TC 0076-06

FINAL REPORT
REMEDIAL INVESTIGATION

BUILDING 233

CAMP NAVAJO
BELLEMONT, ARIZONA

July 1999

Prepared for:

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REMEDIAL INVESTIGATION
AT
CAMP NAVAJO

BUILDING 233

FINAL REPORT

Contract DACA05-93-D-0019

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LIST OF ACRONYMS

Acronym	Full Phrase
ADEQ	Arizona Department of Environmental Quality
ADHS	Arizona Department of Heath Services
bgs	below ground service
CERCLA	Comprehensive Environmental Response, Compensation, and Liablity Act of 1980
COC	chemical of concern
ESE	Environmental Science and Engineering
GSA	General Services Administration
HBGL	Health Based Guidance Levels
HA	hand auger
LDC	Laboratory Data Consultants
MS	matrix spike
PRG	Preliminary Remediation Goals
QA	Quality Assurance
QC	Quality Control
RI	remedial investigation
RPD	relative percent diference
SS	surface soil
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
UST	underground storage tank

SECTION 1
INTRODUCTION

1.1 PURPOSE OF REPORT

This report summarizes the results of the remedial investigation conducted at Building 233 (NAAD 31, NADA 31, AREE 31) (site) at Camp Navajo (formerly Navajo Depot Activity), in Bellemont, Arizona (Figure 1-1). Tetra Tech was retained by the United States Army Corps of Engineers to conduct the work described in this report.

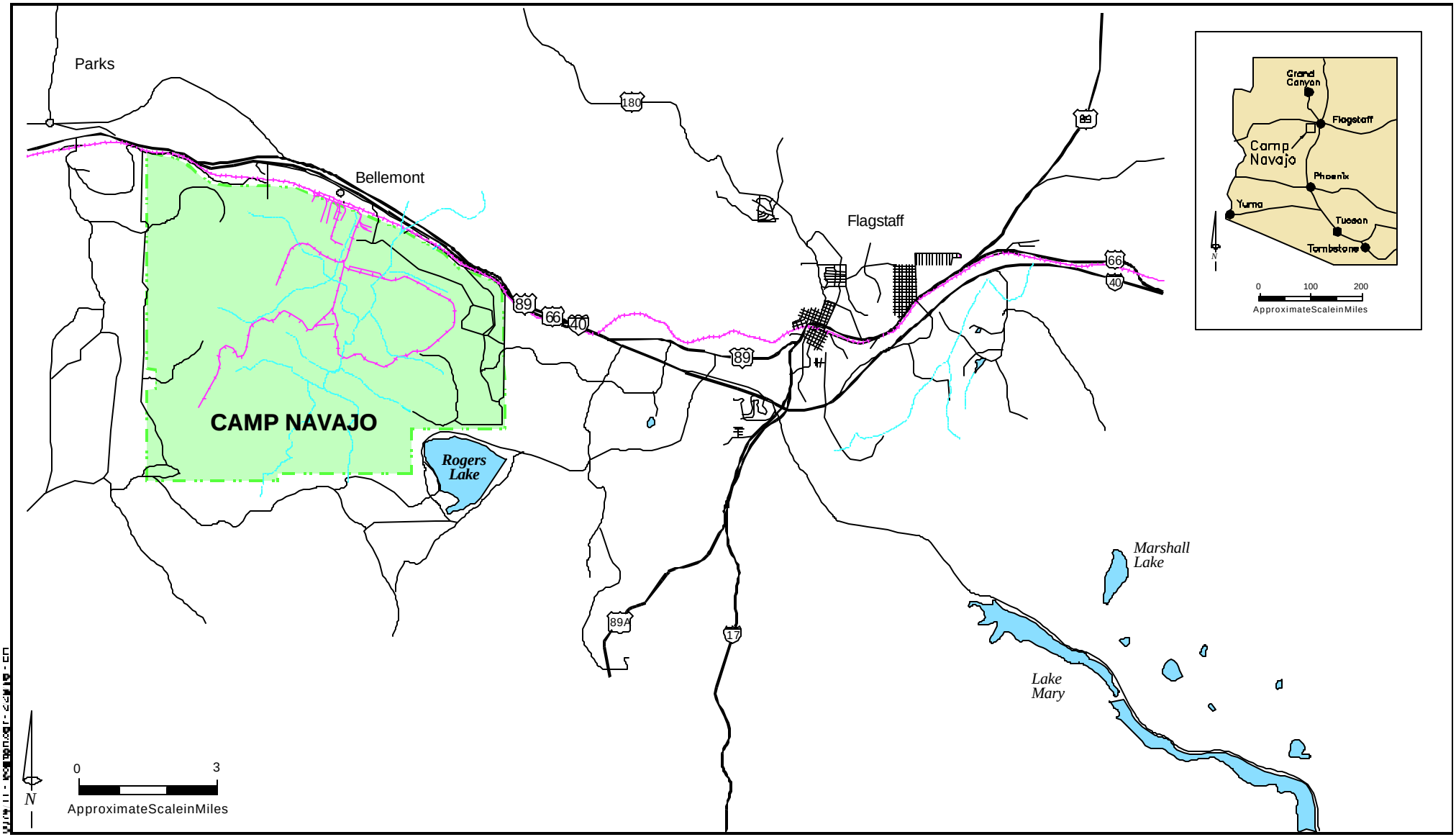
1.2 SITE BACKGROUND

1.2.1 Site Description

GSA mercury stocks were housed in Building 231 or 233, or both, from 1953 until they were moved to Igloo Area H in 1960. The mercury warehouse building collapsed in a snowstorm in 1967, and the superstructure was subsequently removed (EBASCO 1990) (Figures 1-2 and 1-3). Mercury leaks were reported to have occurred in the GSA warehouse where mercury was stored (USATHAMA 1979). In 1979, there were visible traces of mercury in the cracked foundation of former Building 231 (USATHAMA 1979). The concrete pad at Building 233 (approximately 141,000 square feet) and the surrounding soil are potentially contaminated.

1.2.2 Previous Investigations

The pads of the former mercury storage warehouses were not sampled by ESE in their 1981 study because investigators could not visually locate any spill sites (EBASCO 1990). During a separate site inspection of the former warehouses foundation pads in October 1993, cracks in the foundations were filled with concrete dust and there was no visible mercury. The pad for Building 231 was being used for storing soils from UST excavations at the time of the inspection (Uribe 1993).



CampNavajoisinnorthcentralArizona
about12mileswestofthecityofFlagstaff.

LEGEND:

- Highways
- Roads
- Railroad
- Rivers/Streams

Camp Navajo Location Map

Camp Navajo
Bellemont,Arizona

Tetra Tech, Inc.

Figure 1-1

Legend:

Fence
Grass
Railroad

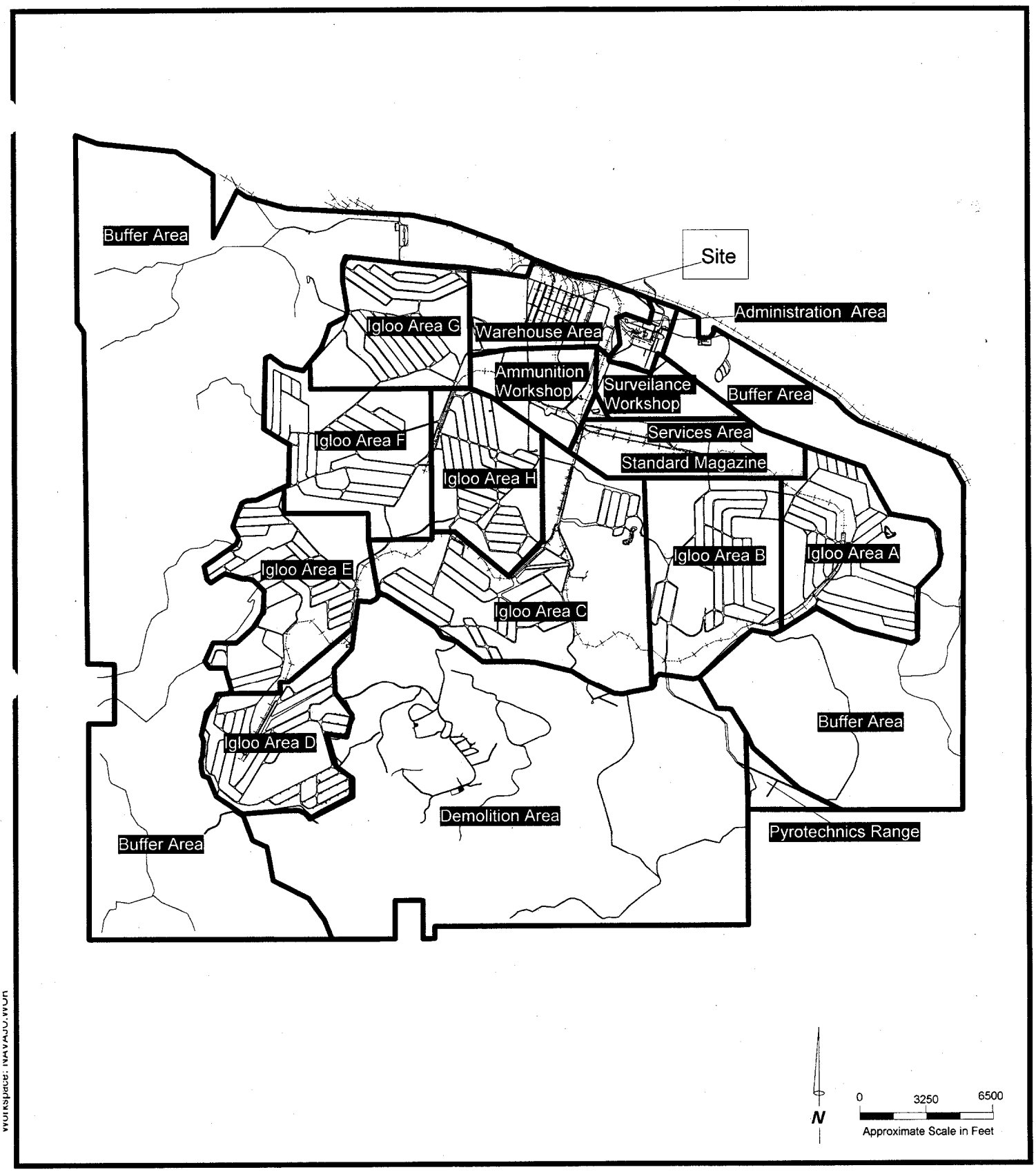
Building 233 - Former Mercury Storage

Site Plan

Camp Navajo, Bellemont, Arizona

Tetra Tech, Inc.

Figure 2-1



Building 233 - Former Mercury Storage

Site Map

Camp Navajo, Bellemont, Arizona

Tetra Tech, Inc.

Figure 1-3

1.3 STATEMENT OF THE PROBLEM

Previous operations at this site are reported to have resulted in the release of mercury on the building floor. Some of the mercury was reportedly still visible in foundation cracks in 1979. Of specific concern at the site is the identification of mercury contamination in and beneath the foundation.

1.4 REPORT ORGANIZATION

This report follows United States Environmental Protection Agency (USEPA) guidance for remedial investigation (RI) reports as provided in the Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (USEPA 1988). Section 2 describes the field investigations conducted as part of the RI. Sections 3 and 4 present the physical and chemical results respectively. Section 5 presents risk screening for the identified contaminants. All results are summarized with conclusions in Section 6.

SECTION 2
SAMPLING PROGRAM

2.1 SAMPLING OBJECTIVES

The specific objectives for the investigation of Building 233 are to identify mercury spill areas, to evaluate the extent of mercury contamination on and below the concrete pads, and to evaluate possible mercury contamination of surrounding soils in order to determine if remedial action of the site is necessary and to estimate the volume of contaminated media that requires remediation.

2.2 SAMPLING APPROACH

Photo documentation is provided in Appendix A. Field notes are presented in Appendix B. Field investigations were conducted in accordance with the procedures outlined in the field sampling plan provided in Appendix C. Surveyor results can be found in Appendix D.

Task 1: Visual Inspection/Jerome Meter

A visual inspection of all cracks was conducted throughout the concrete building foundation. Each crack was also monitored with a Jerome meter to detect possible mercury vapors. Dirt filled cracks were uncovered for inspection by removing the dirt with an awl.

Task 2: Surface Soil Sampling

Surface soil sampling was performed outside each of the former doors to the building. Twelve surface soil samples were taken at the locations shown in Figure 2-1 Samples were collected by driving a 2-inch by 12-inch California modified split spoon sampler, as described in Appendix C. As shown in Table 2-1, surface soil samples were analyzed for mercury and pH. Two samples also were analyzed for bulk density and grain size.

Table 2-1
Building 233 Sample Analyses

Sample ID	Sample Date	Depth (feet)	Percent Water ASTM D2216	pH SW9045B	Dry Density ASTM D2937	Particle-Size Distribution ASTM D422	Metals SW6010A	Mercury SW7471A
233-SS01S-01	10/22/95	1	X	X				X
233-SS02S-01	10/22/95	1	X	X				X
233-SS03S-01	10/22/95	1	X	X				X
233-SS04S-01	10/22/95	1	X	X	X			X
233-SS05S-01	10/22/95	1	X	X				X
233-SS06S-01	10/22/95	1	X	X				X
233-SS07S-01	10/22/95	1	X	X				X
233-SS08S-01	10/22/95	1	X	X	X	X		X
233-SS09S-01	10/22/95	1	X	X				X
233-SS10S-01	10/22/95	1	X	X				X
233-SS11S-01	10/22/95	1	X	X				X
233-SS12S-01	10/22/95	1	X	X				X
233-SS13S-01*	10/22/95	1	X	X				X
233-SS14S-01*	10/22/95	1	X	X				X
233-HA01S-01	5/2/96	0.5	X	X			X	X
233-HA01S-02	5/2/96	2.5	X	X			X	X
233-HA02S-01	5/2/96	0.5	X	X			X	X
233-HA02S-02	5/2/96	2.5	X	X	X	X	X	X
233-HA02S-03	5/2/96	5	X	X			X	X
233-HA03S-01	5/2/96	0.5	X	X			X	X
233-HA03S-02	5/2/96	2.5	X	X			X	X
233-HA03S-03	5/2/96	4.5	X	X			X	X
233-HA04S-01	5/2/96	0.5	X	X			X	X
233-HA04S-02	5/2/96	2.5	X	X			X	X
233-HA05S-01*	5/2/96	2.5	X	X			X	X
233-HA05S-02*	5/2/96	2.5	X	X			X	X

Notes:
* Blind duplicate sample (see section 4.3)
ASTM American Society for Testing and Materials

Legend:

- Hand Auger Location
- Fence
- Grass
- Railroad
- Surface Soil Sample/Sediment Sample

Building 233 - Former Mercury Storage

Investigation Plan

Camp Navajo, Bellemont, Arizona

Tetra Tech, Inc.

Figure 2-1

Task 3: Hand Auger Sampling

Four hand auger locations were sampled within the building foundation. The hand auger borings were located in heavily cracked area of the pad identified during the inspection (Figure 2-1). Hand auger sampling was done to a maximum depth of five feet bgs. Samples were collected at 0.5, 2.5, and five feet bgs from each location. Samples were collected by driving a 2-inch by 12-inch California modified split spoon sampler, as described in Appendix C. Soil samples were analyzed for metals and pH as shown in Table 2-1. One sample also was analyzed for bulk density and grain size.

Task 4: Surveying

After the investigations were completed, Aztech Surveying, an Arizona-licensed land surveyor, surveyed the horizontal location of the samples. Horizontal coordinates for each location were surveyed relative to a permanent control point established on-site. Horizontal control is accurate to ±0.1 feet. Sample locations in Figure 2-1 are based on survey results. A table of surveyed sample locations is included in Appendix D.

2.3 SAMPLE ANALYSIS

Twenty-six soil samples were collected and analyzed during this investigation. Soil sample analyses conducted as part of this investigation included metals and pH by Quanterra Laboratories in California. Three soil samples also were analyzed for bulk density and particle-size distribution by Earth Tech Laboratories in California. Table 2-1 summarizes the samples collected and the types of analyses conducted on each sample.

SECTION 3
PHYSICAL CHARACTERISTICS

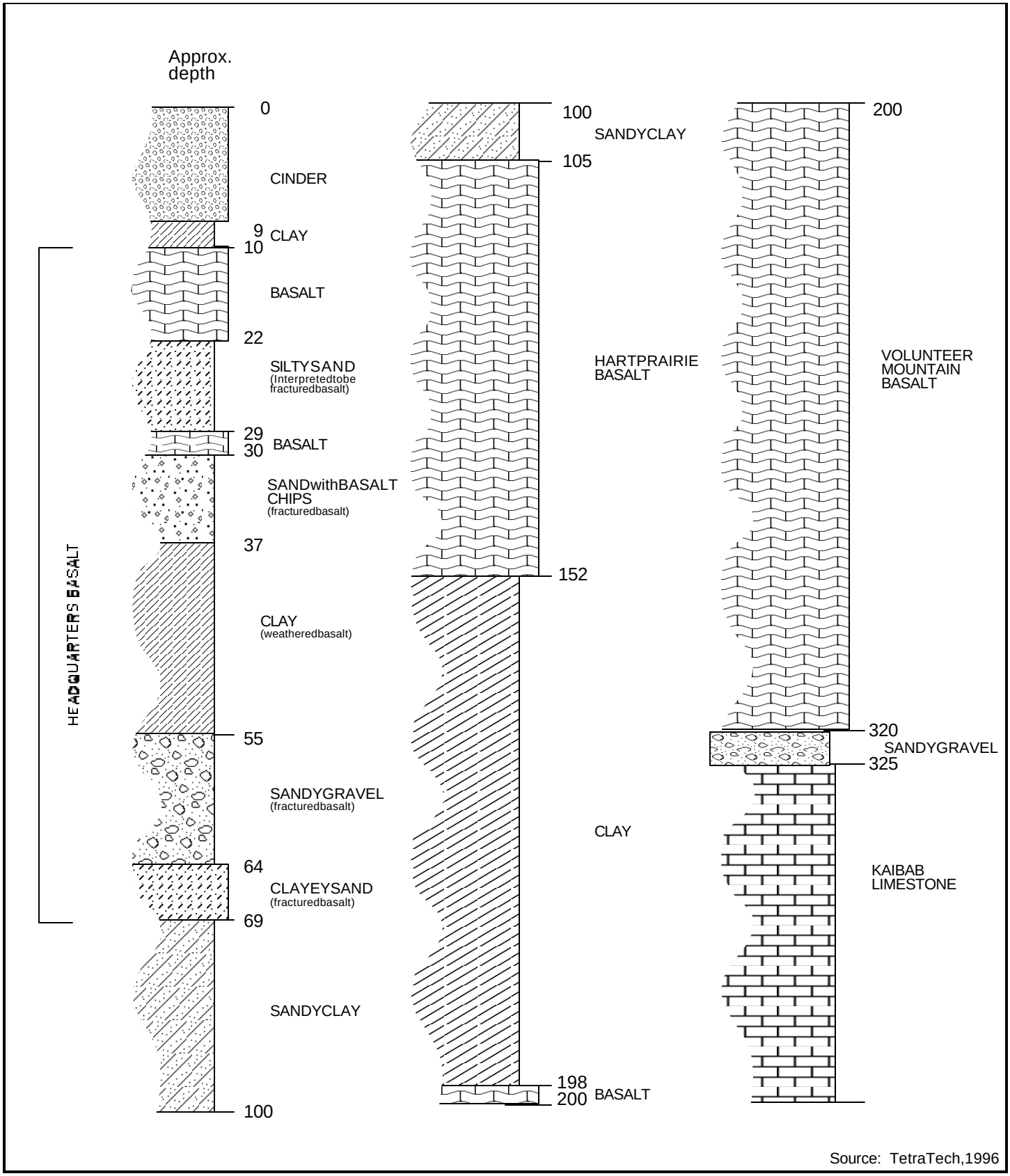
3.1 SURFACE FEATURES

Surface features at the site consist of a 141,000 square foot concrete pad remaining from the demolition of Building 233. The building is located in the central portion of the warehouse area (Figure 1-3). Unpaved ground surface surrounding the building is covered with gravel or grass.

The topography in the area of Building 233 is generally of low relief, and slopes to the south. There is a northeast-southwest trending escarpment approximately 3,100 feet east of the site (Bellemont Fault). This feature has a drop in ground surface elevation of about 80 feet. Ground surface generally consists of gravel with less than 50 percent of sand.

3.2 GEOLOGY

The following description of the geologic units deeper than 20 feet is compiled from surface geologic mapping, from soil borings in other portions of the Warehouse Area, and from geophysical surveys (Figures 3-1 and 3-2) (Tetra Tech 1999a). A monitoring well drilled in 1996 approximately 2,000 feet east of the site encountered a thin veneer (<10 feet) of clayey soil overlying a thickness of basalt. This basalt is interpreted to be the Headquarters Basalt which underlies the entire Warehouse Area as well as the adjacent Administration Area. The flow is estimated to be about 60 feet thick and overlies a thickness (<35 feet) of Camp Navajo Clay. The Camp Navajo Clay was deposited directly on top of a second basalt flow. This second basalt flow is interpreted to be the Hart Pairie basalt and is 45 feet thick. Below the second basalt is a second clay (45 feet thick) and a third basalt. The third basalt is interpreted to be the Volunteer Mountain basalt and is 120 feet thick. Below the third basalt is a thin zone of gravel and weathered Kaibab Formation (<20 feet) and the underlying Kaibab Formation.



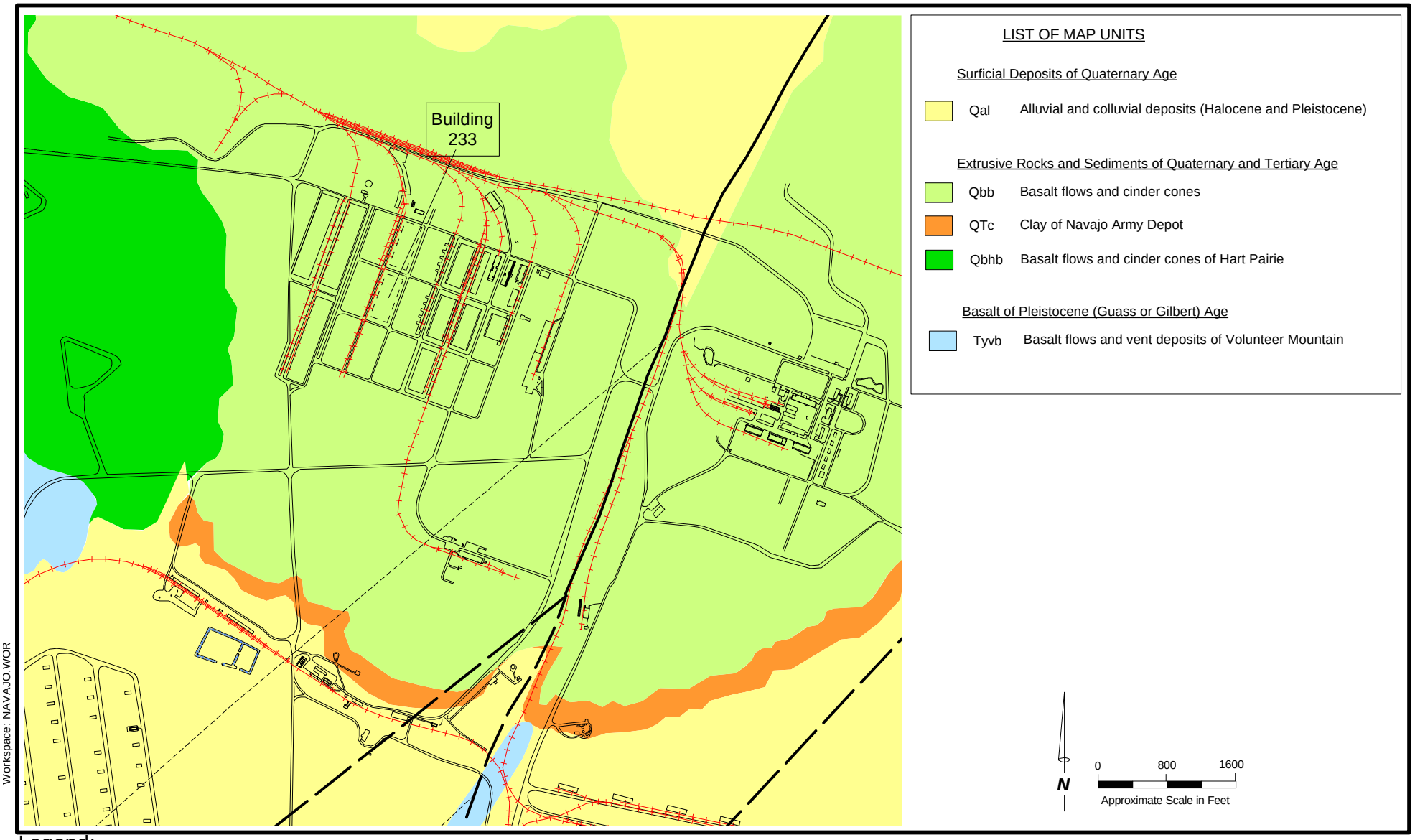
Source: TetraTech,1996

Building 233 Stratigraphy

CampNavajo
Bellemont, Arizona

Tetra Tech, Inc.

Figure 3-1



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Legend:

- Faults
- Lineaments/ Fracture Zones
- Railroad

Warehouse Area Geology

Camp Navajo, Bellemont, Arizona

Tetra Tech, Inc.

Figure 3-2

3.3 SOILS

The soils beneath the site have been classified by the Navajo Army Depot Soil Survey, Coconino County, Arizona, as Soil Unit 10 (USDA 1970). These are moderately deep gravelly clay soils with a loam surface and usually have zero to five percent slopes. The surface soil is generally a brown granular loam, having a pH of 7.0 and a thickness of three to five inches. The subsoil is generally a dark reddish gray gravelly clay with a blocky structure, having a pH of 7.8 and a thickness of 20 to 30 inches. This type of soil comprises approximately five percent of Navajo Army Depot soils, which accounts for approximately 1,400 acres of land on the base.

Physical testing of the soil samples collected during this investigation showed moisture ranging from 7.5 percent up to 29.6 percent. Dry densities of the soils range from 79.9 pounds per cubic foot (pcf) up to 88.3 pcf. Grain size distributions ranged from 22 percent gravel, 16 percent sand, 16 percent fines up to 41 percent gravel, 43 percent sand, and 54 percent fines. All physical analysis results are included in Appendix F.

3.4 HYDROGEOLOGY

Four water bearing zones have been identified within the upper 2,000 feet beneath the warehouse area. The uppermost zone, which feeds the springs from which the base receives its water supply, exists in fractures in the bottom of the uppermost basalt flow. The bottom of this zone is marked by a 30-foot thick clay aquitard at a depth of 70 feet bgs. A second water bearing zone exists in fractures at the base of the second basalt flow and is bounded on the bottom by a second clay aquitard at a depth of 150 feet bgs. A third water bearing zone exists in a 50 foot thick deposit of stream gravels and volcanic cinder that directly overlies the Kaibab Formation at a depth of 350 feet bgs. The fourth water bearing zone is the regional aquifer in the Coconino and Supai Formations at a depth of about 1,300 feet bgs.

Ground water recharge to the various water bearing zones occurs along fractures in the basalt flows and through fractures in the underlying Kaibab limestone. The presence and lateral continuity of the aquitards suggests that downward migration does not occur homogeneously throughout the area but is limited to areas of fracturing and faulting. In addition, the existence of the water bearing zones within fractures in the basalt suggests that contaminant migration would not be predictable using standard hydrogeologic techniques. Thus, remediation of contaminants in the ground water within the basalt zones would be problematic.

No drilling was done as part of the investigation of Building 233. Laterally discontinuous perched ground water conditions may exist throughout the alluvium. Drilling northeast, southeast, and east of the site also identified perched ground water within fractures in the basalt overlying the Camp Navajo Clay. Deeper ground water is likely to be present at an approximate depth of 1,300 feet bgs. This is based on the depth to the regional aquifer as measured in the deep water supply well 8,000 feet south of the site.

SECTION 4
NATURE AND EXTENT OF CONTAMINATION

The following section summarizes the nature and extent of contamination identified at Building 233. All soil gas results are located in Appendix F. All analytical results are tabulated by analysis method in Appendix G. Soil physical characteristics are in Appendix H. Appendix I includes copies of all laboratory reports for this site.

4.1 SURFACE SOILS

Concentrations of various metals occur naturally in soils. With the exception of selenium, no metals were identified at concentrations above background in any of the surface soil samples collected at this site (Table 4-1). Concentrations of selenium were detected above background (0.8 mg/kg) in four surface soil samples (up to 2.7 mg/kg) (Figure 4-1). All detected metals concentrations, except for arsenic and beryllium, were detected at concentrations less than the Arizona Department of Environmental Quality (ADEQ) nonresidential Health Based Guidance Levels (HBGLs). Arsenic and beryllium were found at concentrations higher than the ADEQ nonresidential HBGLs, but the concentrations are within background ranges previously defined for the installation (Tetra Tech 1997).

Background concentrations were established by statistical analysis of all samples collected at Camp Navajo. Outliers were identified during the analysis and were eliminated from the statistical test prior to determination of the background concentrations (Tetra Tech 1997).

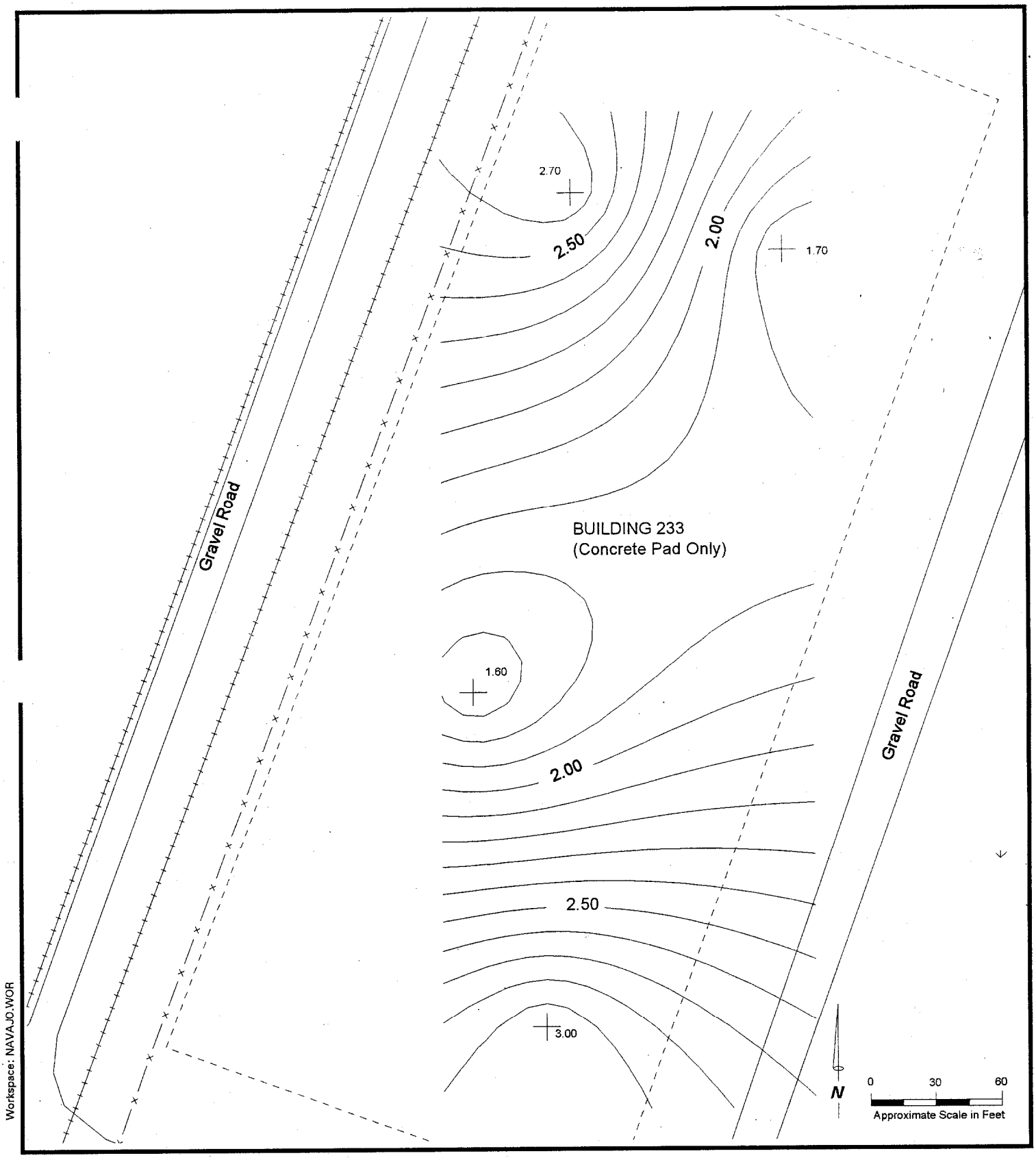
4.2 SUBSURFACE SOILS

Concentrations of various metals occur naturally in soils. With the exception of selenium, no metals were identified at concentrations above background in any of the subsurface soil samples collected at this site (Table 4-1). Concentrations of selenium were detected above background (0.8 mg/kg) in three subsurface soil samples (up to 2.5 mg/kg) (Figure 4-2). All detected metals concentrations, except for arsenic and beryllium, were detected at concentrations less than the ADEQ nonresidential

Table 4-1
Building 233 Metals
(Detections Only)

Sample ID	Sample Date	Depth	Arsenic, Total	Barium, Total	Beryllium, Total	Cadmium, Total	Chromium, Total	Lead, Total	Mercury, Total	Potassium, Total	Selenium, Total	Silver, Total
		CRQL	0.5	2	0.2	0.2	0.5	0.5	0.2	500	0.5	0.5
		Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
233-HA01S-01	5/2/96	0.5	8.3	882 J	1.6	0.22 J	35.6 J+	13.7	< 0.02	2240	1.7 J	0.74 J
233-HA01S-02	5/2/96	2.5	4.8 J	610	1.9	0.14 J	42.2 J+	14.3	< 0.02	1830	1.6	< 0.2
233-HA02S-01	5/2/96	0.5	10.1	691	1.5	0.44 J	45.8 J	18.8	0.027 J	2820	2.7	0.71 U
233-HA02S-02	5/2/96	2.5	5.4	350	2.1	< 0.1	16.4 J+	7	< 0.02	1510	< 0.6	0.3 U
233-HA02S-03	5/2/96	5	2.7	287	1.9	< 0.1	14.3 J+	4.7	< 0.02	1410	1.3	0.27 U
233-HA03S-01	5/2/96	0.5	8.9	478	1.6	< 0.15	36.3 J+	13.1	< 0.02	2250	1.6 U	< 0.3
233-HA03S-02	5/2/96	2.5	8.2	858	1.9	< 0.15	36.4 J+	11.3	< 0.02	1900	2.5	0.63 U
233-HA03S-03	5/2/96	4.5	5.8	444	2	< 0.15	32.8 J+	13.1	< 0.02	2180	< 0.9	< 0.3
233-HA04S-01	5/2/96	0.5	8.6	359	1.5	0.37 J	42.4 J	16.4	0.025 J	2770	3	< 0.3
233-HA04S-02	5/2/96	2.5	5.7	708	1.7	< 0.15	18.1 J+	7	< 0.02	944	< 0.9	< 0.3
233-HA05S-01	5/2/96	2.5	8.9 J	623	1.9	< 0.15	46.9 J+	16.8	< 0.02	2330	< 0.9	< 0.3
233-HA05S-02	5/2/96	2.5	6	371 J	1.4	< 0.1	37.2 J+	16.5	0.029 J	2270	< 0.6 UJ	0.33 J
Analyses			12	12	12	12	12	12	26	12	12	12
Detections			12	12	12	4	12	12	3	12	7	6
Maximum Concentration			10.1	882	2.1	0.44	46.9	18.8	0.029	2820	3	0.74
Arizona HBGL - Nonresidential			3.82	28700	1.34	244	5950	1400	123		2030	2030
Arizona HBGL - Nonresidential Hits			11	0	12	0	0	0	0		0	0
Maximum Background Concentration			44	1610	5	1.5	90	30	0.3	0	0.8	2.6
Background Hits			0	0	0	0	0	0	0	0	7	0

Notes:
CRQL Contract required quantitation limits
< Less than the indicated detection limit
Data Qualifiers are defined in Appendix E



Legend:

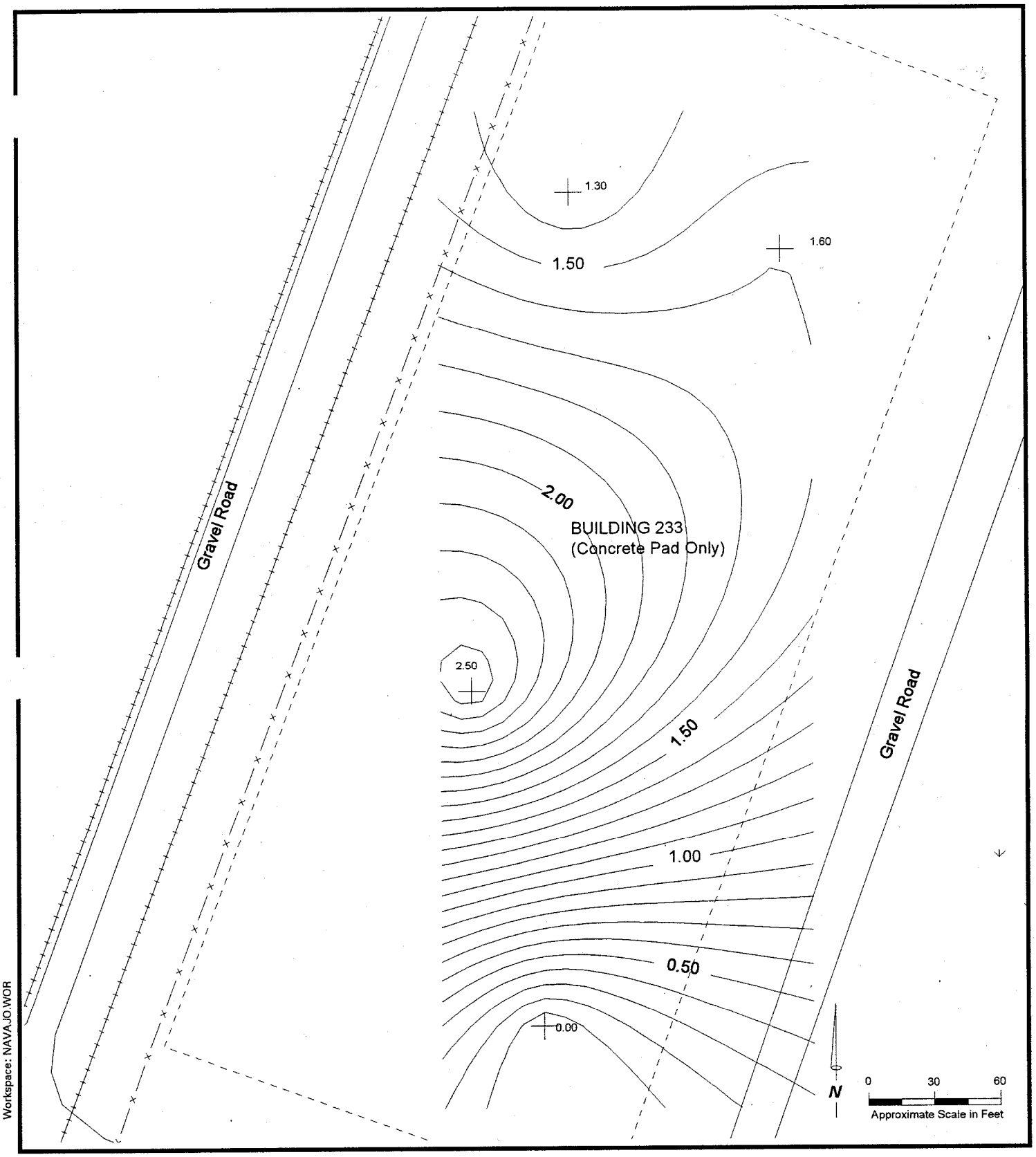
Fence
Grass
Railroad

Building 233 - Former Mercury Storage Selenium Concentrations in Surface Soils

Camp Navajo, Bellemont, Arizona

Tetra Tech, Inc.

Figure 4-1



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Legend:

Fence
Grass
Railroad

Building 233 - Former Mercury Storage
Selenium Concentrations in Subsurface Soils

Camp Navajo, Bellemont, Arizona

Tetra Tech, Inc.

Figure 4-2

HBGLs. Arsenic and beryllium were found at concentrations higher than the ADEQ nonresidential HBGLs, but the concentrations are within background ranges previously defined for the installation (Tetra Tech 1997).

Background concentrations were established by statistical analysis of all samples collected at Camp Navajo. Outliers were identified during the analysis and were eliminated from the statistical test prior to determination of the background concentrations (Tetra Tech 1997).

4.3 QA/QC

All samples were sent to Quanterra Incorporated (Quanterra) of Santa Ana, California for inorganic parameter analyses. Temperature blanks for all coolers forwarded to the laboratory were within an acceptable range and all coolers arrived with custody seals intact. Applicable holding times were met for all analyses. Four field duplicate samples, including two surface soil (SS) and two subsurface soil (HA) samples, were collected at the site during the investigation, as shown below. Validation of the data was conducted by Laboratory Data Consultants, Inc., (LDC) of Carlsbad, California.

- 233-SS13S-01 blind duplicate of 233-SS08S-01
- 233-SS14S-01 blind duplicate of 233-SS04S-01
- 233-HA05S-01 blind duplicate of 233- HA01S -02
- 233-HA05S-02 blind duplicate of 233-HA01S-01

Evaluation of field duplicate results for metals analyses indicated excellent qualitative and quantitative agreement between reported results. All relative percent differences (RPDs) were within QC acceptance criteria with the exception of field duplicates whose RPDs incorporated either nondetect or trace element concentrations into their precision calculations. In addition, these reported incidents of imprecision may be attributed to the high clay content and typical heterogeneity of soils in the Camp Navajo area. Although USEPA guidelines for inorganic data assessment do not require data qualification on the basis of field duplicate precision alone, associated results for the affected samples were flagged as quantitatively estimated. However, no significant adverse effects on overall data quality are expected.

Results of the validation performed by LDC indicated a potential for high biases in several chromium results as based on a single matrix spike (MS) recovery (138%) exceeding QC acceptance criteria (75-125%). Although the chromium concentration in the selected sample did not exceed the spike amount by greater than a factor of four, the high MS recovery was attributed by the laboratory to sample matrix effects. In addition, all associated laboratory control sample and duplicate control sample recoveries for chromium were within QC criteria. Consequently, all chromium results flagged as quantitatively estimated with a potential high bias are considered qualitatively valid and according to USEPA guidelines, considered useable for risk evaluation purposes.

Validation of these same data resulted in the qualification of element concentrations located above the method detection limit but below the respective sample quantitation limit. These reported values are considered to be qualitatively acceptable but quantitatively estimated due to uncertainties in analytical precision near the limit of detection. According to USEPA guidelines, however, these low concentration metals data are considered suitable for risk evaluation applications with appropriate recognition of the noted quantitative uncertainties.

Additional validation findings indicated trace metals contamination in select analytical method blanks. Although the concentrations observed in the method blanks were less than one-half of the respective sample quantitation limits, low-level metals results in associated field samples were qualified as non-detected and considered to be useable for risk evaluation purposes at the adjusted reporting limits. All other metals data for submitted samples were determined to be valid without qualification and considered useable for all purposes.

SECTION 5
RISK SCREENING

Current activities and activity patterns at the site are considered part-time commercial/industrial, as are the documented uses of land surrounding the site. Therefore, for purposes of this risk screening, land use of the site is assumed to be industrial. Previous operations at the site have indicated inorganic metal compounds to be the principal chemicals of concern (COCs) posing a potential exposure risk to workers involved in commercial/industrial activities onsite.

With the exception of arsenic and beryllium, laboratory results for this group of COCs show that maximum reported concentrations of all metals contained in soils onsite are below the respective HBGLs developed by the Arizona Department of Health Services (ADHS) for ADEQ using non-residential exposure assumptions. Potassium was eliminated from the risk screening based on its relative low toxicity and because its maximum reported concentration was less than the USEPA "ceiling limit" of 1x10+5 mg/kg reserved for "less toxic inorganic contaminants." Consequently, all metals except arsenic and beryllium have been excluded as COCs since they are not indicated to be present at concentrations high enough to pose a potential exposure or health threat during onsite commercial/industrial activities.

The maximum reported concentrations for arsenic (10.1 mg/kg) and beryllium (2.1 mg/kg) were observed to exceed the current HBGLs for nonresidential soils (3.82 mg/kg and 1.34 mg/kg, respectively) as well as the current USEPA Region IX Preliminary Remediation Goals (PRGs) for industrial soils (2.4 mg/kg and 1.1 mg/kg, respectively). However, from a quantitative risk screening perspective using USEPA "total risk" criteria, these reported concentrations are considered to reside within an acceptable range of both health-based standards under expected part-time occupational exposure conditions.

In addition, maximum reported concentrations of both elements were below naturally occurring background levels recorded for the geographical area encompassing the Camp Navajo base. Background concentration levels of 44 mg/kg for arsenic and

5.0 mg/kg for beryllium (Tetra Tech 1997) indicate that the reported analytical results are consistent with regional conditions. According to both USEPA and USACE guidelines, if inorganic chemicals are detected at the site at naturally occurring concentrations, they may be eliminated from the corresponding risk evaluation.

Consequently, results of the overall risk screening indicate that the maximum reported concentrations of identified contaminants in soils at the site would not be expected to result in adverse health effects relevant to part-time commercial/industrial land use. This determination incorporates the most current ADEQ, USEPA and USACE "acceptable" target risk criteria into its approach and is intended to be a "health-conservative" evaluation of potential risk and hazard.

SECTION 6
SUMMARY AND CONCLUSIONS

6.1 SUMMARY

No contamination has been identified above action levels around or beneath Building 233.

6.2 CONCLUSIONS

All data collected during this investigation meet acceptable QA/QC standards are considered to be representative of site conditions. Therefore, based on the lack of detected contamination at this site, no further action is warranted. Tetra Tech recommends this site for consideration for closure by the Arizona Department of Environmental Quality.

SECTION 7
REFERENCES

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APPENDIX A

PHOTO DOCUMENTATION

5-8 Panorama Warehouse Waste Pile (Shot 2 of 2), NW, 7/23/94, by Brad Hall

49-1 D. Wrzosek HA02 @ Bldg (pad) 233, 5/2/96, S., by Andrea Hatch

49-2 D. Wrzosek taking out sample #HA02s-01 @ Bldg 233, 5/2/96, S., by Andrea Hatch

APPENDIX B

FIELD NOTES

APPENDIX C

STANDARD OPERATING PROCEDURES

SECTION 1
SURFACE-SOIL SAMPLING

1.1 PURPOSE

The purpose of this standard operating procedure (SOP) is to describe the considerations and procedures for collecting representative surface samples. Analysis of surface samples can determine whether concentrations of specific surface pollutants exceed established action levels, and if the concentrations of soil pollutants present a risk to public health, welfare, or the environment.

Materials exposed on the land surface, including soils, sediments, and wastes, are subject to disturbance by weather conditions, vehicle traffic, bioturbation, and other effects. Because volatile contaminants are unlikely to be present in surficial materials, it generally is not necessary to obtain undisturbed samples from the surface. An exception to is when surface samples are collected from beneath an impermeable surface, such as a road or building slab. Surface soils are typically very heterogeneous in compositions and texture, and chemical concentrations in surface soils may vary dramatically over short depth intervals. Often, the first few inches of soil contain gravel, vegetation, or debris. It is desirable to use a sampling method that reduces the impacts of these heterogeneities without biasing the results.

For surface-soil sampling, some judgment may be needed to identify the ground surface datum. The objective is to sample the soil matrix and avoid collecting rock and plant material to the extent possible. Vegetation will be moved aside, dense vegetative matting, detritus or roots will be removed, and gravel will be scraped away to expose the ground surface. Surface samples from beneath pavement or concrete slabs will be collected after first removing road base and gravel to expose the underlying soil. In some locations, such as in the basements of buildings, the ground surface will be below grade. In these cases, depth below grade will be measured and recorded.

1.2 TECHNIQUE - DESCRIPTION

Soil samples may be collected using a variety of methods and equipment. The methods and equipment used are dependent on the type of sample required (disturbed versus undisturbed) and the type of soil. Samples that do not need to be undisturbed may be easily sampled using a spade, trowel, or scoop. Collecting undisturbed samples may be performed using a hand-auger, a trier, or a split-spoon sampler.

1.3 PROCEDURES

1.3.1 Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and which equipment and supplies are required.

2. Obtain necessary sampling and air monitoring equipment.

3. Decontaminate or preclean equipment, and ensure that it is in working order.

4. Prepare schedules, and coordinate with staff, client, and regulatory agencies as appropriate.

5. Perform a general site survey prior to site entry in accordance with the site-specific health and safety plan.

6. Use stakes, buoys, or flagging to identify and mark all sampling locations. Consider specific site factors, including extent and nature of contaminant, when selecting sample location. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions. All staked locations will be cleared for underground utilities by the property owner prior to soil sampling.

1.3.2 Interferences and Potential Problems

There are two primary interferences or potential problems associated with soil sampling. These are cross-contamination of samples and improper sample collection methods. Cross-contamination can be eliminated or minimized through the use of sampling equipment dedicated to each sample location. If this is not possible or practical, then decontamination of sampling equipment is necessary. Improper sample collection methods include using contaminated sampling equipment, disturbing of the matrix causing in compaction of the sample, or inadequate homogenizing of the samples where required, which results in variable, non-representative analytical results.

1.3.3 Sampling Considerations

This method can be used in most soil types. Surface soil samples may be collected with spades, shovels, or scoops. Surface material can be removed to the required

depth with this equipment, then a stainless steel or plastic scoop can be used to collect the sample.

Accurate, representative samples can be collected with this procedure depending on the care and precision taken. A flat, pointed mason trowel can be used to cut a block of the desired soil when undisturbed profiles are required. A stainless steel scoop, lab spoon, or plastic spoon will suffice in most other cases. Avoid the use of devices plated with chrome or other materials. Plating is particularly common with garden implements such as potting trowels.

Follow these procedures to collect surface-soil samples.

1. Carefully remove the top layer of soil or debris to the desired sample depth with a pre-cleaned spade.

2. Using a pre-cleaned, stainless-steel scoop, plastic spoon, or trowel, remove and discard a thin layer of soil from the area which came in contact with the spade.

3. If the sample is to be analyzed for volatile organics, volatile organic analysis is to be performed, transfer a portion of the sample directly into an appropriate, labeled sample container(s) with a stainless-steel lab spoon, plastic lab spoon, or equivalent and secure the cap(s) tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogeneous sample representative of the entire sampling interval. Then, place the sample into an appropriate, labeled container(s) and secure the cap(s) tightly.

1.3.4 Sample Containers and Preservation Techniques

In order to ensure proper sample preservation, samples should be refrigerated to 9°C or less and holding time should be kept to a minimum.

1.3.5 Field Quality Control Sampling Procedures

There are no specific quality-assurance activities which apply to the implementation of these procedures. However, the following general QA procedures apply:

- All data must be documented on field data sheets or within site logbooks.

- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior and after sampling/operation and they must be documented.

1.3.6 Decontamination Procedures

All sample equipment that comes into contact with soil or water must be decontaminated prior to sampling. Decontamination procedures for sampling equipment are described in the Decontamination of Field Equipment SOP.

SECTION 2
SHALLOW SUBSURFACE-SOIL SAMPLING

2.1 PURPOSE

The purpose of this standard operating procedure (SOP) is to describe the considerations and procedures for collecting representative shallow subsurface soil samples. Analysis of shallow subsurface samples can determine whether concentrations of specific subsurface pollutants exceed established action levels, and if the concentrations of soil pollutants present a risk to public health, welfare, or the environment.

Because volatile contaminants are likely to be present in subsurface materials, it generally is necessary to obtain undisturbed samples from the subsurface. Subsurface soils are typically very heterogeneous in compositions and texture, and chemical concentrations in subsurface soils may vary dramatically over short depth intervals.

2.2 TECHNIQUE - DESCRIPTION

Subsurface soil samples may be collected using a variety of methods and equipment. The methods and equipment used are dependent on the depth of the desired sample, the type of sample required (disturbed versus undisturbed), and the type of soil. Near-surface soils may be easily sampled using a spade, trowel, or scoop. Sampling at greater depths may be performed using a hand-auger, a trier, a split-spoon sampler, or, if required, a backhoe.

2.3 PROCEDURES

2.3.1 Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and which equipment and supplies are required.

2. Obtain necessary sampling and air monitoring equipment.

3. Decontaminate or preclean equipment, and ensure that it is in working order.

4. Prepare schedules, and coordinate with staff, client, and regulatory agencies as appropriate.

5. Perform a general site survey prior to site entry in accordance with the site-specific health and safety plan.

6. Use stakes, buoys, or flagging to identify and mark all sampling locations. Consider specific site factors, including extent and nature of contaminant, when selecting sample location. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions. All staked locations will be cleared for underground utilities by the property owner prior to soil sampling.

2.3.2 Interferences and Potential Problems

There are two primary interferences or potential problems associated with subsurface soil sampling. These are cross-contamination of samples and improper sample collection methods. Cross-contamination can be eliminated or minimized through the use of sampling equipment dedicated to each sample location. If this is not possible or practical, then decontamination of sampling equipment is necessary. Improper sample collection methods include using contaminated sampling equipment, disturbing of the matrix causing in compaction of the sample, or inadequate homogenizing of the samples where required, which results in variable, non-representative analytical results.

2.3.3 Sampling Considerations

Sampling at Depth with Augers and Thin-Wall Tube Samplers

This system consists of an auger, a series of handle extensions to allow sampling at depth, a “T” handle, and a thin-wall tube sampler. The auger is used to bore a hole to a desired sampling depth, and is then withdrawn. The sample may be collected directly from the auger. If a core sample is to be collected, the auger tip is then replaced with a thin-wall tube sampler. The sampler is then lowered down the borehole and driven into the soil at the completion depth. The sampler is then withdrawn and the core removed.

Several types of augers are available. These include: bucket, continuous flight (screw), and posthole augers. Bucket augers are better for direct sample recovery since they can remove a large volume of sample in a short time. When continuous flight augers are used, the sample can be collected directly from the auger flights. Sampling from continuous flight augers is satisfactory when a composite of the complete soil column is desired. Posthole augers have limited utility for sample collection.

Follow these procedures for collecting subsurface soil samples with the auger and a thin-wall tube sampler.

1. Attach the auger bit to a drill rod extension, and attach the "T" handle to the drill.

2. Clear the area to be sampled of any surface debris (e.g. twigs, rocks, liter). It may be advisable to remove the first 3 to 6 inches of surface soil for an area approximately 6 inches in radius around the drilling location.

3. Begin augering, periodically removing and depositing accumulated soils onto a plastic sheet spread near the hole. This helps prevent accidental brushing of loose material back down the borehole when removing the auger or adding extensions. It also facilitates refilling the hole, and avoids possible contamination of the surrounding area.

4. After reaching the desired depth, slowly and carefully remove the auger from boring. When sampling directly from the auger, collect sample after the auger is removed from boring and proceed to step 10.

5. Remove auger tip from drill rods and replace with a pre-cleaned thin-wall tube sampler. Install proper cutting tip.

6. Carefully lower the tube sampler down the borehole. Gradually force the tube sampler into the soil. Care should be taken to avoid scraping the borehole sides. Avoid hammering the drill rods to facilitate coring as the vibrations may cause the boring walls to collapse.

7. Remove the tube sampler, and unscrew the drill rods.

8. Remove the cutting tip and the core from the device.

9. Discard the top of the core (approximately 1 inch), as this represents material collected before penetration of the layer of concern. Place the remaining core into the appropriate labeled sample container(s). Sample homogenization is not required.

10. If volatile organic analysis is to be performed, transfer portion of the sample directly into an appropriate, labeled container(s) with a stainless steel lab spoon, plastic lab spoon, or equivalent and secure the cap(s) tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogeneous sample representative of the entire sampling interval. Then, place the sample into an appropriate, labeled container(s) and secure the cap(s) tightly.

11. If another sample is to be collected in the same hole, but at a greater depth, reattach the auger bit to the drill and assembly, and follow steps 3 through 11, making sure to decontaminate the auger and tube sampler between samples.

12. Abandon the hole according to applicable state regulations. Generally, shallow holes can simply be backfilled with the removed soil material.

Sampling at Depth with a Trier

The system consists of a trier, and a "T" handle. The auger is driven into the soil to be sampled and used to extract a core sample from the appropriate depth.

Follow these procedures to collect subsurface soil samples with a sampling trier.

1. Insert the trier into the material to be sampled at a 0° to 45° angle from horizontal. This orientation minimizes the spillage of sample.

2. Rotate the trier once or twice to cut a core of material.

3. Slowly withdraw the trier, making sure that the slot is facing upward.

4. If volatile organic analysis is to be performed, transfer portion of the sample directly into an appropriate, labeled container(s) with a stainless steel lab spoon, plastic lab spoon, or equivalent and secure the cap(s) tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogeneous sample representative of the entire sampling interval. Then, place the sample into an appropriate, labeled container(s) and secure the cap(s) tightly.

Sampling at Depth with a Split-Spoon Sampler

The procedure for split-spoon sampling describes the collection and extraction of undisturbed soil cores of 18 or 24 inches in length. A series of consecutive cores may be extracted with a split spoon sampler to give a complete soil column profile, or an auger may be used to drill down to the desired depth for sampling. The split spoon is then driven to its sampling depth through the bottom of the augered hole and the core extracted.

When split-tube sampling is performed to gain geologic information, all work should be performed in accordance with ASTM D 1586-84.

Follow these procedures for collecting subsurface soil samples with a split spoon.

1. Assemble the sampler by aligning both sides of the barrel and then screwing the bit onto the bottom and the heavier head piece onto the top.

2. Place the sampler in a perpendicular position on the sample material.

3. Using a sledge hammer or well ring, if available, drive the tube. Do not drive past the bottom of the head piece or compression of the sample will result.

4. Record in the site logbook or on field data sheets the length of the tube used to penetrate the material being sampled, and the number of blows required to obtain this depth.

5. Withdraw the sampler, and open by unscrewing the bit and head and splitting the barrel. If a split sample is desired, a cleaned, stainless steel knife should be used to divide the tube contents in half longitudinally. The split-spoon sampler typically is available in diameters of 2 and 3 1/2 inches. A larger barrel may be required to obtain the required sample volume.

6. Without disturbing the core, transfer it to an appropriate labeled sample container(s) and seal tightly.

2.3.4 Sample Containers and Preservation Techniques

In order to ensure proper sample preservation, samples should be refrigerated to 9°C or less and holding time should be kept to a minimum.

2.3.5 Field Quality Control Sampling Procedures

There are no specific quality-assurance activities which apply to the implementation of these procedures. However, the following general QA procedures apply:

- All data must be documented on field data sheets or within site logbooks.

- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior and after sampling/operation and they must be documented.

2.3.6 Decontamination Procedures

All sample equipment that comes into contact with soil or water must be decontaminated prior to sampling. Decontamination procedures for sampling equipment are described in the Decontamination of Field Equipment SOP.

APPENDIX D

SURVEYOR RESULTS

Survey

SiteID	PTID	Northing	Easting	Elevation
233	CS01	28027.81	18313.29	
233	CS02	27986.11	18426.73	
233	CS03	28138.64	18358.16	
233	CS04	28099.87	18467.22	
233	CS05	28253.86	18395.36	
233	CS06	28213.62	18510.27	
233	CS07	28366.16	18438.77	
233	CS08	28324.09	18552.22	
233	SS01	28357.47	18621.67	
233	SS02	28243.43	18580.84	
233	SS03	28150.12	18546.38	
233	SS04	28036.08	18505.54	
233	SS05	27935.56	18425.96	
233	SS06	27988.99	18281.85	
233	SS07	28114.97	18280.62	
233	SS08	28231.4	18324.08	
233	SS09	28324.49	18355.7	
233	SS10	28439.37	18396.6	
233	SS11	28508.69	18470.29	
233	SS12	28457.69	18612.51	
233	HA01	28367.25	18537.99	
233	HA02	28393.22	18442.42	
233	HA03	28167.17	18397.55	
233	HA04	28015.74	18430.02	

APPENDIX E

ANALYTICAL RESULTS TABLE

Description of Qualifiers

J	Data are considered quantitatively estimated.
J+	Data are considered quantitatively estimated with a possible high bias.
J-	Data are considered quantitatively estimated with a possible low bias.
N	Data are considered quantitatively presumptive due to tentative analyte identification.
NJ	Data are considered quantitatively presumptive due to tentative analyte identification; the associated value is considered quantitatively estimated.
R	Data are rejected and considered unusable for all purposes.
U	Analyte is considered not present above the level of the associated value.
UJ	Analyte is considered not present above the level of the associated value; the associated value is considered quantitatively estimated.
UJ-	Analyte is considered not present above the level of the associated value; the associated value is considered quantitatively estimated with a possible low bias.

Building 233
Remediation Parameters

Sample ID	Sample Date	Depth	Percent Water	pH
		CRQL	0	0
		Units	PERCENT	PH UNITS
233-SS01S-01	10/22/95	1	3.6	8.2
233-SS02S-01	10/22/95	1	7.4	8.6
233-SS03S-01	10/22/95	1	2.8	8.1
233-SS04S-01	10/22/95	1	10	7.8
233-SS05S-01	10/22/95	1	5	7.8
233-SS06S-01	10/22/95	1	6.1	7.5
233-SS07S-01	10/22/95	1	5.6	7.9
233-SS08S-01	10/22/95	1	6.6	7.9
233-SS09S-01	10/22/95	1	8.6	7.4
233-SS10S-01	10/22/95	1	5.6	7.1
233-SS11S-01	10/22/95	1	7.4	8.2
233-SS12S-01	10/22/95	1	6.7	7.8
233-SS13S-01	10/22/95	1	6.4	7.9
233-SS14S-01	10/22/95	1	9.9	7.8
233-HA01S-01	5/2/96	0.5	26	7.5
233-HA01S-02	5/2/96	2.5	28	7.4
233-HA02S-01	5/2/96	0.5	22	7.6
233-HA02S-02	5/2/96	2.5	22	7.7
233-HA02S-03	5/2/96	5	24	7.8
233-HA03S-01	5/2/96	0.5	20	7.4
233-HA03S-02	5/2/96	2.5	26	7.2
233-HA03S-03	5/2/96	4.5	24	7.3
233-HA04S-01	5/2/96	0.5	20	7.8
233-HA04S-02	5/2/96	2.5	20	7.5
233-HA05S-01	5/2/96	2.5	22	7.3
233-HA05S-02	5/2/96	2.5	19	7

Analyses	26	26
Detections	26	26
Maximum Concentration	28	8.6

Building 233
Metals

Sample ID	Sample Date	Depth	Arsenic, Total	Barium, Total	Beryllium, Total	Cadmium, Total	Chromium, Total	Lead, Total	Mercury, Total	Potassium, Total	Selenium, Total	Silver, Total
		CRQL	0.5	2	0.2	0.2	0.5	0.5	0.2	500	0.5	0.5
		Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
233-SS01S-01	10/22/95	1	NA	NA	NA	NA	NA	NA	<0.033	NA	NA	NA
233-SS02S-01	10/22/95	1	NA	NA	NA	NA	NA	NA	<0.033	NA	NA	NA
233-SS03S-01	10/22/95	1	NA	NA	NA	NA	NA	NA	<0.033	NA	NA	NA
233-SS04S-01	10/22/95	1	NA	NA	NA	NA	NA	NA	<0.033	NA	NA	NA
233-SS05S-01	10/22/95	1	NA	NA	NA	NA	NA	NA	<0.033	NA	NA	NA
233-SS06S-01	10/22/95	1	NA	NA	NA	NA	NA	NA	<0.033	NA	NA	NA
233-SS07S-01	10/22/95	1	NA	NA	NA	NA	NA	NA	<0.033	NA	NA	NA
233-SS08S-01	10/22/95	1	NA	NA	NA	NA	NA	NA	<0.033	NA	NA	NA
233-SS09S-01	10/22/95	1	NA	NA	NA	NA	NA	NA	<0.033	NA	NA	NA
233-SS10S-01	10/22/95	1	NA	NA	NA	NA	NA	NA	<0.033	NA	NA	NA
233-SS11S-01	10/22/95	1	NA	NA	NA	NA	NA	NA	<0.033	NA	NA	NA
233-SS12S-01	10/22/95	1	NA	NA	NA	NA	NA	NA	<0.033	NA	NA	NA
233-SS13S-01	10/22/95	1	NA	NA	NA	NA	NA	NA	<0.033	NA	NA	NA
233-SS14S-01	10/22/95	1	NA	NA	NA	NA	NA	NA	<0.033	NA	NA	NA
233-HA01S-01	5/2/96	0.5	8.3	882 J	1.6	0.22 J	35.6 J+	13.7	<0.02	2240	1.7 J	0.74 J
233-HA01S-02	5/2/96	2.5	4.8 J	610	1.9	0.14 J	42.2 J+	14.3	<0.02	1830	1.6	<0.2
233-HA02S-01	5/2/96	0.5	10.1	691	1.5	0.44 J	45.8 J	18.8	0.027 J	2820	2.7	0.71 U
233-HA02S-02	5/2/96	2.5	5.4	350	2.1	<0.1	16.4 J+	7	<0.02	1510	<0.6	0.3 U
233-HA02S-03	5/2/96	5	2.7	287	1.9	<0.1	14.3 J+	4.7	<0.02	1410	1.3	0.27 U
233-HA03S-01	5/2/96	0.5	8.9	478	1.6	<0.15	36.3 J+	13.1	<0.02	2250	1.6 U	<0.3
233-HA03S-02	5/2/96	2.5	8.2	858	1.9	<0.15	36.4 J+	11.3	<0.02	1900	2.5	0.63 U
233-HA03S-03	5/2/96	4.5	5.8	444	2	<0.15	32.8 J+	13.1	<0.02	2180	<0.9	<0.3
233-HA04S-01	5/2/96	0.5	8.6	359	1.5	0.37 J	42.4 J	16.4	0.025 J	2770	3	<0.3
233-HA04S-02	5/2/96	2.5	5.7	708	1.7	<0.15	18.1 J+	7	<0.02	944	<0.9	<0.3
233-HA05S-01	5/2/96	2.5	8.9 J	623	1.9	<0.15	46.9 J+	16.8	<0.02	2330	<0.9	<0.3
233-HA05S-02	5/2/96	2.5	6	371 J	1.4	<0.1	37.2 J+	16.5	0.029 J	2270	<0.6 UJ	0.33 J

Building 233
Metals

Sample ID	Sample Date	Depth	Arsenic, Total	Barium, Total	Beryllium, Total	Cadmium, Total	Chromium, Total	Lead, Total	Mercury, Total	Potassium, Total	Selenium, Total	Silver, Total
		CRQL	0.5	2	0.2	0.2	0.5	0.5	0.2	500	0.5	0.5
		Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Analyses			12	12	12	12	12	12	26	12	12	12
Detections			12	12	12	4	12	12	3	12	7	6
Maximum Concentration			10.1	882	2.1	0.44	46.9	18.8	0.029	2820	3	0.74
Arizona HBGL - Nonresidential			3.82	28700	1.34	244	5950	1400	123		2030	2030
Arizona HBGL - Nonresidential Hits			11	0	12	0	0	0	0		0	0
Maximum Background Concentration			44	1610	5	1.5	90	30	0.3	0	0.8	2.6
Background Hits			0	0	0	0	0	0	0	0	7	0

APPENDIX F

SOIL PHYSICAL CHARACTERISTICS

APPENDIX G

QUANTERRA CERTIFICATES OF ANALYSIS

Note: Certificates of Analysis are not included in the Final Reports. Certificates of Analysis will be provided in select copies of the Final Report. For access to a complete copy of the Certificates of Analysis, please contact the Camp Navajo Environmental Office at (520) 773-3208.

APPENDIX H

SCOPE OF WORK