). Although the exact reason for this observation is unknown at this time, a partial explanation may be derived from the waste use history of the site as presented earlier in this report: two- to four-fold more ^{239}Pu was in the waste than ^{238}Pu (on a radionuclide activity basis).

Another important point should be made to clarify the overall significance of the plutonium data collected in 1984. As we pointed out earlier, the soil samples collected only represent what occurred on the mesa tops, i.e. at elevations ranging from 7146 to 7100 ft at MDA-T. None of these samples reflect the impact of the treated and untreated liquid wastes discharged to DP Canyon (to the north of the disposal site).

(2) The 1986 Survey Results

The 1986 survey of the soil radionuclides at MDA-T involved samples collected at only one sampling depth, 0-5 cm. Whereas the 1984 sampling locations were on 20 m centers, the 1986 soil samples were collected 10 m apart, thus improving the accuracy of the radionuclide concentration contours.

Because of the more detailed data collected in this survey compared with the 1984 survey, larger land areas were found with higher plutonium concentrations than in the 1984 survey. Thus, when the radionuclide concentration contours were estimated for the disposal site larger land areas could be interconnected in more comprehensive pattern than could be accomplished in the 1984 survey. Using the ^{238}Pu concentration contours in the 1 to 10 pCi/g range (contours with the yellow color) as an example, the 1986 survey results show a northeast-southwest trending yellow contour proceeding across the western end of MDA-T encompassing an area of higher concentrations to the south (Fig. 18). This entire area was influenced by water erosion which occurred across this end of the disposal area for several years. ^{238}Pu and ^{239}Pu (Fig. 19) associated with soil was evidently transported across the western portion of the site, proceeded in a southeastern direction along the fence (which is south of the north perimeter road adjacent to the north fence of the disposal site), crossed the road to the north of the site, and proceeded down the naturally-occurring drainage way starting between the 7120 ft and 7110 ft elevation contours (see Fig. 11).

Another important observation concerning the soil plutonium concentration contours involves the sampling results north of the north disposal site fence, an area characterized by an undisturbed pinyon juniper woodland. Except for the soil erosion phenomena described above, the samples collected north of the north perimeter road were almost consistently within the dark green-colored contours in Figures 18 and 19. This meant that soil ^{238}Pu and ^{239}Pu concentrations were consistently 0.1 to 1.0 pCi/g and 1 to 10 pCi/g, respectively. Estimates of the ratios of ^{239}Pu to ^{238}Pu were made for the samples collected across this area (Fig. 20), which demonstrate consistently observed ratios of 5 to 25. Although the reason for this is not fully understood at this time, this area probably received local airborne fallout from DP site which influenced this entire area. It is also possible that liquid effluents originally contained in absorption beds 3 and 4 overflowed during the early waste history of the site, and plutonium was transported to the low-elevation areas north of the disposal area. The plutonium ratios presented in Figure 20 suggest that more ^{239}Pu was contained in the surface soils than ^{238}Pu in the western portion of the disposal area. The reason for this observation is also not fully understood at this time, but the fact that the disposal shafts contained much lower ^{239}Pu/^{238}Pu ratios suggests an alternative source term. This alternate source term could have involved a high ^{239}Pu source which migrated into the disposal site from drainage areas west of this disposal site via site runon near the southwestern corner of the site. Although ^{241}Am assays were not performed for the soil samples collected in 1984, this was a major concern in the 1986 survey (Fig. 21). Very large amounts of ^{241}Am were processed in the pug mill operations at this site, especially within the CMPs. It is not surprising then that the soils around the areas where the CMPs were filled with a plastic-wrapped fire hose contained the highest ^{241}Am concentrations found at the site (notice the dark green contour centered at the western end of the disposal shaft field).

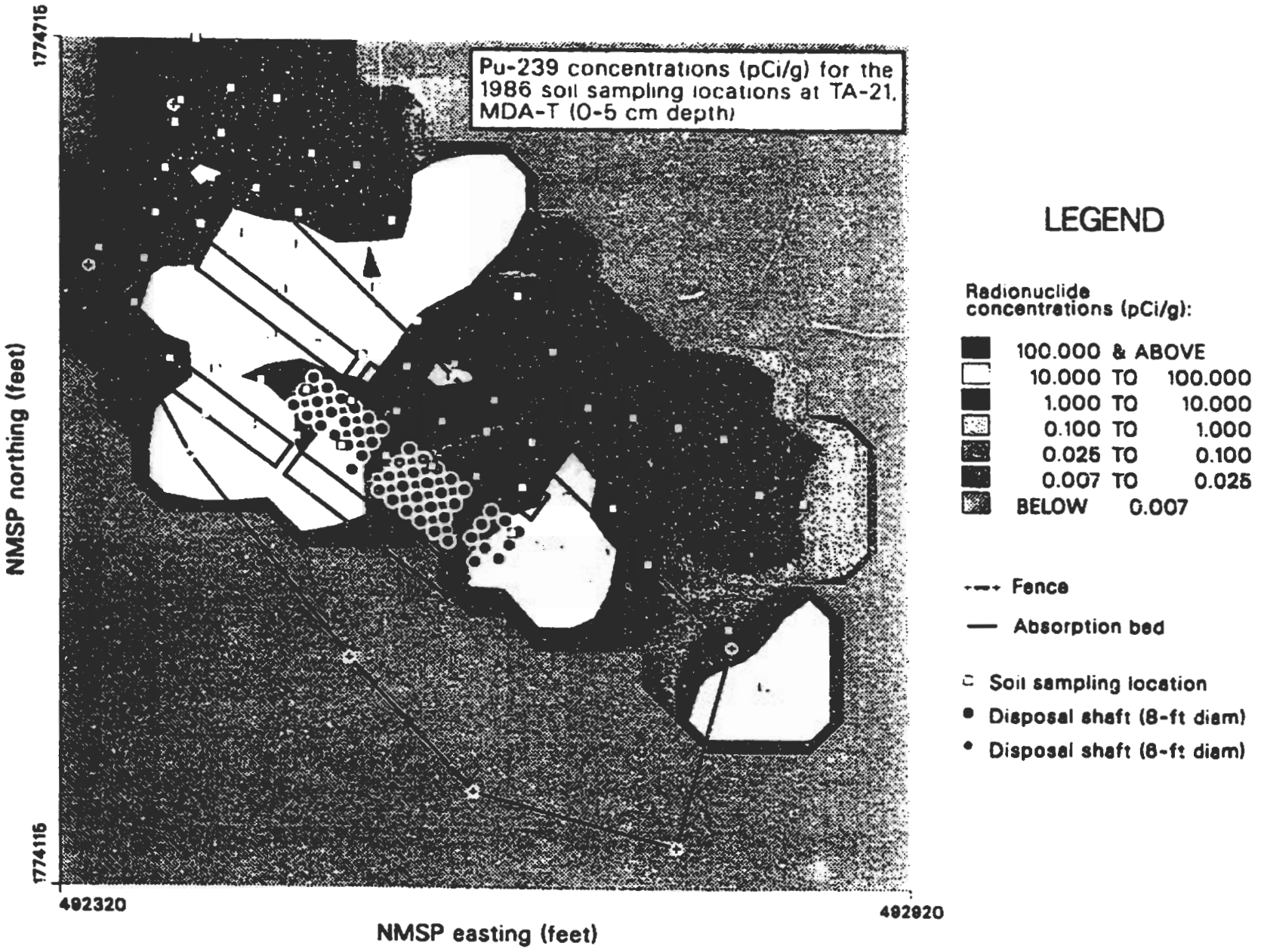

Fig. 19. Soil ^{239}Pu concentration contours for the 1986 sampling grid at Materials Disposal Area T (0–5 cm depth).

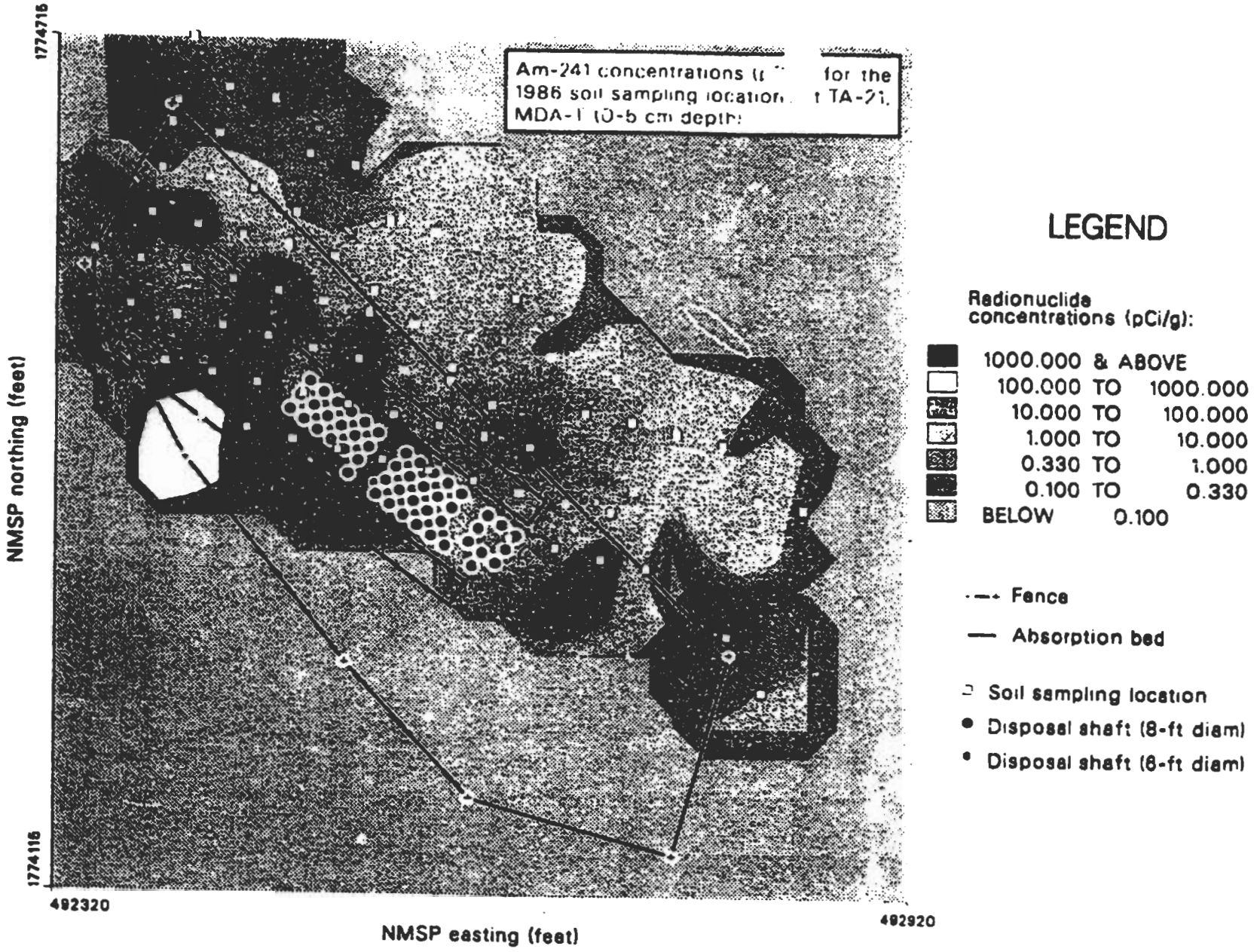

Fig. 21. Soil ^{241}Am concentration contours for the 1986 sampling grid at Materials Disposal Area T (0–5 cm depth)

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