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NAS FORT WORTH  
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FINAL BASEWIDE BACKGROUND STUDY VOLUME 1 NAS FORT WORTH TX  
1/1/1998  
JACOBS ENGINEERING



**NAVAL AIR STATION  
FORT WORTH JRB  
CARSWELL FIELD  
TEXAS**

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**ADMINISTRATIVE RECORD  
COVER SHEET**

AR File Number 409

409 1

File: 17A-76  
A.F.

409



# United States Air Force Air Force Base Conversion Agency

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FINAL

NAS Fort Worth JRB, Texas  
(Formerly Carswell AFB, Texas)

BASEWIDE BACKGROUND STUDY  
VOLUME I

JANUARY 1998

By:



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IRP-J03-05G47900-M17-0004

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## ACRONYMS AND ABBREVIATIONS

AFB	Air Force Base
ASTM	American Society for Testing and Materials
BFB	bromofluorobenzene
CBZ	chlorobenzene-d5
DFB	1,4-difluorobenzene
DFTPP	decafluorotriphenylphosphine
DOI	U.S. Department of the Interior
DQO	data quality objective
EPA	U.S. Environmental Protection Agency
FWS	U.S. Fish and Wildlife Service
GC	gas chromatograph
GFAA	gas furnace atomic absorption
I-30	Interstate Highway 30
ICP	inductively coupled plasma
ICS	interference check standards
Jacobs	Jacobs Engineering Group Inc.
JRB	Joint Reserve Base
LCS	laboratory control samples/spikes
LCSD	LCS duplicates
MDL	method detection limit
MS	matrix spikes
MSD	matrix spike duplicates
NAS	Naval Air Station
NRHP	National Register of Historic Places
PA	Preliminary Assessment
ppb	parts per billion
PQL	practical quantitation limit
PVC	polyvinyl chloride
QC	quality control
RI	Remedial Investigation

**ACRONYMS AND ABBREVIATIONS**

RPD	relative percent difference
RRF	relative response factors
SDG	sample delivery group
SI	Site Investigation
SOP	standard operating procedures
SVOC	semivolatile organic compound
TDPW	Texas Department of Parks and Wildlife
TNRCC	Texas Natural Resource Conservation Commission
TI	tolerance interval
UTL	upper tolerance limit
VOC	volatile organic compound
>	greater than
±	plus or minus

**EXECUTIVE SUMMARY**

A basewide background study was conducted at the Naval Air Station Fort Worth Joint Reserve Base, Carswell Field, Texas (referred to as NAS Fort Worth) to establish background concentrations of inorganic constituents in various site media. Background concentrations were determined for 24 inorganic constituents in each of the following background populations:

- surface soil;
- subsurface soil;
- groundwater sampled via a low-volume sampling technique (to approximate filtered samples);
- groundwater sampled with a bailer (unfiltered samples);
- surface water; and
- sediment in the surface water drainages.

A total of 30 surface soil, 30 subsurface soil, 12 groundwater samples (one low-volume sample and one bailer sample per well), 8 surface water, and 8 stream sediment samples were collected to characterize these media for background concentrations.

The Tolerance Interval (TI) method (U.S. Environmental Protection Agency [EPA] 1989, 1992) was used to estimate upper tolerance limits (UTLs) of the distribution of each constituent in the background data population. Table ES-1 presents the results of the NAS Fort Worth Background Study. The  $UTL_{95,95}$  listed in the table is the value that we can say, with 95 percent confidence, will exceed 95 percent of the background data. Any site value greater than the UTL has only a 5 percent probability of being drawn from the background data population, and thus may indicate the presence of site-related contamination.

**TABLE ES-1**  
**Summary of Background UTLs by Matrix**  
**Naval Air Station Fort Worth**

Analyte	Surface Soil (mg/kg)	Subsurface Soil (mg/kg)	Low-Stress Procedure Groundwater (mg/L)	Bailer Sampled Groundwater (mg/L)	Surface Water (mg/L)	Stream Sediment (mg/kg)
Aluminum	22035	20260	1.332	11.07	0.272	28767
Antimony	0.56	0.712	ND at 0.002	0.0024	0.003	0.33
Arsenic	5.85	6.58	ND at 0.0049	0.0067	ND at 0.0049	7.02
Barium	233	128.1	0.587	1.133	0.151	180.4
Beryllium	1.02	1.13	0.0003	0.0019	ND at 0.0003	1.189
Calcium	167788	272000	266.3	2438	133.7	337544
Cadmium	0.556	0.59	ND at 0.0005	0.0016	ND at 0.0005	0.507
Chromium	25.86	16.31	0.006	0.0136	0.0078	17.0
Cobalt	11.05	6.19	ND at 0.0089	0.01	ND at 0.0089	6.65
Copper	17.37	13.72	0.0028	0.0101	0.010	22.18
Iron	17717	17469	0.224	7.23	0.921	10696
Lead	30.97	12.66	ND at 0.0016	ND at 0.0016	ND at 0.0016	104.1
Magnesium	3003	2420	37.80	68.78	9.35	2772
Manganese	849	351.7	0.175	10.571	0.4193	491
Mercury	0.14	ND at 0.035	ND at 0.0001	ND at 0.0001	0.0001	0.036
Molybdenum	1.460	1.93	ND at 0.0144	ND at 0.0144	ND at 0.0144	9.69
Nickel	14.6	19.76	0.0204	0.036	0.0178	19.8
Potassium	2895	1717	15.03	3.9	6.35	3227
Selenium	0.907	0.313	0.0077	0.0072	0.0025	0.214
Silver	0.213	0.128	0.0002	0.0003	0.0003	0.144
Sodium	37300	53200	167	176.2	45.5	6.07
Thallium	2.43	1.5	ND at 0.0632	ND at 0.0632	ND at 0.0632	ND at 1.32
Vanadium	46.3	37.4	0.012	0.0653	0.0159	32.3
Zinc	38.8	31.3	0.118	0.0682	0.0122	101.3

**Notes:**

mg/kg = milligrams per kilogram

mg/L = milligrams per liter

ND = not detected

UTL = upper tolerance limit

# TAB

Section 1

## 1.0 INTRODUCTION

This report describes field activities, summarizes analytical results, and presents background concentrations calculated for the basewide background study at the Naval Air Station (NAS) Fort Worth Joint Reserve Base (JRB), Carswell Field, Texas (referred to as NAS Fort Worth). Jacobs Engineering Group Inc. (Jacobs) completed this work under Contract F41624-94-D-8046, Delivery Order 0021, issued by the Air Force Center for Environmental Excellence. The project consisted of sampling soil, groundwater, surface water, and sediment, and calculating background concentrations for select metals in each of these media.

This report is organized into five sections. Section 1.0 introduces the basewide background study, the history of NAS Fort Worth, the physical setting of the station, project objectives, the general approach, and the rationale for the selection of sampling locations and the analytical suites. Section 2.0 describes the field sampling activities. Section 3.0 provides an overview of data quality. Section 4.0 presents the data analysis and statistical calculations of background concentrations for each of the media sampled. Section 5.0 is the list of references used to prepare this report. In addition to the five sections, this report includes the following seven appendices:

- Appendix A - Preliminary Analytical Results
- Appendix B - Chain of Custody Records
- Appendix C - Soil Probe Boring Logs
- Appendix D - Monitoring Well Boring Logs, Construction Details, Groundwater Sampling Data Sheets, and Development Records
- Appendix E - Surface Water Data Sheets
- Appendix F - Statistical Calculations Support Tables
- Appendix G - Photographs

## 1.1 LOCATION AND HISTORY OF NAS FORT WORTH

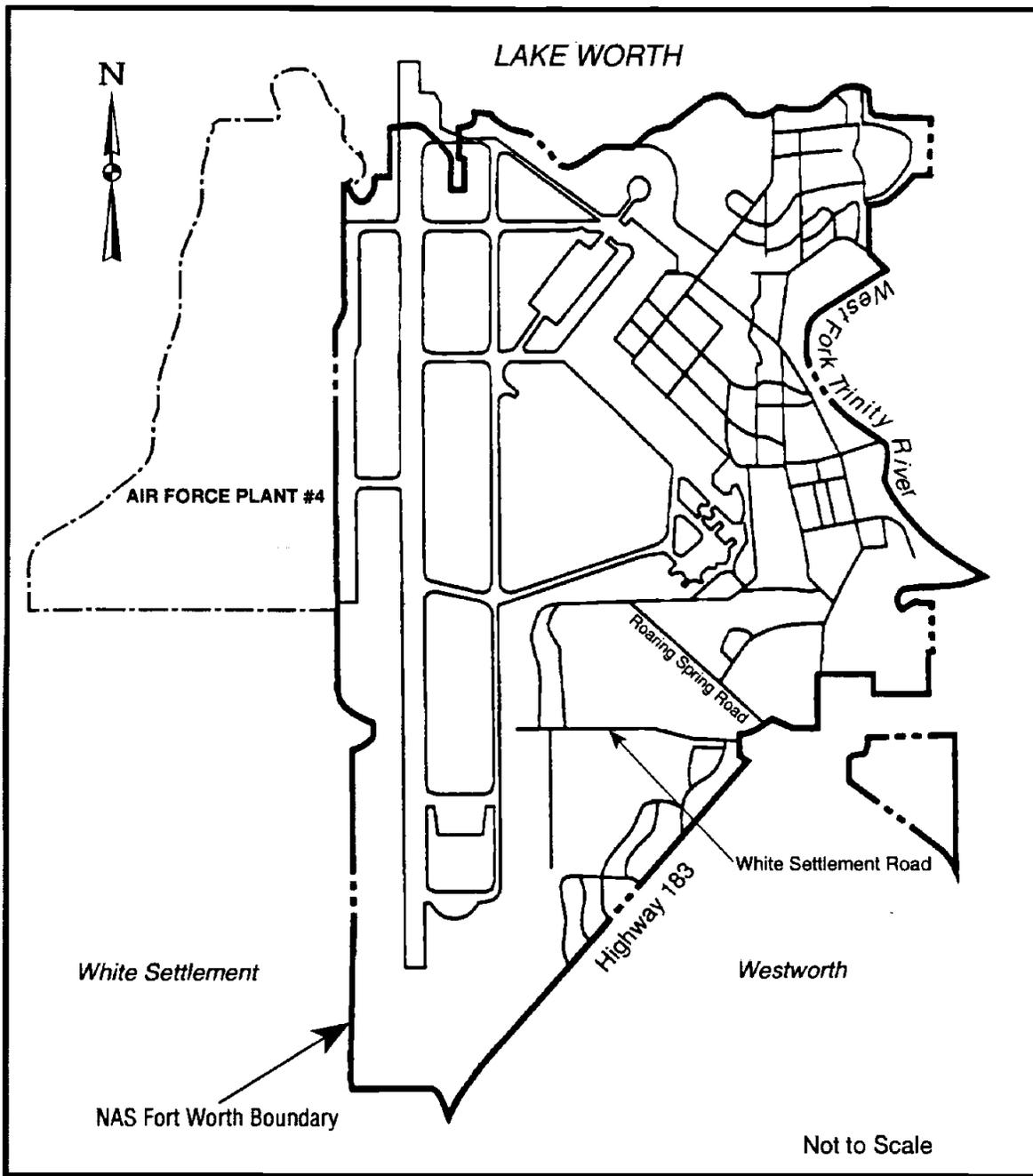
NAS Fort Worth is located in north-central Texas, 8 miles west of downtown Fort Worth (Figure 1-1). The area surrounding the station is mostly suburban, including the residential areas of the cities of Fort Worth, Westworth Village, and White Settlement. The main station totals 2,264 acres and is bordered on the north by Lake Worth, on the east by the West Fork Trinity River and Westworth Village, on the northeast and southeast by Fort Worth, on the west and southwest by White Settlement, and on the west by Air Force Plant 4 (Lockheed).

NAS Fort Worth was originally a modest dirt runway built to service the aircraft manufacturing plant now called Air Force Plant 4. The installation was established in 1942 and was referred to as the Tarrant Field Airdrome. Its mission was to provide training for B-24 bomber pilots. The Strategic Air Command assumed control of the installation in 1946. In 1948, the base was renamed Carswell Air Force Base (AFB) in honor of Fort Worth native, Major Horace S. Carswell. Carswell AFB became host base for its first B-52s and KC-135s in 1956.

Pursuant to the Base Closure and Realignment Act of 1990, Carswell AFB was selected for closure and associated property disposal during Round II Base Closure Commission deliberations. This announcement initiated the closure and disposal and reuse planning process. Drawdown activities were initiated in 1992, and all aircraft were relocated by January 1993. The base officially closed on 30 September 1993. On 1 October 1994, the U.S. Navy assumed control of Carswell AFB; the base was renamed NAS Fort Worth. The base is under the regulatory oversight of the Texas Natural Resource Commission Conservation (TNRCC) through permit HW-50289 issued in 1991.

## 1.2 INSTALLATION ENVIRONMENTAL SETTING

NAS Fort Worth is located in the Grand Prairie Section of the Central Lowlands Physiographic Province. The area is characterized by broad, gently to moderately



Naval Air Station Fort Worth JRB  
Fort Worth, Texas

LOCATION OF NAS FORT WORTH

PROJ. MGR. L. SCHUETTER	FIGURE NO. 1-1
DRAWN BY G. HAND	PROJ. NO. 05-G-47900
	DATE 01/17/97

sloping terraces of sedimentary rock mantled by a variable thickness of light brown to black loamy soil. The Grand Prairie Section is typically grass-covered with isolated stands of upland timber.

Topography at NAS Fort Worth is generally flat except in areas along Farmers Branch, West Fork of the Trinity River, and Lake Worth. Elevations at NAS Fort Worth range from approximately 590 feet above mean sea level along the shore of Lake Worth to approximately 660 feet above mean sea level in the southwest corner of the site.

In the immediate vicinity of the station are industrial, commercial, residential, and recreational areas. West of the station are industrial complexes at Air Force Plant 4 and in White Settlement and some residential and supporting commercial areas. South of the station are commercial areas at the interchange of Interstate Highway I-30 (I-30) and State Highway 183. This area includes a regional shopping mall, a discount shopping center, and a small convenience center. Both single-family and multifamily residential developments dominate the area southeast of the station and north of I-30 and the area east of the station. The area north of the station is predominantly composed of recreational and public facilities. The south shore of Lake Worth is restricted to public access because of the presence of NAS Fort Worth and Air Force Plant 4, but the lake is open for recreation. A fish hatchery, a YMCA camp, and private recreational land are along the West Fork of the Trinity River northeast of the station.

### **1.2.1 Demography**

NAS Fort Worth is located in north-central Tarrant County. Based on the 1990 census, the population of Tarrant County (which encompasses most of the Fort Worth metropolitan area) is approximately 1.17 million; approximately 447,600 live in the City of Fort Worth. Numerous smaller communities represent the balance of the population. The communities of White Settlement, Lake Worth Village, Westworth Village, River Oaks, and Sansom Park Village all lie within a 3-mile radius of NAS

Fort Worth. Most of the land surrounding NAS Fort Worth is zoned for residential use, but also includes areas zoned for recreational, commercial, and industrial uses.

## 1.2.2 Geology

The following sections discuss the regional geology for NAS Fort Worth.

### 1.2.2.1 Regional Geology

The geology of west-central Tarrant County consists of Early Cretaceous marine sedimentary rocks underlain by undifferentiated Paleozoic rocks. Unconsolidated thin alluvial deposits of the Quaternary period overlie bedrock along major stream and river valleys.

Sediments were deposited in the area during most of the Paleozoic era. Late in the Paleozoic era the area was uplifted, and extensive erosion during the Jurassic period produced a surface upon which early Cretaceous marine sediments were deposited as part of an oscillating shoreline. These marine sediments now exist as a southeast-thickening wedge extending into the East Texas basin. From the late Cretaceous period through the Tertiary period, the sea withdrew toward the Gulf of Mexico, and the land surface was eroded and shaped by streams. During the Quaternary period, the streams deposited alluvial sediments. The older sediments are represented by terrace deposits cut by the alluvial valleys of present streams.

Major structural features in the vicinity of Tarrant County include the Mexia-Talco fault system about 80 miles to the east, the leading edge of the Ouachita overthrust about 30 miles to the east, and the south end of the axis of the Fort Worth basin, located just to the east of the site.

The generalized regional stratigraphic units in the vicinity of Tarrant County are presented in Table 1-1. The units are briefly described in the following paragraphs.

**TABLE 1-1**  
**Stratigraphic Units of Interest in the**  
**Vicinity of NAS Fort Worth**

Era	System	Series	Group	Stratigraphic Units
Cenozoic	Quaternary	Holocene		Fill Material Alluvium
		Pleistocene		Fluvial Terrace Deposits
Mesozoic	Cretaceous	Comanche	Washita	Duck Creek Limestone Kiamichi Formation
			Fredericksburg	Goodland Limestone Walnut Formation
			Trinity	Paluxy Formation Glen Rose Formation Twin Mountains Formation
Paleozoic				Paleozoic Undifferentiated

The fill materials consist of clay, silt, sand, gravel, and organic material occasionally mixed with general refuse and construction debris. The alluvial deposits fill present-day stream and river valleys and consist of sand, silt, clay, and gravel. The Terrace Alluvium, consisting of gravel, sand, silt, and clay, represent older floodplain sediments and occur above and are generally cut by the present stream valleys.

The Cretaceous rocks of the Comanche Series (the Washita, Fredericksburg, and Trinity Groups) all dip gently to the east-southeast at a rate of approximately 37 feet per mile (Leggat 1957). Units of the Washita Group (the Duck Creek Limestone and Kiamichi) do not occur at the sites, but do occur to the south and east of NAS Fort Worth (McGowen et al. 1988).

The Fredericksburg Group, which consists of the Goodland Limestone and the Walnut Formation, underlie most of the area and occasionally crop out. The Goodland Limestone is composed of white, chalky, fossiliferous, dense, thinly to massively bedded limestone interbedded with gray to yellow-brown stiff clay and marl (Hargis + Associates 1989a). The formation is extensively jointed and ranges from 0 to 130 feet thick in Tarrant County. The Walnut Formation, which averages

300 feet in thickness, is a fossiliferous limestone and shell coquinite, and consists of interbedded brown sandy clay, thinly bedded fossiliferous clay, fissile clay, and iron-stained limestone (Leggat 1957).

Rocks of the Trinity Group, consisting of the Paluxy, Glen Rose, and Twin Mountains Formations, underlie NAS Fort Worth. The Paluxy Formation consists of sandstone and siltstone interbedded with sandy to silty, calcareous, waxy clay, and shale (Nordstrom 1982). The sandstone is composed of fine- to coarse-grained, well-sorted, poorly consolidated, and cross-bedded white quartz. The thickness of the Paluxy Formation in Tarrant County is approximately 140 to 190 feet (Leggat 1957). Underlying the Paluxy Formation is the Glen Rose Formation consisting of sandstone, claystone, limestone, and anhydrite. In the vicinity of the Lake Worth, the Glen Rose Formation is approximately 250 feet thick.

Underlying the Glen Rose Formation is the Twin Mountains Formation. The Twin Mountains Formation grades upward from a chert and quartz conglomerate to a fine- to coarse-grained sandstone interbedded with shale and clay, and is approximately 250 feet thick in the vicinity of Lake Worth. Undifferentiated Paleozoic deposits underlie the Twin Mountains Formation and consist of shales, sandstones, and limestones 6,000 to 7,000 feet thick.

#### **1.2.2.2 Geology of NAS Fort Worth**

The geologic units of concern at NAS Fort Worth include, in stratigraphic order, the following:

- fill materials;
- alluvium;
- terrace deposits;
- Goodland Limestone;
- Walnut Formation; and
- Paluxy Formation.

No major faults or fracture zones have been mapped near the site. The following sections describe the physical characteristics, location, and thickness of each unit found at the site.

Fill. Fill material at NAS Fort Worth consists of variable mixtures of clay, silt, sand, and gravel, sometimes mixed with general refuse, chemical sludge, and construction debris. The fill occurs in landfills, waste pits, excavated areas, and other areas where the land surface has been altered for construction of buildings, roads, or runways.

Alluvium. Terrace alluvial material deposited by the Trinity River underlies the fill material or is found at the surface and consists of heterogeneous interbedded clay, silt, and poorly to moderately sorted sand, gravel, and occasional cobbles. Individual beds are continuous only over very short distances. The clastic materials in these sediments consist primarily of limestone and shell fragments, while quartz sand grains are a minor constituent.

Vertically, the Terrace Alluvium can be divided into two general lithologies: (1) a shallower unit composed of varying amounts of clayey sand, sandy clay, and gravelly clay; and (2) a deeper sand or gravel unit, usually saturated, that immediately overlies the bedrock. The upper part of the shallower unit (from the surface to a depth of 2 to 4 feet) has been discolored to a dark gray from the accumulation of organic matter, and for the purposes of the background studies, will be considered as a separate soil horizon.

The fill and alluvial deposits are found in nearly all areas of NAS Fort Worth; the thickness of these deposits varies considerably around the site. The thickest accumulations correspond to erosional depressions in the bedrock. One of these erosional depressions, or paleochannels, extends northeast from the southern end of the Plant 4 Assembly Building to the Plant 4 East Parking Lot is approximately 60 feet deep, and is a prominent subsurface feature governing Terrace Alluvium groundwater flow under NAS Fort Worth. A secondary channel appears to extend to

the southeast under the flight line. A cross section presented in the Summary of Interim Remedial Investigation (Hargis + Associates 1989a) indicates that this channel has cut down through nearly the entire thickness of the Walnut Formation.

Coarse sand and gravel deposits occur immediately above bedrock in several areas at NAS Fort Worth. The greatest thickness of these coarse deposits is in the paleochannels where the gravels were deposited as channel lag on the scoured bedrock surface. Basal sand and gravel in the paleochannel in the Plant 4 East Parking Lot area reaches a thickness of at least 15 feet (Hargis + Associates 1989a). Basal sand and gravel in the southeastward extension of this paleochannel under the runways at NAS Fort Worth range up to at least 35 feet thick. Sand and gravel greater than 20 feet thick also occur in an area that trends eastward approximately aligned with White Settlement Road. These deposits probably coincide with the location of a former channel of what is now Farmers Branch (Radian 1990).

Goodland Limestone. The Goodland Limestone is present in the subsurface throughout Plant 4 and NAS Fort Worth, except (1) where erosion has removed it in the northwest part of Plant 4, (2) in the northern portion of NAS Fort Worth, and (3) in deeply eroded meander bends cut by former courses of the West Fork of the Trinity River beneath both Plant 4 and NAS Fort Worth. The top of the formation is highly weathered in places because it was exposed for a long period before overlying alluvium was deposited. The thickness of the formation on the site is variable, depending on the amount of erosion that has occurred. The thickest Goodland Limestone encountered near the site (just west of Plant 4 at well EPA-4) is 47 feet.

The Goodland Limestone consists of chalky white, fossiliferous, dense, thinly to massively bedded limestone interbedded with gray to yellow-brown stiff clay and marl. Extensive jointing is common in weathered portions of the formation; however, core samples from the Goodland Limestone indicate that joints are rare when

unweathered. No faults are known to occur in the Goodland Limestone in the vicinity of Plant 4 (Hargis + Associates 1989b).

Walnut Formation. The Walnut Formation underlies most of Plant 4 and NAS Fort Worth. Where erosional channels have not been cut into the top of the Walnut Formation, the thickness of the formation is fairly constant at between 25 and 35 feet. Except for the deep paleochannel cut into the Walnut Formation in the East Parking Lot, the top of the Walnut Formation shows few abrupt changes in elevation.

The Walnut Formation is mainly a coquinite that contains abundant *Gryphaea marcoui* and *Exogyra texana* shell fossils (Leggat 1957). The coquinite often has a matrix of calcareous shale and clay. Interbeds of calcareous shale and clay also occur. Black, fissile shale was encountered in several boreholes from the upper part of the formation just above the coquinite. Dense sandy limestone, silty shale, and minor pyrite also occur in the lower part of the formation.

A disconformity separates the base of the Walnut Formation from the top of the Paluxy Formation. No faults are known to occur in the Walnut Formation in the vicinity of NAS Fort Worth.

Paluxy Formation. The Paluxy Formation, commonly called the Paluxy sand, is the upper member of the Early Cretaceous Trinity Group. The Paluxy Formation underlies all of NAS Fort Worth and Plant 4, and its uppermost part crops out along the Lake Worth shoreline.

The thickness of the Paluxy Formation ranges from 133 to 175 feet in the NAS Fort Worth and Plant 4 area (Hargis + Associates 1989b). The formation predominantly consists of several thick sandstone layers (cumulatively, about 120 feet thick in this area) separated by thin, discontinuous shale and claystone layers. The lower part of the Paluxy Formation is generally coarser grained than the upper part. This intercalated sandstone and shale sequence was deposited as a shifting complex of near-shore (littoral) environments on the western margin of the East Texas

embayment. The top of the underlying Glen Rose Formation is defined as the first occurrence of a limestone unit.

Sandstones in the Paluxy Formation are porous, fine- to very fine-grained, and composed of moderately to well sorted, subangular to subrounded white quartz sand. The sandstones are poorly cemented (friable) to slightly indurated with sparry calcite cement (Caughey 1977). Traces of pyrite, iron oxides (limonite concretions), and glauconite occur in the sandstone, and these can be locally abundant. Thinner sandstone beds may contain pyrite nodules, traces of lignite, silicified wood, and carbonized plant fragments. Low-angle cross-bedding has been observed in cores from the Paluxy Formation and in outcrops along the Lake Worth shoreline northwest of Plant 4 where horizontal, fossiliferous limestone beds of the Walnut Formation truncate cross-bedded yellow-brown sandstone of the upper Paluxy Formation.

Bedding in the gray to green-gray or olive-green shales (mudrocks) and silty claystones of the Paluxy Formation may be horizontally laminated, massive, or burrowed (churned or bioturbated). The mudstones commonly contain carbonized plant fragments and thin beds of lignite.

The thicknesses of individual sandstone and shaley units in the Paluxy Formation vary across the site. In the upper part of the Paluxy Formation, differences in the individual sandy and clayey units can be subtle (i.e., silty claystone compared with very fine-grained sandstone), and facies changes occur across the site (claystone may grade into very fine-grained sandstone).

### **1.2.3 Hydrogeology**

The hydrogeology in the vicinity of NAS Fort Worth consists of three main units:

1. a shallow (or water table) aquifer within the fill, alluvium, and weathered Goodland Limestone;
2. an aquitard composed of competent bedrock of the Goodland Limestone and Walnut Formation; and

3. the Paluxy Aquifer, which is a source of municipal water supply for the city of White Settlement.

Discussions of each of these hydrogeologic units are presented in the following sections.

Shallow Aquifer. Shallow groundwater occurs in unconsolidated fill, alluvium, and weathered Goodland Limestone, all of which overlie competent bedrock. The lithology of the shallow groundwater system consists primarily of silt and clay material, with silty sand and gravel deposits often present in paleochannels incised into bedrock. The direction of groundwater flow is generally controlled by bedrock topography of the Goodland Formation. Groundwater flow in the shallow aquifer is generally to the east toward the West Fork of the Trinity, with some localized flow to the north toward Lake Worth, and in various directions toward Farmers Branch in the southern end of NAS Fort Worth.

The shallow groundwater system is underlain by competent Goodland Limestone and Walnut Formation. These two formations form an aquitard that restricts the flow of groundwater between the shallow aquifer and the underlying Paluxy Formation. In many areas, the Goodland Limestone is located at or very near the land surface, and the shallow groundwater is essentially absent in these areas. Elsewhere, the Goodland Limestone and Walnut Formation are eroded by paleochannels filled with alluvium. The Goodland Limestone is often entirely absent in these areas. Locally, for example at the Plant 4 East Parking Lot "window area," the Walnut Formation has been eroded almost completely by a paleochannel.

Groundwater recharge to the fill and alluvium is from local rainfall and infiltration from streams and drainage ditches. Extensive paved areas and buildings restrict the natural infiltration of precipitation over much of NAS Fort Worth and Plant 4. However, precipitation does infiltrate through several large grassy areas that include portions of the flight line area, the radar range, and Landfills No. 2, 3, and 4.

Additional recharge also occurs as leakage from water-supply lines, fire-fighting pipe systems, cooling-water systems, sanitary sewers, and storm sewers.

Discharge from the shallow aquifer occurs primarily as seeps to Meandering Road Creek, baseflow to Farmers Branch, and discharge to the West Fork of the Trinity River. Discharge from the shallow groundwater also occurs as vertical leakage into the Paluxy Aquifer. Most of the vertical leakage occurs in the paleochannels where considerable portions of the Goodland Limestone and Walnut Formation are absent.

Slug tests completed during the Plant 4 Remedial Investigation (RI) Preliminary Assessment (PA)/Site Investigation (SI) to obtain estimates of hydraulic conductivity in easterly flowing upper zone groundwater, averaged  $0.5 \times 10^{-4}$  centimeters per second (cm/sec). These slug tests were completed on 13 wells, some of which were screened in the weathered portions of the Goodland Limestone (Rust Geotech 1995).

Hydraulic conductivities determined from slug tests ranged from  $4.1 \times 10^{-4}$  cm/sec to  $7.98 \times 10^{-3}$  cm/sec, while pump tests conducted in groundwater monitoring wells LF04-02 and LF04-03 averaged  $2.8 \times 10^{-1}$  cm/sec (Radian 1991). This value is within the typical range for clean sand and gravel deposits (U.S. Geological Survey 1989).

Goodland Limestone and Walnut Formation Aquitard. These two formations form an aquitard that restricts the vertical flow of groundwater between the shallow aquifer system and the Paluxy Aquifer. The entire section of Walnut Formation and at least a portion of the Goodland Limestone are present throughout most of NAS Fort Worth and the Plant 4 area. In the vicinity of NAS Fort Worth and Plant 4, the maximum thickness of the aquitard is approximately 30 feet, but is considerably thinner or absent in areas where paleochannels have incised into the Goodland Limestone and Walnut Formation. In highly incised areas, such as the window area, there is a potential for groundwater flow into the Paluxy Formation.

Vertical hydraulic conductivity of the competent Walnut Formation was measured on several drilling core samples collected during the Plant 4 RI PA/SI. The logarithmic mean of the measured hydraulic conductivity values is  $7.0 \times 10^{-10}$  cm/sec, based on a sampling of six cores. Additionally, hydrographs for paired Terrace Alluvium and Paluxy Formation monitoring wells also indicate that there is relatively little flow from the Terrace Alluvium to the Paluxy Formation (Rust Geotech 1995).

These estimates of vertical flow velocity through the Walnut Formation suggest that as long as the Walnut Formation is present, the downward flow of groundwater is very limited. The distribution of chemical constituents in the Paluxy Formation over most of Plant 4 confirms that there is very little flow of shallow groundwater through the aquitard.

The Paluxy Aquifer. The Paluxy Aquifer is an unconfined to semiconfined sandstone aquifer that underlies the Walnut Formation aquitard. The bottom of the Paluxy Aquifer is defined as the first occurrence of limestone beneath the Paluxy Formation. Limestone is the dominant component of the Glen Rose Formation, which underlies the Paluxy Formation.

In Tarrant and Dallas Counties, the Paluxy Aquifer is widely used as a source of water for domestic, municipal, and industrial water supplies. Development of the Paluxy Aquifer began in the early 1900s, with total production in the Tarrant and Dallas County areas reaching a peak in the late 1960s (Nordstrom 1982). The decline in production since the late 1960s resulted from large declines in hydraulic head caused by heavy pumping in eastern Tarrant County and central Dallas County. The declining water levels led to the abandonment of inefficient wells (Nordstrom 1982), which were then replaced by the development of other sources, such as the Twin Mountains Aquifer. In the immediate vicinity of Plant 4, seven water supply wells for the City of White Settlement obtain water from the Paluxy Aquifer.

The Paluxy Aquifer has been characterized in previous site reports as a stratified aquifer consisting of three distinct flow systems separated by continuous aquitards composed of siltstone, claystone, and/or shale. However, in most instances individual shale and

siltstone/claystone units cannot be correlated over large distances because of the variable distribution of the units and the uncertainty associated with the lithologic logs prepared on the basis of drill cuttings. Because of these observations, the Paluxy Aquifer is regarded as a single unconfined to semiconfined flow system consisting of a largely sandstone matrix with abundant layers of interbedded shale, siltstone, and claystone.

Recharge to the Paluxy Aquifer occurs largely as infiltration of precipitation falling on the outcrop in Wise, Parker, Hood, and Tarrant Counties. Recharge also occurs as infiltration from Lake Worth and Eagle Mountain Lake, both of which lie at least partially within the boundary of the outcrop. Additional minor amounts of recharge also occur as infiltration from streams that cross the outcrop. In the immediate vicinity of Plant 4, it is evident that small amounts of recharge are also derived from leakage of upper-zone Terrace Alluvium groundwater through the window area (where the Walnut Formation has been severely eroded) and leakage of surface water through the lower reaches of Meandering Road Creek. In both of these areas, most if not all of the Walnut Formation has been eroded reducing the capacity of this aquitard to impede the vertically downward flow of upper-zone groundwater and surface water.

#### **1.2.4 Surface Water**

The primary surface-water features in the vicinity of NAS Fort Worth include Lake Worth, Farmers Branch, and the West Fork of the Trinity River. Lake Worth is located along the northern boundary of the site, Farmers Branch flows eastward near the southern end of the site discharging into the West Fork of the Trinity River, and the West Fork of the Trinity River flows southeasterly from Lake Worth and borders the site on the east. Lake Worth was created by damming the West Fork of the Trinity River. Portions of NAS Fort Worth fall within the 100-year floodplain. These areas occur along portions of the West Fork of the Trinity River, Lake Worth, Farmers Branch, and Kings Branch.

## **1.2.5 Climatology/Meteorology**

NAS Fort Worth is located at approximately 32 degrees north latitude and 97 degrees west longitude, in north-central Texas. The climate of the sites is typified by hot summers and cool, relatively dry winters.

### **1.2.5.1 Precipitation**

Mean annual precipitation is 31.6 inches, with the highest mean precipitation occurring in April and May (3.8 and 4.4 inches), and in September and October (3.2 and 3.6 inches). Mean monthly precipitation amounts are lowest from November through February (1.8 inches or less), and during August (1.9 inches). Most precipitation occurs as rain; snowfall accounts for appreciable amounts of precipitation only during the months of January and February.

### **1.2.5.2 Temperature**

Historical meteorological data from NAS Fort Worth during the years 1942 through 1990 indicate the mean annual temperature is 66 degrees Fahrenheit ( $^{\circ}$  F). Mean monthly temperatures range from a high of 86 $^{\circ}$  F (July) to a low of 45 $^{\circ}$  F (January). High and low extreme temperatures were 110 and 0 $^{\circ}$  F, respectively, during the record-keeping period.

### **1.2.5.3 Wind**

During most of the year, the predominant wind direction is from the south at a speed of 6 to 8 knots. Typically, the wind blows from the north only during December through February, at a speed of 7 to 8 knots.

## **1.2.6 Biological Resources**

The following sections describe the biological resources at NAS Fort Worth.

### **1.2.6.1 Flora and Fauna**

Because of the urban environmental setting, few natural terrestrial and aquatic communities exist at NAS Fort Worth. The richest ecological community in the immediate area exists in the riparian corridor along Meandering Road Creek, west of Plant 4. At NAS Fort Worth, limited terrestrial and aquatic communities exist along the shores of Lake Worth, the West Fork of the Trinity River, Kings Branch and Farmers Branch.

Aquatic species observed in the West Fork of the Trinity include catfish, sunfish, and numerous varieties of bass. Common birds observed in the area include herons, kestrels, kingfishers, seagulls, mourning doves, meadowlarks, grackles, and starlings.

### **1.2.6.2 Threatened and Endangered Species**

The U.S. Fish and Wildlife Service (FWS) and the Texas Department of Parks and Wildlife (TDPW) have identified 12 bird, two reptile, and one sensitive plant species that are threatened and endangered species potentially occurring in Tarrant County. The two federal-listed candidate reptile species that could also inhabit Tarrant County are the Texas horned lizard, which lives on grassy hillsides, and the Texas garter snake, which inhabits prairie seeps and wet grassy swales.

However, no state- or federal-listed threatened or endangered species are known to live on NAS Fort Worth property. The closest sensitive habitat to the sites is the great blue heron rookeries to the north of NAS Fort Worth, across Lake Worth.

### **1.2.7 Cultural/Archaeological Resources**

One historical structure listed in the National Register of Historic Places (NRHP) exists within the boundaries of NAS Fort Worth. No significant archaeological or prehistoric sites have been identified within the boundary of NAS Fort Worth. Fossils are present in outcrops at NAS Fort Worth, but have not been identified as a significant paleontological resource.

### 1.3 PROJECT OBJECTIVES

The objectives of the basewide background study are as follows:

- To obtain samples that are representative, to the degree possible, of background concentrations. This may be difficult in the highly urban setting of NAS Fort Worth and because NAS Fort Worth is bounded on the west by Air Force Plant 4.
- To establish background levels of metals in Terrace Alluvium groundwater, surface water, sediment, and soil.

### 1.4 GENERAL APPROACH AND RATIONALE

The approach and rationale for the background study at NAS Fort Worth were developed to generate chemical compound constituent populations for pertinent media. The following discusses the approach and rationale used to select media and chemical analyses.

#### 1.4.1 Media Classification

The media selected for determining background concentrations are surface soils, subsurface soils, the Terrace Alluvium aquifer, and surface water and sediments of the Farmers Branch. The surface and subsurface soils were designated in the field as Horizons A and B, respectively, for identification purposes and do not refer to soil horizons used in the pedological classification system (U.S. Department of the Interior [DOI] 1985). Although the Paluxy aquifer lies below the base, previous investigations have not indicated any impact from past installation operations on this aquifer. Therefore, the Paluxy aquifer was not evaluated for background concentrations.

Surface soils, Horizon A, are defined as the first-encountered soil type from the base of surficial vegetation to a depth of 2 feet. This soil type varies from a sandy clay to clay with varying amounts of silt and fine subrounded gravel and is dark grayish

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brown to dark gray in color. This soil type is the predominant surface soil at NAS Fort Worth, and has been observed up to depths of 4 feet below ground surface (bgs). However, in some locations this soil type is not found on the surface because of erosional effects and construction activities.

Subsurface soils, Horizon B, are defined as the second encountered soil type below the organically rich surface soil. The subsurface soil is a sandy clay with varying amounts of fine subrounded limestone clasts, reddish brown to strong brown. The thickness of this unit has been found to be from 5 to 15 feet across the base. Local differences in depositional environments provide for a wide variety of soil types at the base. However, Horizon B is found to be predominant from below Horizon A to within proximity of the groundwater capillary fringe in general. Sandy soils which tend to be saturated, are found below the reddish brown to brown sandy clays. The section of unsaturated sandy soils from the bottom of the Horizon B and the groundwater is generally thin and subject to saturation; therefore, it was not included in the background evaluation.

The Terrace Alluvium aquifer is found below the clay soils in coarser-grained sands and gravels at various depths ranging from a few feet to 37 feet below the ground surface. The depth to groundwater at the base is controlled by the depth of bedrock. The Terrace Alluvium is included in the background evaluation because of the widespread occurrence of Terrace Alluvium groundwater at NAS Fort Worth and the potential for environmental impacts to the groundwater.

The Farmers Branch Creek surface water and sediments were selected for background evaluation because the Farmers Branch is the only consistent upstream source flowing onto the base. Quarterly groundwater monitoring for the Air Force Plant 4 facility has shown that volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs) are present in the Farmers Branch Creek at the base indicating the potential for environmental impact.

### 1.4.2 Chemical Analyses

All media were selected for metals, volatile compound, and semivolatile compound analyses. Because many metals are naturally occurring in soils, groundwater, surface water, and sediments in various concentrations, this study is concerned with the background concentrations of these metals.

Volatile and semivolatile organic compounds were also analyzed for in all media because of the urban setting of the base. Concentrations of volatiles and semivolatiles have been detected in all media addressed in this background study. The organic analyses performed will assist in determining whether samples may have been affected by past activities at the installation. When organic compounds were detected in a sample above the detection limits and unqualified, except for estimated qualifiers, the sample results for metals were not included in the statistical determination of background concentrations.

It is possible that samples could be impacted by metals without the presence of organic compounds. If this occurred in the data set, outlier tests determined whether the result was an outlier, or whether the result could be included in the population.

Metals analyses were performed on two sets of Terrace Alluvium groundwater samples. The first set of samples was collected using low-stress techniques, which produced samples with approximately zero turbidity. The second set of groundwater samples were collected using typical purging and bailer sampling techniques, which produced samples with higher turbidity and typically higher metals concentrations. The low-turbidity sample results were used to determine background concentrations for metals for sampling efforts that may be performed in this fashion in the future. The second set of sample results were used to determine background concentrations for comparison with data collected previously using the same sampling methodology.

### 1.4.3 Background Study

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The analytical results were used to calculate background concentrations for 24 inorganic constituents in each of six background populations. A total of 30 surface soil, 30 subsurface soil, 12 groundwater samples (one low-volume sample and one bailer sample per well), eight surface water, and eight stream sediment samples were collected to characterize these media for background concentrations. The Tolerance Interval (TI) method (U.S. Environmental Protection Agency [EPA] 1989, 1992) was used to estimate background concentrations in site media. The TI method is used to estimate the concentration of a given constituent in a given medium and is expressed as an appropriate upper tolerance limit (UTL) of the distribution of the constituent in the background data population.

Section 4.0 discusses the process by which the UTLs were developed and reports the results for each inorganic analyte by media.

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Section 20

## 2.0 BACKGROUND SAMPLING PROGRAM

### 2.1 SAMPLING LOCATIONS

Sampling locations were chosen to represent background concentrations of selected inorganics in the chosen media. Given the urban setting of the NAS Fort Worth, locations for background sampling were somewhat limited. Soil sampling locations were chosen away from known or suspected anthropogenic source areas, and based on historical analytical data indicating the absence of contamination. Soil samples in the housing areas were collected at least 100 feet from houses and at least 25 feet from other painted surfaces (fire hydrants, playground equipment, curbs, etc.) to limit any effect from lead based paint or other household derived substances. Groundwater monitoring wells, existing and newly installed, were located up- and cross-gradient from known source areas, and from wells that are known to contain volatile and semivolatile compounds. Surface water and sediment sampling locations were selected upstream on the Farmers Branch because this stream is the main surface water source flowing onto the installation.

#### 2.1.1 Soil Probes in Terrace Alluvium

Thirty-five soil probes were driven to collect samples in the Terrace Alluvium for surface and subsurface soils (Horizons A and B). Locations were selected based on the absence of potential source areas. If possible, samples were collected at both depths at each location. Horizon A and B samples were not colocated for one or more of the following reasons:

- Horizon A or B was not present.
- The sampling tool encountered shallow refusal.
- The possibility of influence from outside sources such as painted surfaces (lead) was identified.

Sample locations were adjusted from the planned locations described in the Work Plan (Jacobs 1996a) according to field conditions and circumstances, but these changes were minor. Plate 1 shows the locations of the soil probes and the horizons sampled at each location.

### **2.1.2 Terrace Alluvium Groundwater Sampling**

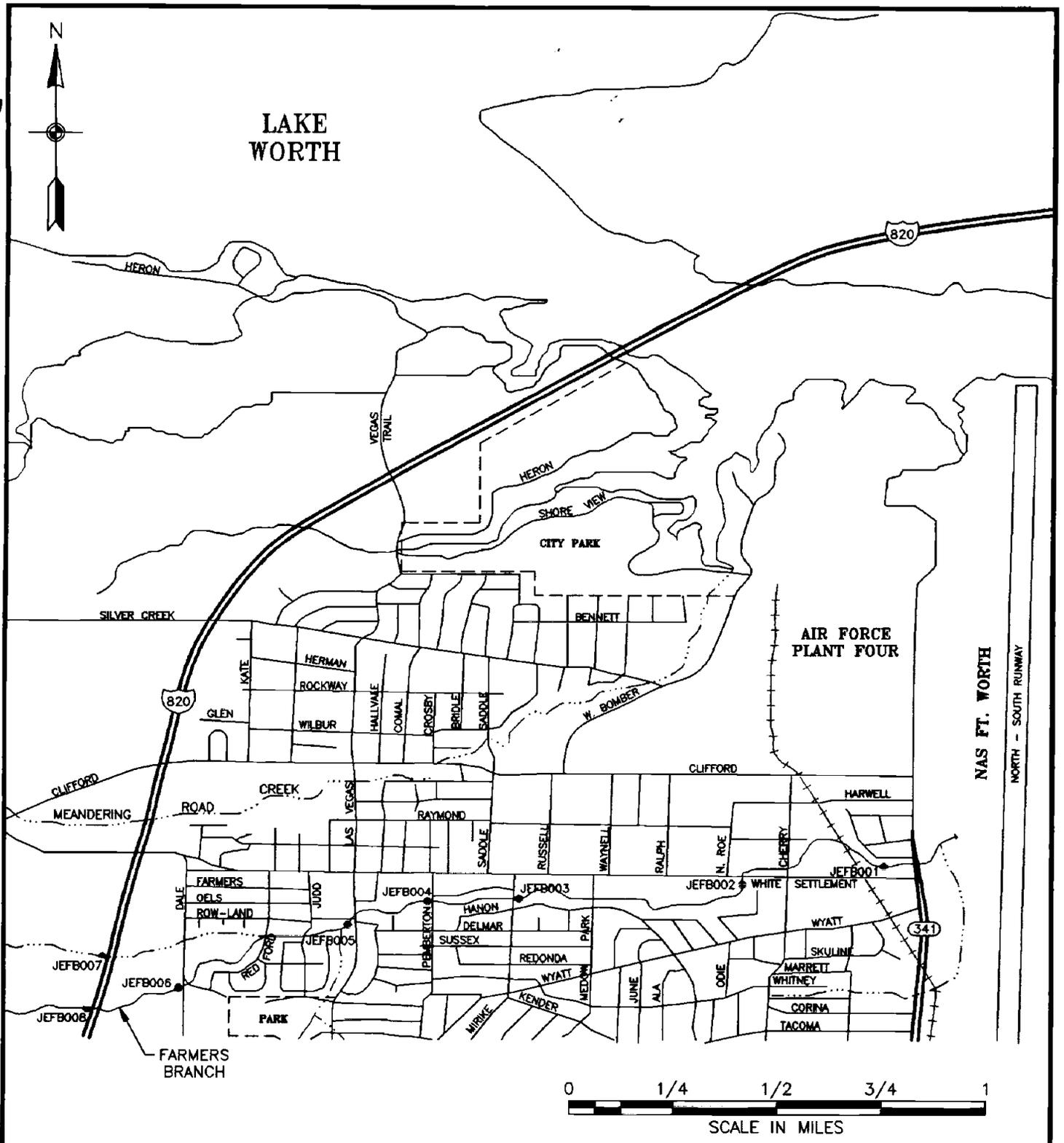
Eight existing Terrace Alluvium groundwater monitoring wells were sampled. To increase the total number of samples collected for the background population needed to attain a reasonable level of confidence, four additional Terrace Alluvium wells were constructed and sampled. Existing wells sampled were selected based on historical analytical data indicating the absence of contamination. Newly constructed monitoring well locations were chosen as upgradient or cross gradient from known sources of contamination. The locations of both the existing and the recently constructed wells are illustrated on Plate 2. Additionally, during the drilling activities for the monitoring well construction, three dry boreholes were drilled. The locations of the boreholes are also shown on Plate 2.

### **2.1.3 Surface Water and Sediment Sampling**

Eight surface water and sediment sampling locations are shown in Figure 2-1. All surface water locations selected were upstream from the base, had adequate sediment for sampling, and were on public or city-owned property. The two different types of samples are approximately colocated. Sediment sample locations were adjusted in relation to their associated surface water sample locations to facilitate the sample collection procedure. Table 2-1 briefly describes each sample location. Appendix G provides color photographs of locations JEFB001 through JEFB006 and JEFB008.

## **2.2 SAMPLING AND DATA COLLECTION**

Sampling and data collection activities were performed in accordance with the Work Plan (Jacobs 1996a) and the Sampling and Analysis Plan (Jacobs 1996b) with minor



**LEGEND:**

- JEFB001 ● SAMPLE LOCATION
- +++++ UNION PACIFIC RAILROAD
- ~~~~~ RIVERS, CREEKS, OR STREAMS
- - - - - INTERMITTANT RIVERS, CREEKS, OR STREAMS
- — — — — ROADS
- ==== HIGHWAYS

<b>Naval Air Station Fort Worth JRB Fort Worth, Texas</b>		
Surface Water and Sediment Sampling Locations		
PROJ. MGR. L. SCHUETTER	ACAD FILE NO. FIG2-1.DWG	FIGURE NO. 2-1
DRAWN BY J. HUNTER	PROJ. NO. 05-G-47900	DATE 01/14/97

**TABLE 2-1**  
**Surface Water and Sediment Sampling Locations**

Location	Approximate Channel Width (feet)	Water Depth (feet)	Estimated Flow (gallons per minute)	Location Description
JEFB001	40	1	150	South-southeast of city well WS-12, approximately 75 feet downstream from railroad trestle. Trash noted in water and along bank. Sediment sample taken 8 feet upstream.
JEFB002	40	0.4	150	100 feet upstream from the White Settlement Road bridge. Sediment collected from 8 feet upstream. Strong organic decay odor.
JEFB003	35	0.4	130	East side of Minke Street bridge. Sediment collected 6 feet upstream. Sediment thickness was approximately 0.7 feet thick on top of concrete bridge footing. Sample collected to 3-inch depth. Strong organic decay odor.
JEFB004	35	0.4	130	West side of Pemberton Street bridge. Water sampled on the north side of the channel. Sediment sampled on the south side of the channel. Sediment was saturated, but not in active flow. Moderate organic decay odor.
JEFB005	35	1	130	Linear Park just upstream from Las Vegas Trail. A small, dry tributary is located approximately 40 feet upstream. No odors detected.
JEFB006	40	1.1	130	West side of the Dale Street bridge on the Farmers Branch Creek. Sediment samples were partially saturated. No organic material noted. Sediment is coarser grained than other sediment.
JEFB007	35	0.1	50 (all three channels)	West side of Highway 820 bridge on northern tributary. Three main channels present at this location. Oily sheen noted on standing water in the south channel. North channel sampled. Higher content of iron and magnesium minerals than other sediment.
JEFB008	20	1.5	70	West side of 820 bridge on the Farmers Branch. Sediment sampled contained approximately 25 percent fines. No organic odor noted.

variations. Surface soil, subsurface soil, Terrace Alluvium groundwater, surface water, and sediment samples were collected to determine selected inorganic constituent background concentrations in these media. Field activities are described in the following sections.

### **2.2.1 Soil Probe and Borehole Logging**

During soil probe and auger borehole drilling, the location of each borehole, sample intervals, sample recovery, drilling information, and sample descriptions were recorded on borehole logs (Appendix C).

Where soil core recoveries were adequate, in both soil probe and auger boreholes, samples of unconsolidated soils were described continuously using the Unified Soil Classification System according to the American Society for Testing and Materials (ASTM) procedure D2488-93 (ASTM 1996). When bedrock was encountered, the lithology was described according to standard professional nomenclature (Jacobs 1996b).

### **2.2.2 Soil Probe Sampling**

Soil samples were collected at the locations illustrated on Plate 1 using a truck-mounted soil probe rig. Soil samples were collected from soil probes for submittal to EMAX Laboratories, Inc., to determine concentrations of metals and volatile and semivolatile organic compounds. Drive probes were completed by hydraulically pushing and hammering samplers into the ground. Two sizes of stainless steel samplers were used: a 4-foot-long by 2-inch-diameter sampler and a 2-foot long by 1-inch-diameter sampler. Three-foot-long drive rods were added to the drive string as necessary to reach the target depth for each probe. The entire depth of each soil probe was sampled using the 4-foot-long sample barrel fitted with a plastic liner. The 4-foot sampler was used to collect soil samples for semivolatile organic compounds and metals analyses. After the total depth of each soil probe was reached, the 4-foot long

sampler and drive rod were removed from the probe hole. The probing rig was moved and a second probe was drilled using the 2-foot long sampler fitted with four 6-inch long stainless steel liners to collect volatile organic samples at discreet intervals selected by using the previous continuous sampling information.

The entire length of the 4-foot sampler used to collect samples for semivolatile organic and metals analyses was driven into the ground and then removed. The plastic liner was removed from the sampler with the soil core inside the liner. The soil was examined to determine that the Horizon A was intersected. The soil representing the Horizon A to the 2-foot depth was removed from the plastic liner, logged, and placed into a stainless steel bowl. All surficial vegetation and roots were discarded prior to composting the sample. In many drive probes, Horizon A was less than 2 feet thick. In these cases, the Horizon A was collected to its total depth. Additionally, the thickness of the Horizon A occasionally was not adequate to provide enough sample volume for the analyses, and a second probe within 6 inches of the original was necessary to provide enough sample volume. After an adequate amount of sample was collected, the soil was then mixed in the bowl, and large pieces of gravel were removed. The soil samples collected for semivolatile organic compounds and metals analyses were put in a single 8-ounce jar, labeled, and placed in an iced cooler.

After the Horizon A soils were collected, the remaining core in the first 4 feet was examined to determine whether the Horizon B had been encountered. If Horizon B had not been encountered, or there was not a sufficient amount of material for a Horizon B sample, a second 4-foot-long sample probe was driven. If the Horizon B was encountered in the soil probe, a soil sample was collected for semivolatile organics and metals analyses as previously described.

The soil profile information gained during the first soil probe was then used to determine sample depths for the volatile organics samples. The 2-foot sampler was

driven to the top of the target interval and the conical tip of the sampler was retracted. The sampler was then driven another 2 feet to collect the soil sample. The sampler was removed from the soil probe. The stainless steel liners were then extracted from the sampler and in most cases the second sample liner from the bottom was selected as the sample. The second liner from the bottom was typically chosen because this section of the sample is usually the least disturbed; the bottom liner often containing sluff, and the upper two liners being subjected to more vibration and friction as the sampler is advanced. The sample was evaluated for the presence of petroleum hydrocarbons using a HNu PI-101 photoionization analyzer. Each end of the liner was covered with a Teflon™ swatch, held in place by a tight-fitting plastic cap, and sealed with Parafilm™. The sample was appropriately labeled and placed in an iced cooler. Photographs in Appendix G show the soil probe activities.

Most soil probes were advanced to a depth between 4 and 8 feet; however, in the southern portion of the Wherry Housing area, refusal was met at shallow depths at soil probe locations. Additionally, soil probe BJETA517 was advanced to a total depth of 24 feet to investigate the potential for groundwater on the south side of the Carswell Golf Course. Soil probe total depths, sample depths, and horizons sampled are depicted in Table 2-2.

### **2.2.3 Terrace Alluvium Groundwater Monitoring Well Installation**

Four Terrace Alluvium groundwater monitoring wells were installed to augment the eight existing wells on NAS Fort Worth for background sampling. These wells, WJETA530, WJETA531, WJETA534, and WJETA535, were installed in the Wherry Housing Area near the school as depicted on Plate 2. It should be noted that these wells were not collocated with the BJETA boreholes of the same identification number. Three boreholes, BJETA507, BJETA535, and BJETA536, were dry as drilled and were not completed as monitoring wells. BJETA507 and BJETA535 are collocated with soil probes, and are continuations of those probes. BJETA536 was

**TABLE 2-2**  
**Soil Probe Information**  
**NAS Fort Worth Background Study**

Soil Probe Identification	Total Depth	Sample Depth (feet)			
		Horizon A Volatile Compounds	Horizon A Semivolatile Compounds and Metals	Horizon B Volatile Compounds	Horizon B Semivolatile Compounds and Metals
BJETA 501	5.0	0.5 - 1.0	0.0 - 1.0	3.5 - 4.0	3.5 - 4.0
BJETA 502	4.0	0.5 - 1.0	0.0 - 1.0	2.5 - 3.0	3.0 - 4.0
BJETA 503	4.0	0.5 - 1.0	0.0 - 1.0	2.5 - 3.0	3.0 - 4.0
BJETA 504	4.0	0.5 - 1.0	0.0 - 1.0	2.5 - 3.0	3.0 - 4.0
BJETA 505	8.0	0.5 - 1.0	0.0 - 1.0	4.5 - 5.0	3.5 - 4.5
BJETA 506	8.0	0.5 - 1.0	0.0 - 1.0	4.5 - 5.0	4.0 - 5.0
BJETA 507	8.0	2.5 - 3.0	1.5 - 3.5	7.0 - 7.5	6.0 - 8.0
BJETA 508	2.3	0.5 - 1.0	0.0 - 1.0	Not Sampled	
BJETA 509	4.0	1.0 - 1.5	0.0 - 2.0	2.5 - 3.0	2.25 - 3.4
BJETA 510	3.4	0.5 - 1.0	0.0 - 2.0	2.5 - 3.0	2.0 - 3.0
BJETA 511	8.0	1.0 - 1.5	0.0 - 2.0	5.5 - 6.0	5.0 - 7.0
BJETA 512	10.5	1.0 - 1.5	0.0 - 1.5	5.0 - 5.5	4.5 - 5.5
BJETA 513	6.0	Not Sampled		3.0 - 4.0	2.0 - 4.0
BJETA 514	8.0	1.0 - 1.5	0.0 - 2.0	5.0 - 5.5	4.0 - 6.0
BJETA 515	6.0	Not Sampled		2.0 - 2.5	2.0 - 3.0
BJETA 516	4.0	1.0 - 1.5	0.0 - 2.0	Not Sampled	
BJETA 517	24.0	0.5 - 1.0	0.0 - 1.0	1.0 - 1.5	2.0 - 4.0
BJETA 518	4.0	0.5 - 1.0	0.0 - 1.0	3.0 - 3.5	2.0 - 4.0
BJETA 519	4.0	0.5 - 1.0	0.0 - 1.5	3.0 - 3.5	2.0 - 4.0
BJETA 520	8.0	1.0 - 1.5	0.0 - 2.0	7.0 - 7.5	6.0 - 8.0
BJETA 521	4.0	0.5 - 1.0	0.0 - 1.0	3.0 - 3.5	2.0 - 4.0
BJETA 522	16.0	1.0 - 1.5	0.0 - 2.0	4.0 - 4.5	4.0 - 5.0
BJETA 523	9.0	1.0 - 1.5	0.0 - 1.5	7.5 - 8.0	7.0 - 8.0
BJETA 524	8.0	1.0 - 1.5	0.0 - 2.0	6.0 - 6.5	6.0 - 7.0
BJETA 525	5.0	Not Sampled		3.5 - 4.0	3.0 - 4.0
BJETA 526	5.0	Not Sampled		3.5 - 4.0	3.0 - 4.0
BJETA 527	4.0	0.5 - 1.0	0.0 - 1.0	3.0 - 3.5	3.0 - 4.0
BJETA 528	4.0	0.0 - 0.5	0.0 - 0.5	1.5 - 2.0	1.5 - 2.0
BJETA 529	4.0	Not Sampled		3.0 - 3.5	3.0 - 4.0
BJETA 530	4.0	0.0 - 0.5	0.0 - 0.5	1.5 - 2.0	1.5 - 2.0
BJETA 531	4.0	0.0 - 0.5	0.0 - 0.5	1.5 - 2.0	1.5 - 2.0
BJETA 532	4.0	0.0 - 0.5	0.0 - 0.5	1.5 - 2.0	1.5 - 2.0
BJETA 533	4.0	0.0 - 0.5	0.0 - 0.5	Not Sampled	
BJETA 534	4.5	3.0 - 3.5	3.0 - 4.0	Not Sampled	
BJETA 535	29.0	3.0 - 3.5	3.0 - 4.0	Not Sampled	

drilled between the active runway and the parallel taxiway (running north-south), and between taxiway C, and D (running roughly east-west) also shown on Plate 2. After the full depth of the dry boreholes was reached, the borehole was abandoned by pumping a bentonite-cement grout from the bottom of the hole to the ground surface. After 24 hours, each abandoned borehole was checked for settlement of the grout. If the grout had settled, additional material was added to the surface.

Each well and dry borehole location was initially drilled with 3.25-inch inside diameter by 6.6-inch outside diameter hollow-stem augers. During drilling a 3-inch inside diameter by 5-foot-long split-barrel sampler was advanced along with the auger to continuously collect soil core. Boreholes completed as monitoring wells were drilled to the top of the Goodland Formation and typically terminated in the first competent limestone unit encountered. Boreholes that were completed as monitoring wells were reamed using 6.25-inch inside diameter by 9.6-inch outside diameter augers to facilitate placement of well construction materials through the annulus of the auger. After reaching the full depth, 2-inch diameter, 0.020-inch slotted well screen and solid casing were placed in the annulus of the auger.

Sand was then placed through the annulus of the auger from the bottom of the borehole to a depth of approximately 2 feet above the top of the screen. In monitoring wells WJETA530 and WJETA531, a 20/40 graded sand was used, and in wells WJETA534 and WJETA535, a 16/30 graded sand was used. As the sand was placed, measurements were made as the auger was being removed to ensure the sand was not bridging and that the material was always in the auger annulus to reduce void development. After the sand was placed, the well was surged for 10 minutes to compact the sand pack and eliminate any possible bridging. The top of the sand level was measured after surging and more sand was added as necessary.

After the sand pack was placed, a 2-foot bentonite seal was installed by placing 0.25- to 0.5-inch bentonite pellets through the auger annulus. The bentonite was hydrated

and a bentonite-cement grout was pumped from the top of the seal to the surface. To complete the well construction, flush-type vault boxes were installed in a 3-foot by 3-foot by 4-inch concrete pad at the surface. Appendix D presents well construction diagrams, showing the details of each well constructed. Additionally, photographs of the drilling and the well installation process are provided in Appendix G.

#### 2.2.4 Monitoring Well Development

Well development was initiated within approximately 24 hours after well completion. Wells were developed using a Teflon™ bailer and a Grundfos® Rediflo II pump. Each well was alternately surged with the bailer or pump, and overpumped. During overpumping the Grundfos® Rediflo II pump was used to continuously and alternately surge the well by running the pump up and down the entire length of screen with the pump on and off respectively. In this fashion the entire length of screen was developed. All of the wells developed a cone of depression during overpumping; therefore, the section of screen that was unsaturated due to the cone of depression could not be subjected to the same development flows as the saturated length of screen.

With one exception, well development continued on each well until the following criteria were met:

- The sediment content of the water was less than 0.75 mL/L, as measured in an Imhoff cone according to Method E160.5.
- The turbidity remained within a 10 nephelometric turbidity unit range for at least 30 minutes.
- The stabilization criteria for pH, temperature, and conductivity were met. (Stabilization is defined as temperature plus or minus  $[\pm] 1^{\circ} \text{C}$ ,  $\text{pH} \pm 0.1$ , and conductivity  $\pm 5$  percent).

Turbidity in well WJETA535 did not stabilize to within 10 nephelometric units for at least 30 minutes; however, the turbidity dropped rapidly during the last three

parameter measurements. The water was clear and maintaining water in the well at development flow rates was becoming difficult. Because the cone of depression had developed nearly to the pump inlet and all parameter results, except for turbidity, were within specifications, development was terminated.

The results from the well development activities are detailed in the Monitoring Well Development Records presented in Appendix D.

### **2.2.5 Groundwater Sampling**

Groundwater was sampled using two methods. The first method employed was a low-stress sampling protocol for the collection of groundwater for metals analysis. The second method employed was to rapidly purge three well volumes of water from the well and complete the sampling using a bailer to collect groundwater samples for analyses of metals and volatile and semivolatile organic compounds. Both methods were used to collect samples that could be used to generate background information. The bailer sampling method has been used extensively in the past at The base. Background information generated using the bailer sampling method will be useful in determining the disposition of sites investigated and monitored using the bailer method. Future sampling at NAS Fort Worth may evolve to the low-stress method. The background information gathered using the low-stress method will then be useful for future activities. Groundwater sampling data sheets are presented in Appendix D.

#### **2.2.5.1 Low-Stress Aquifer Sampling**

The EPA guidance for low-stress sampling described in the April 1996 publication, Ground Water Issue (EPA 1996) was followed to sample groundwater at each selected well. In general a peristaltic or bladder pump was used to perform the low-stress purging. Because of ease of use, the peristaltic pump was the preferred method of low-stress sampling, however a peristaltic pump cannot raise water greater than approximately 27 feet. When groundwater in a well was greater than 27 feet below

ground surface a bladder pump was utilized. The two different low-stress methods should have no effect on sample representativeness.

Before inserting any equipment into the well, the groundwater level was measured with an electronic sounding device. To minimize disturbances in the well, a total depth measurement was not taken before initiating the low-stress sampling procedure. The water level measuring device was then left in the well to collect draw down information during purging.

The peristaltic pump was fitted with 0.1925-inch inside diameter by 0.3915-inch outside diameter medical-grade silicone tubing at the roller section of the pump. The medical-grade tubing was connected to 3/16-inch inside diameter by 5/16-inch outside diameter Tygon 2275 high-purity tubing using a polyethylene tapered end connector. The Tygon 2275 high-purity tubing was used in the well and was weighted using a series of stainless steel washers and nuts threaded onto the end of the tubing. Before lowering the tubing into the well, the target sampling depth was determined and the appropriate length of tubing was measured. The tubing was then lowered slowly and carefully into the well to the target depth and secured at the surface with nylon cable ties. The pump was then turned on, and the purging and sampling process was started as subsequently described.

The bladder pump was constructed of polyvinyl chloride (PVC) and was fitted with polyethylene tubing using compression fitting where necessary. The bladder itself was made of Teflon™, which aided decontamination procedures. The appropriate length of tubing was measured before inserting the pump into the well. The pump was slowly and carefully lowered to the target depth. An oilless air compressor was used to supply compressed air to the pump. Power was supplied by a 12-volt automotive battery.

After the pump inlets were placed at the target depth (the middle of the saturated screened section), the pump was turned on and the flow rate was adjusted. Flow rates

for purging were generally set at approximately 200 milliliters per minute (mL/min) for the peristaltic pump and 700 mL/min for the bladder pump. Purge rates were dictated primarily by the amount of drawdown observed in each well. Drawdown was not allowed to exceed 0.31 foot. While purging was being performed, groundwater quality parameters were collected using a Horiba Water Checker U-10. The parameters of pH, temperature, conductivity, dissolved oxygen, and turbidity were measured. Samples were collected after these parameters stabilized as defined by the following:

- The temperature did not vary more than  $\pm 1$  degree Celsius.
- The pH did not vary more than  $\pm 0.1$  units.
- Conductivity did not vary more than  $\pm 5$  percent.

These results are presented in Table 2-3. Samples were collected through the tubing end at the surface by decreasing the pumping rate to less than 100 milliliters per minute. Then the sampler filled sample bottles from the tubing, being careful to minimize sample disturbance. Photographs in Appendix G illustrate the low-stress groundwater sampling set up.

#### **2.2.5.2 Sampling Groundwater Using Bailer Technique**

After collecting the water samples using the low-stress procedure, the pump was removed from the well, and a total depth of the well was measured using the same sounding device used for groundwater level measurements. The casing volume was calculated to determine the proper purge volume. Three casing volumes of water were then removed from the well using a dedicated tri-loc pump in wells HM-120 and HM-127, and a Teflon™ bailer for the remaining wells. After each purge volume was removed, groundwater quality measurements were collected as previously described. When three casing volumes had been removed and the water quality parameters stabilized, samples were collected for analyses of metals and volatile and semivolatile organic compounds according to procedures detailed in the Sampling and Analysis

**TABLE 2-3**  
**Field Parameter Measurements of Low-Stress Collected Samples**  
**NAS Fort Worth Background Study**

Pump Type and Location	Water Level (feet btoc)	Purge Rate (milliliter/minute) / Total Volume Purged (liters)	Maximum Drawdown (feet)	Field Parameter Measurements					Sample Date
				Temp. (° C)	Specific Conductance (mmho/centimeter)	pH	Dissolved Oxygen (milligram/liter)	Turbidity (NTU)	
<b>Peristaltic</b>									
HM-120	4.65	260.0 / 10.4	0.08	19.2	1.660	6.59	1.28	0	8-Dec-96
-127	25.36	275.0 / 9.5	0.01	18.9	0.775	6.81	4.24	2	13-Dec-96
LF03-3D	12.67	275.0 / 9.5	0.01	19.4	1.110	6.79	2.75	0	12-Dec-96
-4A	11.95	145.0 / 9.5	0.35	19.9	0.722	6.83	2.17	0	7-Dec-96
-4B	17.30	225.0 / 12.0	0.08	18.1	0.505	6.71	3.15	0	7-Dec-96
WJETA531	22.86	225.0 / 6.8	0.01	19.3	0.940	6.86	5.93	0	8-Dec-96
USGS01T	11.22	135.0 / 6.8	0.06	20.0	0.827	6.93	2.90	9	9-Dec-96
02T	18.94	240.0 / 8.4	0.01	20.5	0.597	7.25	0.36	0	9-Dec-96
<b>Bladder</b>									
MTAC-001	33.97	700.0 / 34.2	0.11	19.4	1.040	6.66	5.7	0	12-Dec-96
WJETA530	35.74	680.0 / 23.9	0.14	19.6	0.960	6.74	5.55	0	14-Dec-96
534	30.99	780.0 / 32.3	0.03	20.2	0.949	6.69	5.69	0	14-Dec-96
535	34.24	700.0 / 31.5	0.31	20.4	0.918	6.61	4.42	0	14-Dec-96

**Notes:**

- btoc = below top of casing
- mL/min = milliliter per minute
- mg/L = milligrams per liter
- mmho/cm = millimho per centimeter
- NTU = nephelometric turbidity units
- ° C = degrees Celsius

When more than one field parameter measurement was taken (pH, temperature, etc.), the final, stabilized measurement is shown in this table.

Plan (Jacobs 1996b). Field parameter measurements for bailer-collected samples are given in Table 2-4.

### **2.2.6 Surface Water Sampling**

Surface water samples were collected following the procedures in the Sampling and Analysis Plan (Jacobs 1996b). Surface water samples were collected starting at location JEFB001 (Figure 2-1) and working upstream. Samples were collected from the stream bank, or by approaching the sampling location from downstream in situations where the sampler needed to enter the stream. Water was collected in a polypropylene beaker and transferred to the appropriate sample bottles. Additional water was collected to take water quality parameters of pH, temperature, conductivity, dissolved oxygen, and turbidity. Water quality parameter results are recorded on the surface water sampling data sheets presented in Appendix E. Samples were submitted to the laboratory for analyses of metals and volatile and semivolatile organic compounds.

### **2.2.7 Sediment Sampling**

Sediment sampling was performed in accordance with the Sampling and Analysis Plan (Jacobs 1996b), except as noted. Sediment samples were collected using a stainless steel spoon as a dredge. Sediment samples were collected after surface water samples were collected, approximately 8 feet upstream from each surface water sample location. Sediment samples were submitted to the laboratory for analyses of volatile and semivolatile organic compounds and metals. The sediment samples collected are described in detail on the surface water sampling data sheets in Appendix E.

**TABLE 2-4**  
**Field Parameters Measurements for Bailer-Collected Samples**  
**NAS Fort Worth Background Study**

Field Parameter Measurements										
Location	Water Level (feet btoc)	Total Depth (feet btoc)	Casing Volume/ Total Volume Purged (gallons)	Temperature (° C)	Specific Conductance (mmhos/ centimeter)	pH	Dissolved Oxygen (milligrams/ liter)	Turbidity (NTU)	Observations/Comments	Sample Date
HM-120	4.68	17.54	8.4 / 25.2	19.7	1.730	6.82	5.50	370	Light brown, no odor	8-Dec-96
HM-127	25.36	37.83	8.0 / 24.0	19.1	0.720	6.84	4.27	110	Clear, no odor	13-Dec-96
LF03-3D	12.67	17.98	0.9 / 3.0	19.8	1.100	6.83	3.65	>999	Light brown, no odor	12-Dec-96
LF04-4A	11.98	25*	2.2 / 6.6	20.4	0.722	6.95	3.68	>999	Brown, no odor	7-Dec-96
LF04-4B	17.30	25.48	1.3 / 6.0	17.9	0.539	6.97	4.08	>999	Light brown, no odor	7-Dec-96
MTAC-001	33.97	44.63	1.8 / 5.4	19.2	1.040	6.67	5.80	>999	Light brown, no odor	12-Dec-96
WJETA530	35.74	43.76	1.3 / 4.5	19.7	0.950	6.77	5.84	>999	Light brown, no odor, turbidity estimated, samples effervesce	14-Dec-96
WJETA531	22.87	33.78	1.8 / 5.4	19.2	0.940	6.90	5.83	>999	Light brown, no odor	8-Dec-96
WJETA534	30.99	39.73	1.4 / 4.6	20.0	0.961	6.71	7.40	>999	Brown, no odor	14-Dec-96
WJETA535	34.24	43.68	1.5 / 4.5	20.2	0.919	6.65	5.07	730	Gray, no odor	14-Dec-96
USGS01T	11.22	20.01	1.4 / 4.2	20.1	0.807	6.94	2.92	>999	Brown, no odor, replaced cap and lock	9-Dec-96
USGS02T	18.95	30.23	1.8 / 5.6	20.5	0.613	7.25	1.25	>999	Brown, no odor, turbidity meter not operable; estimated	9-Dec-96

**Notes:**

btoc = below top of casing

mmhos = millimhos

° C = degrees Celsius

\* = Estimated total depth information used due to indistinct measurements.  
 When more than one field parameter measurement was taken (pH, temperature, etc.), the final stabilized measurement is shown in this table.

## **2.3 CHEMICAL ANALYSES**

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Samples of soil, groundwater, surface water, and sediment were analyzed to provide data for characterization of background concentrations of selected inorganics at NAS Fort Worth.

### **2.3.1 Metals**

Metals analyses have been included in the background study analytes because some metals releases may have occurred on the installation and metals are naturally occurring in soils. The development of background concentrations will be useful in determining the disposition of areas of concern. Metals included in the background study are presented in Table 2-5.

### **2.3.2 Volatile and Semivolatile Organic Compound Analyses**

Volatile and semivolatile organic compounds are included in the background study analyte list but are not intended to be used in determining background concentrations. Volatiles and semivolatiles organics are included as an indicator for potential impacts on a sample location due to previous site activities. The results of these analyses will be used to determine whether locations are suitable for obtaining background concentrations of metals. Table 2-5 provides a complete list of the analytes for these analyses.



**TABLE 2-5**  
**Background Soils, Groundwater, Surface Water,**  
**and Sediment Analytical Parameters**

**Semivolatile Compounds Analyte List**

<b>Method</b>	<b>Analyte</b>	<b>Method</b>	<b>Analyte</b>
SW8270	1,2,4-Trichlorobenzene	SW8270	Dibenzofuran
	1,2-DCB		Diethyl phthalate
	1,3-DCB		Dimethyl phthalate
	1,4-DCB		Fluoranthene
	2,4-DNT		Fluorene
	2,6-DNT		Hexachlorobenzene
	2-Chloronaphthalene		Hexachlorobutadiene
	2-Methylnaphthalene		Hexachlorocyclopentadiene
	2-Nitroaniline		Hexachloroethane
	3-Nitroaniline		Indeno (1,2,3-cd) pyrene
	3,3'-Dichlorobenzidine		Isophorone
	4-Bromophenyl phenyl ether		n-Nitrosodiphenylamine
	4-Chloroaniline		n-Nitrosodi-n-propylamine
	4-Chlorophenyl phenyl ether		Naphthalene
	4-Nitroaniline		Nitrobenzene
	Acenaphthylene		Phenanthrene
	Acenaphthene		Pyrene
	Anthracene		2,4,5-Trichlorophenol
	Benz (a) anthracene		2,4,6-Trichlorophenol
	Benzo (a) pyrene		2,4-Dichlorophenol
	Benzo (b) fluoranthene		2,4-Dimethylphenol
	Benzo (g,h,i) perylene		2,4-Dinitrophenol
	Benzyl alcohol		2-Chlorophenol
	Bis (2-chloroethoxy) methane		2-Methylphenol
	Bis (2-chloroethyl) ether		2-Nitrophenol
	Bis (2-chloroisopropyl) ether		4,6-Dinitro-2-methylphenol
	Bis (2-ethylhexyl) phthalate		4-Chloro-3-methylphenol
	Butyl benzylphthalate		4-Methylphenol
	Chrysene		4-Nitrophenol
	Di-n-butylphthalate		Benzoic acid
	Di-n-octylphthalate		Pentachlorophenol
	Dibenz (a,h) anthracene		Phenol

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# TAB

Section 3

### 3.0 DATA QUALITY

This section summarizes the quality of analytical data produced by the project. Definitive data were produced through the documented and approved methods described in the Sampling and Analysis Plan (Jacobs 1996b). The data are in the following eight data packages, or sample delivery groups (SDGs), produced by EMAX Laboratories, Torrance, California. The sample locations included in each data package are listed in Appendix A.

96K042	96K047
96K088	96K097
96K120	96L032
96L039	96L051

Cumulatively, the packages listed above consisted of over 100 environmental samples and their associated quality control (QC) samples. The analytical data are compared with the original sampling objectives in Table 3-1. Such a comparison allows a measure of completeness, a fundamental data quality objective (DQO) of the project (greater than [ $>$ ] 90 percent for solid matrices and  $>95$  percent for waters).

The samples were collected at NAS Fort Worth from 8 November to 16 December 1996 and shipped to EMAX Laboratories for the following contaminant analyses (methods):

- VOCs: U.S. Environmental Protection Agency (EPA) method 8240B;
- SVOCs: EPA method 8270A; and
- metals: EPA method 6010A and selected 7000 series.

Data supplied in a combination of hard copy and digital files, which make up the total data package, were compared against the following data validation criteria:

**TABLE 3-1**  
**Summary of Quality Control (QC) Samples Collected**

Medium <sup>1</sup>	Method	Environmental Samples	Field Duplicate	Ambient Blank	Trip Blank	Equipment Blank	Matrix Spike	Matrix Spike Duplicate
S	SW6010	69	8	0	0	0	5	5
S	SW7041	69	8	0	0	0	5	5
S	SW7471	68	8	0	0	0	5	5
S	SW7520	68	8	0	0	0	5	5
S	SW7740	69	8	0	0	0	5	5
S	SW7761	68	8	0	0	0	5	5
S	SW8240	70	8	0	0	0	3	3
S	SW8270	69	8	0	0	0	4	4
W	SW6010	31	4	0	0	14	6	6
W	SW7041	31	4	0	0	14	6	6
W	SW7470	24	3	0	0	12	6	6
W	SW7520	31	4	0	0	14	6	6
W	SW7740	31	4	0	0	14	6	6
W	SW7761	31	4	0	0	14	6	6
W	SW8240	19	3	1	9	14	4	4
W	SW8270	19	3	0	0	14	3	3
TOTALS <sup>2</sup>		767	93	1	9	110	80	80
actual %			12%	50%	1/shipment	14%	10%	10%
DQO (completeness)		note <sup>3</sup>	≥10%	2	1/shipment	≥10%	≥5%	≥5%
SATISFACTORY?		Yes <sup>3</sup>	Yes	Yes <sup>4</sup>	Yes	Yes	Yes	Yes

NOTES: <sup>1</sup>S = soil or sediment; W = surface water or groundwater.  
<sup>2</sup>TOTALS = method and sample combinations per matrix type.  
<sup>3</sup>Data Quality Objectives (DQOs) were based on a comparison of actuals, by medium and method type, with planned totals stated in the Sampling and Analysis Plan (Table 3-1)(Jacobs 1996b).  
<sup>4</sup>See text for explanation of DQO adequacy.

**Accuracy**

calibrations -- initial and continuing;  
surrogates;  
Laboratory Control Samples/Spikes (LCS);  
matrix spikes (MS);  
retention times;  
Relative Response Factors (RRFs);  
Relative Standard Deviation (%RSD);  
blanks (method, ambient, equipment, trip);  
gas chromatograph (GC) confirmation;  
tune criteria (GC/mass spectrometer);  
Internal Standards (GC/MS); and  
interference check standards (Inductively Coupled Plasma [ICP]).

**Precision**

LCS duplicates (LCSD);  
MS duplicates (MSD); and  
field duplicates.

**Representativeness**

sample chain of custody; and  
holding times and preservation.

**Comparability**

standard operating procedures (SOPs); and  
established analytical methods.

**Completeness**

samples (environmental, QC); and  
data packages (forms, runlogs, extraction logs, etc.).

The criteria listed above are derived from the project-specific Sampling and Analysis Plan (Jacobs 1996b) and EPA National Functional Guidelines (EPA 1994a, b).

“Control limits” and “tolerances” generically referenced throughout this section are found in Section 7.0 of the Sampling and Analysis Plan. The validation criteria used for evaluating this package were consistent with EPA Level III quality requirements. Where applicable, the criteria were evaluated with respect to frequency and acceptability of the test measures. The qualifiers used to flag data in the referenced data packages are defined in the Sampling and Analysis Plan. Checklists were completed and compiled with the data package hardcopies to document details of the validation process.

The data quality is categorized and discussed by the type of analytical method. General quality issues are addressed, with references to specific data packages, samples, and analytes as needed. Details of the data validation process are summarized; checklists were used in the validation process to ensure that all applicable criteria were addressed. For the affected sample/analyte records, validation qualifiers are assigned (or “flagged”) in the digital data file within the “Validation Code” field. This method of assignment ensures that subsequent data users are aware of the data’s limitations. Several types of backup quality records are available for further reference, including checklists used for validation, digital data, and the data packages themselves.

All reported data within this package should be considered valid and usable for the NAS Fort Worth project, with the qualifications described in the body of this report, and the specific qualifiers applied within the digital data files.

### **3.1 VOLATILE ORGANIC COMPOUNDS**

The following sections describe the data validation results for VOCs analyzed by EPA methods 5030A/8240B.

### 3.1.1 Accuracy

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Calibrations were performed at the required frequencies and with the required standards for all organic analyses. Initial calibrations were established with five-point curves, with tuning (ion abundance criteria via bromofluorobenzene [BFB]) and continuing calibrations implemented every 12 hours. The initial and continuing calibrations performed were adequate based on percent relative standard deviation and percent recovery values within the tolerances.

In general, LCS values were adequate based on percent recoveries within QC tolerances. The primary reason for unacceptable LCS values was when the percent recovery was above the upper control limit, which causes an estimate qualification ("J") of the related data. LCS samples with recovery limits below the lower acceptable threshold cause rejection of associated nondetected values.

For VOC's vinyl acetate was the only compound with recovery values less than its lower control limit. Four analytical batches (VOL0502, VOL2302, VOL2402, and VOL2802) had low vinyl acetate recoveries in the LCS/LCD analysis. Any non detect value for vinyl acetate in the samples associated with these four batches are 'R' flagged. The laboratory ran two LCS samples (LCS/LCD) with each batch, the AFCEE QAPP only requires one LCS per batch. Vinyl acetate was qualified if either the LCS or the LCD was below QC recovery limits. Two water samples are associated with batch VOL0502 in SDG 96K120, all eleven water samples in SDG 96L032 and three water in SDG 96L039 are associated with batch VOL2302. Thirteen soil samples from SDG 96L039 are associated with batch VOL2402, and twelve water samples from SDG 96L051 are associated with batch VOL2802.

Most surrogate recoveries (also known as system monitoring compounds) were within control limits based on percent recovery values. Surrogate compounds consisted of 1,2 dichloroethane-d4, bromofluorobenzene, and toluene-d8. If a samples had high surrogate recoveries only positive results are 'J' qualified. When a

sample had low surrogate recoveries the non detected values are 'R' qualified along with the 'J' qualified positive results. The laboratory re-analyzed any sample that had low surrogate recoveries. There were three samples that had low bromofluorobenzene recoveries on both analysis. This low BFB recovery can be due to a matrix effect in the sample. Following the validation criteria for inadequate surrogate recoveries, all non detect results are 'R' flagged in the following soil samples ("S" for soil/sediment, "W" for water):

CR-A152101 (S)	CR-A152601 (S)	CR-A153601 (S)
CR-A151901 (S)	CR-A152101 (S)	CR-A152401 (S)
CR-A160701 (W)	CR-A160001 (W)	CR-A152601 (S)
CR-A152901 (S)	CR-A153007 (S)	CR-A153601 (S)
CR-A153501 (S)		

The majority of matrix spike samples, which are used to reflect bias due to matrix effects, were within specified QC tolerances. However, many of the compounds were qualified with "M", signifying matrix effects based on unacceptable percent recovery (accuracy) values. Compounds most commonly exhibiting matrix effects included 2-chloroethyl vinyl ether and vinyl acetate, though several other compounds were flagged as out of tolerance in both solid and water matrices. Individual records are flagged in the digital file and on hardcopy outputs from the digital files.

Internal standards, consisting of bromochloromethane, 1,4-difluorobenzene (DFB), and chlorobenzene-d5 (CBZ) were included at the appropriate frequencies and were within acceptable limits.

Trace levels of various analytes, especially methylene chloride (a common laboratory contaminant), were detected in blank samples, but were typically below their respective PQLs. All environmental samples associated with blank contamination were qualified accordingly ("B") in the validation qualifier field, except where higher

priority qualifiers were assigned, for example "F." An assignment of "F" indicates that the analyte of concern was between the method detection limit (MDL) and the practical quantitation limit (PQL). Laboratory, equipment, trip, and ambient blanks were analyzed and are discussed below.

### **3.1.2 Precision**

Precision results were determined by LCS/LCSD, MS/MSD and field duplicate values, where all input values are calculated and compared against relative percent difference (RPD) tolerances. Compounds outside of LCS/LCSD control limits were qualified as "J" (estimated), whereas those outside the MS/MSD limits were qualified as "M" (estimated value due to matrix effects on measurement of the compound). No compounds outside the RPD limits for field duplicates were noted.

### **3.1.3 Representativeness**

Chain of custody was intact for all samples based on completed custody forms and tamper seals on shipping containers. Preservation and analysis were satisfactory with respect to required holding times. Sample locations were in accordance with the project-specific Sampling and Analysis Plan and associated standard operating procedures (Jacobs 1996b). Therefore, samples are representative of the media and locations described in the Sampling and Analysis Plan.

### **3.1.4 Completeness**

Based on the data rejected due to LCS and surrogate results below lower control limits (all nondetects), the data set completeness for VOCs in water media is 98 percent and for soil and sediments it is 96 percent complete.

Although one ambient blank QC sample was collected where two were planned, the disparity does not affect data use. Equipment rinsate blanks may also be used to

imply cross-contamination at ambient conditions. All samples affected by blank contamination were qualified with a "B", as discussed in Section 3.1.1. No detrimental trends were noted with respect to potential cross-contamination between equipment and samples.

Quality records produced from this analytical method are in the data packages (the SDGs) and provide adequate documentation for the validation process described. The records are complete with respect to the validation criteria.

### **3.1.5 Sensitivity**

Reporting limits were at or below the required PQLs listed in the project-specific Sampling and Analysis Plan (Jacobs 1996b), except for total xylenes. The requirement in the Sampling and Analysis Plan is 5 parts per billion (ppb), whereas laboratory PQLs list 5 ppb for o-Xylene and 10 ppb for m/p-Xylenes. Detection limits are a function of the moisture content of soils and sediments. Detection limits can also be raised because of sample dilution.

## **3.2 SEMIVOLATILE ORGANIC COMPOUNDS**

The following section discusses data validation of SVOCs by EPA method 3520B/8270B.

### **3.2.1 Accuracy**

Calibrations were performed at the required frequencies and with the required standards for all organic analyses. Initial calibrations were established with five-point curves, with tuning (ion abundance criteria via decafluorotriphenylphosphine [DFTPP]) and continuing calibrations implemented every 12 hours. The initial and continuing calibrations performed were adequate based on percent relative standard deviation and percent recovery values within the tolerances.

In general, LCS values were adequate based on percent recoveries within QC tolerances. LCS samples were spiked with all SVOC analytes of interest. The primary reason for unacceptable LCS values was when the percent recovery was above the upper control limit, which causes an estimate ("J") qualification of the related data. Those LCS samples with recovery limits below the lower acceptable threshold cause rejection of associated nondetect values. For SVOCs, the following compounds in the associated environmental samples (i.e., in the same SDG) were rejected (qualified with "R"):

Benzoic acid	96K120, 96K088, 96K097, 96K047, 96K042, 96L051
Hexachlorocyclopentadiene	same as above
Nitrobenzene	96K120
2-Chloronaphthalene	96K042

Most surrogate recoveries were within control limits based on percent recovery values. Surrogate compounds consisted of 2,4,6-tribromophenol, 2-fluorobiphenyl, 2-fluorophenol, nitrobenzene-d5, phenol-d5, and terphenyl-d14. Based on inadequate recovery of at least one of the above-listed surrogates (i.e., surrogate recovery below the lower control limit), nondetected compounds within sample CR-A160206 (water) are rejected.

The majority of matrix spike samples, which are used to reflect bias due to matrix effects, were within specified QC tolerances. However, some of the compounds were qualified with "M", signifying some matrix effects based on relative percent difference (precision) values. A variety of semivolatile organic compounds exhibit matrix effects in both solid and liquid media. Individual records are flagged in the digital file and on hardcopy outputs from the digital files. MS samples were spiked with all SVOC analytes of interest.

Internal standards, consisting of 1,4-dichlorobenzene-d4, naphthalene-d8, acenaphthene-d10, phenanthrene-d10, chrysene-d12, and perylene-d12 were included at the appropriate frequencies (every sample) and were within acceptable limits.

Various phthalates were detected in several blank samples, but were typically below or only slightly above their respective PQLs. Note that phthalates are typically characterized as common laboratory contaminants, and would not be considered "real" contaminant detections unless real sample values exceeded 10 times that concentration in the blank. All real samples associated with blank contamination were qualified accordingly ("B") in the Validation Qualifier field, except where higher priority qualifiers were applied instead of "B" (such as "F", which indicates that the analyte of concern was between the MDL and the PQL).

### 3.2.2 Precision

Precision results were determined by LCS/LCSD, MS/MS, and field duplicate values, where all input values are calculated and compared against relative percent difference (RPD) tolerances. Compounds outside the LCS/LCSD control limits were qualified as "J" (estimated), whereas those outside of MS/MSD limits were qualified as "M" (estimated value due to matrix effects on measurement of the compound). No compounds outside the RPD limits for field duplicates were noted.

### 3.2.3 Representativeness

Chain of custody was maintained for all samples based on completed custody forms and tamper seals on shipping containers. Preservation and analysis were satisfactory with respect to required holding times. Sample locations were in accordance with the project-specific Sampling and Analysis Plan and associated standard operating procedures (Jacobs 1996b). Therefore, samples are representative of the media and locations described in the Sampling and Analysis Plan.

### 3.2.4 Completeness

Based on estimates of the data rejected due to LCS and surrogate recoveries below lower control limits (all nondetects), the data set completeness for SVOCs in water media is approximately 90 percent and for soil and sediments, it is approximately 95 percent. The completeness percentage for water media is slightly below the project's DQO of  $\geq 95$  percent, but should not affect the conclusions given the preponderance of nondetects in the remainder of the data set.

Quality records produced from this analytical method(s) are in the data package, and provide adequate documentation for the validation process. The records are complete with respect to the validation criteria.

### 3.2.5 Sensitivity

Reporting limits were at or below the required PQLs listed in the project-specific Sampling and Analysis Plan (Jacobs 1996b). High moisture contents in soils or sediments can raise detection limits, as can elevated dilution factors.

## 3.3 METALS

The metals addressed in this section include the general suite of metals analyzed by the EPA method 6010A (ICP), a 6010A Trace method for lower detection limits of selected metals, and metals analyzed through the Gas Furnace Atomic Absorption (GFAA) technique: 7041 (antimony), 7471 (mercury), 7520 (nickel), 7740 (selenium), and 7760 (silver). These techniques are typically used instead of the 6010A method to achieve lower detection limits for the metals of interest.

### 3.3.1 Accuracy

Based on the standard calibration records and Analysis Run Logs, initial and continuing calibrations were performed at satisfactory frequencies and with acceptable results.

In general, LCS values were adequate based on percent recoveries within QC tolerances (80 to 120 percent). The primary reason for unacceptable LCS values was percent recovery above the upper control limit, which only causes an estimate ("J") qualification of the related data. Those LCS samples with recovery limits below the lower acceptable threshold caused rejection of associated nondetect values (12 lead results in SDG 96L051).

MS samples, which are used to reflect bias due to matrix effects, were also within the same specified QC tolerances. Several RPD values that were out-of-control (i.e., exceeding the blank acceptance criteria) were with samples containing significantly more of the analyte(s) than the spiked amount (environmental sample concentration greater than four times the spike concentration).

Interference check standards (ICS) were performed at appropriate frequencies, at the beginning and end of each analytical sequence, and were within acceptable limits.

Trace levels of various metals were detected in blank samples, but were typically below their respective PQLs. All real samples associated with blank contamination were qualified accordingly ("B") in the Validation Qualifier field, except where higher priority qualifiers were applied instead of "B" (such as "F", which indicates that the analyte of concern was between the MDL and the PQL). The most frequent metal exceeding PQLs in blank samples was sodium.

Serial dilutions were performed and, where results were unacceptable, post-analysis spikes were performed. The following elements, with their associated data packages,

were considered estimates (qualified "J") as a result of both serial dilutions and post-analysis spikes being out of control:

calcium, iron (soils only)—96K042;  
calcium, iron (soils only)—96K047; and  
calcium, lead (soils only)—96K097.

### 3.3.2 Precision

Precision results were determined by LCS/LCSD, MS/MS and field duplicate values, where all input values are calculated and compared against relative percent difference (RPD) tolerances. Compounds outside of LCS/LCSD control limits were qualified as "J" (estimated), whereas those outside of MS/MSD limits were qualified as "M" (estimated value due to matrix effects on measurement of the compound). Compounds outside the RPD limits for field duplicates are qualified as estimates ("J") for detects, but nondetects are rejected (qualified with "R").

### 3.3.3 Representativeness

Chain of custody was maintained for all samples based on completed custody forms and tamper seals on shipping containers. Preservation and analyses were satisfactory with respect to required holding times. Sample locations were in accordance with the project-specific Sampling and Analysis Plan and associated standard operating procedures (Jacobs 1996b). Therefore, samples are, representative of the media and locations described in the Sampling and Analysis Plan.

### 3.3.4 Completeness

Based on estimates of the data rejected due to LCS and precision measurements (field duplicate relative percent difference values) exceeding control limits (all nondetects), the data set completeness for metals in water media is approximately 96 percent and

for soil and sediments approximately 96 percent. These completeness percentages comply with the project's DQOs of  $\geq 95$  percent and  $\geq 90$  percent for waters and soil and sediments, respectively.

Quality records produced from the stated analytical method (s) are contained within the data package, and provide adequate documentation for the validation process described herein. The records are complete with respect to the said validation criteria.

### 3.3.5 Sensitivity

PQLs reported by the laboratory were acceptable for all water analyses, based on comparisons of laboratory values with the Sampling and Analysis Plan (Jacobs 1996b). For soils analyzed by EPA method 6010, several elements exceeded the required PQLs by less than 2 milligrams per kilogram. Other metals showed slightly higher PQL exceedances, including aluminum, magnesium, sodium, thallium, and potassium. MDLs were also reported for all results, and sensitivity of the MDLs typically ranges to an order of magnitude better resolution than the PQLs.

PQLs for those analytes determined through the EPA 7000 series of tests were the same or better than those required PQLs stated in the SAP (Jacobs 1996b). Arsenic, cadmium, and lead were not analyzed by their respective 7000 series methods, but met quantitation requirements through EPA method 6010A Trace method instead.

# TAB

Section 4

#### 4.0 BACKGROUND CHARACTERIZATION

To assess whether site activities at NAS Fort Worth have affected the concentrations of inorganic constituents in site groundwater, surface water, sediment, and soils, it is necessary to compare the concentrations of inorganic constituents in site media with their concentrations in background samples. The TI method was used to estimate reasonable background concentrations. According to the TI method (EPA 1989, 1992), the concentration of a given constituent in a given media is expressed as an appropriate UTL of the distribution of the constituent in the background data population. A UTL is generally expressed in terms of confidence and coverage levels, so that it can be said with a specified level of confidence that the UTL indicates the concentration of the constituent below which a specified proportion of the background data distribution will occur. Thus, a UTL with 95 percent confidence and 95 percent coverage (UTL<sub>95,95</sub>) is the value that we can say, with 95 percent confidence, will exceed 95 percent of the background data. Any site value greater than the UTL has only a 5 percent probability of being drawn from the background data population, and thus may indicate the presence of site-related constituents.

UTLs (and other statistical properties) were determined for a total of 24 inorganic constituents in each of six background populations. The populations consisted of surface and subsurface soil; groundwater sampled via a low-stress technique (to approximate filtered samples), groundwater sampled with a bailer (unfiltered samples), surface water, and sediment within the surface water drainages.

A total of 30 surface soil, 30 subsurface soil, 12 groundwater samples (one low-stress and one bailer sample per well), 8 surface water, and 8 stream sediment samples were collected to characterize these media for background concentrations.

#### 4.1 STATISTICAL PARAMETERS OF BACKGROUND DATA SETS

The following statistical parameters are to be defined for each constituent:

- Frequency of Detection – The frequency of detection is reported.
- Range – Minimum and maximum observed values are reported.
- Mean – The arithmetic mean is reported.
- Standard Deviation – The sample standard deviation is reported.
- Upper Tolerance Limit (UTL) – The UTL 95 percent confidence, 95 percent coverage value (UTL<sub>95,95</sub>) is reported.
- Outlier Identification – Potential outlier values are identified but not removed from the data set unless rejected by the data validation process.

The statistical analyses applied were drawn from the following references:

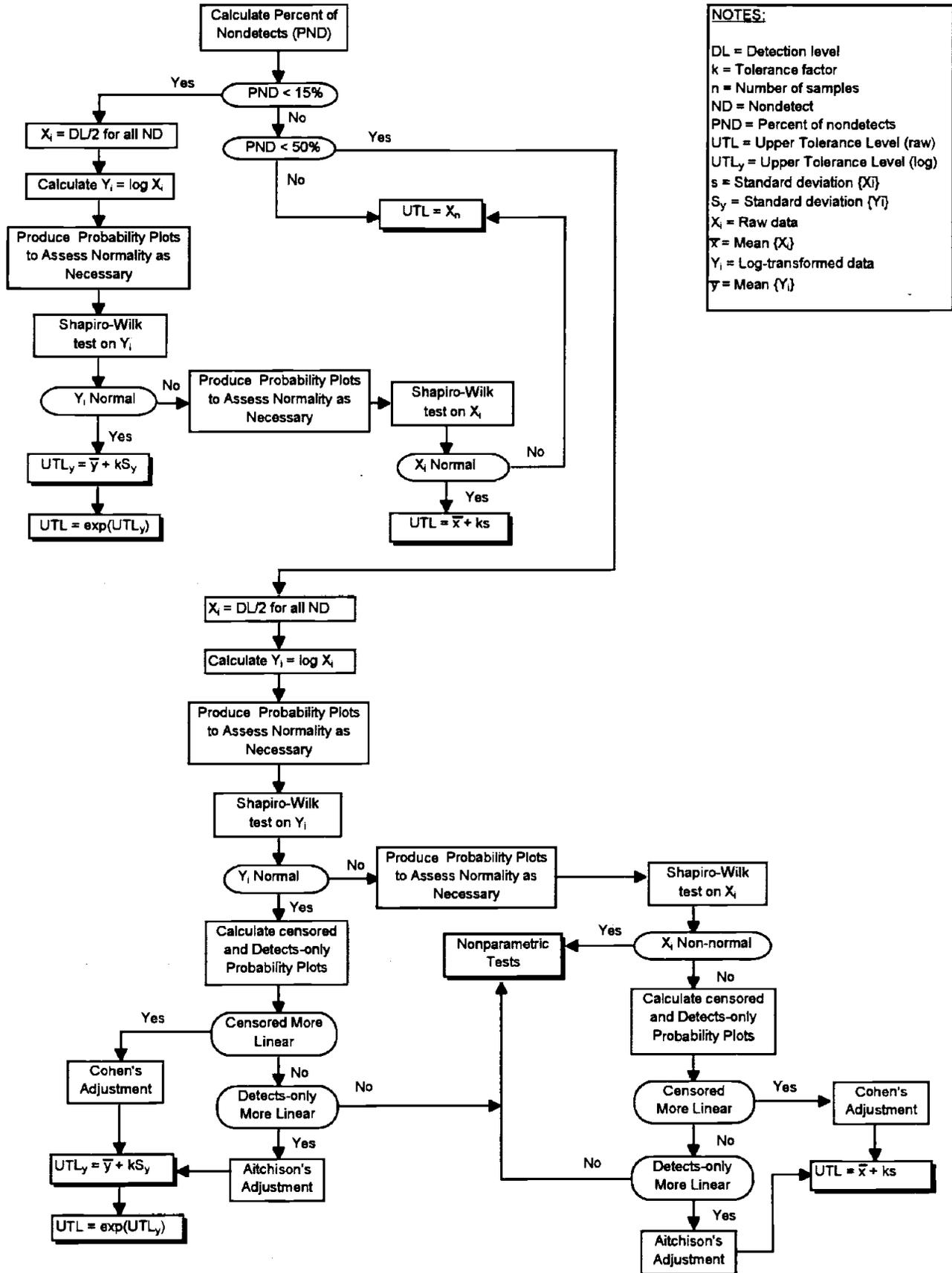
- *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities: Interim Final Guidance*. (EPA 1989); and
- *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities: Addendum to Interim Final Guidance* (EPA 1992).

#### 4.2 PROCEDURES

The data for a given constituent were analyzed according to the procedure outlined in Figure 4-1. The frequency of nondetects in the data set was calculated first. Unless the frequency of nondetects exceeded 50 percent, lognormality and normality of the data set were tested using graphical and formal calculation tests. Various statistical parameters were then calculated using formulas appropriate for the apparent distribution of the data set. In particular the UTL<sub>95,95</sub> was calculated as the value that we can say, with 95 percent confidence, will exceed 95 percent of the background data. If the frequency of nondetects exceeded 50 percent, or the distribution of the data set could not be demonstrated to be either normal or lognormal, then nonparametric estimates of the UTL were determined (typically the highest value in the data set). If the frequency of nondetects was between 15 and 50 percent,

**FIGURE 4-1.**  
**Naval Air Station Fort Worth Background Study**  
**Flowchart of Data Analyses**

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**NOTES:**  
 DL = Detection level  
 k = Tolerance factor  
 n = Number of samples  
 ND = Nondetect  
 PND = Percent of nondetects  
 UTL = Upper Tolerance Level (raw)  
 UTL<sub>y</sub> = Upper Tolerance Level (log)  
 s = Standard deviation {X<sub>i</sub>}  
 S<sub>y</sub> = Standard deviation {Y<sub>i</sub>}  
 X<sub>i</sub> = Raw data  
 $\bar{x}$  = Mean {X<sub>i</sub>}  
 Y<sub>i</sub> = Log-transformed data  
 $\bar{y}$  = Mean {Y<sub>i</sub>}

appropriate adjustments to the calculated statistical parameters were used to account for the nondetects. For groundwater, a criteria of 17 percent as the minimum percentage of nondetects rather than the 15 percent recommended in the references was used based on the small sample size of 12 where each sample represents 8.33 percent of the total. This change allowed for analytes with only one or two nondetects out of 12 analyses to be handled by the simple substitution of one-half the detection limit and the subsequent calculation of a  $UTL_{95,95}$ .

The following sections discuss in greater detail the methods used to calculate UTLs and other statistical properties of background data sets.

#### 4.2.1 Nondetects

Nondetected analytes are those with concentrations less the detection limit. The detection limit in the laboratory results is the Method Detection Limit (MDL) adjusted for sample specific variables like percent moisture and dilution (and known variously as the "Laboratory Detection Limit", or "Sample Quantitation Limit"). Values above the Practical Quantitation Limit (PQL) are detects, and values between the MDL and the PQL are estimated and given a "J" flag.

Data that were reported at less than a detection level (i.e., nondetects) were treated differently depending on the frequency of nondetects. If the frequency of nondetects was less than 15 percent (17 percent for groundwater), the nondetects were replaced by one-half of the analytical method detection limit (EPA 1989, 1992), statistics were calculated, and statistical tests conducted using the data set with these replacement values. If the frequency of nondetects exceeded 50 percent, but was less than 100 percent, the nonparametric UTL was selected as the highest value in the data set (EPA 1989, 1992). In cases where the highest value was identified as a potential outlier, the second highest value was chosen as the UTL. If the frequency of nondetects was 100 percent, then the UTL was designated as the nondetect with the highest detection limit.

If the frequency of nondetects was between 15 and 50 percent, then the calculated statistics were adjusted for the presence of nondetects. Two adjustments are possible, depending on whether it appeared that the nondetects more likely represent zero values (i.e., the constituent is not present in the sample), or represent the presence of the constituent but at values less than the detection level. These adjustments are discussed further in Section 4.2.4.

#### 4.2.2 Normality

The calculation of statistical parameters, and in particular the UTL, is affected significantly by the population distribution of the data set. Both formal and graphical statistical tests have been applied to assess normality. The general process is outlined in Figure 4-1.

To assess the population distribution of the data sets, each set was first addressed using a formal test for normality. Probability plots of the raw and log-transformed data were generated for some analytes to provide a graphical indication of whether the data distribution was normal or lognormal.

For the calculated statistical test of normality, it was first assumed that the data were lognormally distributed (EPA 1989, 1992). This assumption is based on the observation that environmental data are commonly distributed lognormally (i.e., logarithms of the observed data are distributed normally). This may be because environmental data are bounded by zero (i.e., negative constituent concentrations are not possible), so the data sets are often skewed to the right, which is characteristic of a lognormal distribution. Consequently, logarithms of the data were calculated before the tests for normality were performed.

Let  $x_i$  represent the raw data, and let  $y_i = \ln(x_i)$ , where  $\ln$  is the natural or Napierian logarithm. Let  $n$  be the statistical sample size (i.e., the number of data in the data set). If  $n \leq 50$ , then normality of the distribution of  $y_i$  was tested by the Shapiro-Wilk test

(EPA 1989, 1992). If  $n \geq 50$ , then the alternate Shapiro-Francia test was applied (EPA 1992). In each case for the NAS Forth Worth AFB background groundwater data sets, the statistical sample size  $n$  was less than 50, and the Shapiro-Wilk test of normality was applied.

The Shapiro-Wilk test is described in EPA (1992). To test for normality of the data, a test statistic  $W$  is calculated as:

$$W = \left[ \frac{b}{s\sqrt{n-1}} \right]^2$$

where:

$$b = \sum_{i=1}^k a_{n-i+1} (x_{(n-i+1)} - x_{(i)}) = \sum_{i=1}^k b_i$$

and  $x_i$  is the  $i$ th smallest ordered value;

$a_i$  is a coefficient dependent on the sample size ( $n$ );

$s$  is the standard deviation;

$n$  is the number of samples; and

$k$  is the greatest integer less than or equal to  $\frac{n}{2}$

The null hypothesis of normality of the logs of the data was rejected if  $W$  was less than the appropriate critical value (dependent on  $n$ ) (Appendix A, EPA 1992). If normality of the natural logs of the data was rejected, the test was repeated using the raw data  $x_i$  and the standard deviation  $s$  of the raw data. If the null hypothesis of normality was also rejected for the raw data, then probability plots of the raw and log-transformed data were examined to determine whether the data distribution was more nearly normal or lognormal. When a reasonable choice between normality and lognormality could still not be made, then a nonparametric test is recommended to compare site data with background data, rather than comparing site data to a background a single UTL.

### 4.2.3 Statistical Parameters

The following statistical parameters were calculated:

- frequency of detection;
- range;
- mean;
- standard deviation;
- UTL; and
- potential outlier statistic.

The calculation of these various parameters depends in part on whether the data set has been judged to be normally or lognormally distributed.

The frequency of detection is a simple ratio of the number of values greater than the MDL to the total number of samples in the data set. The range of the background data set for a given constituent is reported as the minimum and maximum observed values in the data set. These values do not depend on the shape of the distribution.

The mean  $\bar{x}$  was calculated as the arithmetic mean of the data set

$$\bar{x} = (\sum_i x_i) / n.$$

The standard deviation  $s$  was calculated as the sample standard deviation of the data set

$$s = \{[n \sum_i x_i^2 - (\sum_i x_i)^2] / [n(n-1)]\}^{1/2}.$$

The UTL<sub>95,95</sub> was calculated as

$$\text{UTL}_{95,95} = \bar{x} + k s.$$

where  $k$  is the tolerance factor for a one-sided normal (or lognormal) tolerance interval with a minimum of 95 percent coverage, a 95 percent probability, and  $n$  background observations.

For distributions that were determined to be lognormal rather than normal, the UTL was calculated in the same fashion except that  $\bar{x}$  was replaced by  $\bar{y}$  (the mean of the logarithms of the  $x_i$ ) and  $s$  was replaced by  $S_y$  (the standard deviation of the logarithms of the  $x_i$ ). The resultant value of the UTL (designated UTLY) is the UTL of the log-transformed data. The UTL for the raw data was then calculated as the exponential function of the UTLY of the log-transformed data; i.e.,  $UTL = \exp(UTLY)$ .

#### 4.2.4 Adjustment for Nondetects

If the frequency of nondetects for a given data set was between 15 (17 for groundwater) and 50 percent, appropriate adjustments to the calculated statistical parameters were used to account for the nondetects. Either Cohen's adjustment or Aitchison's adjustment was used, as outlined in EPA (1992) and excerpted below:

Cohen's adjustment ... assumes that all the data (detects and nondetects) come from the same Normal or Lognormal population, but that nondetect values have been "censored" at their detection limits. This implies that the [constituent] of concern is present in nondetect samples, but the analytical equipment is not sensitive to concentrations lower than the detection limit. Aitchison's adjustment ... is constructed on the assumption that nondetect samples are free of contamination, so that all nondetects may be regarded as zero concentrations...

To decide which approach is more appropriate ..., two separate Probability Plots can be constructed. In [the first] method, the combined set of detects and nondetects is ordered (with nondetects being

given arbitrary but distinct ranks). ...Normal quantiles ... are then computed for the data set ... However, only the detected values and their associated Normal quantiles are actually plotted. If the shape of the Censored Probability Plot is reasonably linear, then Cohen's assumption that nondetects have been "censored" at their detection limit is probably acceptable ... If the Censored Probability Plot has significant bends and curves ..., one might consider Aitchison's procedure instead.

To test the assumptions of Aitchison's method, a Detects-Only Probability Plot may be constructed. [N]ondetects are completely ignored and a standard Probability Plot is constructed using only the detected measurements. ... Thus, ... Normal quantiles are computed only for the ordered detected values. ... If the Detects-Only Probability Plot is reasonably linear, then the assumptions underlying Aitchison's adjustment (i.e., that "nondetects" represent zero concentrations ...) are probably reasonable.

Cohen's Adjustment. If it was determined that Cohen's adjustment was appropriate, the sample mean  $\bar{x}_d$  and sample variance  $s_d^2$  for only the data greater than the detection limit were first calculated. Then two parameters  $h$  and  $\gamma$  were computed as

$$h = (n - l)/n$$

and

$$\gamma = s_d^2 / (\bar{x}_d - MDL)^2,$$

where  $l$  is the number of observations greater than the detection level, and  $MDL$  is the method detection limit. Based on the values of  $h$  and  $\gamma$ , a value  $\lambda$  was determined from a table in Appendix B of EPA (1989), and corrected values of the mean  $\bar{x}$  and standard deviation  $s$  were calculated by

$$\bar{x} = \bar{x}_d - \lambda (\bar{x}_d - MDL)$$

and

$$s = [s_d^2 + \lambda (\bar{x}_d - MDL)^2]^{1/2}.$$

If the distribution appeared to be lognormal rather than normal, the adjustment was made using the mean and standard deviation of the logarithms of the detected values, rather than  $\bar{x}_d$  and  $s_d^2$ .

Aitchison's Adjustment. If it was determined that Aitchison's adjustment is appropriate, the sample mean  $\bar{x}_d$  and sample variance  $s_d^2$  for only the data greater than the method detection limit were first calculated. Let  $d = n - l$  be the number of nondetects. Then the adjusted mean  $\bar{x}$  and standard deviation  $s$  are given by

$$\bar{x} = (1 - d/n) \bar{x}_d$$

and

$$s = \{[n - (d + 1)] s_d^2 / (n - 1) + [d(n - d) \bar{x}_d^2] / [n(n - 1)]\}^{1/2}.$$

If the distribution appeared to be lognormal rather than normal, then the adjustment was made using the mean and standard deviation of the logarithms of the detected values, rather than  $\bar{x}_d$  and  $s_d^2$ .

#### 4.2.5 Outlier Identification

The highest value ( $x_n$ ) in each data set with a frequency of detection greater than 50 percent was subjected to a formal test as an outlier (EPA 1989). The mean  $\bar{x}$  and standard deviation  $s$  of the entire data set were first calculated. A test statistic  $T_n$  was then calculated

$$T_n = (x_n - \bar{x})/s.$$

$T_n$  was then compared to a critical value (dependent on  $n$ ) (Appendix B, EPA 1989). If  $T_n$  was greater than the tabulated critical value, this provided evidence that  $x_n$  was a statistical outlier and not truly a member of the background data set. However,  $x_n$  was not rejected, modified, or otherwise excluded from the data set solely on this basis. Only if the data validation process or other review of the data indicated some problem with the datum (such as a transcription error or failure to account for dilution) was any change made to the data set. The test for outliers merely identified those data that might be outliers and for which additional data review was warranted.

### 4.3 BACKGROUND CONCENTRATIONS

Results of the background study, including percent of samples below the detection limit, number of detects, minimum, maximum, mean, standard deviation, UTL, and outlier identification, are listed in Tables 4-1 through 4-6. Additionally, the tables identify the results of the Shapiro-Wilk test for normality, indicating the sample-size dependent critical value ( $W_{(crit)}$ ) and the calculated test result for the log-transformed ( $W_{(log)}$ ), and untransformed ( $W_{(raw)}$ ) data. The following sections briefly explain the process by which background values were calculated for each media based on the Figure 4-1 flowchart for each analyte.

#### 4.3.1 Soils

The Horizon A and Horizon B soils were evaluated separately.

##### 4.3.1.1 Horizon A Soils

The following paragraphs briefly describe the process used to calculate each UTL. The analytes are grouped according to how the UTL was derived, based on the frequency of detection and the distribution of the data.

**TABLE 4-1**  
**Summary of Background Values for Surface Soil**  
**Naval Air Station Fort Worth**

Analyte	% Non-detects	Detects / Total	W (crit)	W (log)	W (raw)	Min	Max	Mean	Standard Deviation	UTL <sub>95,95</sub>	Outlier?
Aluminum	0.0%	30 / 30	0.927	0.896 Reject	0.960 Accept	1790	19900	10775	5072	22035	No
Antimony	80.0%	6 / 30	-----	-----	-----	< 0.215	0.56	nc	nc	0.56	-----
Arsenic	0.0%	30 / 30	0.927	0.851 Reject	0.959 Accept	1.23	5.88	3.50	1.06	5.85	No
Barium	0.0%	30 / 30	0.927	0.810 Reject	0.281 Reject	24.9	1980	145.3	349.3	233	Yes
Beryllium	0.0%	30 / 30	0.927	0.808 Reject	0.911 Reject	0.164	1.02	0.655	0.243	1.02	No
Calcium	0.0%	30 / 30	0.927	0.969 Accept	0.687 Reject	418	11000	20991	28270	167788	No
Cadmium	6.7%	28 / 30	0.927	0.928 Accept	0.809 Reject	0.054	0.625	0.212	0.112	0.566	No
Chromium	0.0%	30 / 30	0.927	0.952 Accept	0.965 Accept	5.06	20.1	11.73	4.20	25.86	No
Cobalt	0.0%	30 / 30	0.927	0.961 Accept	0.953 Accept	1.54	10.2	4.75	1.85	11.05	No
Copper	0.0%	30 / 30	0.927	0.909 Reject	0.964 Accept	4.44	16.7	10.77	2.97	17.37	No
Iron	0.0%	30 / 30	0.927	0.879 Reject	0.946 Accept	3460	15500	10199	3386	17717	No
Lead	0.0%	30 / 30	0.927	0.927 Reject	0.750 Reject	6.08	40.5	14.59	6.63	30.97	Yes
Magnesium	0.0%	30 / 30	0.927	0.830 Reject	0.968 Accept	112	2830	1369	736	3003	No
Manganese	0.0%	30 / 30	0.927	0.923 Reject	0.624 Reject	132	1420	337	238	849	Yes
Mercury	93.3%	2 / 30	-----	-----	-----	< 0.031	0.14	nc	nc	0.14	-----
Molybdenum	80.0%	6 / 30	-----	-----	-----	< 0.657	1.460	nc	nc	1.460	-----
Nickel	0.0%	30 / 30	0.927	0.856 Reject	0.918 Reject	3.74	14.6	9.75	3.28	14.6	No
Potassium	0.0%	30 / 30	0.927	0.963 Accept	0.950 Accept	434	2790	1253	489	2895	No
Selenium	40.0%	18 / 30	0.927	0.857 Reject	0.840 Reject	0.059	0.637	0.212	0.161	0.907	No
Silver	3.3%	29 / 30	0.927	0.918 Reject	0.821 Reject	< 0.025	0.213	0.070	0.035	0.213	No
Sodium	3.3%	29 / 30	0.927	0.723 Reject	0.467 Reject	< 2.57	37300	3482	8904	37300	No
Thallium	73.3%	8 / 30	-----	-----	-----	< 1.10	2.43	nc	nc	2.43	-----
Vanadium	0.0%	30 / 30	0.927	0.884 Reject	0.966 Accept	5.82	48.5	23.89	10.08	46.3	No
Zinc	0.0%	30 / 30	0.927	0.819 Reject	0.488 Reject	13.3	124	29.3	19.0	38.8	Yes

**Notes:**  
 All units are in milligrams per kilogram (mg/kg).

----- = not applicable  
 nc = not calculated  
 ND = not detected

UTL<sub>95,95</sub> = Upper Tolerance Level (95% confidence and 95% coverage)  
 Outlier? = Result of test to determine if the maximum value is a potential outlier.  
 W (crit) = Shapiro-Wilk critical value  
 W (log) = calculated W using log-transformed data and result when compared to W (crit)  
 W (raw) = calculated W using raw data and result when compared to W (crit)

TABLE 4-2  
Summary of Background Values for Subsurface Soil  
Naval Air Station Fort Worth

Analyte	% Non-detects	Detects / Total	W (crit)	W (log)	W (raw)	Minimum	Maximum	Mean	Standard Deviation	UTL <sub>95,ss</sub>	Outlier?
Aluminum	0.0%	30 / 30	0.927	0.960 Accept	0.955 Accept	3780	17700	9905	3277	20260	No
Antimony	80.0%	6 / 30	-----	-----	-----	< 0.21	0.712	nc	nc	0.712	-----
Arsenic	0.0%	30 / 30	0.927	0.963 Accept	0.942 Accept	1.42	5.31	3.03	1.13	6.58	No
Barium	0.0%	30 / 30	0.927	0.922 Reject	0.974 Accept	16.4	127	65.8	28.0	128.1	No
Beryllium	0.0%	30 / 30	0.927	0.966 Accept	0.969 Accept	0.208	1.07	0.56	0.18	1.13	No
Calcium	0.0%	30 / 30	0.927	0.733 Reject	0.853 Reject	751	347000	91395	76216	272000	Yes
Cadmium	33.3%	20 / 30	0.927	0.829 Reject	0.390 Reject	0.055	1.48	0.18	0.25	0.59	Yes
Chromium	0.0%	30 / 30	0.927	0.937 Accept	0.847 Reject	5.77	17.90	9.49	2.77	16.31	No
Cobalt	10.0%	27 / 30	0.927	0.762 Reject	0.954 Accept	0.4395	5.5	3.18	1.36	6.19	No
Copper	0.0%	30 / 30	0.927	0.848 Reject	0.952 Accept	2.61	13.30	8.12	2.52	13.72	No
Iron	0.0%	30 / 30	0.927	0.936 Accept	0.941 Accept	3840	16900	9185	2720	17469	No
Lead	6.7%	28 / 30	0.927	0.746 Reject	0.949 Accept	0.073	14.3	5.28	3.33	12.66	No
Magnesium	0.0%	30 / 30	0.927	0.697 Reject	0.843 Reject	292	2420	1569	582	2420	No
Manganese	0.0%	30 / 30	0.927	0.904 Reject	0.964 Accept	28.7	317	169.6	82.0	351.7	No
Mercury	100.0%	0 / 30	-----	-----	-----	< 0.03	< 0.035	nc	nc	ND at 0.035	-----
Molybdenum	80.0%	6 / 30	-----	-----	-----	< 0.638	1.930	nc	nc	1.93	-----
Nickel	0.0%	30 / 30	0.927	0.959 Accept	0.837 Reject	4.17	22.1	9.17	3.86	19.76	No
Potassium	0.0%	30 / 30	0.927	0.909 Reject	0.977 Accept	271	1900	1000	323	1717	No
Selenium	80.0%	6 / 30	-----	-----	-----	< 0.12	0.3130	nc	nc	0.313	-----
Silver	33.3%	20 / 30	0.927	0.862 Reject	0.847 Reject	< 0.021	0.0928	0.035	0.027	0.128	No
Sodium	10.0%	27 / 30	0.927	0.898 Reject	0.426 Reject	1.1	53200	4225	11762	53200	No
Thallium	76.7%	7 / 30	-----	-----	-----	< 1.09	1.5	nc	nc	1.5	-----
Vanadium	0.0%	30 / 30	0.927	0.980 Accept	0.926 Reject	9.7	37.8	20.3	6.2	37.4	No
Zinc	0.0%	30 / 30	0.927	0.851 Reject	0.963 Accept	5.9	31	18.7	5.7	31.3	No

Notes:

All units are in milligrams per kilogram (mg/kg).

----- = not applicable

nc = not calculated

ND = not detected

UTL<sub>95,95</sub> = Upper Tolerance Level (95% confidence and 95% coverage)

Outlier? = Result of test to determine if the maximum value is a potential outlier.

W (crit) = Shapiro-Wilk critical value

W (log) = calculated W using log-transformed data and result when compared to W (crit)

W (raw) = calculated W using raw data and result when compared to W (crit)

**TABLE 4-3**  
**Summary of Background Values for Low-Stress Groundwater Samples**  
**Naval Air Station Fort Worth**

Analyte	% Non-defects	Detects / Total	W (crit)	W (log)	W (raw)	Minimum	Maximum	Mean	Standard Deviation	UTL <sub>95,95</sub>	Outlier?
Aluminum	25.0%	9 / 12	0.859	0.930 Accept	0.505 Reject	0.052	0.472	0.075	0.191	1.332	No
Antimony	100.0%	0 / 12	---	---	---	< 0.002	< 0.002	nc	nc	ND at 0.002	---
Arsenic	100.0%	0 / 12	0.859	---	---	< 0.0049	< 0.0049	nc	nc	ND at 0.0049	---
Barium	0.0%	12 / 12	0.859	0.887 Accept	0.647 Reject	0.052	0.472	0.135	0.114	0.587	Yes
Beryllium	91.7%	1 / 12	---	---	---	< 0.0003	0.0003	nc	nc	0.0003	---
Calcium	0.0%	12 / 12	0.859	0.855 Reject	0.905 Accept	56.5	193	141.7	45.5	266.3	No
Cadmium	100.0%	0 / 12	---	---	---	< 0.0005	< 0.0005	nc	nc	ND at 0.0005	---
Chromium	91.7%	1 / 12	---	---	---	< 0.0053	0.0064	nc	nc	0.006	---
Cobalt	100.0%	0 / 12	---	---	---	< 0.0089	< 0.0089	nc	nc	ND at 0.0089	---
Copper	91.7%	1 / 12	---	---	---	< 0.0008	0.0028	nc	nc	0.0028	---
Iron	0.0%	12 / 12	0.859	0.874 Accept	0.872 Accept	0.0049	0.072	0.0253	0.0194	0.224	No
Lead	100.0%	0 / 12	---	---	---	< 0.0016	< 0.0016	nc	nc	ND at 0.0016	---
Magnesium	0.0%	12 / 12	0.859	0.839 Reject	0.639 Reject	2.76	37.8	10.32	10.49	37.80	No
Manganese	0.0%	12 / 12	0.859	0.820 Reject	0.376 Reject	0.0019	2.86	0.2713	0.8177	0.175	Yes
Mercury	100.0%	0 / 12	---	---	---	< 0.0001	< 0.0001	nc	nc	ND at 0.0001	---
Molybdenum	100.0%	0 / 12	---	---	---	< 0.0144	< 0.0144	nc	nc	ND at 0.0144	---
Nickel	75.0%	3 / 12	---	---	---	< 0.002	0.0204	nc	nc	0.0204	---
Potassium	33.3%	8 / 12	0.859	0.890 Accept	0.665 Reject	0.233	5.55	1.28	2.08	15.03	No
Selenium	25.0%	9 / 12	0.859	0.823 Reject	0.882 Accept	0.00055	0.0046	0.0021	0.0012	0.0077	No
Silver	91.7%	1 / 12	---	---	---	< 0.0002	0.0002	nc	nc	0.0002	---
Sodium	0.0%	12 / 12	0.859	0.885 Accept	0.519 Reject	6.17	144	28.8	37.1	167	Yes
Thallium	100.0%	0 / 12	---	---	---	< 0.0632	< 0.0632	nc	nc	ND at 0.0632	---
Vanadium	18.2%	9 / 11	0.850	0.893 Accept	0.863 Accept	< 0.0029	0.0074	0.0034	0.0018	0.012	No
Zinc	36.4%	7 / 11	0.850	0.877 Accept	0.622 Reject	0.00195	0.0487	0.0101	0.0170	0.118	No

**Notes:**

All units are in milligrams per liter (mg/L).

----- = not applicable

nc = not calculated

ND = not detected

UTL<sub>95,95</sub> = Upper Tolerance Level -  
 (95% confidence and 95% coverage)

Outlier? = Result of test to determine if the  
 maximum value is a potential outlier.

W (crit) = Shapiro-Wilk critical value

W (log) = calculated W using log-transformed data  
 and result when compared to W (crit)

W (raw) = calculated W using raw data and result when compared to W (crit)

**TABLE 4-4**  
**Summary of Background Values for Unfiltered Groundwater Samples**  
**Naval Air Station Fort Worth**

Analyte	% Non-detects		Detects / Total		W (crit)	W (log)	W (raw)	Minimum	Maximum	Mean	Standard Deviation	UTL <sub>95,95</sub>	Outlier?
Aluminum	0.0%	12 / 12	0.859	0.950 Accept	0.779 Reject	0.0699	2.45	0.807	0.859	11.07	No		
Antimony	91.7%	1 / 12				< 0.002	0.0024	nc	nc	0.0024			
Arsenic	91.7%	1 / 12				< 0.0049	0.0067	nc	nc	0.0067			
Barium	0.0%	12 / 12	0.859	0.982 Accept	0.882 Accept	0.0358	0.513	0.193	0.136	1.133	No		
Beryllium	66.7%	4 / 12				< 0.0003	0.0019	nc	nc	0.0019			
Calcium	0.0%	12 / 12	0.859	0.916 Accept	0.806 Reject	102	881	407	301	2438	No		
Cadmium	66.7%	4 / 12				< 0.0005	0.0016	nc	nc	0.0016			
Chromium	58.3%	5 / 12				< 0.0053	0.0136	nc	nc	0.0136			
Cobalt	91.7%	1 / 12				< 0.0089	0.01	nc	nc	0.01			
Copper	50.0%	6 / 12				< 0.0008	0.0101	nc	nc	0.0101			
Iron	0.0%	12 / 12	0.859	0.984 Accept	0.828 Reject	0.0768	2.64	0.784	0.703	7.23	No		
Lead	100.0%	0 / 12				< 0.0016	< 0.0016	nc	nc	ND at 0.0016			
Magnesium	0.0%	12 / 12	0.859	0.905 Accept	0.735 Reject	3.79	35.6	11.91	10.65	68.78	No		
Manganese	0.0%	12 / 12	0.859	0.958 Accept	0.863 Accept	0.0393	2.17	0.705	0.659	10.571	No		
Mercury	100.0%	0 / 12				< 0.0001	< 0.0001	nc	nc	ND at 0.0001			
Molybdenum	100.0%	0 / 12				< 0.0144	< 0.0144	nc	nc	ND at 0.0144			
Nickel	0.0%	12 / 12	0.859	0.919 Accept	0.785 Reject	0.0022	0.0203	0.0068	0.0055	0.036	No		
Potassium	50.0%	6 / 12				< 0.466	3.9	nc	nc	3.9			
Selenium	16.7%	10 / 12	0.859	0.891 Accept	0.851 Reject	< 0.0011	0.0042	0.0018	0.0009	0.0072	No		
Silver	91.7%	1 / 12				< 0.0002	0.0003	nc	nc	0.0003			
Sodium	0.0%	12 / 12	0.859	0.960 Accept	0.630 Reject	1.96	91.5	20.2	23.7	176.2	No		
Thallium	100.0%	0 / 12				< 0.0632	< 0.0632	nc	nc	ND at 0.0632			
Vanadium	9.1%	10 / 11	0.850	0.943 Accept	0.920 Accept	0.00145	0.0247	0.0093	0.0066	0.0653	No		
Zinc	9.1%	10 / 11	0.850	0.964 Accept	0.874 Accept	0.00195	0.0307	0.0107	0.0082	0.0682	No		

**Notes:**  
 All units are in milligrams per liter (mg/L).  
 --- = not applicable  
 nc = not calculated  
 ND = not detected  
 UTL<sub>95,95</sub> = Upper Tolerance Level-  
 (95% confidence and 95% coverage)  
 Outlier? = Result of test to determine if the  
 maximum value is a potential outlier.

W (crit) = Shapiro-Wilk critical value  
 W (log) = calculated W using log-transformed data  
 and result when compared to W (crit)  
 W (raw) = calculated W using raw data and result  
 when compared to W (crit)

TABLE 4-5  
Summary of Background Values for Surface Water  
Naval Air Station Fort Worth

Analyte	% Non-detects	Detects / Total	W (crit)	W (log)	W (raw)	Minimum	Maximum	Mean	Standard Deviation	UTL <sub>95.95</sub>	Outlier?
Aluminum	0.0%	8 / 8	0.818	0.848 Accept	0.729 Reject	0.0509	0.178	0.084	0.041	0.272	Yes
Antimony	75.0%	2 / 8	---	---	---	< 0.002	0.0031	nc	nc	0.003	---
Arsenic	100.0%	0 / 8	---	---	---	< 0.0049	< 0.0049	nc	nc	ND at 0.0049	---
Barium	0.0%	8 / 8	0.818	0.957 Accept	0.928 Accept	0.0759	0.124	0.095	0.015	0.151	No
Beryllium	100.0%	0 / 8	---	---	---	< 0.0003	< 0.0003	nc	nc	ND at 0.0003	---
Calcium	0.0%	8 / 8	0.818	0.908 Accept	0.879 Accept	84.1	118	96.0	10.6	133.7	No
Cadmium	87.5%	1 / 8	---	---	---	< 0.0005	0.0005	nc	nc	ND at 0.0005	---
Chromium	62.5%	3 / 8	---	---	---	< 0.0053	0.0078	nc	nc	0.0078	---
Cobalt	100.0%	0 / 8	---	---	---	< 0.0089	< 0.0089	nc	nc	ND at 0.0089	---
Copper	25.0%	6 / 8	0.818	0.566 Reject	0.566 Reject	< 0.0004	0.0101	0.008	0.004	0.010	No
Iron	0.0%	8 / 8	0.818	0.930 Accept	0.989 Accept	0.0221	0.223	0.113	0.063	0.921	No
Lead	100.0%	0 / 8	---	---	---	< 0.0016	< 0.0016	nc	nc	ND at 0.0016	---
Magnesium	0.0%	8 / 8	0.818	0.993 Accept	0.976 Accept	2.07	5.52	3.58	1.11	9.35	No
Manganese	0.0%	8 / 8	0.818	0.937 Accept	0.864 Accept	0.0038	0.0716	0.0251	0.0218	0.4193	No
Mercury	87.5%	1 / 8	---	---	---	< 0.0001	0.0001	nc	nc	0.0001	---
Molybdenum	100.0%	0 / 8	---	---	---	< 0.0144	< 0.0144	nc	nc	ND at 0.0144	---
Nickel	87.5%	1 / 8	---	---	---	< 0.002	0.0178	nc	nc	0.0178	---
Potassium	0.0%	8 / 8	0.818	0.893 Accept	0.924 Accept	2.06	3.93	3.00	0.68	6.35	No
Selenium	25.0%	6 / 8	0.818	0.689 Reject	0.779 Reject	< 0.0011	0.0025	0.0018	0.0008	0.0025	No
Silver	75.0%	2 / 8	---	---	---	< 0.0002	0.0003	nc	nc	0.0003	---
Sodium	0.0%	8 / 8	0.818	0.959 Accept	0.943 Accept	19.3	32.9	25.7	4.8	45.5	No
Thallium	100.0%	0 / 8	---	---	---	< 0.0632	< 0.0632	nc	nc	ND at 0.0632	---
Vanadium	25.0%	6 / 8	0.818	0.882 Accept	0.941 Accept	< 0.0029	0.0058	nc	nc	0.0159	---
Zinc	75.0%	2 / 8	---	---	---	< 0.0039	0.0122	nc	nc	0.0122	No

Notes:

All units are in milligrams per liter (mg/L).

--- = not applicable

nc = not calculated

ND = not detected

UTL<sub>95.95</sub> = Upper Tolerance Level (95% confidence and 95% coverage)

Outlier? = Result of test to determine if the maximum value is a potential outlier.

W (crit) = Shapiro-Wilk critical value

W (log) = calculated W using log-transformed data and result when compared to W (crit)

W (raw) = calculated W using raw data and result when compared to W (crit)

TABLE 4-6  
Summary of Background Values for Stream Sediment Samples  
Naval Air Station Fort Worth

Analyte	% Non-detects	Detects / Total	W (crit)	W (log)	W (raw)	Minimum	Maximum	Mean	Standard Deviation	UTL <sub>95,95</sub>	Outlier?
Aluminum	0.0%	8 / 8	0.818	0.852 Accept	0.924 Accept	2280	9240	5540	2679	28767	No
Antimony	87.5%	1 / 8	-----	-----	-----	< 0.244	0.33	nc	nc	0.33	-----
Arsenic	0.0%	8 / 8	0.818	0.951 Accept	0.925 Accept	2.85	5.27	3.75	0.78	7.02	No
Barium	0.0%	8 / 8	0.818	0.920 Accept	0.918 Accept	21.9	76.8	48.0	19.6	180.4	No
Beryllium	0.0%	8 / 8	0.818	0.912 Accept	0.912 Accept	0.194	0.557	0.373	0.134	1.189	No
Calcium	0.0%	8 / 8	0.818	0.877 Accept	0.928 Accept	75100	189000	139888	35825	337544	No
Cadmium	0.0%	8 / 8	0.818	0.859 Accept	0.866 Accept	0.152	0.292	0.216	0.059	0.507	No
Chromium	0.0%	8 / 8	0.818	0.869 Accept	0.885 Accept	4.81	9.59	7.55	1.84	17.0	No
Cobalt	0.0%	8 / 8	0.818	0.882 Accept	0.872 Accept	1.59	3.43	2.51	0.78	6.65	No
Copper	0.0%	8 / 8	0.818	0.961 Accept	0.953 Accept	4.28	11.7	7.43	2.63	22.18	No
Iron	0.0%	8 / 8	0.818	0.807 Reject	0.832 Accept	5030	8080	6923	1184	10696	No
Lead	0.0%	8 / 8	0.818	0.956 Accept	0.818 Reject	2.21	26.9	9.1	8.3	104.1	No
Magnesium	0.0%	8 / 8	0.818	0.912 Accept	0.938 Accept	1450	2140	1876	221.7	2772	No
Manganese	0.0%	8 / 8	0.818	0.840 Accept	0.743 Reject	143	362	198	71	491	Yes
Mercury	87.5%	1 / 8	-----	-----	-----	< 0.037	0.0360	nc	nc	0.036	-----
Molybdenum	12.5%	7 / 8	0.818	0.894 Accept	0.963 Accept	0.4355	2.68	1.66	0.77	9.69	No
Nickel	0.0%	8 / 8	0.818	0.937 Accept	0.958 Accept	5.55	12	9.0	2.1	19.8	No
Potassium	0.0%	8 / 8	0.818	0.904 Accept	0.929 Accept	386	1300	788	340	3227	No
Selenium	87.5%	1 / 8	-----	-----	-----	< 0.134	0.214	nc	nc	0.214	-----
Silver	0.0%	8 / 8	0.818	0.965 Accept	0.888 Accept	0.0311	0.0929	0.0532	0.0188	0.144	No
Sodium	75.0%	2 / 8	-----	-----	-----	< 2.44	6.07	nc	nc	6.07	-----
Thallium	100.0%	0 / 8	-----	-----	-----	< 1.12	< 1.32	nc	nc	ND at 1.32	-----
Vanadium	0.0%	8 / 8	0.818	0.902 Accept	0.896 Accept	15.4	24.1	19.3	3.2	32.3	No
Zinc	0.0%	8 / 8	0.818	0.971 Accept	0.853 Accept	11.3	53.9	25.5	13.1	101.3	No

Notes:

All units are in milligrams per kilogram (mg/kg).

----- = not applicable

nc = not calculated

ND = not detected

UTL<sub>95,95</sub> = Upper Tolerance Level (95% confidence and 95% coverage)

Outlier? = Result of test to determine if the maximum value is a potential outlier.

W (crit) = Shapiro-Wilk critical value

W (log) = calculated W using log-transformed data and result when compared to W (crit)

W (raw) = calculated W using raw data and result when compared to W (crit)

Calcium, Chromium, Cobalt, and Potassium. Calcium, chromium, cobalt, and potassium were detected in 30 of 30 samples. Based on the Shapiro-Wilk test, the null hypothesis of normality was accepted for the log-transformed data for each analyte (Table 4-1). The mean and standard deviation listed in Table 4-1 are for the raw data. Because the null hypothesis of log-normality was accepted, a UTly based on the mean and standard deviation of the log-transformed data was calculated, and the UTL was calculated as  $\exp(\text{UTly})$ . No outliers were identified based on the formal test of the log-transformed data.

Lead and Manganese. Lead and manganese were detected in 30 of 30 samples. Based on the Shapiro-Wilk test, the null hypothesis of normality was rejected for the log-transformed data for each analyte (Table 4-1). However, because the calculated  $W$  was equal to  $W_{(\text{crit})}$  ( $W 0.927 = W_{(\text{crit})} 0.927$ ) for lead, and was very close ( $W 0.923 < W_{(\text{crit})} 0.927$ ) for manganese, the data sets were considered to be lognormally distributed. The mean and standard deviation listed in Table 4-1 are for the raw data. Because the null hypothesis of log-normality was accepted, a UTly based on the mean and standard deviation of the log-transformed data was calculated, and the UTL was calculated as  $\exp(\text{UTly})$ . The highest concentration for both lead and manganese was identified as a potential outlier based on the formal test of the log-transformed data.

Aluminum, Arsenic, Copper, Iron, Magnesium, and Vanadium. Aluminum, arsenic, copper, iron, magnesium, and vanadium were detected in 30 of 30 samples. Based on the Shapiro-Wilk test, the null hypothesis of normality was rejected for the log-transformed data but accepted for the raw data for these analytes (Table 4-1). The mean, standard deviation, and UTL listed in Table 4-1 are for the raw data. No outliers were identified based on the formal test of the log-transformed data.

Cadmium. Cadmium was detected in 28 of 30 samples. Based on the Shapiro-Wilk test, the null hypothesis of normality was accepted for the log-transformed data for

cadmium (Table 4-1). The mean and standard deviation listed in Table 4-1 are for the raw data. Because the null hypothesis of log-normality was accepted, a UTLy based on the mean and standard deviation of the log-transformed data was calculated, and the UTL was calculated as  $\exp(\text{UTLy})$ . No outliers were identified based on the formal test of the log-transformed data.

Antimony, Mercury, Molybdenum and Thallium. Antimony, mercury, molybdenum and thallium were not detected in a large percentage of samples. Antimony and molybdenum were not detected in 80 percent of the samples, mercury was not detected in 93.3 percent of samples, and thallium was not detected in 73.3 percent of the samples. For these four analytes the minimum value is a nondetect at the lowest detection limit and the maximum value is the maximum detected value. Mean and standard deviation were not calculated because data were insufficient. The UTL was established as the highest detected value. No test for outliers was performed because of the high number of nondetects.

Beryllium Nickel, Silver and Sodium. Beryllium and nickel were detected in 30 of 30 samples, and silver and sodium were detected in 29 of 30 samples. Based on the Shapiro-Wilk test, the null hypothesis of normality was rejected for both the log-transformed and the raw data (Table 4-1). The mean and standard deviation listed in Table 4-1 are for the raw data. The UTL was established as the highest detected value. No outliers were identified based on the formal test of the log-transformed data.

Barium and Zinc. Barium and zinc were detected in 30 of 30 samples. Based on the Shapiro-Wilk test, the null hypothesis of normality was rejected for both the log-transformed and the raw data (Table 4-1). The mean and standard deviation listed in Table 4-1 are for the raw data. The UTL, which would normally be established as the highest detected value in this case, was found to be a potential outlier. The second highest value was therefore established as the UTL.

Selenium. Selenium was detected in 18 of 30 samples, so the frequency of nondetects was 40 percent. Based on the Shapiro-Wilk test, the null hypothesis of normality was rejected for both the log-transformed and the raw data (Table 4-1). The mean and standard deviation listed in Table 4-1 are for the raw data. Review of the data suggested that either the raw data or log-transformed data might be reasonably normal under Cohen's assumption that nondetects represent the presence of these analytes at levels too small to be quantified by the laboratory. Consequently, the censored and detects-only probability plots were prepared for both the raw data and log-transformed data. The most linear of the probability plots was the censored data plot for log-transformed data. Therefore, Cohen's adjustment was applied to the log-transformed data.

Based on Cohen's adjustment, estimates were calculated for the mean,  $\bar{y}$ , and standard deviation,  $s_y$ , of the log-transformed data. The UTLY was then calculated from these values, and the UTL was calculated as  $UTL = \exp(UTLY)$ .

Because Cohen's adjustment was applied to the log-transformed data, we only have estimates of the mean and standard deviation of the log-transformed data. To obtain reliable estimates of the mean and standard deviation of the raw data set, estimates provided by Gilbert (1987) were applied. Thus, the mean  $\bar{x}$  is estimated by

$$\bar{x} = \exp(\bar{y} + s_y^2/2),$$

and the standard deviation  $s$  is estimated by

$$s = \bar{x} [\exp(s_y^2) - 1]^{1/2}.$$

No outliers were identified using the formal test for outliers using the mean and standard deviation from the Cohen adjustment for log-transformed data.

Recommendations for Nonparametric Tests. The UTL was established as the highest or second highest value for several constituents either because the distributions were not clearly normal or lognormal, or because the percent of nondetects was between 50

and 90 percent. Although UTLs have been calculated for all such constituents, it is recommended that site-specific comparisons against UTLs for some constituents be supplemented by nonparametric tests such as the Wilcoxon rank-sum test or the Kruskal-Wallis test (Gilbert 1987; EPA 1992). Supplemental nonparametric tests are recommended for antimony, barium, beryllium, lead, manganese, mercury, molybdenum, nickel, silver, sodium, thallium, and zinc.

#### 4.3.1.2 Horizon B Soils

Aluminum, Arsenic, Beryllium, Chromium, Iron, Nickel, and Vanadium. Aluminum, arsenic, beryllium, chromium, iron, nickel, and vanadium were detected in 30 of 30 samples. Based on the Shapiro-Wilk test, the null hypothesis of normality was accepted for the log-transformed data for all seven analytes (Table 4-2). The mean and standard deviation listed in Table 4-2 are for the raw data. Because the null hypothesis of log-normality was accepted, a UTLy based on the mean and standard deviation of the log-transformed data was calculated, and the UTL was calculated as  $\exp(\text{UTLy})$ . No outliers were identified based on the formal test of the log-transformed data.

Barium, Copper, Manganese, Potassium, and Zinc. Barium, copper, manganese, potassium, and zinc were detected in 30 of 30 samples. Based on the Shapiro-Wilk test, the null hypothesis of normality was rejected for the log-transformed data but accepted for the raw data for these analytes (Table 4-2). The mean, standard deviation, and UTL listed in Table 4-2 are for the raw data. No outliers were identified based on the formal test of the log-transformed data.

Calcium. Calcium was detected in 30 of 30 samples. Based on the Shapiro-Wilk test, the null hypothesis of normality was rejected for both the log-transformed and raw data (Table 4-2). The UTL, which would have been chosen as the highest value, was chosen as the second highest value because the highest value was identified as a potential outlier.

Cobalt and Lead. Cobalt and lead were detected in 27 and 28 of 30 samples, respectively. Based on the Shapiro-Wilk test, the null hypothesis of normality was rejected for the log-transformed data but accepted for the raw data for these analytes (Table 4-2). The mean, standard deviation, and UTL listed in Table 4-2 are for the raw data. No outliers were identified based on the formal test of the log-transformed data.

Magnesium and Sodium. Magnesium and sodium were detected in 30 and 27 of 30 samples, respectively. Based on the Shapiro-Wilk test, the null hypothesis of normality was rejected for both the log-transformed and the raw data (Table 4-2). The mean and standard deviation listed in Table 4-2 are for the raw data. The UTL was established as the highest detected value. No outliers were identified based on the formal test of the log-transformed data.

Antimony, Molybdenum, Selenium and Thallium. Antimony, molybdenum, and selenium were detected in six of 30 samples, and thallium was detected in 7 of 30 samples. For these four analytes the minimum value is a nondetect at the lowest detection limit and the maximum value is the maximum detected value. Mean and standard deviation were not calculated because data were insufficient. The UTL was established as the highest detected value. No test for outliers was performed because of the high number of nondetects.

Mercury. Mercury was not detected in any of the 30 background samples. Therefore, the minimum and maximum values in Table 4-2 are reported as less than the minimum and maximum detection limits, respectively. Mean and standard deviation were not calculated for these analytes. As outlined in the flowchart (Figure 4-1), the UTL for analytes with greater than 90 percent nondetects is defined as the highest ranked value, or in this case nondetects at a given detection limit. Because none of these analytes were detected, no test for outliers was performed.

Cadmium and Silver. Cadmium and silver were detected in 20 of 30 samples for a frequency of nondetection of 33 percent. Based on the Shapiro-Wilk test, the null hypothesis of normality was rejected for both the log-transformed and the raw data (Table 4-2). The mean and standard deviation listed in Table 4-2 are for the raw data. Review of the data suggested that either the raw data or log-transformed data might be reasonably normal under Cohen's assumption that nondetects represent the presence of these analytes at levels too small to be quantified by the laboratory. Consequently, the censored and detects-only probability plots were prepared for both the raw data and log-transformed data. The most linear of the probability plots for both analytes was the censored data plot for log-transformed data. Therefore, Cohen's adjustment was applied to the log-transformed data.

Based on Cohen's adjustment, estimates were calculated for the mean,  $\bar{y}$ , and standard deviation,  $s_y$ , of the log-transformed data. The UTly was then calculated from these values, and the UTL was calculated as  $UTL = \exp(UTly)$ .

Because Cohen's adjustment was applied to the log-transformed data, estimates of the mean and standard deviation of the log-transformed data were obtained by the Gilbert (1987) method described in Section 4.3.1.1 above.

Based on the formal test for outliers using the mean and standard deviation from the Cohen adjustment for log-transformed data, the highest cadmium concentration was identified as a potential outlier.

Recommendations for Nonparametric Tests. The UTL was established as the highest or second highest value for several constituents either because the distributions were not clearly normal or lognormal, or because the percent of nondetects was between 50 and 90 percent. Although UTLs have been calculated for all such constituents, it is recommended that site-specific comparisons against UTLs for some constituents be supplemented by nonparametric tests such as the Wilcoxon rank-sum test or the

Kruskal-Wallis test (Gilbert 1987; EPA 1992). Supplemental nonparametric tests are recommended for antimony, calcium, magnesium, molybdenum, selenium, sodium, and thallium.

### 4.3.2 Groundwater

Groundwater collected by the low-stress method and by the bailing technique were evaluated separately. The bailer technique of sampling results in greater suspended solids in the groundwater sample. The amount of suspended solids in current and future samples is not reproducible; thus the corresponding metals concentrations will be highly variable. Consequently, the background values calculated using the bailer technique samples (total metals) will be less comparable than the values calculated with the low-stress technique.

#### 4.3.2.1 Metals in Groundwater Sampled by the Low-Stress Procedure

Barium, Iron, and Sodium. Barium, iron, and sodium were detected in 12 of 12 samples. Based on the Shapiro-Wilk test, the null hypothesis of normality was accepted for the log-transformed data for all three analytes (Table 4-3). The mean and standard deviation listed in Table 4-3 are for the raw data. Because the null hypothesis of log-normality was accepted, a UT<sub>Ly</sub> based on the mean and standard deviation of the log-transformed data was calculated, and the UTL was calculated as  $\exp(\text{UT}_{Ly})$ . The formal test for outliers of the log-transformed data indicated that the highest concentration detected for barium and sodium were potential outliers.

Calcium. Calcium also was detected in 12 of 12 samples. The Shapiro-Wilk test rejected the null hypothesis of normality for the log-transformed data but accepted the hypothesis for the raw data for these analytes (Table 4-3). The mean, standard deviation, and UTL listed in Table 4-3 are for the raw data. No outliers were identified based on the formal test of the log-transformed data.

Antimony, Arsenic, Cadmium, Cobalt, Lead, Mercury, Molybdenum, and Thallium.

Antimony, arsenic, cadmium, cobalt, lead, mercury, molybdenum, and thallium were not detected in any of the background samples. Therefore, the minimum and maximum values in Table 4-3 are reported as less than the minimum and maximum detection limits, respectively. Additionally, the minimum and maximum values are the same because all of the detection limits for each analyte were the same. Mean and standard deviations were not calculated for these analytes. As outlined in the flowchart (Figure 4-1), the UTL for analytes with greater than 50 percent nondetects is defined as the highest ranked value, or in this case, nondetects at a given detection limit.

Beryllium, Chromium, Copper, Nickel, and Silver.

Beryllium, chromium, copper, and silver were each detected in one of 12 samples, while nickel was detected in three of 12 samples. For these five analytes the minimum value is a nondetect at the lowest detection limit and the maximum value is the highest detected value. Mean and standard deviation were not calculated because data were insufficient. The UTL was established as the highest detected value. No test for outliers was performed because of the high number of nondetects.

Aluminum, Potassium, Selenium, and Zinc.

Aluminum and selenium were detected in nine of 12 samples, and potassium and zinc were detected in eight of 12 and seven of 11 samples, respectively. One of the zinc results was rejected during the data-validation process. Review of the data suggested that either the raw data or log-transformed data might be reasonably normal under Cohen's assumption that nondetects represent the presence of these analytes at levels too small to be quantified by the laboratory. Consequently, the censored and detects-only probability plots were prepared for both the raw data and log-transformed data. The most linear of the probability plots was the censored data plot for log-transformed data. Therefore, Cohen's adjustment was applied to these data.

Based on Cohen's adjustment, estimates were calculated for the mean,  $\bar{y}$ , and standard deviation,  $s_y$ , of the log-transformed data. The UTLY was then calculated as  $UTL = \exp(UTLY)$ .

Because Cohen's adjustment was applied to the log-transformed data, we only have estimates of the mean and standard deviation of the log-transformed data. To obtain reliable estimates of the mean and standard deviation of the raw data set, estimates provided by Gilbert (1987) were applied.

No outliers were identified using the formal test for outliers using the mean and standard deviation from the Cohen adjustment of log-transformed data.

Magnesium and Manganese. Magnesium and manganese were detected in 12 of 12 samples. Based on the Shapiro-Wilk test, the null hypothesis of normality was rejected for both the log-transformed and the raw data (Table 4-3). The mean and standard deviation listed in Table 4-3 are for the raw data. The UTL for magnesium was established as the highest detected value. The UTL for manganese was established as the second highest value, because the highest value was determined to be a potential outlier.

Vanadium. Vanadium was detected in nine of 11 samples. One of the vanadium analytical results was rejected during the data-validation process. Based on the Shapiro-Wilk test, the null hypothesis of normality was accepted for the log-transformed data (Table 4-3). The mean and standard deviation listed in Table 4-3 are for the raw data. Because the null hypothesis of log-normality was accepted, a UTLY based on the mean and standard deviation of the log-transformed data was calculated, and the UTL was calculated as  $\exp(UTLY)$ . No outliers were identified by the formal test of the log-transformed data.

Recommendations for Nonparametric Tests. The UTL was established as the highest or second highest value for several constituents either because the distributions were

not clearly normal or lognormal, or because the percent of nondetects was between 50 and 90 percent. Although UTLs have been calculated for all such constituents, it is recommended that site-specific comparisons against UTLs for some constituents be supplemented by nonparametric tests such as the Wilcoxon rank-sum test or the Kruskal-Wallis test (Gilbert 1987; EPA 1992). Supplemental nonparametric tests are recommended for magnesium, manganese, and nickel.

#### 4.3.2.2 Total Metals in Groundwater

##### Aluminum, Barium, Calcium, Iron, Magnesium, Manganese, Nickel, and Sodium.

Aluminum, barium, calcium, iron, magnesium, manganese, nickel, and sodium were detected in 12 of 12 samples. Based on the Shapiro-Wilk test, the null hypothesis of normality was accepted for the log-transformed data for all analytes (Table 4-4). The mean and standard deviation listed in Table 4-4 are for the raw data. Because the null hypothesis of log-normality was accepted, a UTly was calculated using the mean and standard deviation of the log-transformed data, and the UTL was calculated as  $\exp(\text{UTly})$ . No outliers were identified by the formal test of the log-transformed data.

Selenium, Vanadium, and Zinc. Selenium was detected in 10 of 12 samples, and vanadium and zinc were detected in 10 of 11 samples. One vanadium and one zinc result was rejected during the validation process. The Shapiro-Wilk test, accepted the null hypothesis of normality for the log-transformed data for all three analytes (Table 4-4). The mean and standard deviation listed in Table 4-4 are for the raw data. Because the null hypothesis of log-normality was accepted, a UTly was calculated using the mean and standard deviation of the log-transformed data, and the UTL was calculated as  $\exp(\text{UTly})$ . No outliers were identified based on the formal test of the log-transformed data.

Beryllium, Cadmium, Chromium, Copper, and Potassium. Beryllium and cadmium were detected in four of 12 samples, chromium was detected in five of 12 samples,

and copper and potassium were each detected in six of 12 samples. The minimum value is a nondetect at the lowest detection limit and the maximum value is the maximum detected value. The UTL was estimated as the highest detected value. No test for outliers was performed.

Antimony, Arsenic, Cobalt, and Silver. Antimony, arsenic, cobalt, and silver were detected in one of 12 samples. For these four analytes the minimum value is a nondetect at the lowest detection limit and the maximum value is the only detected value. Mean and standard deviation were not calculated because data were insufficient. The UTL was established as the highest detected value. No test for outliers was performed because of the high number of nondetects.

Lead, Mercury, Molybdenum, and Thallium. Lead, mercury, molybdenum, and thallium were not detected in any of the background samples. Therefore, the minimum and maximum values in Table 4-4 are reported as less than the minimum and maximum detection limits, respectively. Additionally, the minimum and maximum values are the same because all of the detection limits for a each analyte were the same. The UTL for these analytes is defined as the highest ranked value, or in this case nondetects at a the highest method detection limit.

Recommendations for Nonparametric Tests. The UTL was established as the highest or second highest value for several constituents either because the distributions were not clearly normal or lognormal, or because the percent of nondetects was between 50 and 90 percent. Although UTLs have been calculated for all such constituents, it is recommended that site-specific comparisons against UTLs for some constituents be supplemented by nonparametric tests such as the Wilcoxon rank-sum test or the Kruskal-Wallis test (Gilbert 1987; EPA 1992). Supplemental nonparametric tests are recommended for beryllium, cadmium, chromium, copper, and potassium.

### 4.3.3 Surface Water

#### Aluminum, Barium, Calcium, Iron, Magnesium, Manganese, Potassium, and Sodium.

Aluminum, barium, calcium, iron, magnesium, manganese, potassium, and sodium were detected in eight of eight samples. Based on the Shapiro-Wilk test, the null hypothesis of normality was accepted for the log-transformed data for these analytes (Table 4-5). The mean and standard deviation listed in Table 4-5 are for the raw data. Because the null hypothesis of log-normality was accepted, a UTLY based on the mean and standard deviation of the log-transformed data was calculated, and the UTL was calculated as  $\exp(\text{UTLY})$ . The highest value detected for aluminum was the only result identified as a potential outlier based on the formal test of the log-transformed data.

Copper and Selenium. Copper and selenium were each detected in six of eight samples. The null hypothesis of normality was rejected for both the log-transformed and raw data. The minimum value is a nondetect at the lowest detection limit and the maximum is the maximum detected concentration. The UTL was established as the highest detected value. No outliers were identified by the formal test.

Vanadium. Vanadium was detected in six of eight samples. Based on the Shapiro-Wilk test, the null hypothesis of normality was accepted for the log-transformed data for these analytes (Table 4-5). The minimum value is a nondetect at the lowest detection limit and the maximum is the maximum detected concentration. Because the null hypothesis of log-normality was accepted, a UTLY based on the mean and standard deviation of the log-transformed data was calculated, and the UTL was calculated as  $\exp(\text{UTLY})$ . No outliers were identified by the formal test.

Arsenic, Beryllium, Cobalt, Lead, and Molybdenum, and Thallium. Arsenic, beryllium, cobalt, lead, molybdenum, and thallium were not detected in any of the background samples. Therefore, the minimum and maximum values in Table 4-5 are reported as less than the minimum and maximum detection limits, respectively.

Additionally, the minimum and maximum values are the same because all of the detection limits for a each analyte were the same. Mean and standard deviation were not calculated for these analytes. The UTL for these analytes is defined as the highest ranked value, or in this case nondetects at a given detection limit. No test for outliers was performed.

Antimony, Cadmium, Chromium, Mercury, Nickel, Silver, and Zinc. Cadmium, mercury, and nickel were detected in one of eight samples; antimony, silver, and zinc were detected in two of eight samples and chromium was detected in three of eight. For these seven analytes the minimum value is a nondetect at the lowest detection limit and the maximum value is the maximum detected concentration. Mean and standard deviation were not calculated because data were insufficient. The UTL was established as the highest detected value. No test for outliers was performed because of the high number of nondetects.

Recommendations for Nonparametric Tests. The UTL was established as the highest or second highest value for several constituents either because the distributions were not clearly normal or lognormal, or because the percent of nondetects was between 50 and 90 percent. Although UTLs have been calculated for all such constituents, it is recommended that site-specific comparisons against UTLs for some constituents be supplemented by nonparametric tests such as the Wilcoxon rank-sum test or the Kruskal-Wallis test (Gilbert 1987; EPA 1992). Supplemental nonparametric tests are recommended for antimony, cadmium, chromium, copper, mercury, nickel, silver, and zinc.

#### 4.3.4 Stream Sediments

Aluminum, Arsenic, Barium, Beryllium, Calcium, Cadmium, Chromium, Cobalt, Copper, Lead, Magnesium, Manganese, Nickel, Potassium, Silver, Vanadium, and Zinc. All of these metals were detected in eight of eight samples. Based on the Shapiro-Wilk test, the null hypothesis of normality was accepted for the log-

transformed data for these analytes (Table 4-6). The mean and standard deviation listed in Table 4-6 are for the raw data. Because the null hypothesis of log-normality was accepted, a UTly was calculated on the mean and standard deviation of the log-transformed data, and the UTL was calculated as  $\exp(\text{UTly})$ . The highest value detected for manganese was the only result identified as a potential outlier by the formal test of the log-transformed data.

Molybdenum. Molybdenum was detected in seven of eight samples. The Shapiro-Wilk test accepted the null hypothesis of normality for the log-transformed data for these analytes (Table 4-6). The mean and standard deviation listed in Table 4-6 are for the raw data, and the UTL was estimated from the mean and standard deviation of the log-transformed data and calculated as  $\exp(\text{UTly})$ . The highest value detected for molybdenum was not identified as a potential outlier based on the formal test of the log-transformed data.

Iron. Iron was detected in eight of eight samples. Based on the Shapiro-Wilk test, the null hypothesis of normality was rejected for the log-transformed data but accepted for the raw data for these analytes (Table 4-6). The mean, standard deviation, and UTL listed in Table 4-6 are for the raw data. No outliers were identified based on the formal test of the raw data.

Antimony, Mercury, Selenium, and Sodium. Antimony, mercury and selenium were detected in one of eight samples, and sodium was detected in two of eight samples. For these four analytes, the minimum value is a nondetect at the lowest detection limit and the maximum value is the maximum detected value. Mean and standard deviation were not calculated because data were insufficient. The UTL was established as the highest detected value. No test for outliers was performed because of the high number of nondetects.

Thallium. Thallium was not detected in any of the background samples. Therefore, the minimum and maximum values in Table 4-6 are reported as less than the

minimum and maximum detection limits, respectively. Mean and standard deviation was not calculated. The UTL for thallium is defined as the highest ranked value, or in this case a nondetect at a given detection limit. No test for outliers was performed.

Recommendations for Nonparametric Tests. The UTL was established as the highest or second highest value for several constituents either because the distributions were not clearly normal or lognormal, or because the percent of nondetects was between 50 and 90 percent. Although UTLs have been calculated for all such constituents, it is recommended that site-specific comparisons against UTLs for some constituents be supplemented by nonparametric tests such as the Wilcoxon rank-sum test or the Kruskal-Wallis test (Gilbert 1987; EPA 1992). Supplemental nonparametric tests are recommended for antimony, mercury, selenium, and sodium.

#### 4.4 ORGANICS IN BACKGROUND SAMPLES

Background samples were collected from locations believed to be unaffected by operations at NAS Fort Worth. However, all of the samples were collected from locations on or near the base, and are thus potentially affected by previous base operations, or by operations at Plant 4. To help verify that the background locations were in fact unaffected by previous activities, the results of analyses for organic constituents were reviewed.

Each background sample was analyzed for volatile and semivolatile organic compounds, in addition to the inorganic constituents noted previously. Only a limited number of organic constituents were detected (Table 4-7).

The following paragraphs discuss the VOCs and SVOCs detected in each sample matrix.

**TABLE 4-7**  
**Organic Analytes Detected in Background Samples**  
**Naval Air Station Fort Worth**

MATRIX	SAMPLE ID	LOCATION	VALUE	LAB_QUAL	JEG_QUAL	UNITS	NAME	DETECT	PQUANT	DILUTION
SURFACE SOIL	BJETA508-A	BJETA508	365.0000 F			MG/KG	BENZYL BUTYL PHTHALATE	256.0000	863.0000	1.00
SURFACE SOIL	BJETA530-A	BJETA530	219.0000 F			MG/KG	BIS(2-ETHYLHEXYL) PHTHALATE	105.0000	753.0000	1.00
SURFACE SOIL	BJETA514-A	BJETA514	2660.0000			MG/KG	DI-N-BUTYL PHTHALATE	134.0000	844.0000	1.00
SURFACE SOIL	BJETA511-A	BJETA511	702.0000 F			MG/KG	DI-N-BUTYL PHTHALATE	135.0000	854.0000	1.00
SURFACE SOIL	BJETA512-A	BJETA512	369.0000 F			MG/KG	DI-N-BUTYL PHTHALATE	138.0000	871.0000	1.00
SURFACE SOIL	BJETA530-A	BJETA530	175.0000 F			MG/KG	DI-N-BUTYL PHTHALATE	119.0000	753.0000	1.00
SURFACE SOIL	BJETA534-A	BJETA534	161.0000 F			MG/KG	DI-N-BUTYL PHTHALATE	132.0000	833.0000	1.00
SURFACE SOIL	BJETA532-A	BJETA532	147.0000 F			MG/KG	FLORANTHENE	115.0000	781.0000	1.00
SURFACE SOIL	BJETA517-ARS	BJETA517	6.6500			UG/KG	METHYLENE CHLORIDE	3.0400	6.1100	1.00
SURFACE SOIL	BJETA527-A	BJETA527	6.4900			UG/KG	METHYLENE CHLORIDE	2.8500	5.7200	1.00
SURFACE SOIL	BJETA523-A	BJETA523	6.4500		e	UG/KG	METHYLENE CHLORIDE	3.1000	6.2300	1.00
SURFACE SOIL	BJETA524-A	BJETA524	5.1500 F		e	UG/KG	METHYLENE CHLORIDE	3.1600	6.3400	1.00
SURFACE SOIL	BJETA518-A	BJETA518	3.7700 F		e	UG/KG	METHYLENE CHLORIDE	2.9300	5.8800	1.00
SURFACE SOIL	BJETA509-A	BJETA509	3.7200 F		be	UG/KG	METHYLENE CHLORIDE	3.1400	6.3000	1.00
SURFACE SOIL	BJETA522-A	BJETA522	3.6500 F		e	UG/KG	METHYLENE CHLORIDE	2.9100	5.8400	1.00
SURFACE SOIL	BJETA519-A	BJETA519	3.2100 F		e	UG/KG	METHYLENE CHLORIDE	2.7800	5.5900	1.00
SURFACE SOIL	BJETA508-A	BJETA508	3.2000 F		be	UG/KG	METHYLENE CHLORIDE	3.0900	6.2100	1.00
SURFACE SOIL	BJETA504-A	BJETA504	3.1000 F		be	UG/KG	METHYLENE CHLORIDE	3.0600	6.1400	1.00
SURFACE SOIL	BJETA508-A	BJETA508	1.6000 F			UG/KG	TOLUENE	0.5020	6.2100	1.00
SURFACE SOIL	BJETA508-A	BJETA508	1.0900 F			UG/KG	TOLUENE	0.5020	6.2100	1.00
SURFACE SOIL	BJETA506-A	BJETA506	0.9510 F			UG/KG	TOLUENE	0.5030	6.2300	1.00
SURFACE SOIL	BJETA502-A	BJETA502	0.8020 F			UG/KG	TOLUENE	0.5180	6.4100	1.00
SURFACE SOIL	BJETA503-A	BJETA503	0.7830 F			UG/KG	TOLUENE	0.4980	6.1700	1.00
SURFACE SOIL	BJETA509-A	BJETA509	0.6980 F			UG/KG	TOLUENE	0.5090	6.3000	1.00
SURFACE SOIL	BJETA506-A	BJETA506	0.6950 F			UG/KG	TOLUENE	0.5030	6.2300	1.00
SURFACE SOIL	BJETA501-A	BJETA501	0.6540 F			UG/KG	TOLUENE	0.5070	6.2700	1.00
SURFACE SOIL	BJETA510-A	BJETA510	0.6620 F			UG/KG	TOLUENE	0.4920	6.0900	1.00
SUBSURFACE SOIL	BJETA503-B	BJETA503	8.3000 F			UG/KG	ACETONE	4.7600	106.0000	1.00
SUBSURFACE SOIL	BJETA526-B	BJETA526	8.0600 F			UG/KG	ACETONE	4.9600	111.0000	1.00
SUBSURFACE SOIL	BJETA521-B	BJETA521	6.3400 F			UG/KG	ACETONE	5.0900	114.0000	1.00
SUBSURFACE SOIL	BJETA510-B	BJETA510	6.0900 F			UG/KG	ACETONE	5.1700	115.0000	1.00
SUBSURFACE SOIL	BJETA525-B	BJETA525	5.7500 F			UG/KG	ACETONE	4.9500	110.0000	1.00
SUBSURFACE SOIL	BJETA518-B	BJETA518	5.1900 F			UG/KG	ACETONE	5.0500	113.0000	1.00
SUBSURFACE SOIL	BJETA513-B	BJETA513	2170.0000			MG/KG	DI-N-BUTYL PHTHALATE	126.0000	796.0000	1.00
SUBSURFACE SOIL	BJETA510-B	BJETA510	1070.0000			MG/KG	DI-N-BUTYL PHTHALATE	126.0000	796.0000	1.00
SUBSURFACE SOIL	BJETA511-B	BJETA511	427.0000 F			MG/KG	DI-N-BUTYL PHTHALATE	131.0000	824.0000	1.00

TABLE 4-7  
Organic Analytes Detected in Background Samples  
Naval Air Station Fort Worth

MATRIX	SAMPLE ID	LOCATION	VALUE	LAB_QUAL	JEG_QUAL	UNITS	NAME	DETECT	QQUANT	DILUTION
SUBSURFACE SOIL	BJETA512-B	BJETA512	381.0000	F		MG/KG	DI-N-BUTYL PHTHALATE	122.0000	772.0000	1.00
SUBSURFACE SOIL	BJETA514-B	BJETA514	338.0000	F		MG/KG	DI-N-BUTYL PHTHALATE	121.0000	766.0000	1.00
SUBSURFACE SOIL	BJETA532-B	BJETA532	130.0000	F		MG/KG	DI-N-BUTYL PHTHALATE	123.0000	779.0000	1.00
SUBSURFACE SOIL	BJETA503-B	BJETA503	3.3700	F		UG/KG	METHYL ETHYL KETONE (2-BUTANONE)	2.4000	106.0000	1.00
SUBSURFACE SOIL	BJETA525-B	BJETA525	6.0600	F	e	UG/KG	METHYLENE CHLORIDE	2.7500	5.5200	1.00
SUBSURFACE SOIL	BJETA526-B	BJETA526	5.9300	F	e	UG/KG	METHYLENE CHLORIDE	2.7600	5.5400	1.00
SUBSURFACE SOIL	BJETA523-B	BJETA523	5.6200	F	e	UG/KG	METHYLENE CHLORIDE	2.8400	5.7100	1.00
SUBSURFACE SOIL	BJETA524-B	BJETA524	5.4200	F	e	UG/KG	METHYLENE CHLORIDE	2.7900	5.6100	1.00
SUBSURFACE SOIL	BJETA522-B	BJETA522	3.6200	F	e	UG/KG	METHYLENE CHLORIDE	2.6700	5.3600	1.00
SUBSURFACE SOIL	BJETA519-B	BJETA519	3.2800	F	e	UG/KG	METHYLENE CHLORIDE	2.9100	5.8500	1.00
SUBSURFACE SOIL	BJETA518-B	BJETA518	3.1400	F	e	UG/KG	METHYLENE CHLORIDE	2.8000	5.6300	1.00
SUBSURFACE SOIL	BJETA521-B	BJETA521	2.8400	F	e	UG/KG	METHYLENE CHLORIDE	2.8300	5.6800	1.00
GROUNDWATER	LF044A-01	LF04-4A	16.8000	F		UG/L	BIS(2-ETHYLHEXYL) PHTHALATE	4.2000	10.0000	1.00
GROUNDWATER	WJETA531	WJETA531	5.9400	F	e	UG/L	BIS(2-ETHYLHEXYL) PHTHALATE	4.2000	10.0000	1.00
GROUNDWATER	HM127-01	HM-127	4.9600	F		UG/L	BIS(2-ETHYLHEXYL) PHTHALATE	4.2000	10.0000	1.00
GROUNDWATER	WJETA530-01	WJETA530	4.3600	F	baa	UG/L	METHYLENE CHLORIDE	0.7710	5.0000	1.00
GROUNDWATER	MWMTAC001-01	MWMTAC-00	4.3000	F	be	UG/L	METHYLENE CHLORIDE	0.7710	5.0000	1.00
GROUNDWATER	LF033D-01	LF03-3D	3.9400	F	e	UG/L	METHYLENE CHLORIDE	0.7710	5.0000	1.00
GROUNDWATER	WJETA531	WJETA531	3.6900	F	be	UG/L	METHYLENE CHLORIDE	0.7710	5.0000	1.00
GROUNDWATER	WJETA535-01	WJETA535	2.5600	F	baa	UG/L	METHYLENE CHLORIDE	0.7710	5.0000	1.00
GROUNDWATER	LF044B-01	LF04-4B	2.2600	F	be	UG/L	METHYLENE CHLORIDE	0.7710	5.0000	1.00
GROUNDWATER	USGS01T	USGS01T	1.8100	F	b	UG/L	METHYLENE CHLORIDE	0.7710	5.0000	1.00
GROUNDWATER	HM127-01	HM-127	1.7800	F	b	UG/L	METHYLENE CHLORIDE	0.7710	5.0000	1.00
GROUNDWATER	HM120-01	HM-120	1.6600	F	be	UG/L	METHYLENE CHLORIDE	0.7710	5.0000	1.00
SURFACE WATER	JEFB008-SW	JEFB008	2.8300	F		UG/L	BENZYL BUTYL PHTHALATE	2.8000	10.0000	1.00
SURFACE WATER	JEFB001-SW	JEFB001	60.1000	F		UG/L	DI-N-BUTYL PHTHALATE	5.4000	10.0000	1.00
SURFACE WATER	JEFB006-SW	JEFB006	38.5000	F		UG/L	DI-N-BUTYL PHTHALATE	5.4000	10.0000	1.00
SURFACE WATER	JEFB008-SW	JEFB008	35.3000	F		UG/L	DI-N-BUTYL PHTHALATE	5.4000	10.0000	1.00
SURFACE WATER	JEFB003-SW	JEFB003	3.2900	F	be	UG/L	METHYLENE CHLORIDE	0.7710	5.0000	1.00
SURFACE WATER	JEFB008-SW	JEFB008	3.0600	F	be	UG/L	METHYLENE CHLORIDE	0.7710	5.0000	1.00
SURFACE WATER	JEFB007-SW	JEFB007	2.2000	F	be	UG/L	METHYLENE CHLORIDE	0.7710	5.0000	1.00
SURFACE WATER	JEFB001-SW	JEFB001	1.8800	F	be	UG/L	METHYLENE CHLORIDE	0.7710	5.0000	1.00
SEDIMENT	JEFB004-SE	JEFB004	146.0000	F		MG/KG	BENZO(B)FLUORANTHENE	144.0000	943.0000	1.00
SEDIMENT	JEFB002-SE	JEFB002	207.0000	F		MG/KG	BIS(2-ETHYLHEXYL) PHTHALATE	124.0000	854.0000	1.00
SEDIMENT	JEFB007-SE	JEFB007	179.0000	F		MG/KG	BIS(2-ETHYLHEXYL) PHTHALATE	138.0000	985.0000	1.00

**TABLE 4-7**  
**Organic Analytes Detected in Background Samples**  
**Naval Air Station Fort Worth**

MATRIX	SAMPLE ID	LOCATION	VALUE	LAB_QUAL	JEG_QUAL	UNITS	NAME	DETECT	PQUANT	DILUTION
SEDIMENT	JEFB003-SE	JEFB003	175.0000	F		MG/KG	BIS(2-ETHYLHEXYL) PHTHALATE	140.0000	1000.0000	1.00
SEDIMENT	JEFB005-SE	JEFB005	157.0000	F		MG/KG	BIS(2-ETHYLHEXYL) PHTHALATE	138.0000	989.0000	1.00
SEDIMENT	JEFB004-SE	JEFB004	138.0000	F		MG/KG	BIS(2-ETHYLHEXYL) PHTHALATE	132.0000	943.0000	1.00
SEDIMENT	JEFB001-SE	JEFB001	207.0000	F		MG/KG	FLUORANTHENE	126.0000	854.0000	1.00
SEDIMENT	JEFB004-SE	JEFB004	174.0000	F		MG/KG	FLUORANTHENE	139.0000	943.0000	1.00
SEDIMENT	JEFB001-SE	JEFB001	131.0000	F		MG/KG	PYRENE	117.0000	854.0000	1.00

**Notes:**

- a = detection less than five times the ambient blank value
  - b = detection less than five times the trip blank value
  - e = detection less than five times the equipment blank value
  - F = detection greater than the detection limit (DETECT), but less than the practical quantitation limit (PQUANT)
- Lab\_qual = laboratory qualifier  
 JEG\_qual = Jacobs qualifier

#### 4.4.1 Surface Soil

Twenty-seven positive detections of organic chemicals from 21 individual samples were recorded. Of the organics detected, the phthalates and methylene chloride are common laboratory contaminants. Eight of 10 methylene chloride detections were qualified during the data validation process as nondetected because these chemicals were also present in associated blank samples. Toluene was detected nine times in seven individual samples, and fluoranthene was detected in a single sample. All of the toluene and fluoranthene detections were "F" qualified by the laboratory as a value above the detection limit, but below the practical quantitation limit.

#### 4.4.2 Subsurface Soil

Twenty-one positive detections of organic chemicals from 15 individual samples were recorded. All of the organics detected—acetone, di-n-butyl phthalate, 2-butanone, and methylene chloride—are common laboratory contaminants. All of the methylene chloride detections were qualified during the data validation process as nondetected because these chemicals were also present in associated blank samples.

#### 4.4.3 Groundwater

Twelve positive detections of organic chemicals from 10 individual samples were recorded. Both bis(2-ethylhexyl) phthalate and methylene chloride are common laboratory contaminants. All of the methylene chloride detections and one of the bis(2-ethylhexyl) phthalate detections were qualified during the data validation process as nondetected because these chemicals were also present in associated blank samples.

#### 4.4.4 Surface Water

Eight positive detections of organic chemicals from five individual samples were recorded. The organics detected—benzyl butyl phthalate, di-n-butyl phthalate, and methylene chloride—are common laboratory contaminants. All four of the methylene chloride detections were qualified during the data validation process as nondetected because these chemicals were also present in associated blank samples

#### 4.4.5 Sediment

Nine positive detections of organic chemicals from six individual samples were recorded. Of the organics detected, bis(2-ethylhexyl) phthalate is a common laboratory contaminant. Benzo(b)fluoranthene and pyrene were detected once, and fluoranthene was detected twice. All of the detections were “F” qualified by the laboratory as a value above the detection limit, but below the practical quantitation limit.

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# TAB

Sections

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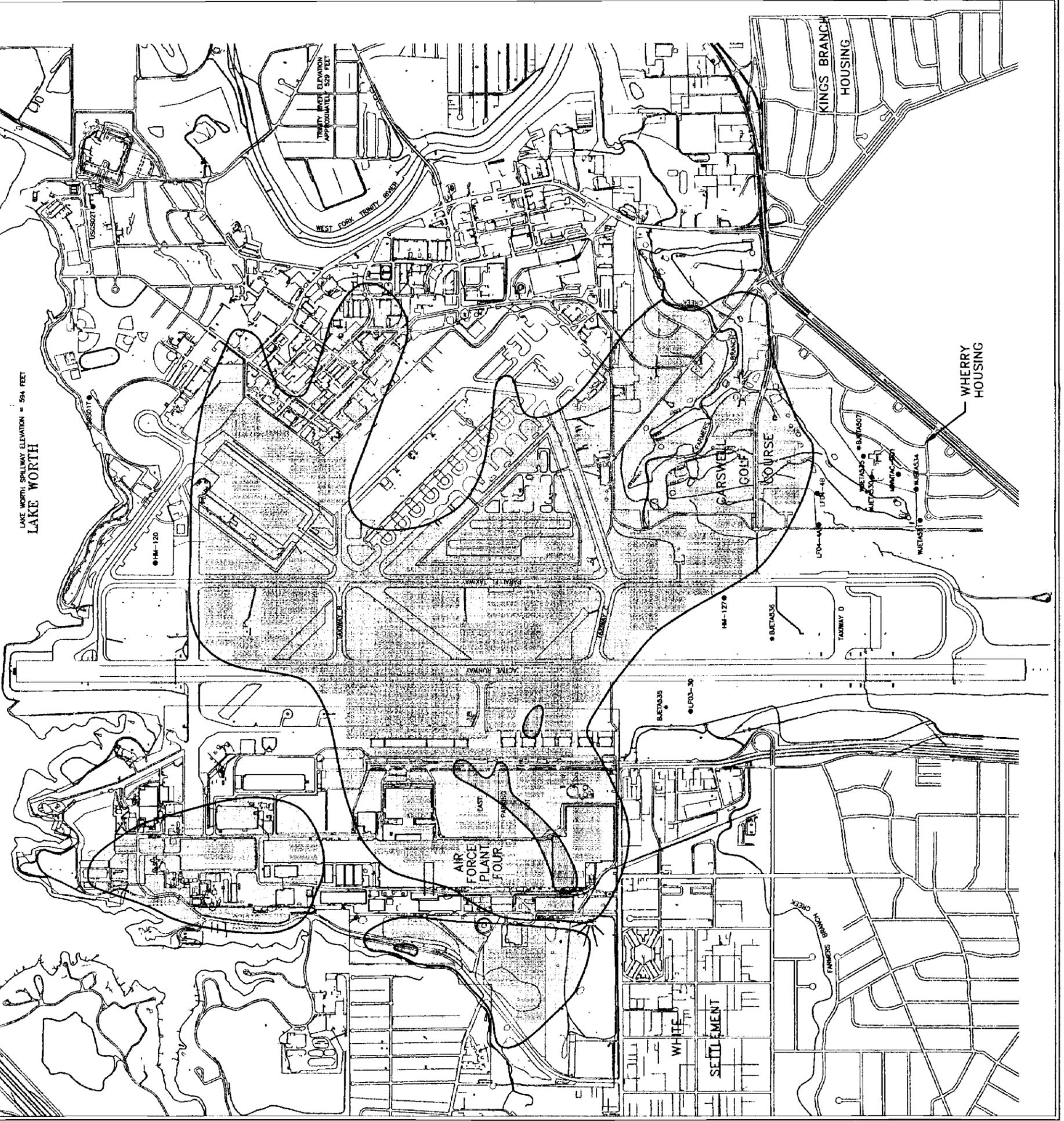
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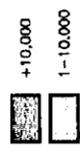


**Legend**

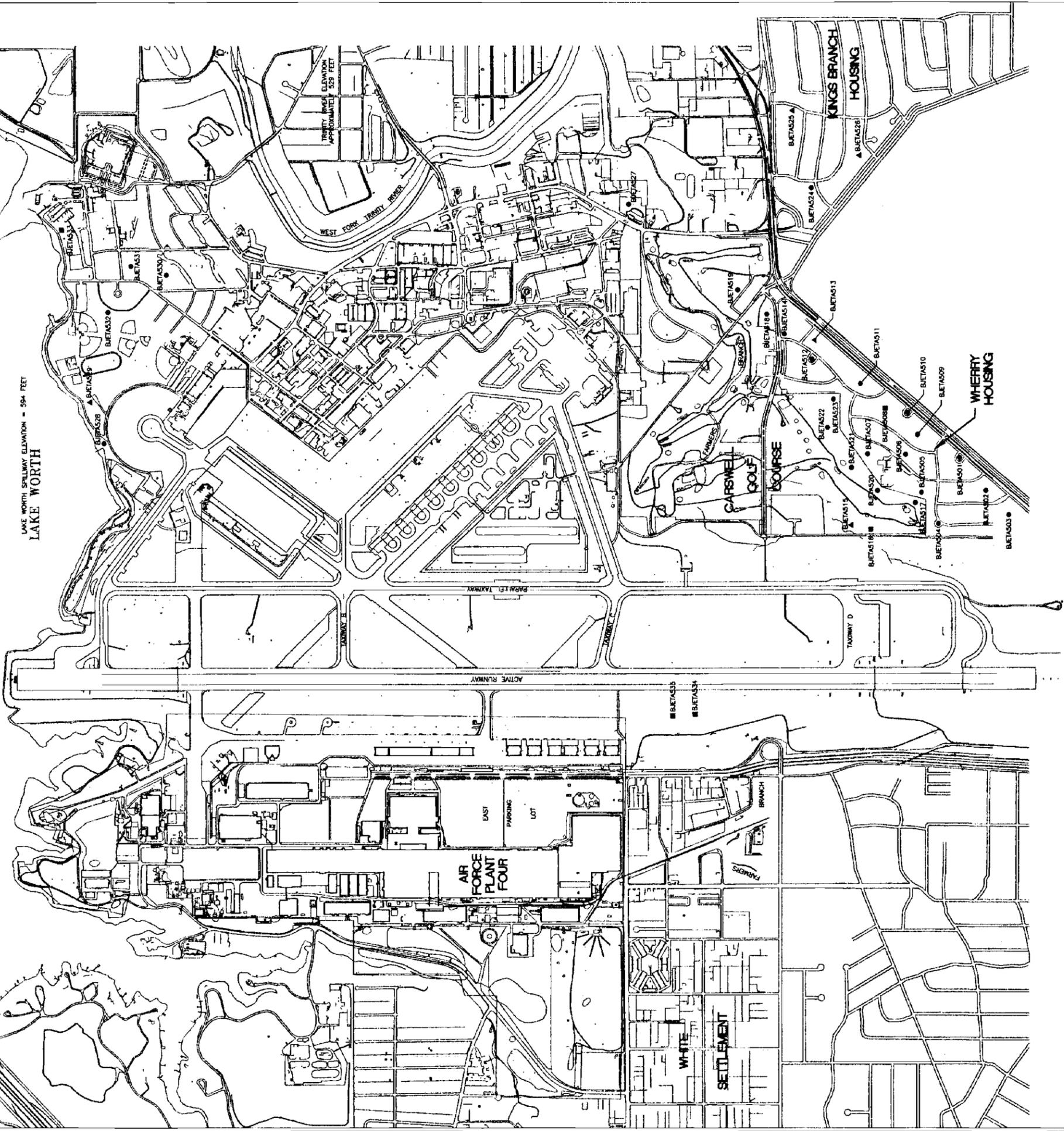
- HM-127 • Existing Well Location Sampled for Background Determination Using a Peristaltic Pump for Low Stress Sampling
- HWATAC-001 • Existing Well Location Sampled for Background Determination Using a Bladder Pump for Low Stress Sampling
- WETAS31 • Well Installed for Background Determination and Sampled Using a Peristaltic Pump for Low Stress Sampling
- WETAS30 • Well Installed for Background Determination and Sampled Using a Bladder Pump for Low Stress Sampling
- BETAS07 • Dry Borings Drilled. Monitoring Well was not installed

NOTE: After Low Stress Sampling, all wells were sampled by rapidly purging three well volumes of groundwater from the well followed by sample collection using a bailer.

CONTOUR INTERVAL AND COLOR KEY FOR TCE PLUMES ( $\mu\text{g/L TCE}$ )



Naval Air Station Fort Worth JRB Fort Worth, Texas	
Background Groundwater Sampling Locations	
PROJECT NO.	05-G-47900
DATE	01/05/98
DESIGNED BY	D. HOFSLIEN
CHECKED BY	L. SCHUIETER
SCALE	AS SHOWN
FIGURE NO.	PLATE 2B DWG PLATE 2



**Legend**

- Surface and Subsurface (Horizons A and B) Background Soil Sample Location
- Surface (Horizon A) Background Soil Sample Location
- ▲ Subsurface (Horizon B) Background Soil Sample Location

Naval Air Station Fort Worth JRB  
Fort Worth, Texas

Background Soil Sample Locations

PROJECT NO.	409116	DATE	01/14/97
DRAWN BY	J. HUNTER	SCALE	AS SHOWN
CHECKED BY	L. SCHUETTER	PLATE NO.	PLATE 1 (OF 1)
DESIGNED BY		PROJECT NO.	05-G-47900

**FINAL PAGE**

**ADMINISTRATIVE RECORD**

**FINAL PAGE**

**FINAL PAGE**

**ADMINISTRATIVE RECORD**

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