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Site 1
NAS Pensacola
Pensacola, Florida

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The remedial investigation for Site 1 — Sanitary Landfill at the Naval Air Station Pensacola identified parameters in wetland surface water and sediment and site surface soil, landfill wastes, and groundwater.

Currently, groundwater does not appear to be greatly affecting wetland sediment and surface water quality. However, generally low concentrations detected in wetland samples are partially attributable to past groundwater discharge to these features. Data generated will be used to develop the wetland sampling approach for the investigation of Site 41 — NAS Pensacola wetlands, to determine the site's impact on nearby surface water bodies and wetlands.

Past landfill activities have impacted the soil inside its boundary. Buried wastes have been characterized as containing concentrations of all parameter groups (inorganics, VOCs, semivolatiles, pesticides, and PCBs). Toxicity Characteristic Leaching Procedure results, however, indicate appreciable leaching is not occurring at tested locations. While surface soil within the landfill contains elevated concentrations of inorganic and organic constituents, surface soil quality outside the boundary appears to be generally comparable to reference conditions.

Relatively low concentrations of inorganic and organic constituents are present in the surficial zone groundwater beneath the site. Metals concentrations (cadmium, chromium, and nickel) exceeding state and federal standards were detected in only a limited number of 1994 samples. The center of the site — along the landfill's eastern, western, and northwestern boundaries — has the greatest impact of inorganics on shallow and intermediate groundwater quality. Except for aluminum, iron, and manganese, inorganic concentrations exceeding state and federal standards are limited to areas in and around the landfill perimeter.

Volatile, semivolatile, and pesticide compounds were detected in concentrations near state and federal standards in surficial groundwater. The highest concentrations of organics occurred in the center of the site, along the eastern and western boundaries. Relatively lower organic concentrations extend downgradient to areas along Bayou Grande's coastline, adjacent wetlands, and east-northeast beneath the golf course. Only a single low pesticide concentration was detected in samples from the most downgradient wells across the golf course. This indicates organic-impacted groundwater is limited to the area beneath the golf course. .Organics concentrations exceeding state and federal standards are limited to areas in and around the landfill perimeter.

Deep groundwater sample results indicate quality in the main producing zone has not been impacted by the site. However, additional deep well installation in areas hydraulically downgradient of impacted shallow intermediate zone groundwater should be considered during remedial design activities to confirm the vertical extent of potential contaimination. Previously installed deep wells, which were not double-cased, should be abandoned to avoid cross-contamination if deep well integrity degrades.

The Site 1 remedial investigation has adequately assessed the nature and extent of soil and groundwater contamination and provided sufficient initial aquifer parameter data for the feasibility study. A feasibility study is recommended to evaluate alternatives for site management decisions. The Navy recommends addressing the landfill as a whole, as opposed to individually delineating and treating numerous "hot spots" or "microplumes."

The human health risk assessment determined that the risk and/or hazard associated with exposure to all environmental media (and combinations thereof) was within USEPA's generally acceptable ranges for the trespassing child and the potential future site worker.

Exposure to the shallow intermediate groundwater medium presented an unacceptable risk and/or hazard via the ingestion and inhalation exposure pathways for the hypothetical future Site resident. No unacceptable risk and/or hazard was projected for exposure to surface soil or surface and subsurface soil.

Species at Site 1 are not considered to be at risk based on the contaminant concentrations observed. Community-level effects are considered negligible due to the suspected lack of contaminant transfer, and due to the confined areas of contamination. Information from the Florida Natural Areas Inventory shows no threatened or endangered (T&E) species will be impacted at Site 1. In addition, no T&E species' habitats were observed in or around the site.

No appreciable ecological risks from groundwater discharge to wetlands near Site 1 are currently apparent. A more detailed risk assessment of Site 1 wetlands will be made during the Site 41 investigation.

Specific effects to overall biota within the area are unknown. Elevated concentrations of contaminants at locations 01S8001 and 01S8201 indicate ecological risk may be higher for these areas compared to the site overall.

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List of Abbreviations

The following list contains many of the acronyms, initialisms, abbreviations, and units of measure used in this report.

"C	Degrees Celsius
"F	Degrees Fahrenheit
% RSD	Percent Relative Standard Deviation
%D	Percent Difference
µg/kg	Micrograms per kilogram
µg/L	Micrograms per liter
µR/hr	Micro-Roentgen equivalent man units per hour
µS/cm	Microsiemens per centimeter
1,1-DCA	1,1-Dichloroethane
1,1-DCE	1,1-dichloroethylene
1,1,1-TCA	1,1,1-trichloroethane
1,1,2-TCA	1,1,2-trichlorethane
95% UCL mean	95 percent upper confidence level
ABB	Asea, Brown, Boveri Environmental Services
ABF	Absorption Factor
AOC	Area of Concern
AQTESOLV	Aquifer Test Solver
ARARs	Applicable or Relevant and Appropriate Requirements
ASTM	American Society for Testing and Materials
AWQC	Ambient Water Quality Criteria
B(a)P	Benzo(a)pyrene
BAFs	Bioaccumulation Factors
bls	Below Land Surface
BNAs	Base neutral/acid extractable
BOD	Biochemical oxygen demand
BRA	Baseline Risk Assessment
BTEX	Benzene, toluene, ethylbenzene, xylene
c-1,2-DCE	Cis-1,2-dichloroethene
CDE	Chronic Daily Exposure
CDI	Chronic Daily Intake
CEC	Cation Exchange Capacity
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act of 1980
CG	Cleanup Goal
CH_2Cl_2	Methylene Chloride
$CHCl_3$	Chloroform
CLEAN	Comprehensive Long-term Environmental Action Navy
CLP	Contract Laboratory Program
cm/s	Centimeters per second
COCs	Chemicals of Concern

COD	Chemical Oxygen Demand
COPCs	Chemicals of Potential Concern
CPSSs	Chemicals Present in Site Samples
CRQL	Contract Required Quantitation Limit
CSAP	Comprehensive Sampling and analysis Plan
CSS	Contaminant Source Survey
CT	Central Tendency
D	Duplicate
DOT	Department of Transportation
E/A&H	EnSafe/Allen & Hoshall
E&E	Ecology & Environment, Inc.
ECAO	Environmental Criteria and Assessment Office
ECD	Electron Capture Detection
EnSafe	Environmental and Safety Designs, Inc.
EPC	Exposure Point Concentrations
ESD	Environmental Services Division
FAC	Florida Administrative Code
FDEP	Florida Department of Environmental Protection formerly the Florida Department of Enironmental Regulation (FDER)
FDWS	Florida Drinking Water Standard
FGGC	Florida Groundwater Guidance Concentrations
FID	Flame Ionization Detector
FNAI	Florida Natural Areas Inventory
FPDWS	Florida Primary Drinking Water Standard
FS	Feasibility Study
FSDWS	Florida Secondary Drinking Water Standard
ft/day	Feet per day
G&M	Geraghty and Miller, Inc.
GC	Gas Chromatograph
gpd	Gallons per day
GPL	Gel Permeation Chromatography
gpm	Gallons per minute
GTI	Groundwater Technology, Inc.
H_2SO_4	Sulfuric Acid
HCl	Hydrochloric Acid
HEAST	Health Effects Assessment Summary Tables
HI	Hazard Index
HMW	High Molecular Weight
HNO_3	Nitric Acid
HQ	Hazard Quotient
ICSA	Interference Check Sample Analysis
ID	Inside Diameter
IDL	Instrument Detection Limit
IDW	Investigation — Derived Waste

ILCR	Incremental lifetime Cancer Risk
IRIS	Integrated Risk Information System
ITAS	International Technology Analytical Services
IWTP	Industrial Wastewater Treatment Plant
K	Hydraulic Conductivity
LCSA	Laboratory Control Sample Analysis
LEL	Lower Explosive Limit
LMW	Lower Molecular Weight
MC	Mean Concentration
MCLs	Maximum Contaminant Level
meg/100g	milliequivalents per 100 grams
ml	Milliliters
mS/cm	milliSiemens per centimeter
mg/kg	Milligrams per kilogram
MS/MSD	Matrix Spike/Matrix Spike Duplicate
msl	Mean Sea Level
NADEP	Naval Aviation Depot
NaOH	Sodium Hydroxide
NAS	Naval Air Station
NCP	National Contigency Plan
NEESA	Naval Energy and Environmental Support Activity
NET	National Environmental Testing, Inc.
NOAA	National Oceanic and Atmospheric Administration
NPL	National Priorities List
NTU	Nephelometric Turbidity Unit
NWFWMD	Northwest Florida Water Management District
OERR	Office of Emergency and Remedial Response
OSWER	Office of Solid Waste and Emergency Response
OVA	Organic Vapor Analyzer
PAHs	Polyaromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
PCE	Perchloroethylene
PCi/g	picocurie per gram
PDE	Potential Dietary Exposure
PID	Photoionization Detector
PNAs	Polynuclear Aromatic Hydrocarbons
ppb	Parts per billion
ppm	Parts per million
PPS	physical parameters, soil
ppt	parts per thousand
PPW	physical parameters, water
PRG(s)	Preliminary Remediation Goals
PVC	Polyvinyl Chloride
QA/QC	Quality Assurance/Quality Control
RAGS	Risk Assessment Guidance

RBC	Risk-based Concentration
RC	Reference Concentration
RCRA	Resource Conservation and Recovery Act
RDA	Recommended Daily Allowance
RD/RA	Remedial Design/Remedial Action
RfD(s)	Reference Dose(s)
RfDi	Inhalation Reference Dose
RfDo	Oral Reference Dose
RGO	Remedial Goal Options
RI	Remedial Investigation
RME	Reasonable Maximum Exposure
RRFS	Relative Response Factors
RTVs	Reference Toxicity Value
S	Storativity
SAP	Sampling and Analysis Plan
SDG(s)	Sample Delivery Group(s)
SEGS	Southeastern Geological Society
SF	Slope Factor
SFF	Site Foraging Factor
SFi	Inhalation Slope Factor
SFo	Oral Slope Factor
SMCLs	Secondary Maximum Contaminant Levels
SMP	Site Management Plan
SOP/QAM	Standard Operating Procedure/Quality Assurance Manual
SOW	Statement of Work
SSV	Sediment Screening Values
svocs	Semivolatile Organic Compounds
T	Transmissivity
t-1,2-DCE	Trans-1,2-dichloroethene
TAL	Target Analyte List
TCE	Trichloroethylene
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
TEFs	Toxicity Equivalency Factors
TKN	Total Kjeldahl Nitrogen
TOC	Total Organic Carbon
TRPHs	Total Recoverable Petroleum Hydrocarbons
TSS	Total Suspended Solids
UCL	Upper Confidence Limit
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UST	Underground Storage Tank
VOA	Volatile Organic Analysis
VOCS	Volatile Organic Compounds
VTSR	Verified Time of Sample Receipt
WBZ	Water Bearing Zone

EXECUTIVE SUMMARY

A remedial investigation was conducted for Site 1 — Sanitary Landfill at NAS Pensacola. The investigation objectives were to determine the nature and extent of contaminants in groundwater; to characterize surface soil inside and outside the landfill, and its contents; and to facilitate the evaluation of human health and ecological risk posed by contaminated site media through the baseline risk assessment process. The investigation identified analyzed parameters in wetland surface water and sediment, and site surface soil, landfill wastes, and groundwater.

Wetland sediment and surface water were evaluated with regard to shallow and intermediate groundwater quality (i.e., groundwater to surface water discharge scenario). Currently, site groundwater does not appear to be greatly affecting wetland sediment and surface water quality. However, generally low concentrations detected in wetland samples are partially attributable to past groundwater discharge to these features. Data generated during this investigation will be used to develop the wetland sampling approach for the upcoming investigation of Site 41 — NAS Pensacola wetlands. The impact of landfill activity on nearby surface water bodies and wetlands will be addressed further during the Site 41 investigation.

Soil media inside the landfill's boundary have been impacted by past landfill activities. Buried waste within the landfill has been characterized as containing notable concentrations of all analyzed parameter groups (inorganics, VOCS, semivolatiles, pesticides, and polychlorinated biphenyls). However, Toxicity Characteristic Leaching Procedure results of the waste do not indicate appreciable leaching is currently occurring at tested locations. Surface soil quality outside the landfill boundary appears to be generally comparable to reference (background) soil conditions. However, surface soil within the landfill's boundary does appear to have been impacted by landfill activities, resulting in elevated concentrations of inorganic and organic constituents.

The nature and extent of landfill-impacted groundwater have been evaluated at the site. Relatively low concentrations of inorganic and organic constituents are present in the surfical zone (shallow and intermediate wells depths) beneath the site. In 1994, metals concentrations (cadmium, chromium, and nickel) exceeding FPDWS/USEPA primary drinking water standard MCLs were detected only in a limited number of shallow 1994 samples. The greatest impact to site shallow and intermediate groundwater quality with respect to inorganics appears to be limited to the center of the site, along the landfill's eastern, western, and northwestern boundaries. Except for aluminum, iron, and manganese (indicated by reference data to naturally occur at elevated concentrations), inorganic concentrations exceeding ARARs are generally limited to areas within and around *the* landfill's perimeter.

Volatile, semivolatile and pesticide compounds have been detected at relatively low (near drinking water standard) concentrations in surficial groundwater. Consistent with the distribution of elevated inorganics, the highest concentrations of organics were detected in the center of the site, and along the landfill's eastern and western boundaries. Relatively lower organic concentrations extend downgradient from the landfill to areas along Bayou Grande's coastline, adjacent wetlands, and east-northeast beneath the golf course. However, no elevated inorganics or organics (except a single low pesticide concentration) were detected in samples collected from

the most downgradient, recently installed monitoring wells located across the golf course opposite the landfill. This information indicates the extent of organic-impacted groundwater migrating east-northeast from the landfill is limited to the area beneath the adjacent golf course. As with inorganics, organic concentrations exceeding ARARs are generally limited to areas within and around the landfill's perimeter.

Based on deep well sample results, groundwater quality within the main producing zone beneath the site does not appear to have been affected by site activities. **[However, additional deep well installation in areas hydraulically downgradient of impacted shallow/intermediate zone groundwater should be considered during remedial design activities to confirm the vertical extent of potential contamination.]** Deep wells installed by G&M (G&M 1986) were not double-cased and, therefore, should be abandoned to avoid aquifer zone cross-contamination if deep well integrity degrades.

The Site 1 RI has adequately assessed the nature and extent of soil and groundwater contamination and provided sufficient initial aquifer parameter data for remediation feasibility. A feasibility study is recommended for the site to evaluate potential alternatives for future site management decisions. Recognizing that the site contains numerous contaminant sources, [the Navy] recommends the landfill be addressed as a whole with regard to remedial alternatives (as opposed to individual delineation and treatment of potentially numerous "hot spots" or "micro plumes").

The human health risk assessment determined that the risk and/or hazard associated with exposure to all environmental media (and combinations thereof) was within USEPA's generally acceptable ranges for the trespassing child and the potential future site worker.

Exposure to the shallow/intermediate groundwater medium presented an unacceptable risk and/or hazard via the ingestion and inhalation exposure pathways for the hypothetical future Site resident. No unacceptable risk and/or hazard was projected for exposure to surface soil or surface and subsurface soil.

Species at Site 1 are not considered to be at risk based on the contaminant concentrations observed. Community-level effects are considered negligible due to the suspected lack of contaminant transfer, and due to the confined areas of contamination. Information from the Florida Natural Areas Inventory shows no threatened or endangered (T&E) species will be impacted at Site 1. In addition, no T&E species' habitats were observed in or around the site.

No appreciable ecological risks from groundwater discharge to wetlands near Site 1 are currently apparent. A more detailed risk assessment of Site 1 wetlands will be made during the Site 41 investigation.

Specific effects to overall biota within the area are unknown. Elevated concentrations of contaminants at locations 01S8001 and 01S8201 indicate! ecological risk may be higher for these areas compared to the site overall.

[Bold items in brackets denote changes to the first draft of document.]

1.0 INTRODUCTION

As part of the U.S. Navy Comprehensive Long-Term Environmental Action Navy (CLEAN) program, a Remedial Investigation (RI) recently has been completed at Site 1 — Sanitary Landfill, at Naval Air Station (NAS) Pensacola. Site 1 is within the northcentral portion of NAS Pensacola, immediately south of the inland water body Bayou Grande, and east of Forrest Sherman Airfield.

The investigation was undertaken by EnSafe/Allen & Hoshall (E/A&H) to meet the requirements of the federal Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) program, which administers the investigation and cleanup of former hazardous waste sites. The RI report summarizes the activities, results, and conclusions of the investigation and provides the basis for the feasibility study (FS) to be completed for the site. The objectives of the RI, and the FS which will follow, are outlined below.

Objectives of the Remedial Investigation

- To determine the source, nature, magnitude, and extent of groundwater contamination. Investigative activities also were performed to characterize the contents of the landfill and surface soil in and outside the landfill area. Additionally, an initial evaluation of sediment and surface water associated with Site 1 wetlands was performed (in 1994) to assess the landfill's potential impact on these areas.

- To facilitate the evaluation of human health and ecological risk posed by contaminated media onsite through the baseline risk assessment (BRA) process.

An FS will be conducted to determine appropriate methods of addressing site contamination based on data generated during the RI process.

1.1 Project Organization

The RI was organized into three parts. The first part involved reviewing all available previous investigation reports in the administrative record to develop a comprehensive understanding of the site history and background, and developing the investigative Sampling and Analysis Plan (SAP) (E/A&H 1993a). Next, a contaminant source survey (CSS) was performed to gain additional infomation concerning the history of Site 1 landfill activities and the nature of the wastes buried. Finally, a field investigation in 1993 consisted of soil boring completion, monitoring well installation, and test trench installation; soil, groundwater, and trench waste sampling for chemical and physical analyses; and a hydrologic assessment. Additional sampling performed in 1994 included a second round of groundwater sampling, and sediment and surface water sampling.

1.2 Purpose of Report

This RI report summarizes the activities, methodologies, results, and conclusions of the investigation, providing the basis for an FS to be completed for the site. Sections 2 through 4 of this report contain site description, history, and setting information. Sections 5, 6, and 7 contain investigation methodology, hydrologic results, and nature and extent discussions for the 1993 field activities, respectively. Section 8 contains investigation methodology, hydrologic results, and nature and extent discussions for the 1994 field activities in total. Sections 9 and 11 contain data validation, and contaminant fate and transport discussions, respectively. Section 10 contains the BRA findings and conclusions. Section 12 contains a contaminant summary discussion; investigation conclusions and recommendations are contained in Section 13.

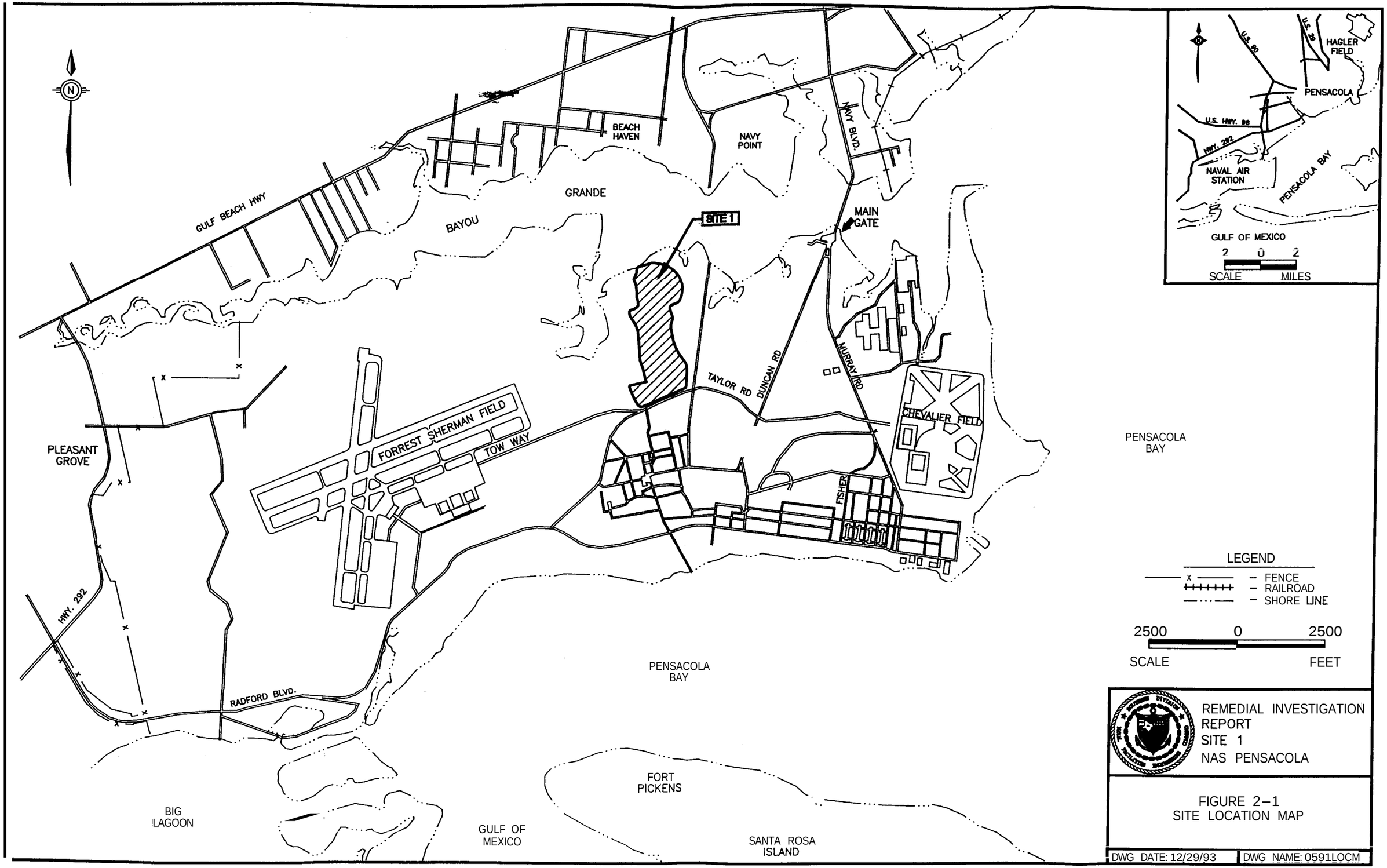
2.0 SITE DESCRIPTION AND HISTORY

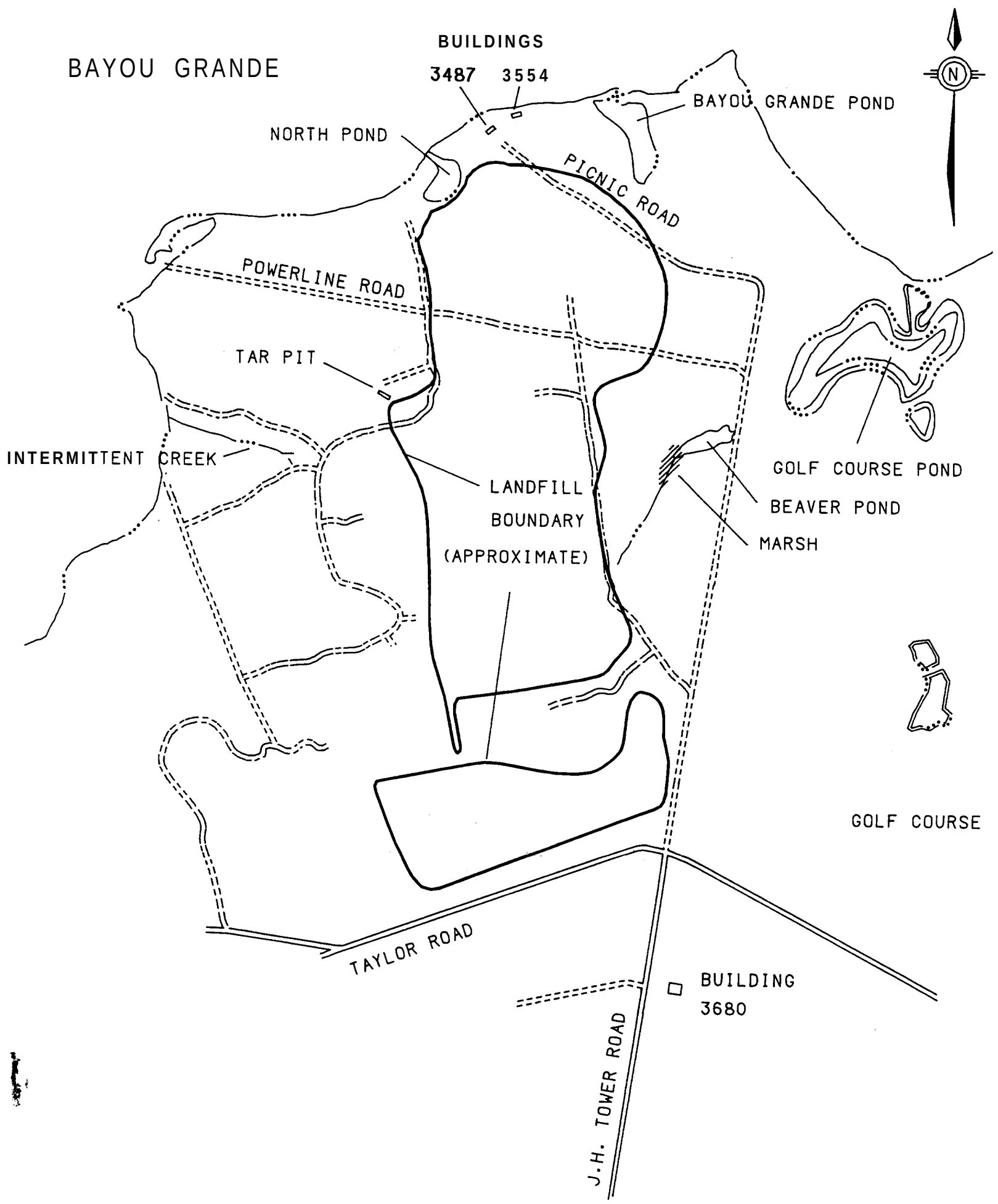
21 Site Description

Site 1 — the Sanitary Landfill, as shown on Figures 2-1 and 2-2, comprises an inactive landfill and 80 acres surrounding it. The landfill is at an elevation of 8 to 20 feet above mean sea level (msl) and is densely vegetated with 15- to 25-foot planted pines and natural scrub vegetation. Located within the northcentral portion of NAS Pensacola, Site 1 is approximately 0.5 miles east of Forrest Sherman Airfield. The site is bordered by an inland water body (Bayou Grande) to the north, by the A.C. Read Golf Course to the east, and by areas of natural scrub vegetation to the west and south. Bayou Grande has been classified by the Florida Department of Environmental Protection (FDEP) as a Class III water body, indicating its use for recreation and maintaining a well-balanced fish and wildlife population (FDEP 1992a). Taylor Road lies approximately 200 feet south of the site, beyond the scrub vegetation.

Developed areas near the site include a Boy Scout camp, a nature trail, an NAS Pensacola picnic area, and recreational use Buildings 3553 and 3487, just noxth of the landfill's northern border. Also within this generally developed area are two tidal-inlet ponds with associated wetlands. Other wetland areas are west and east of the landfill, most of which are associated with marshy intermittent creeks. These creeks appear to provide surface/groundwater-seep drainage from the general landfill area to Bayou Grande.

The nearest residential area is approximately 1,000 feet south of Site 1. Site 16, a brush disposal area and formerly a brush-burning location, is approximately 600 feet west-southwest of the site.


N
GULF BEACH HWY
BEACH HAVEN
NAVY POINT
NAVY BLVD.
GRANDE
BAYOU
SITE 1
MAIN GATE
TAYLOR RD
DUNCAN RD
MURRAY RD
CHEVALIER FIELD
FISHER
FORREST SHERMAN FIELD
TOW WAY
PLEASANT GROVE
HWY. 292
RADFORD BLVD.
PENSACOLA BAY
PENSACOLA BAY
FORT PICKENS
BIG LAGOON
GULF OF MEXICO
SANTA ROSA ISLAND
U.S. 90
U.S. 29
HAGLER FIELD
PENSACOLA
U.S. HWY. 98
HWY. 292
NAVAL AIR STATION
PENSACOLA BAY
GULF OF MEXICO
2 0 2
SCALE MILES
LEGEND
FENCE
RAILROAD
SHORE LINE
2500 0 2500
SCALE FEET
REMEDIAL INVESTIGATION REPORT
SITE 1
NAS PENSACOLA
FIGURE 2–1
SITE LOCATION MAP
DWG DATE: 12/29/93
DWG NAME: 0591LOCM



LEGEND

COASTLINE / SURFACE WATER FEATURE

UNPAVED ROAD

600 0 600

SCALE FEET

REMEDIAL INVESTIGATION REPORT
SITE 1
NAS PENSACOLA

FIGURE 2-2
SITE 1 - SANITARY LANDFILL
SITE MAP

DATE: 11/17/93 DWG NAME: 59FIG2-2

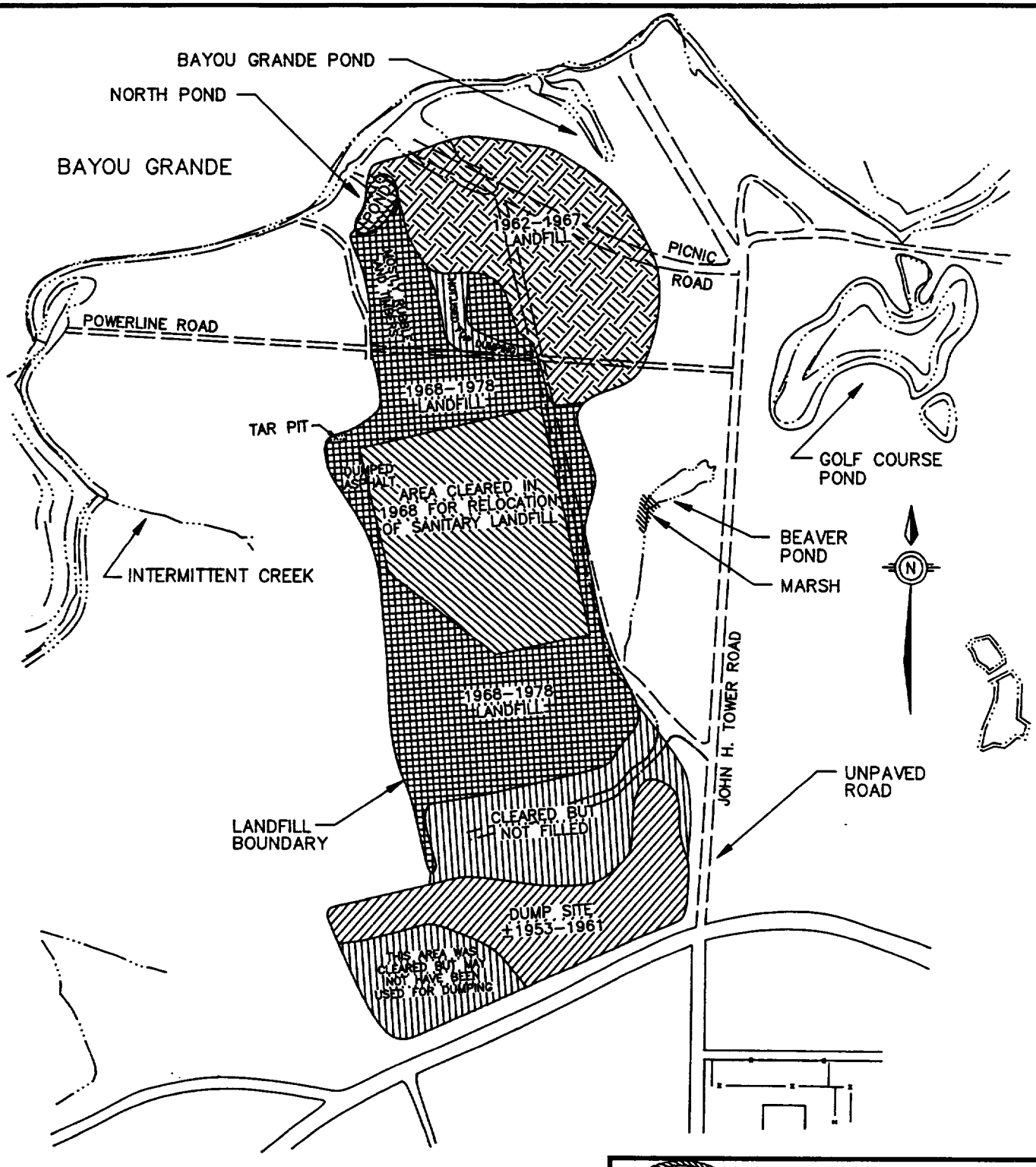
2.2 Site History and Previous Investigations

2.2.1 General History

During the early 1950s and continuing until 1976, a variety of domestic and industrial wastes generated from NAS Pensacola and other outlying Navy facilities were disposed of at Site 1. A partial list of wastes and quantities disposed of at the site include the following (as taken from the Naval Energy and Environmental Support Activity [NEESA] Initial Assessment Study [IAS] 1983):

- Ketone-soaked rags
- PCB- and transformer oil-soaked rags (6,500 cubic feet [ft^3])
- Paint chips
- Paint sludge from water wall paint booth (170,000 pounds [lbs])
- Paint sludge (5,200 gallons [gal])
- Dry air-filter pads from paint booths (11,963 ft^3)
- Compressed air cylinders (200)
- Asbestos from building demolition
- Wood soaked with plating solutions (1,667 ft^3)
- Pesticide rinsate
- Garbage (64,800 tons)
- Wastes from outlying facilities — Corry, Ellison, Saufley, Baron, and Whiting
- Containers from paints, pesticides, oils, strippers, plating chemicals, solvents, thinners, etc.
- Mercury

As shown on Figure 2-3, previous investigation documents and NAS Pensacola Public Works Center (PWC) drawings indicate disposal activities were moved from one portion of the site to another during the time the landfill was active (NEESA 1983). The southernmost extent of the site, used during the 1950s, is the landfill's oldest-known portion. In the early 1960s, waste disposal was moved approximately 3,000 feet north to the northernmost portion of the site.



REMEDIAL INVESTIGATION REPORT
SITE 1
NAS PENSACOLA

FIGURE 2-3
LAND USE MAP

SOURCE: E&E 1991/NAVFAC DRAWING NUMBER 5205053

DWG DATE: 12/29/93 | DWG NAME 059LNDUS

Additionally, an area along the northwestern border of the site also was reportedly filled with construction rubble during the 1950s and 1960s. During the late 1960s and until the closure of the landfill, waste disposal was performed in its central portion. During the earlier years of disposal at Site 1, wastes commonly were burned before burial; however, this practice was ended in the late 1960s due to citizen's concern over air pollution in nearby areas. The landfill officially closed October 1, 1976.

2.2.2 Chronology of Events and Previous Investigations

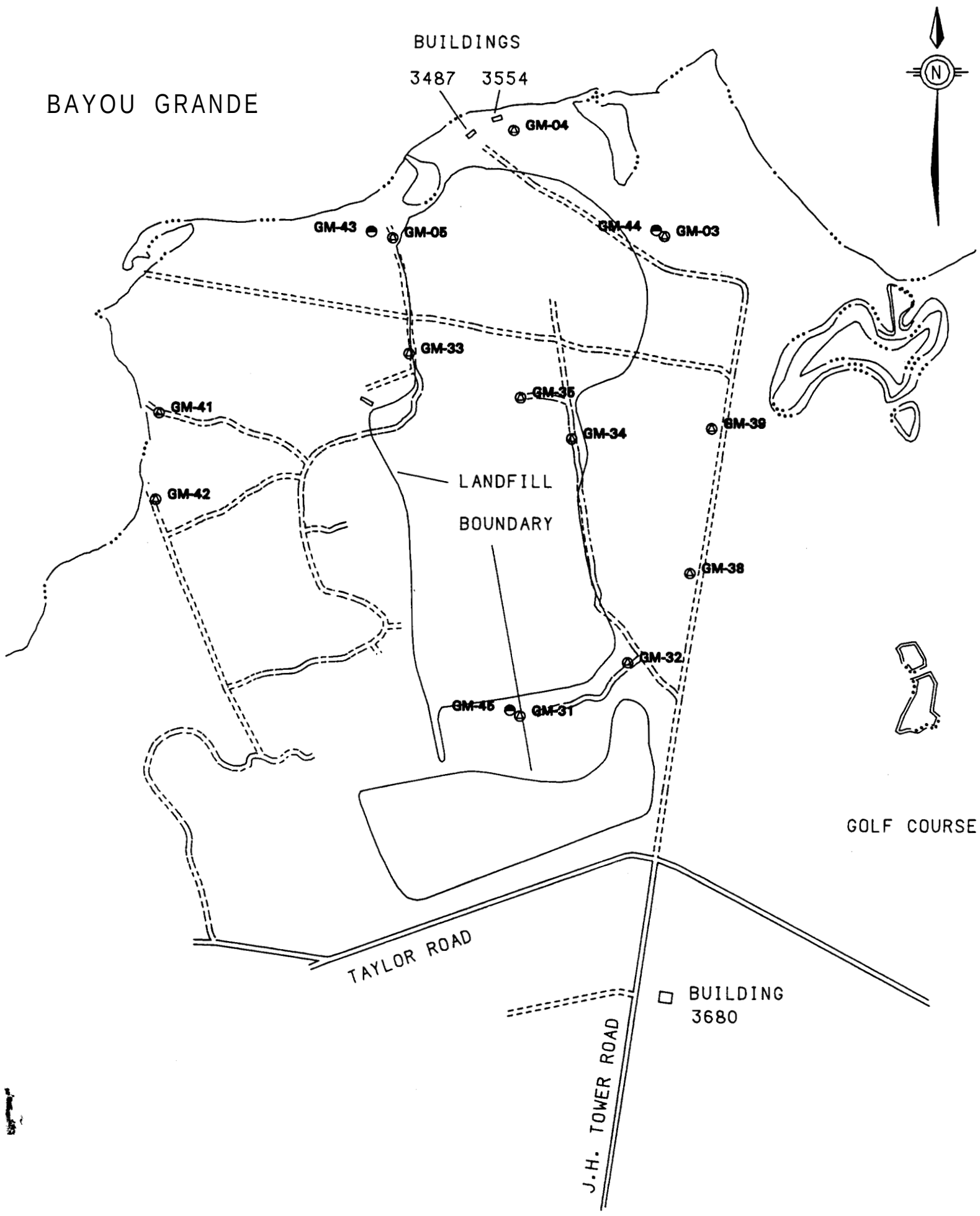
The following chronology of events and previous investigations at Site 1 provide a basis for understanding the history and focus of the RI/FS. As discussed in the following sections, the locations of permanent monitoring wells installed during previous investigations (Geraghty and Miller [G&M] 1984 and 1986) are shown on Figure 2-4. Summary analytical results tables referenced in the following discussions are contained in Appendix A of this report.

1974 — Discovery of Landfill Leachate Discharge

In 1974, landfill leachate was discovered discharging into a nearby golf course pond from an abandoned drainage field. At that time, drainage outlet was plugged, causing the water table to rise and additional leachate to seep to the surface. As a result, an investigation was performed in 1974 and 1975 during which seven galvanized-steel monitoring wells were installed and sampled. Groundwater sample analysis indicated the presence of phenol and several metals (G&M 1984). This investigation (Crawford 1975, unavailable for review) concluded shallow groundwater flowed to the north toward Bayou Grande and groundwater was contaminated in the upper portion of the Sand-and-Gravel Aquifer near the landfill (NEESA 1983).

1983 — Initial Assessment Study

An IAS was performed by NEESA under the Navy Assessment and Control of Installation Pollutants (NACIP) Program. As the first phase of the NACIP program, the IAS' purpose was



LEGEND

COASTLINE / SURFACE WATER FEATURE

UNPAVED ROAD

SHALLOW MONITORING WELL

DEEP MONITORING WELL

600 0 600

SCALE FEET

REMEDIAL INVESTIGATION REPORT

SITE 1

NAS PENSACOLA

FIGURE 2-4

PERMANENT MONITORING WELLS INSTALLED DURING PREVIOUS INVESTIGATIONS

DATE: 11/16/93 DWG NAME: 59FIG2-4

to identify and assess sites posing a potential threat to human health or the environment due to contamination from past hazardous materials operations. This study included reviewing facility records and aerial photographs, interviewing facility personnel, and conducting a field survey. During the survey, limited sampling of landfill leachate and site ponds sediment was performed. Sample analysis indicated concentrations of cadmium, chromium, mercury, nickel, and lead were in sediments, and cadmium and mercury were in the leachate (NEESA 1983). The survey concluded Site 1 presented a potential threat to human health and the environment and therefore was recommended for further investigation to include a confirmation study, Phase II of the NACIP Program.

1984 — Verification Study

Part I of the NACIP confirmation study, the verification study was performed by G&M to assess the presence or absence of potential groundwater contaminants at sites recommended for study in the IAS (G&M 1984). During this study, eight shallow 2-inch polyvinyl chloride (PVC) monitoring wells (GM-3, GM-4, GM-5, GM-31, GM-32, GM-33, GM-34, and GM-35, See Figure 2-4) were installed and sampled. Groundwater samples were analyzed for volatile organic compounds (VOCs), base-neutral/acid extractable organic compounds (BNAs), pesticides, PCBs, metals, cyanide, and field parameters. Analytical results indicated that shallow groundwater quality beneath the landfill had been affected by past disposal practices.

Table A-1 summarizes the analytical results of this study. As shown, organic compounds were detected in all groundwater samples collected. The highest concentrations of organic compounds, most of which were VOCs, were detected in samples from the central portion of the site. Only trace concentrations of BNAs were detected. No PCBs or pesticides were present at concentrations above method detection limits. All detected metals concentrations were below FDEP 1984 drinking water standards. Water levels taken during the study indicated shallow groundwater flows north, northwest, and northeast toward surface water bodies, where it discharges to the bayou, site ponds, and tidal inlets.

1986 — Characterization Study

Part II of the NACIP confirmation study, the characterization study, was performed by G&M to determine the nature and extent of contamination at verification study sites requiring additional analysis (G&M 1986). During this investigation, five additional shallow monitoring wells (GM-38 through GM-42) and three deep wells (GM-43 through GM-45, See Figure 2-4) were installed. Groundwater samples were collected from all newly installed wells and the eight verification study wells. Groundwater samples from the newly installed wells were analyzed for the United States Environmental Protection Agency's (USEPA) list of organic priority pollutants, including VOCs, BNAs, pesticides, and PCBs. Samples collected from the previously installed wells were analyzed for VOCs only. No metals analysis was performed for either well group. Table A-2 summarizes the analytical results from this study, which verified the presence of organic contaminants in site groundwater. Samples collected from 12 of the 16 wells contained one or more VOCs. Additionally, two samples collected from deep wells exhibited VOC contamination. However, the presence of certain VOCs during the characterization study was not consistent with the results of the verification study (e.g., vinyl chloride only detected during characterization, methylene chloride detected only during verification). BNAs, pesticides, or PCBs were not detected during the characterization study. Water level elevation data again confirmed the generally northward flow of shallow groundwater toward site surface water bodies. However, deep well water levels indicated a slight gradient to the south (G&M 1986).

1991 — Contamination Assessment/Remedial Activities Investigation

Phase I of a Contamination Assessment/Remedial Activities Investigation was performed by Ecology and Environment, Inc. (E&E), to identify principal areas and primary contaminants of concern (COCs) at Site 1 and to provide recommendations for subsequent phases of investigation. Various preliminary surveys were performed which included: site reconnaissance survey, aerial photography analysis, radiation survey, surface emissions survey, and a geophysical survey. Additionally, site surface water, sediment, surface soils, and groundwater were sampled for laboratory analysis. Groundwater samples were collected from 15 existing

G&M monitoring wells (See Figure 2-4), along with 28 temporary shallow monitoring wells. Sediment, surface water, and surface soil samples were analyzed for a suite of screening parameters, including VOCs, polynuclear aromatic hydrocarbons (PAHs), phenols, pesticides, total PCBs, total recoverable petroleum hydrocarbons (TRPHs), and metals (water samples analyzed unfiltered). Samples collected from existing G&M wells were analyzed according to USEPA Contract Laboratory Program (CLP) protocol for the full Target Analyte List/Target Compound List (TAL/TCL) plus gross alpha radioactivity. Samples from temporary wells were analyzed for the screening parameters suite. Complete discussions of the investigation are in the corresponding 1991 Interim Data Report (IDR, E&E 1991g). The following passage summarizes E&E's investigation result conclusions.

Preliminary Surveys

Site Reconnaissance Survey — Numerous disturbed areas indicating fill activities or leachate migration were identified across the site. A collapsed/depression feature with remains of metal containers, an oozing tar-like substance, and elevated organic vapor concentrations was located in the northwest comer of the 1950s fill area. An area of exposed medical and industrial waste was located in the southwestern comer of the 1970s fill area. A linear pit containing a black, tar-like material was located in the northwestern comer of the 1970s fill area. This pit measured approximately 40 feet by 15 feet and contained an approximate 1.5-foot thickness of material. A construction rubble field was located south of North Pond extending south across powerline road to the vicinity of well GM-33. Various discolored water/leachate seeps and areas of soil and/or vegetation staining were located in site wetland areas (intermittent streams, ponds, and tidal inlets). **[Specifically, a *circular* depression containing potential leachate seepage was located south of the Beaver Pond Marsh; a flowing spring or leachate seep was located in the southern portion of the same marsh; and discolored sediment or leachate seepages were**

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noted in Bayou Grande Pond's southern portion, North Pond's northwestern side, and the Golf Course Pond's southwestern shoreline.]

Aerial Photography Analysis — Reviewing historical aerial photos generally confirmed the progression of landfill activities, which began in the site's southern portion during the 1950s, moved to the northern portion in the early 1960s, and were concluded in the central portion from the late 1960s through 1976. Additionally, numerous areas of disturbance associated with

landfill activities were noted from these photos. Specifically, three dark areal features, one of which corresponds to the location of the tar pit, were identified on a 1970s photo along the western extent of the 1970s fill area. An apparently low, linear marshy area also was identified on a 1970s photo, corresponding to the construction rubble field. Also, a sizeable dark irregular feature measuring approximately 200 feet by 75 feet was observed in the center of the 1970s fill area on a 1973 photo (E&E 1991g).

Surface Emissions and Radiation Surveys — Elevated organic vapor concentrations ranging from 1.0 to 20.0 parts per million (ppm) above background were detected at five locations. The highest concentration was taken at the collapse/depression feature in the 1950s fill area. The survey detected no significant levels of surface radiation (E&E 1991g).

Geophysical Survey — An electron magnetometer, metal detector, EM-31, and EM-34 were used to perform the survey. Overall, the survey's results indicated subsurface ferrometalic materials are present at relatively shallow depths (20 feet below land surface [bls] or less) across most of the landfill, primarily within the landfill boundary determined by aerial photos and site reconnaissance. Deeper anomalous EM-34 readings collected north, west, and east of the landfill may be attributable to landfill leachate migration toward the bayou in a lower portion of the surficial zone of the Sand-and-Gravel Aquifer. However, these deeper anomalies also may reflect saline water intrusion and/or more conductive lithologies present below the base of the surficial zone (E&E 1991g).

Chemical Analysis and Contaminant Distribution Sediment — Sediment samples collected from Site 1 area ponds and tidal inlets contained concentrations of TRPHs, PAHs, phenols, and elevated concentrations of metals. The analytical results for these samples are listed in Table A-3. Samples collected from Bayou Grande exhibited concentrations of metals, TRPHs, and PAHs. Most of the contaminants, particularly those in pond sediments, were attributed to past landfill activities. However, other ambient sources of contamination may be present and

contributing to site contaminant concentrations, such as PAHs and TRPHs detected in bayou sediments (E&E 1991g).

Surface Water — Most surface water samples collected from Site 1's ponds contained concentrations of zinc and/or chromium. The analytical results for these samples are listed in Table A-4. The VOC chlorobenzene was detected only in samples from North Pond. One sample from Bayou Grande contained zinc. Nearly all detected metals concentrations were below their respective FDEP Class III Surface Water Quality Standards (E&E 1991g).

Surface Soils — Significant concentrations of VOCs, PAHs, and phenols weze detected at only two surface soil sampling locations: the tar pit in the northwestern comer of the late 1960s to 1970s fill area, and in the collapse feature in the northwestern comer of the 1950s fill area. Analytical results for these samples are in Table A-5. Low to moderate concentrations of TRPHs were detected in all but one sample, indicating an ambient source of this contamination may be in the site vicinity (E&E 1991g).

Groundwater — Groundwater samples from temporary and existing Site 1 wells exhibited significant concentrations of one or more of the following contaminants: metals, VOCs, PAHs, phenols, BNAs, and TRPHs. The analytical results for these samples are contained in Tables A-6 and A-7. Cyanide, pesticides, and PCBs were not detected in any groundwater samples. Concentrations of metals and VOCs exceeded Florida drinking water standards in a number of temporary and existing shallow well samples. Sample containing these concentrations weze from wells generally within or adjacent to the landfill boundary, indicating limited off-site migration. Only low concentrations of mostly volatile and BNA tentatively identified compounds (TICs) were detected in the three existing deep well samples. However, an existing downward hydraulic gradient across most of the site, and the sporadic presence of volatile halocarbons in wells farther from the landfill, indicated the potential for off-site contaminant migration to greater depths within the surficial portion of the Sand-and-Gravel Aquifer (E&E 1991g).

1992 — Field Investigation

A field investigation was performed by USEPA Region IV, Environmental Services Division (ESD), Environmental Compliance Branch (ECB), Hazardous Waste Section (HWS) to provide high-quality baseline data on sediments, surface water, and groundwater within the Site 1 vicinity. Sediment and surface water samples were collected from several site wetlands and Bayou Grande. Groundwater samples were collected from two existing monitoring wells (one shallow and one deep). All samples were analyzed for the TAL/TCL. The analytical results for these samples contained in Tables A-8 through A-10 indicate significant concentrations of the following contaminants *are* present in Site 1 media:

- Wetlands sediments — metals, pesticides, and BNAs
- Wetlands surface water — metals and BNAs
- Bayou sediments — metals, pesticides, and BNAs
- Bayou surface water — metals only
- Groundwater — metals and VOCs (shallow well)

Most of the detected contaminants are assumed to originate from the landfill. However, ubiquitous, low concentrations of lead and pesticides detected at NAS Pensacola may be attributed to other sources (i.e., pesticides commonly used for insect control, low concentrations of lead likely occur naturally at NAS Pensacola). In general, groundwater contamination was minimal in the shallow well and nonexistent in the deep well. Additionally, pesticides, organic compounds, and metals were detected more frequently and at higher concentrations in wetlands sediments than in bayou sediments, indicating wetland sediments are effectively binding these materials (ESD 1992).

Previous investigations' results generally *agree* past landfill activity has impacted shallow groundwater quality. Additionally, the Phase I investigation as well as the 1992 field investigation indicate nearby wetlands surface water quality and sediments also may have been affected.

3.0 ENVIRONMENTAL SETTING

3.1 Physiography

NAS Pensacola is located in the Gulf Coast lowlands on a peninsula bounded by Pensacola Bay to the south and east and Bayou Grande to the north. The main topographic feature is a bluff paralleling the southern and eastern shorelines of the peninsula. Landward of the bluff is a gently rolling upland with elevations up to 40 feet above msl (United States Geological Survey [USGS] 1970a and 1970b). In the eastern part of the base, a low and nearly level marine terrace lies east of the bluff with elevations of approximately 5 feet or less above msl, comprising the areas of Chevalier Field and Magazine Point.

Sandy soils typify the NAS Pensacola area. Consequently, most rainfall infiltrates directly into the subsurface, resulting in few natural streams. Streams on base generally are man-made and channelized. Numerous natural wetlands occur in low-lying areas.

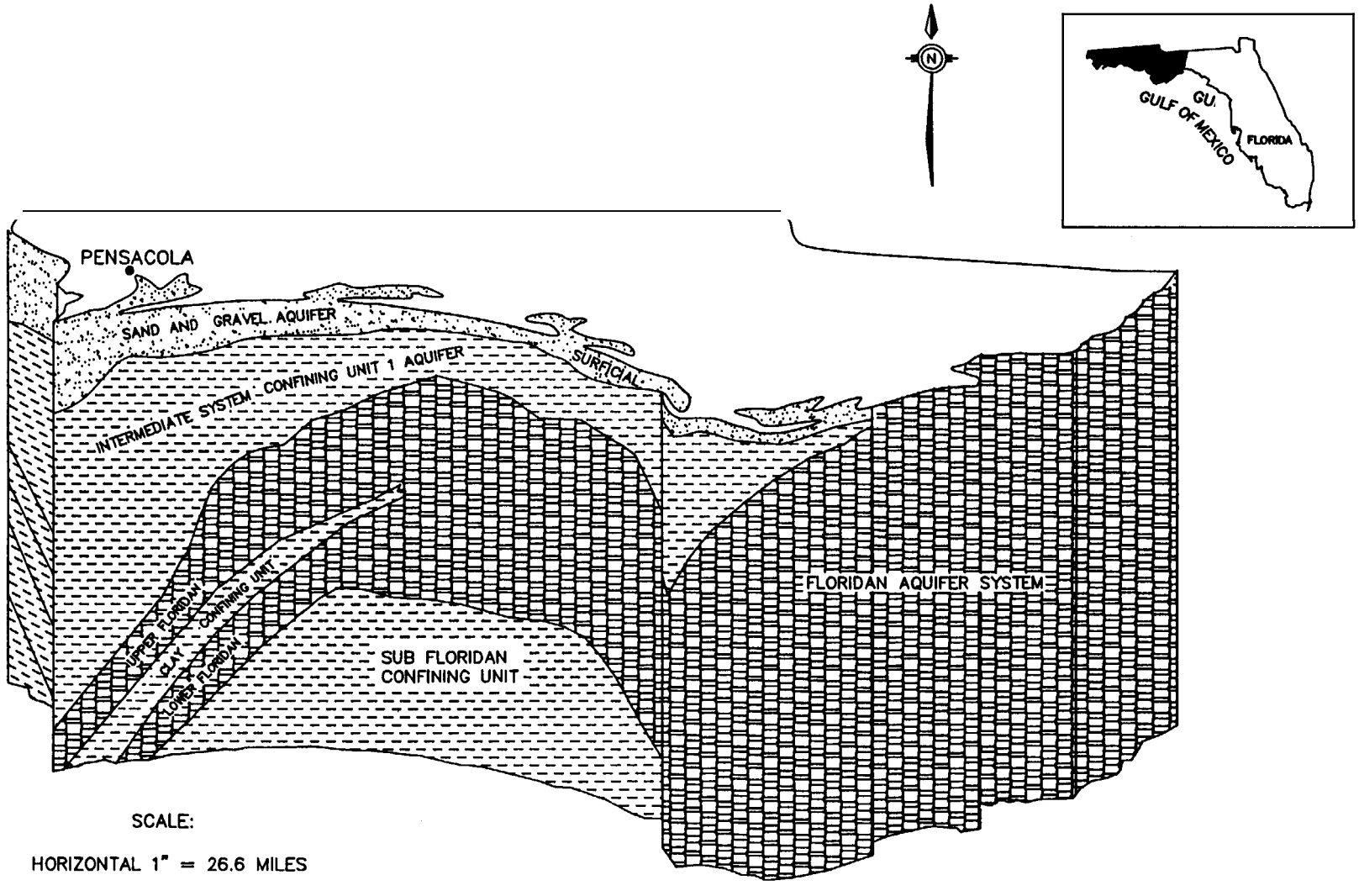
3.2 Stratigraphy and Hydrogeology

3.2.1 Regional Characterization

Stratigraphy beneath the Florida Panhandle, in general, consists of Quaternary terrace marine and fluvial deposits, underlain by a thick sequence of interlayered fine-grained clastic deposits and carbonate strata of Tertiary age (southeastern Geological Society [SEGS 19861). Three main regional hydrogeologic units have been defined within this stratigraphic column (in descending order): the Surficial/Sand-and-Gravel Aquifer, the Intermediate System, and the Floridan Aquifer System. Figure 3-1 provides a generalized cross-section of these hydrogeologic units in northwest Florida.

Surficial/Sand-and-Gravel Aquifer

The Surficial Aquifer is composed of unconsolidated clastic deposits and is approximately 300 feet thick at NAS Pensacola. Geologically, the Surficial Aquifer correlates with near-surface



SCALE:

HORIZONTAL 1" = 26.6 MILES

VERTICAL 1" = 500 FEET

VERTICAL EXAGGERATION = 281

SOURCE: E&E 1992c.

REMEDIAL INVESTIGATION
REPORT
SITE 1
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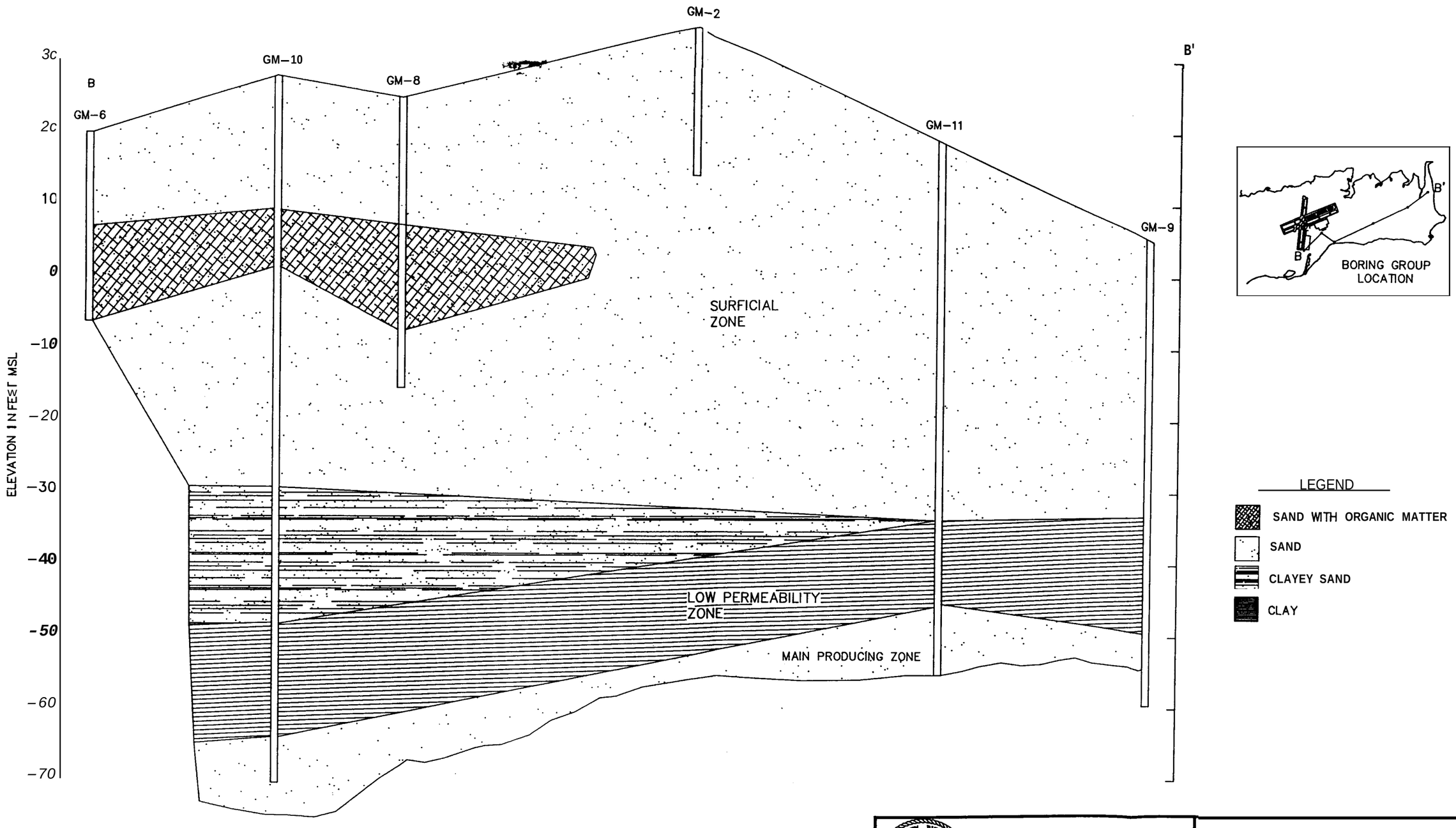
FIGURE 3-1
GENERALIZED GEOLOGIC CROSS-SECTION OF HYDROGEOLOGIC UNITS IN NORTHWEST FLORIDA

DATE: 10/28/93 | DWG. NAME: 05C0CCSU

Quaternary terrace marine and fluvial deposits, down to the Tertiary Citronelle Formation (SEGS 1986). In northwest Florida, west of the Choctawhatchee River, the Surficial Aquifer is referred to as the Sand-and-Gravel Aquifer and is used as a major source of drinking water (SEGS 1986). Groundwater of the aquifer is classified as a G-1 resource (FDEP 1988). Because the Sand-and-Gravel Aquifer is the uppermost unit contiguous with land surface and receives recharge through direct infiltration, it is susceptible to contamination from surface activities. In the vicinity of NAS Pensacola, the unit has been subdivided into three distinct zones based on hydrogeological differences (in descending order): the surficial zone, the lower permeability zone, and the main producing zone (Wilkins *et* al. 1985). The generalized cross-section of the Sand-and-Gravel Aquifer shown in Figure 3-2, illustrates the stratigraphic relationship of these zones (G&M 1984).

Surficial Zone

The surficial zone is contiguous with land surface and contains groundwater under water table or perched conditions. At NAS Pensacola, the surficial zone is approximately 30 to 60 feet thick and generally is composed of a poorly *graded* quartz sand (G&M 1984, 1986). Beneath the western side of the base, a substantial stratum of sand with abundant organic matter occurs within the zone and pinches out to the east. Depth to groundwater ranges from 0 to 20 feet, depending on ground surface elevation. Aquifer tests performed on NAS Pensacola wells within this zone have yielded high hydraulic conductivities ranging from *to* 18 to 62 feet/day (G&M 1986). Shallow groundwater flow is generally influenced by topography, usually resulting in flow and discharge to the nearest water body. Recent investigations have determined that the upper and basal portions of the surficial zone have notably different hydrologic characteristics. Hydraulic conductivities calculated for the upper portion are up to an order of magnitude higher than those for the basal portion (E/A&H 19934).



SOURCE: GERAGHTY & MILLER, 1986

REMEDIAL INVESTIGATION REPORT
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NAS PENSACOLA

FIGURE 3-2
GEOLOGICAL CROSS-SECTION
OF THE SURFICIAL AQUIFER
AT NAS PENSACOIA

DATE: 10/28 /93 | DWG NAME: 059GCSSA

Low ***Permeability*** Zone

The low permeability zone underlies the surficial zone and is characterized by clay and silt-sized sediments. At NAS Pensacola, this zone is composed of gray to blue, sandy and silty marine clay with some shell fragments, and clayey sands with total thickness ranging from 8 to 40 feet (G&M 1984, 1986). Studies at NAS Pensacola indicate this zone may be continuous beneath the air station because the limited number of borings completed to the appropriate depth encountered the clays and silty clays. Beneath the western side of the base, the zone is interpreted to contain a substantial clayey sand layer above the clays, which pinches out eastward. Hydraulic conductivities of the low permeability zone are much lower than the overlying surficial zone, with vertical permeabilities ranging between the orders of 10^{5} feet/day for clays and 10^{-1} feet/day for clayey sands (G&M 1986). Hence the low permeability zone acts as a confining or semiconfining layer to inhibit flow of groundwater between the overlying surficial and underlying main producing zones.

Main Producing Zone

The main producing zone underlies the low permeability zone and comprises the bottom portion of the Sand-and-Gravel Aquifer. Regionally, depth to the top of the zone ranges from 60 to 120 feet. The zone, composed of sand and gravel with thin beds of silt and clay, is estimated to be approximately 300 feet thick at NAS Pensacola. Of the three zones in the Sand-and-Gravel Aquifer, this one is generally the most permeable and is the principal water supply source for the Pensacola area (Wilkins et al. 1985). Groundwater in this zone generally occurs under confiied conditions, and recharge to the zone occurs primarily by leakage through the low permeability zone. Regional groundwater flow in this zone is generally to the east towards Pensacola Bay, and south toward the Gulf of Mexico. Two supply wells at NAS Pensacola are screened into this zone but are used only to supplement the base water supply and to support the golf course irrigation system due to a high iron content in the water. For potable water, NAS Pensacola relies on main producing zone wells at Corry Field, approximately three miles to the north.

Intermediate System

The Intermediate System, a regionally and vertically extensive, laterally persistent hydrological unit, underlies the Sand- and-Gravel Aquifer. The system is defined to coincide with fine-grained clastic units of Miocene age lying beneath coarser-grained clastics of the Surficial Aquifer above. In the vicinity of NAS Pensacola, depth to the top of the unit is approximately 300 feet with a thickness of approximately 1,100 feet (Wilkins et al. 1985, SEGS 1986). The system is regionally characterized by poor to non-water-bearing conditions. Permeabilities are much lower than the overlying Sand-and-Gravel Aquifer, consequently the system functions as a confining unit for the underlying Floridan Aquifer System (SEGS 1986).

Floridan Aquifer System

The Floridan Aquifer System underlies the Intermediate System approximately 1,400 feet bls in the NAS Pensacola area. The unit is composed of the Middle to Lower Miocene age Chickasawhay Limestone and undifferentiated Tampa Stage Limestone, but is separated into upper and lower units by a significant clay layer called the Pensacola Clay (see Figure 3-1). Groundwater within the Floridan System is highly mineralized in the NAS Pensacola area and is not used for water supply (Wagner et al. 1984). However, groundwater from the Upper Floridan Aquifer is used for water supply approximately 25 miles east of NAS Pensacola.

3.2.2 Site-Specific Stratigraphy and Hydrogeology

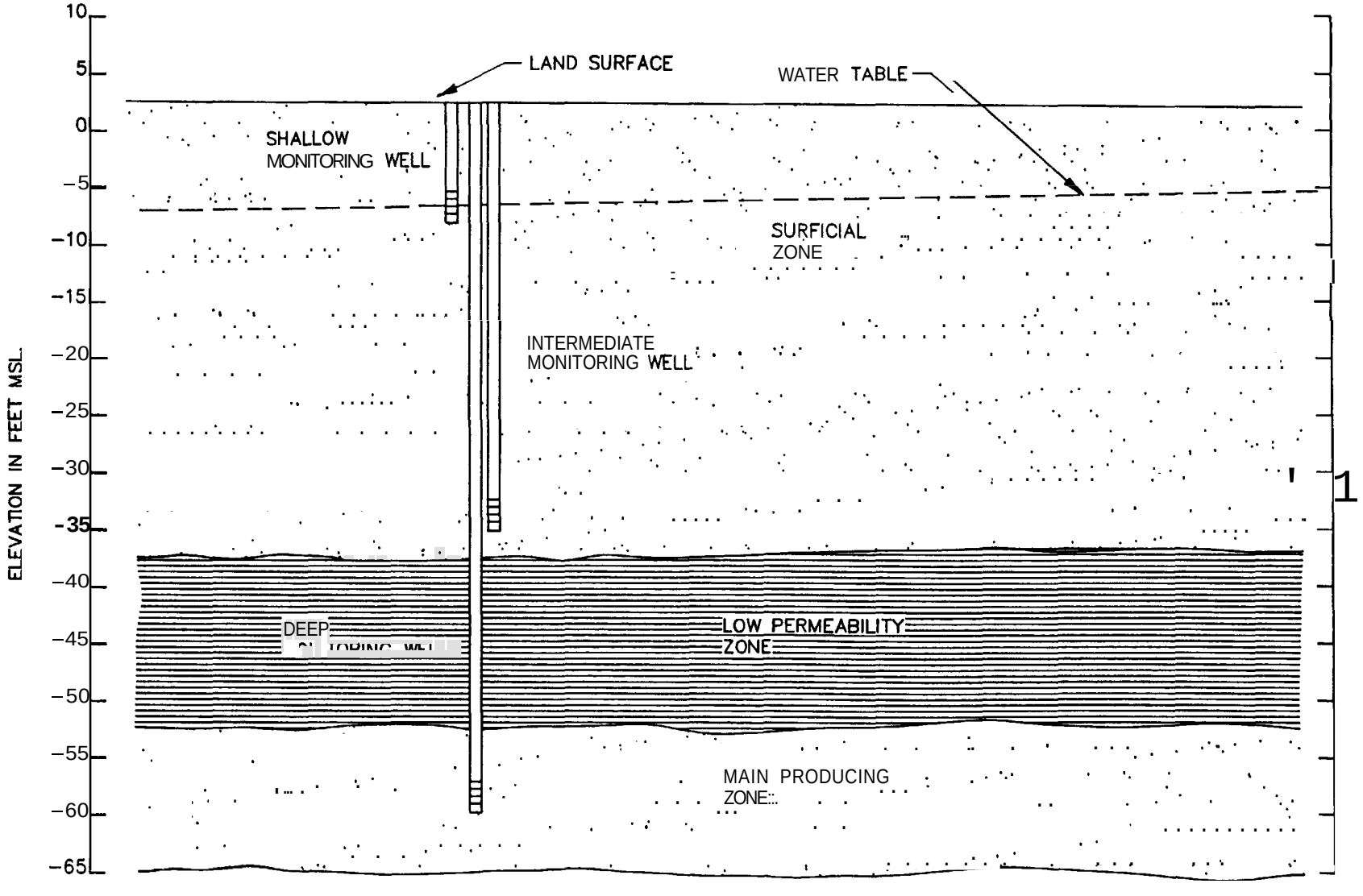
Stratigraphy

Site 1 investigations have been limited to the Sand-and-Gravel Aquifer. Borings have been completed in the surficial zone, low permeability zone, and the upper portion of the main producing zone. Boring logs indicate the surficial zone is composed primarily of buff white to brown to gray, fine- to medium-grain quartz sand, extending to approximately 27 feet bls along the northern portion of the site, and approximately 60 feet bls along the southern portion. Beneath the surficial zone, the low permeability zone has been encountered in all borings extended to the anticipated depth of interception. The thickness of the low permeability zone

varies from approximately 8 to 40 feet (G&M 1986). Boring logs indicate the stratum to be composed of gray to dark gray clays and silty, sandy clays, containing seams of fine- to coarse-grain sand, as well as shell and wood fragments (G&M 1986). The main producing zone has been encountered beneath the low permeability zone on Site 1 at approximately 48 ft bls along the northern portion to 100 ft bls along the southern portion. Boring logs indicate the upper portion of the zone is composed of white to gray, fine- to medium-grain sand with minor silt content (G&M 1986).

Hydrogeology

Previous studies have defined shallow, intermediate, and deep groundwater "zones" within the Sand-and-Gravel Aquifer. Aquifer tests performed at Site 1 during this investigation (see Section 6.0 discussion of Hydrological Results) have shown observable differences in hydraulic conductivities between the "shallow" and "intermediate zones" across most of the site. However, these "zones" do not necessarily correlate to any separation in stratigraphy, as evidenced by boring logs. Moreover, they should not be confused with the previously described regional hydrogeological zones of the Surficial Aquifer. Rather, the shallow, intermediate, and deep "zones" refer to three general depths at which monitoring wells have been completed at Site 1. Therefore, this report shall refer to these zones as "depths" or "levels." Figure 3-3 shows three well completion depths established at Site 1 in relation to the geological strata. All three monitoring depths are present within the Sand-and-Gravel Aquifer with shallow and intermediate depth monitoring wells both completed within the surficial zone. The shallow wells (completed during this and previous investigations) monitor conditions near the water table, whereas the intermediate wells (completed during this investigation) monitor conditions at the base of the surficial zone immediately above the underlying clays and silts of the low permeability zone. Deep monitoring wells completed through the low permeability zone during the 1986 Characterization Study monitor the main producing zone's uppermost portion. Depth to groundwater measured in shallow monitoring wells on site ranges from approximately 2.5 to 16 feet bls, depending on tidal influence and ground surface elevation. Groundwater flow



SOURCE: GERAGHM & MILLER. 1986

LEGEND

SAND

CLAY

REMEDIAL INVESTIGATION
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SITE 1
NAS PENSACOLA

FIGURE 3-3
GENERALIZED WELL COMPLETION
DEPTHS IN RELATION
TO STRATIGRAPHY

DWG DATE: 11/17/93 | DWG NAME: 059STRAT

studies at the site have included piezometric mapping of the shallow well water level elevations. The available studies from the past several years show shallow groundwater flow under natural conditions mimics topography, radiating to the north, northeast, and northwest toward Bayou Grande and site surface water bodies from the central and southern portion of the site.

Because no intermediate depth wells were completed at Site 1 before this investigation, previous data for intermediate groundwater flow have not been available. Deep groundwater flow data are limited by the small number of Site 1 wells completed at those depths. Data available from the 1986 Characterization Study and the 1991 Phase I Investigation for three deep zone wells indicate that deep groundwater flow varies widely with time between trends toward the northeast, northwest, and south. However, the most common trend appears to be southward.

Comparing water levels between the studied depths generally shows a downward potential hydraulic gradient from shallow to deep zone, implying shallow groundwater migrates downward toward the deep zone. However, an upward potential gradient has been observed on occasion from deep to shallow zone in the site's northwest portion, implying deep groundwater within the uppermost portion of the main producing zone is confined or semiconfined by the overlying clays and silts of the low permeability zone.

Geologic and hydrologic results of this investigation will be presented in Section 6.0.

3.3 Ecological *setting*

3.3.1 Regional Setting

The Florida Panhandle contains a wide variety of surface waters and physiographic regions, leading to an ecological diversity found in few other areas of the United States. Watersheds of the panhandle support a diverse array of habitats and vegetative communities. Bottomland hardwoods predominate in river floodplains and pines, *mixed* with a variety of other shrubs, prevail in upland areas. Wetlands are prevalent along the coastal fringe and river floodplains.

Barrier islands support dune vegetation communities and salt marshes. Bays support seagrass meadows and oyster reefs are present in intertidal and subtidal areas (Wolfe et al. 1988).

Seven major rivers in the region discharge into seven bar-built estuaries formed at the mouths of the rivers. The Florida Panhandle is a crossroads where animals and plants from the Gulf Coastal Plain reach their eastward distributional limits, and where many northern species reach their southern limits. Many peninsular Florida species are also distributed there. Due to the wet temperate climate of the region, the panhandle area may support the highest diversity of species of any other similar-size territory in the U.S. (Wolfe et al. 1988).

The high annual rainfall and low, gently sloping terrain creates numerous wetlands in the region. Bogs, swamps, marshes, wet prairies, and wet flatwoods provide a diversity of wetland types supporting a wide variety of flora and fauna. Terrestrial vegetation includes open pine woods and hardwood forests; most are second-growth forests of pines and encroaching hardwoods (Wolfe et al. 1988).

The Florida Panhandle's estuaries and nearshore marine habitats are some of the greatest natural and economic assets of the region. Important commercial organisms (such as oysters and fish) abound in these areas and contribute to the economy of the region. Coastal saltmarsh habitats provide critical nursery, feeding, and refuge areas for these important commercial species. Seagrass beds within estuaries also are vital to the seafood industry (Wolfe et al. 1988).

33.2 NAS Pensacola Setting

NAS Pensacola, which occupies approximately 5,800 acres, is bounded by Bayou Grande to the north and Pensacola Bay to the east and south. On the west, the installation abuts to a less developed portion of Escambia County containing swampy lowlands. NAS Pensacola's eastern portion is largely developed, with military and industrial facilities and historical/cultural sites. Most of the installation's activities are located on the eastern side of the base. The less

developed west side of the base has approximately 3,500 acres of natural or seminatural beach areas, forests, and wetlands.

NAS Pensacola is the setting for numerous, widely varied aquatic and terrestrial habitats, from coastal strand and estuarine environments along the bay and bayou to inland pine flatwoods communities. Wetland environments include a broad spectrum of both estuarine and palustrine wetlands, as well as various disturbed habitats, many in states of recovery as they undergo reforestation or otherwise return to their natural condition.

Vegetation Communities

NAS Pensacola natural vegetation communities fall into several broad categories: (1) coastal dune scrub communities, (2) pine flatwoods communities, (3) hardwood/pine communities, (4) sand pine scrub communities, (5) bay swamps, (6) freshwater marshes, and (7) estuarine coastal marshes (United States Fish and Wildlife Service [USFWS] 1987).

Coastal dune scrub communities are associated with shorelines subject to high energy waves. The vegetation consists of salt-tolerant plants able to establish themselves in shifting sands. Pine flatwood communities in coastal lowlands are characterized by trees that can tolerate various soil moisture conditions. Tree species in flatwoods communities are short, with a wide variety of small shrubs and herbaceous plants in the understory. Hardwood/pine communities are a highly diverse mixture of hardwood trees and pines. Sand pine scrub communities on well drained sandy soils contain sand pines, oaks, and various shrubs. Bay swamps are wetlands with titi and cypress swamps known to contain permanent standing water and high accumulations of organic peat. Freshwater marshes occur as grass/sedge/rush/herb communities in areas with high soil saturation or standing water. Estuarine coastal marshes, including salt marshes, occur along low energy shorelines and in tidal bayous (USFWS 1987).

Wildlife

NAS Pensacola habitats provide potential ranges for a wide variety of animal life, such as deer, squirrel, opossum, raccoon, fox, beaver, and bobcat. The station's beaches serve as resting, feeding, and nesting areas for various shorebirds. Ospreys have been observed nesting along undeveloped shoreline areas of the Big Lagoon, southeast of the Forrest Sherman Airfield. Numerous small mammals, amphibians, and reptiles also inhabit the facility. The coastal marsh, submerged grass bed, and shallow water habitats at NAS Pensacola help support fishery communities within the Pensacola Bay estuarine complex. Approximately 180 species of bony fishes form the basis of the Pensacola Bay fish community (USFWS 1987).

Threatened and Endangered Species

Appendix C of the Group A work plan lists the rare, threatened, and endangered species that may be found within NAS Pensacola boundaries (E&E 19920. E/A&H investigations of different areas of NAS Pensacola thus far have identified the presence of osprey, great blue heron (as well as other shorebirds), alligator snapping turtle, Godfrey's golden aster, Carolina lilaeopsis, white-top pitcher plant, and spoon-leaved sundew. All are considered rare or endangered for Escambia County, Florida, by the Florida Natural Areas Inventory (FNAI 1988).

3.4 Climate

NAS Pensacola has a mild, subtropical climate, with average annual temperature ranging from 55°F in the winter to 81°F in the summer. Daily temperatures *can* be more extreme, ranging from less than 7°F in the winter to more than 102°F in the summer. Thunderstorms, which occur on approximately 'half the summer days, *can* cause a precipitous drop in temperatune of 10 to 20 degrees in a matter of minutes (E&E 1992f).

November is the driest month of the year, with an average rainfall of 3.2 inches, based on climatological data from 1962 to 1991. Annual rainfall averages approximately 60 inches, with the highest amounts in July and August when thunderstorms occur almost daily. Thunderstorms

resulting in 3 to 4 inches of rain in an hour are common. Rainfall is lowest during spring and fall (4 inches average per month). In general, spring and fall rains are less intense, last longer, and produce less surface runoff, but higher rates of infiltration and net recharge (E&E 1992f).

Winds, which prevail from the north during the winter and the south during the summer, are generally moderate in velocity, except during thunderstorms. A difference in the ocean-land temperature produces the sea-breeze effect, a daily clockwise rotation in the surface wind direction near the coast. Hurricanes and tornadoes can substantially damage the nearshore environment. Since 1980, six hurricanes have passed within 50 miles of Pensacola.

4.0 PRELIMINARY SURVEYS

4.1 Phase I Surveys

Several preliminary surveys were performed during the 1991 Phase I investigation conducted by E&E. Section 2.2, Site History and Previous Investigations, summarizes fmdings of selected surveys from this investigation. A detailed discussion of all Phase I investigation preliminary survey fmdings is contained in the Interim Data Report (E&E 1991g).

4.2 Contaminant Source Survey

A CSS of Site 1 was performed in April and May 1993, before fieldwork began, to gain more information on past and present site activities or occurrences that may have resulted in any known or suspected releases of contamination to the environment.

During the CSS, past and present site information was obtained through the following activities:

- A review of all available previous investigations reports and site history information.
- A review of NAS Pensacola PWC drawings and utility maps.
- A review of aerial photographs.
- Interviews with NAS Pensacola personnel.

Background Summary

Information regarding landfill activities is contained in NEESA, G&M, and E&E investigation reports. This information indicates landfill activities were performed in the southernmost portion of the landfill in the late 1950s, in the northernmost portion in the early to mid 1960s, and in the central portion from the mid 1960s to the mid 1970s. During its operation, the landfill accepted domestic and industrial wastes from NAS Pensacola, as well as other outlying airfields including Corry, Saufley, Ellison, Baron, and Whiting. The landfill officially closed in October 1976. Waste material was commonly burned before burial; however, this practice was ended in the late 1960s due to nearby residents' concern over air pollution.

In 1974, landfill leachate began discharging into a nearby golf course pond from an abandoned drain field (E&E 1992f). At this time a drainage outlet was plugged, causing the water table to rise and additional leachate to seep to the surface. As a result, an investigation was performed in 1974 and 1975, during which monitoring wells were installed and sampled. This investigation concluded that shallow groundwater flowed to the north toward Bayou Grande and that groundwater was contaminated in the upper portion of the Sand-and-Gravel Aquifer near the landfill (NEESA 1983). Since the landfill closed, the following investigations have been performed:

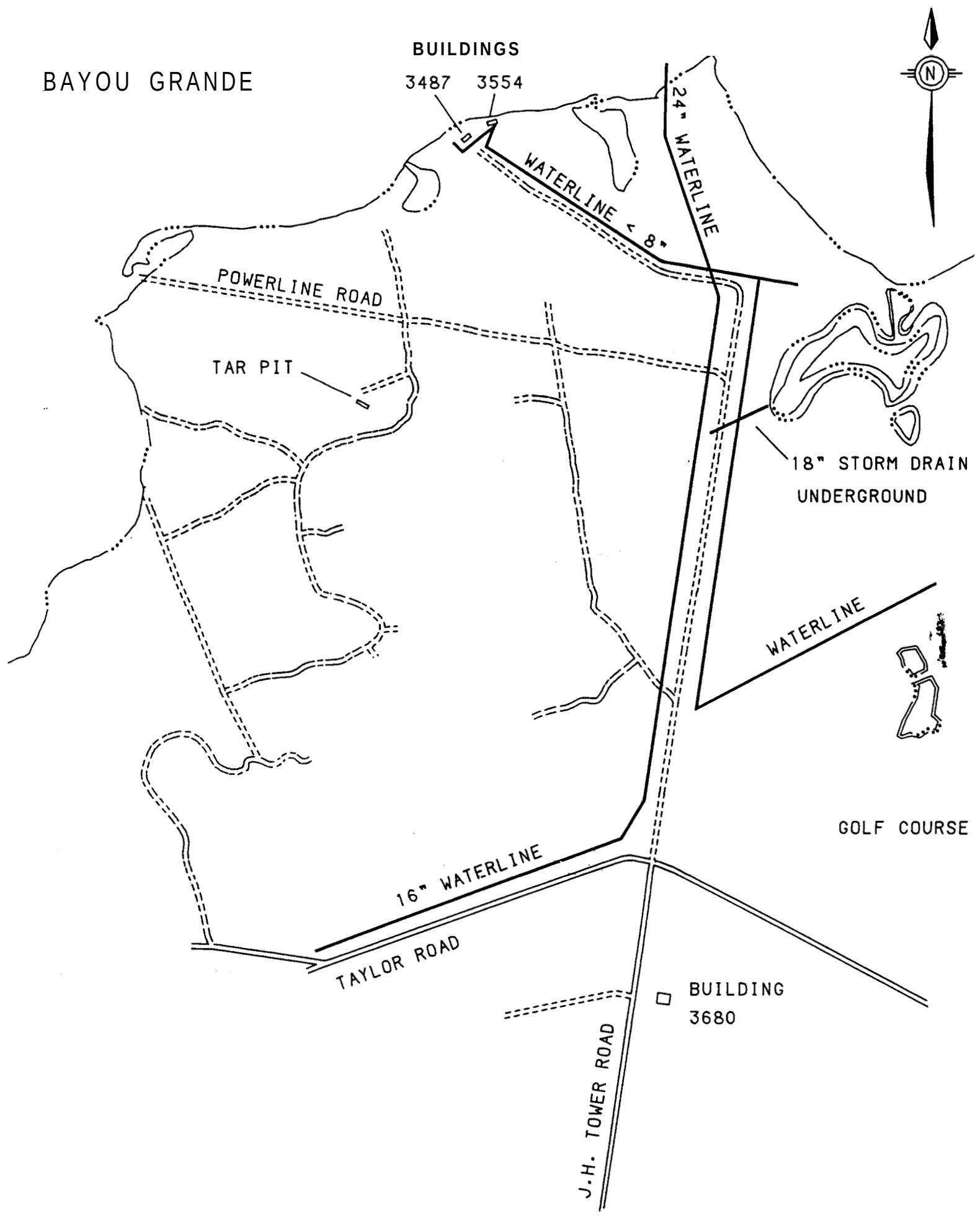
- Initial Assessment Study (NEESA 1983)
- Verification Study (G&M 1984)
- Confirmation Study (G&M 1986)
- Contamination Assessment/Remedial Investigation Phase I (E&E 1991g)
- Field Investigation (USEPA-ESD 1992)

Results of the previous investigations agree previous landfill activities have affected shallow groundwater quality. Additionally, the Phase I investigation and the 1992 field investigation indicate nearby surface water body sediments also may have been impacted by landfill activities.

See Section 2.2 for a detailed discussion of site history and previous investigations.

CSS Findings

Only two buildings (Building Nos. 3554 and 3487) are onsite. They are associated with the recreational/picnic area at the site's northern extent. The only underground utilities illustrated on PWC drawings within the site vicinity are water lines leading to the picnic area, a water main crossing the site north to south from Bayou Grande, and an approximately 250-foot length of storm drain beneath J.H. Tower Road. These utilities are shown on Figure 4-1. However, since bathrooms are present in Building 3554, it is assumed sanitary sewer lines also lead to the recreational area, most likely along Picnic Road.



LEGEND

COASTLINE / SURFACE WATER FEATURE

UNPAVED ROAD

600 0 600

SCALE FEET

REMEDIAL INVESTIGATION REPORT

SITE 1

NAS PENSACOLA

FIGURE 4-1

LOCATION OF UNDERGROUND UTILITIES

DATE: 11/17/93 DWG NAME: 59FIG4-1

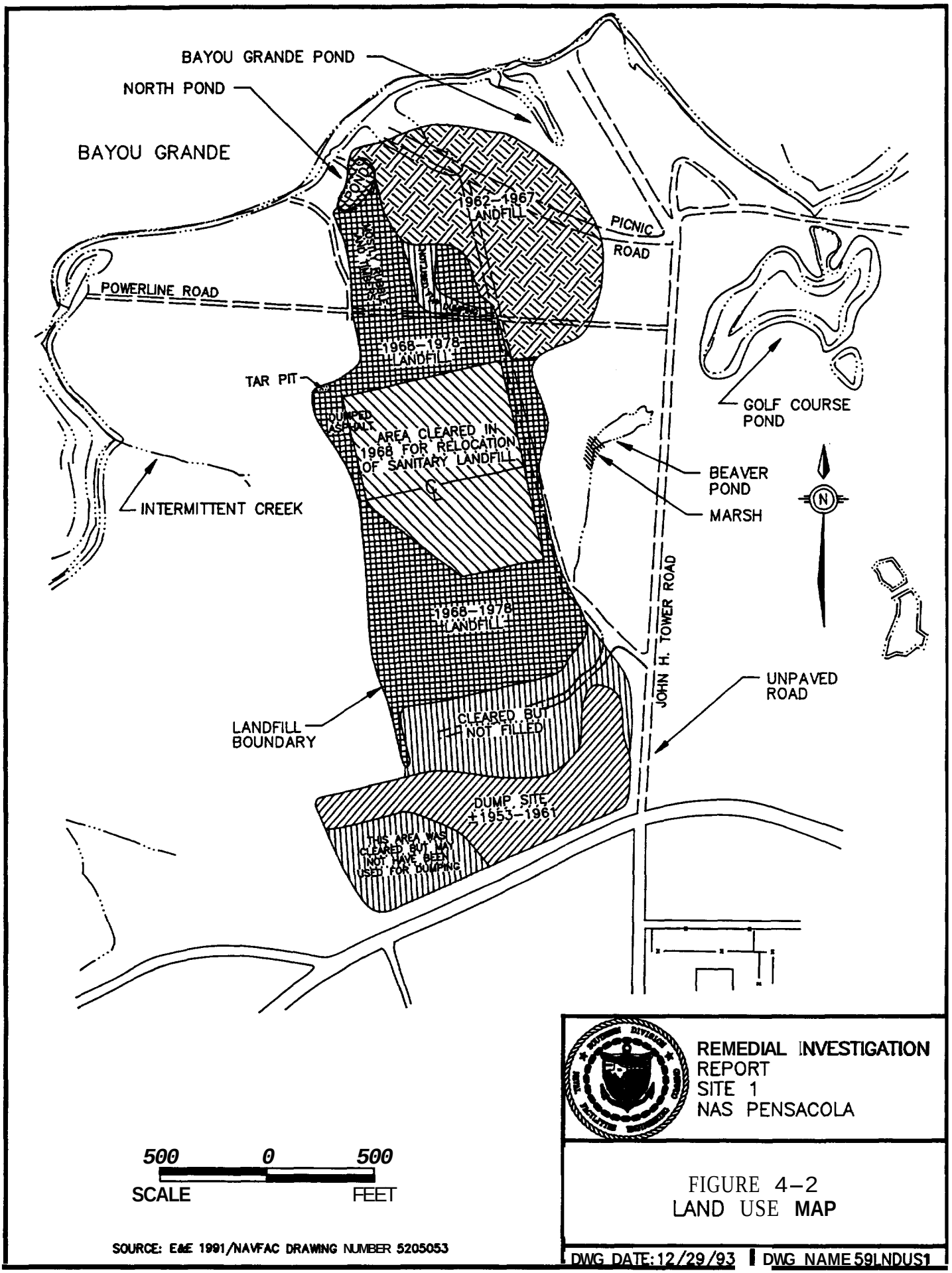
Aerial photographs from 1951 through 1989 were reviewed during the CSS, as were findings of the previous aerial photo analysis (E&E 1991g). Observations made during the review were consistent with ones from previous analyses, which generally documented the progression of fill activities across the site during the 1950s, 1960s, and 1970s.

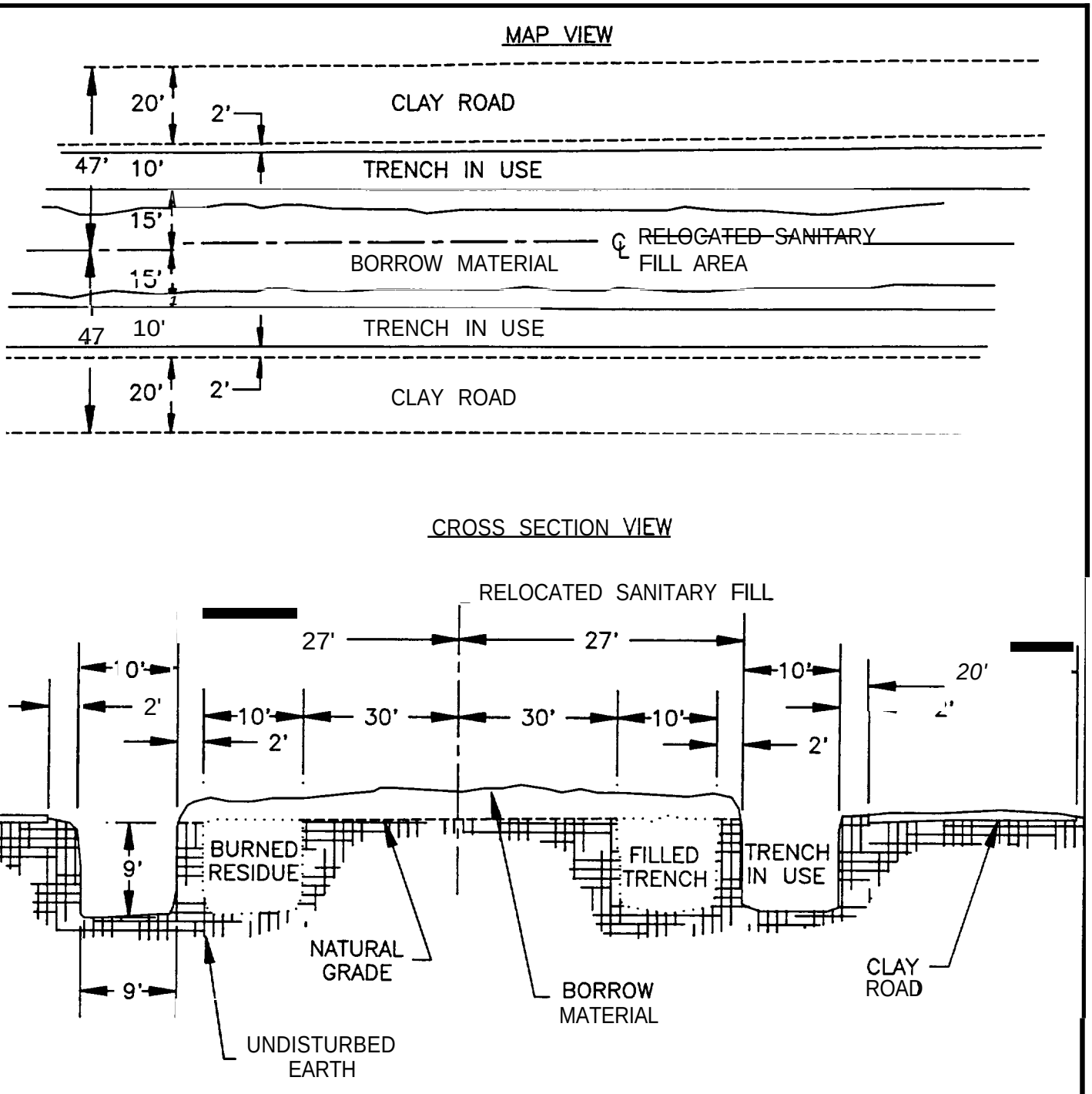
PWC surveyor drawings located during the CSS confirm with greater detail areas where landfill activities occurred during the early 1950s through 1976. Figure 4-2 illustrates a compilation of fill activity information taken from Naval Facility (NAVFAC) drawing No. 5205053 of December 11, 1989. These landfill areas generally were identified in the Site 1 IDR (E&E 1991g) and the IAS of NAS Pensacola (NEESA 1983). Other PWC drawings give general landfill design information for the site's central portion, where intense trench-and-fdl activities occurred from approximately 1968 through 1976. The design information included the general orientation and dimensions of fill trenches, and the thickness of overburden for the landfill's central portion. Figure 4-3 illustrates the planned dimensions of the "typical" fill trench as indicated by NAVFAC drawing No. 121369 of January 30, 1968. The relocation center line in Figure 4-3 is shown in Figure 4-2.

Mr. Ron Cayson, an employee of the PWC Transportation Department, was interviewed during the CSS. He has worked at NAS Pensamla as a heavy-equipment operator since approximately 1967, performing trench-and-fill operations at the landfill from the late 1960s through 1977.

During Mr. Cayson's work at the landfill, various industrial materials and wastes from NAS Pensacola and other nearby naval facilities (Saufley, Whiting, Ellison, and Corry fields) were disposed of in the landfill. These wastes, as confirmed by Mr. Cayson, included:

- Containers of petroleum products
- Containers of pesticides/herbicides
- Metal-plating wastes and sludges


BAYOU GRANDE POND
NORTH POND
BAYOU GRANDE
1962-1967 LANDFILL
PICNIC ROAD
POWERLINE ROAD
1968-1978 LANDFILL
TAR PIT
DUMPED ASPHALT
AREA CLEARED IN 1968 FOR RELOCATION OF SANITARY LANDFILL
GOLF COURSE POND
BEAVER POND
MARSH
INTERMITTENT CREEK
N
JOHN H. TOWER ROAD
1968-1978 LANDFILL
UNPAVED ROAD
LANDFILL BOUNDARY
CLEARED BUT NOT FILLED
DUMP SITE ±1953-1961
THIS AREA WAS CLEARED BUT MAY NOT HAVE BEEN USED FOR DUMPING
500 0 500
SCALE FEET
SOURCE: E&E 1991/NAVFAC DRAWING NUMBER 5205053
REMEDIAL INVESTIGATION REPORT
SITE 1
NAS PENSACOLA
FIGURE 4-2
LAND USE MAP
DWG DATE: 12/29/93
DWG NAME 59LNDUS1



NOTE: SEE FIGURE **4–2** FOR RELOCATION LINE ℄

SOURCE: NAVY PUBLIC WORKS CENTER DRAWING "RELOCATION OF SANITARY FILL AREA LOCATION DRAWING" NAVFAC DRAWING NO. 1213695

REMEDIAL INVESTIGATION REPORT
SITE 1 NAS PENSACOLA
NAS PENSACOIA

FIGURE 4–3
LANDFILL TRENCH
CONSTRUCTION PIAN

DWG DATE: 12/29/93 | DWG NAME 059TRCR1

- Paint wastes and sludges
- Various waste chemicals, solvents, and chemical containers
- Solvent-soaked cloth rags
- Medical wastes
- Asbestos materials
- High-pressure gas canisters
- A creosote-soaked wooden barge
- Airplane wreckage
- Automobile engine parts

Mr. Cayson also confirmed the general south-to-north progression of trench-and-fill activities during his landfill work, as well as the general orientation and dimensions of "typical" trenches in the center of the site. Based on this discussion, landfill activities occurred in the following manner. The central portion of the landfill was cleared of trees in order to excavate the trenches. Trenching activities during the late 1960s and through the mid 1970s began along the southcentral portion of the landfill and progressed northward over time toward Powerline Road. Trenches approximately 10 to 12 feet wide, 8 to 10 feet deep, and up to several hundred feet long were constructed roughly east to west across the width of the fill area. Trenches were spaced approximately 30 to 50 feet apart. During this time, unsegregated wastes were typically placed in the landfill as they were received, into whichever trench was available. Once a trench was filled, it was covered with a 1- to 4-foot thickness of fill dirt taken from a nearby borrow pit off Tow Road. During the landfill's latter years of activity (approximately early to mid 1970s), wastes were buried at a rapid and constant rate as trench-and-fill activities were performed 24 hours a day during consecutive 12-hour shifts. In addition to these fill activities, Mr. Cayson confirmed wastes were likely deposited earlier in areas both north (the early 1960s fill area) and south (the 1950s fill area) of the area where he worked.

All information regarding landfii activities indicates a steady stream of assorted industrial wastes has been buried across an expansive area within the landfill boundary.

4.3 Habitat and Biota Survey

E/A&H biologists conducted Phase I habitat/biota survey for Site 1 from April 26 to May 3, 1993, following procedures in Section 8 of the Comprehensive Sampling and Analysis Plan (CSAP). The Phase I Survey's primary objectives were to obtain sufficient information to confii, update, and append findings of a previous habitathiota survey conducted by E&E (1991g) and to support the development of the Ecological Risk Assessment (ERA). **[Additionally, limited wetland sampling activities were performed to preliminarily assess Site 1's effects on these features, and to identify potential contaminant pathways. Wetland sample results are discussed in Section 8.0]**

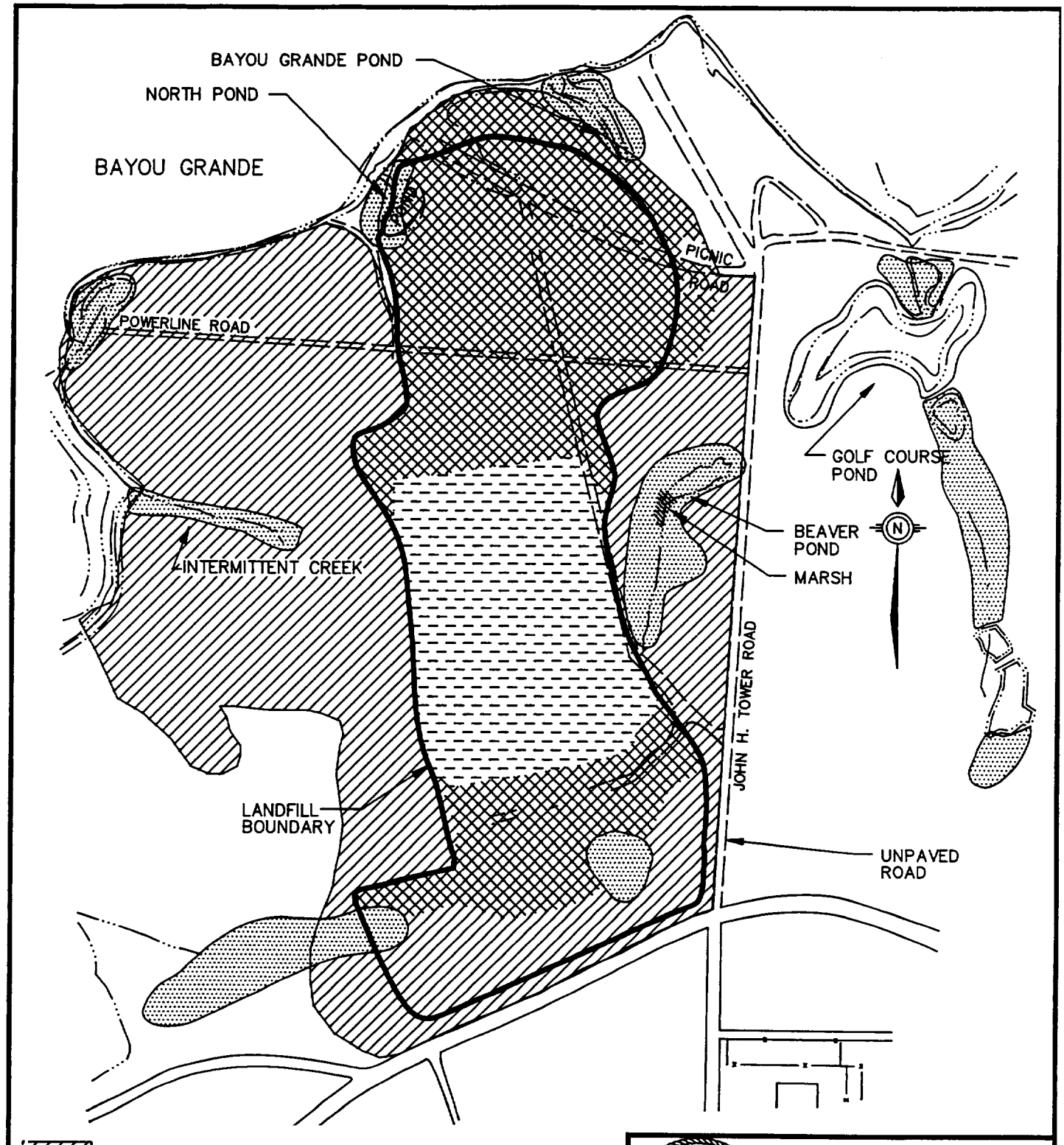
Site 1's approximately 80-acre area includes several habitat types, including wetlands, upland pine forest, mixed pine-hardwood forest, mixed hardwood-pine forest, mesophytic forest, sandhill communities, and early successional waste areas. Figure 4-4 illustrates the distributions of vegetative types present at Site 1. Although numerous wetland areas are adjacent to the site, this survey addresses only terrestrial habitats within Site 1. A subsequent RI for Site 41 (Wetlands-NAS Pensacola) will provide specifics on wetland areas across NAS Pensamla.

Upland Habitats Within Site 1

The upland habitat types — including upland pine forest, mixed pine-hardwood forest, mesophytic forest, sandhill communities, and early successional waste areas — are described and documented for several locations transecting the site.

Pine Forest

Plant communities with an overstory dominated by pines are common throughout Site 1, and are often the result of silvicultural practices. Slash pine *mixed* with sand pine dominate the overstory, with longleaf pine occurring less frequently. Mid and understory species are primarily herbs, shrubs, and vines common to early successional stages. Mid and understory



- PINE FLATWOODS AREA WITH INTERMIXED HARDWOODS
- EARLY SUCCESSIONAL WASTE ARE
- SILVICULTURE COMMUNITY
- WETLANDS (APPROX.)

500 0 500
SCALE FEET

SOURCE: E&E 1991/NAVFAC DRAWING NUMBER 5205053

REMEDIAL INVESTIGATION REPORT
SITE 1
NAS **PENSACOIA**

FIGURE **4–4**
VEGETATIONAL COMMUNITY DISTRIBUTIONS

DWG DATE: 1/03/94 | DWG NAME: 59LNDUS2

p i e s include live oak, laurel oak, turkey oak, sand live oak, yaupon, winged sumac, broomsedge, dewberry, catbrier, virginia creeper, muscadine grape, goldenrod, saw palmetto, mint rosemary (*Conradina canescens*), scarlet basil (*Calamintha coccinea*), inkberry (*Ilex glabra*), gum bumelia (*Bumelia lanuginosa*), cabbage palm (*Sabal* palmetto), and St. John's wort (*Hypericum tetrapetalum*). Biota common to this habitat type, and to those discussed in the following sections, include woodland birds, reptiles, amphibians, and small mammals.

Mixed Pine-Hardwood Forest

Plant communities with an overstory dominated by pines and a substantial number of hardwoods are common at the site's higher elevations. Dominant overstory species include sand pine, southern magnolia, sweetbay magnolia, sand live oak, and Atlantic white cedar (*Chamaecyparis thyoides*). Dominant midstory species include saplings of overstory species and muscadine grape, Virginia creeper, catbrier, yaupon, saw palmetto persimmon, wax myrtle, and American holly (*Ilex opaca*). Herbaceous plants and vines dominate the understory. Understory species include blackberry, dewberry, goldenrod, ragweed (Ambrosia spp.), wood sorrel (Oxalis spp.), and bracken fern (*Pteridium aquilinum*).

Mixed Hardwood-Pine Forest

Plant communities with an overstory dominated by hardwoods and a substantial number of pines occur frequently throughout Site 1. Oaks dominate the overstory in this habitat type. Common species include live oak, sand live oak, laurel oak, and turkey oak. The common pine species in the overstory is sand pine. Sweetbay/southern magnolia also are found in the overstory, as well as cabbage palm, and sour gum (*Nyssa sylvatica, var. sylvatica*). This plant community's midstory is dominated by saplings of the overstory p i e s and persimmon, privet, beautyberry, winged sumac, myrtle oak, sparkleberry (*Vaccinium arboreum*), and gallberry (*Ilex coriacea*). Common p i e s of the understory include scarlet basil, St. Andrew's cross, muscadine grape, catbrier, myrtle oak, saw palmetto, and Virginia creeper. This area provides suitable habitat

for gopher tortoises (*Gopherus polyphemus*) because of the well-drained sandy soils that make burrowing easier, abundant herbaceous groundcover, and open canopies with sparse shrub cover.

Mesophytic *Forest*

This plant community in low alluvial areas of the site is generally associated with wetlands. Common species include sweetbay magnolia, privet, persimmon, water oak, virginia creeper, catbrier, and bracken fern. Although mesophytic forests are found in relatively wet areas, often they do not meet all the requirements for wetlands.

Sandhill Community

Plant communities in dry upland topography often are considered sandhill communities, which are common at Site 1. Dominant species include turkey oak, sand pine, live oak, sand live oak, squawbery, catbrier, sparkleberry, yaupon, bracken fern, bull nettle (*Cnidoscolus stimulosus*), prickly pear cactus (*Opuntia humifusa*), and Spanish bayonet (*Yucca aliofolia*).

Early Successional Waste Areas

Highly disturbed areas often are called areas of fill activity. Early succession is characterized by an abundance of small-to medium-size trees, herbaceous plants, and dense shrubs or vines. Characteristic overstory species of Site 1 waste areas include various oaks, including sand live oak, slash pine, sand pine, cabbage palm, popcorn tree, chinaberry tree, black willow, and silk tree (*Albizia julibrissin*). Midstory species include Carolina laurel cherry, persimmon, yaupon, wax myrtle, Atlantic white cedar, and hawthorne (*Crataegus* spp.). Understory herbs, shrubs, and vines in waste areas include catbrier, greenbrier, Virginia creeper, muscadine grape, myrtle oak, Spanish bayonet, scarlet basil, saw palmetto, winged sumac, St. Andrew's cross, wild potato vine (Ipomea *pandurata*), trumpet vine (*Campsis radicans*), shrub verbena (*Latana camara*), peppervine (*Ampelopsis arborea*), maypop (*Passiflora incarnata*), rattlebox (*Sesbania punicea*), butterfly pea (*Centrosema virginianum*), and day flower (*Commelina erecta*).

Endangered Species or Species of Special Concern

No federally listed threatened or endangered species **[were]** observed during the terrestrial survey of Site 1. **[A]**ppropriate habitat **for** several **Florida** state species-of-concern **was** noted **[but** no **Florida state species-of-concern were observed at Site 1 by E/A&H ecologists during the remedial investigation]**. These habitat **areas are** within the site's boundaries and proximal to the site. In addition, an established **osprey** (*Pandion haliaetus*) nest **was** located approximately 0.5 mile east of Site 1. The osprey is considered a **Florida** state species-of-concern. Given the extended feeding range of the species, it could frequent the site area. **[Tables 4-1 and 4-2 contain information on threatened or endangered animals and plants.]**

For readability this table has not been bolded or bracketed.

Table 4-1
Threatened and Endangered Animals Observed or Likely to Occur at NAS Pensacola and OLF Bronson
Pensacola, Florida

Scientific Name	Common Name	Status	
		FGFWFC	USFWS
Fishes			
Acipenser oxyrhynchus desotoi	Gulf strugeon	SSC	UR2
Fundulus jenkinsi	Salt marsh topminnow	SSC	
[illegible]			
Alligator mississippiensis	American alligator	SSC	T
Caretta caretta caretta	Loggerhead turtle	T	T
Chelonia mydas mydas	Green turtle	E	E
Dermochelys coriacea	Leatherback turtle	E	E
Drymarchon corais couperi"	Eastern indigo snake	T	T
Eretmochelys imbricata imbricata	Hawksbill turtle	E	E
Gopherus polyphemus•	Gopher tortoise	SSC	UR1
Lepidochelys kempi	Atlantic ridley	E	E
Rana areolate aesopus	Florida gopher frog	SSC	UR2

Table 4-1
Threatened and Endangered Animals Observed or Likely to Occur at NAS Pensacola and OLF Bronson
Pensacola, Florida

Scientific Name	Common Name	Status	
		FGFWFC	USFWS
*Macroclemys temmincki**	Alligator snapping turtle	SSC	UR2
Mammals			
Peromyscus polionotus trissyllepsis	Perdido Key beach mouse	T	E
Trichechus manatus latirostris	West Indian manatee	E	E
Ursus americanus floridanus	Florida black bear	T	UR2
Birds			
Charadrius alexandrinus Tenuirostris	Southeastern Snowy plover	T	UR2
Dendroid8 dominica stoddardi	Stoddard's yellow-throated warbler		UR2
Egreeta thula	Snowy egret	SSC	
Falco peregrinus tundrius	Arctic Peregrine falcon	E	T
Falco sparverius paulus	Southeastern kestrel	T	UR2
Haematopus palliatus	American oystercatcher	SSC	
Haliaeetus leucocephalus	Bald eagle	T	E
*Pandion haliaetus**	Osprey		

Table 4-1
Threatened and Endangered Animals Observed or Likely to Occur at NAS Pensacola and OLF Bronson
Pensacola, Florida

Scientific Name	Common Name	Status	
		FGFWFC	USFWS
*Pelecanus occidentalis carolinensis**	Eastern brown pelican	SSC	
Invertebrates			
Copris gopheri	Copris tortoise commensal scarab beetle		UR2

Notes:

E	=	Endangered
T	=	Threatened
SSC	=	Species of Special Concern
UR1	=	Under review for federal listing, with substantial evidence in existence indicating at least some degree of biological vulnerability and/or threat.
UR2	=	Under review, but substantial evidence of biological vulnerability and/or threat is lacking.
FGFWFC	=	Florida Game and Freshwater Fish Commission
USFWS	=	U.S. Fish and Wildlife Service
*	=	Observed at NAS by E/A&H ecologists since October, 1992.

None of these animals were observed by E/A&H ecologists throughout the Site I investigation.

Source: U.S. Fish and Wildlife Service (USFWS), 1987

For readability this table has not been bolded or bracketed.

Table 4-2
Threatened and Endangered Plants Observed or Likely to Occur at NAS Pensacola and OLF Bronson
Pensacola, Florida

Scientific Name	Common Name	Status	
		FDA	USFWS
Chrysopsis gossypina cruiseana	Cruise's golden-aster	E	UR1
Drosera intermedia•	Water sundew	T	
Epigaea repens	Trailing arbutus	E	
Hexastylis arifolia	Heartleaf	T	
Kalmia latifolia	Mountain laurel	T	
Lilium iridollae	Panhandle lily	E	UR2
Polygonella macrophylla	Large-leaved jointweed	T	UR1
Rhododendron austrinum	Orange azalea	E	UR5
Sarracenia leucophylla•	White-top pitcherplant	E	
Sarracenia rubra	Red-flowered pitcherplant	E	UR5

Notes:

E	=	Endangered
T	=	Threatened
UR1	=	Under review for federal listing, with substantial evidence in existence indicating at least some degree of biological vulnerability and/or threat.
UR2	=	Under review, insufficient biological data available.
UR5	=	Still formally under review for listing, but no longer considered for listing because it is more widespread or abundant than previously believed.
FDA	=	Florida Department of Agriculture
USFWS	=	U.S. Fish and Wildlife Service
*	=	Observed at NAS by E/A&H ecologists since October, 1992.

None of these plants were observed by E/A&H ecologists throughout the Site I investigation.

Source: U.S. Fish and Wildlife Service (USFWS), 1987

5.0 FIELD INVESTIGATION AND METHODOLOGY — 1993

The U.S. Navy-, USEPA-, and FDEP-approved Site 1 Work Plan and Site 1 SAP originally outlined an extensive soil, sediment, surface water, and groundwater investigation and sampling program (E/A&H 1993a, E&E 1992f). Sediment and surface water sampling tasks associated with site wetlands were removed from the Site 1 RI's original scope due to the upcoming Site 41 — NAS Pensacola Wetlands Investigation. The Site 41 investigation will address all NAS Pensacola wetlands. However, as discussed in Section 8, limited wetlands surface water and sediment sampling was performed during 1994 sampling activities to initially determine the landfill's impact on these resources.

The Site 1 RI was conducted in 1993 as multiple tasks to address the potential of contamination sources and/or contamination pathways in multiple regions and zones of site soil and groundwater. Additionally, the RI included a hydrologic investigation of the underlying aquifer zones and adjacent surface water bodies to determine groundwater flow direction and velocity. Field sampling and investigation activities for the Site 1 RI were initially performed as a continuous fieldwork effort conducted from May 1993 through August 1993. The CSS and preparatory fieldwork activities (i.e., brush and line clearing for well locations) *started* in April 1993. Based on the 1993 fieldwork results, a second field sampling event was performed during June and July 1994 in order to gain additional information regarding adjacent wetlands surface water and sediment quality, and to confirm inorganic and organic parameter concentrations previously detected in samples from background (inorganic only) and selected site monitoring well locations using low flow (quiescent) sampling techniques, Due to the distinct time frame and purpose of the second sampling event, 1994 sampling activities are discussed in a separate section of this report; Section 8.

A significant modification to the original scope of work was proposed to, submitted to, and approved by the Navy and Technical Review Committee (TRC) during 1993 fieldwork. This modification involved installing additional monitoring wells around the landfill's perimeter, and

performing test trenching within the landfill boundary (E/A&H 1993b). Additional monitoring wells were proposed to improve groundwater monitoring coverage immediately proximal to the landfill. Test trenching was recommended in place of originally proposed soil borings and monitoring wells within the landfill boundary. The purpose of test trenching was to confirm the presence of fill material in selected suspect locations, and to collect quantitative and qualitative data on the contents and depositional methods there. The additional well installation, test trenching, and associated soil, groundwater, and waste sampling activities were performed in conjunction with originally scheduled RI field activities.

Sampling locations were selected based upon results of the preliminary surveys or specifications of the Site 1 work plan and SAP. Sampling and investigation procedures were conducted in accordance with the Site 1 SAP, and the NAS Pensacola CSAP (E/A&H 1993c), except where site conditions and field decisions warranted modification. Specific procedures employed for each sampling and investigative task are organized and presented in Sections 5.1 through 5.4 of this report. **[The** only significant **sampling modification — landfill trenching in place of soil borings inside the landfill boundry — is explained in Section 5.1.1.]** General methods, sample handling, field Quality Assurance/Quality Control (QA/QC), and decontamination procedures are in Section 5.3. Methodologies and results for the initial 1993 fieldwork activities are contained in the remaining portions of Section 5 (Methodology) and Section 7 (Nature and Extent of Contamination), respectively. Section 8 contains subsections discussing sampling methodologies (Section 8.1), groundwater elevations and flow direction (Section 8.2), and analytical results (Section 8.3) for the 1994 sampling event.

Analytical Parameters

Samples of all media were collected for either contamination assessment or physical characterization. Contamination assessment analyses provided a basis for determining nature and extent of site contamination, and physical characterization analyses aided in either determining specific subsurface migration pathways or properties of the site media for the feasibility study.

Contamination assessment analyses were performed by a NEESA-approved laboratory using USEPA CLP protocol. Samples designated for contamination assessment were analyzed for

TAL/TCL parameters and radiation, as shown in Table 5-1. Additionally, several soil/waste samples collected during trenching activities were analyzed using Toxicity Characteristic Leaching Procedure (TCLP).

Samples designated for physical characterization were analyzed for selected physical and chemical-physical parameters; these parameters are shown in Table 5-2. CompuChem Environmental Corporation in Research Triangle Park, North Carolina, analyzed for the contamination assessment parameters, while Thompson Engineering and Testing, Inc., and Savannah Laboratories and Environmental Services, Inc., in Mobile, Alabama, analyzed for physical and chemical-physical characterization, respectively.

Table 5-1
Analytical Parameters
Contamination Assessment

Media	Parameter	Method
Soil, Trench Waste	TCL Volatiles	CLP
	TCL Semivolatiles	CLP
	TCL Pesticides/PCBs	CLP
	TAL Metals and Cyanide	CLP
	Alpha, Beta, Gamma Radiation (soil only)	USEPA 900
	TCLP	1311
Groundwater	TCL Volatiles	CLP
	TCL Semivolatiles	CLP
	TCL Pesticides/PCBs	CLP
	TAL Metals Unfiltered	CLP
	TAL Cyanide	CLP
	Alpha, Beta, Gamma Radiation	USEPA 900
	Gamma Spectroscopy (every 10th sample)	USEPA 901.1

Table 5-2
Sum of Analytical Parameters
Physical Characterization

Media	Parameter	Method
Soil, Trench Waste	Physical (soil only):	
	Permeability	ASTM D2434 (for sand)
	Porosity	ASTM D5084 (for clay)
	Particle Size	ASTM D 422
	Bulk Density	ASTM 4253
	Specific Gravity	ASTM D a54
	Moisture Content	ASTM 2216
	Chemical-Physical:	
	Total Phosphorous	EPA 365.3
	Nitrate-N	EPA 352.1
	Total Kjeldahl Nitrogen	€PA 351.4
	Heterotrophic Plate Count	SM 92158
	Walkey-Black Cation Exchange	SW 846-9081
	Capacity	SW 848-9060
	Total Organic Carbon	
Groundwater	Total Phosphorous	USEPA 365.3
	Nitrate-N	USEPA 352.1
	Total Kjeldahl Nitrogen	USEPA 351.4
	Heterotrophic Plate Count	SM 9215B
	5-day Biochemical Oxygen Demand	USEPA 405.1
	Chemical Oxygen Demand	USEPA 410 (.1 to .3)
	Hardness	USEPA 200.7
	Total Suspended Solids	USEPA 160.2
	Alkalinity	USEPA 310.1

Key:
ASTM = American Society of Testing and Materials
SM = Standard Methods for the Examination of Water and Wastewater
SW = Test Methods for Evaluating Solid Waste

Sample and Location Identification

The *CSAP* specifies an eight-digit sample identification *code* to identify sample location, type, and other pertinent information in this report (or investigation) as follows:

- The first two digits denote the site where the sample was taken, as designated in the NAS Pensacola Site Management Plan *(SMP)*. Samples for Site 1 were designated as "01."

- The third (and, in some instances, fourth and fifth) digit represents the sampled medium as follows:

G	=	Groundwater
GS	=	Shallow depth groundwater
GI	=	Intermediate depth groundwater
GGM	=	Groundwater, previously installed G&M wells
S	=	Soil (including surface soil samples, soil brings, and trench wastes)
SS	=	Soil associated with a shallow depth boring location
SI	=	Soil associated with an intermediate depth boring location
DSW	=	Deep supply well

- The two digits following the media information (occurring sequentially in digit locations four through seven, depending on media notation) represent the sample location identifier. All sampling locations (groundwater, soil, and test trenches) were numbered sequentially prior to conducting each given activity. For groundwater, these digits also represent the designation number of the monitoring well (e.g., 01GS42).

- The last two to three digits are sample specific. For soil and trench waste samples, the two digits represent the depth of collection in feet. Where the sample was taken from a depth interval (e.g., a 2-foot soil interval), the number represents the base of the interval. Additionally, the last digit identifies and designates any QA/QC samples as follows:

T	—	trip blank	X	—	matrix spike sample
E	—	equipment rinsate blank	K		matrix spike duplicate
D	—	duplicate sample	C	—	co-located sample
I	—	analyte free water blank	P	—	potable water blank

The following examples illustrate the interpretation of this code:

Sample Number	Interpretation
01S5602	Site 1/soil/location 56/02 feet depth
01SS0102D	Site 1/shallow soil boring/location 01/02 feet depth/duplicate
01GI41X	Site 1/intermediate groundwater/well 01GI41/matrix spike sample

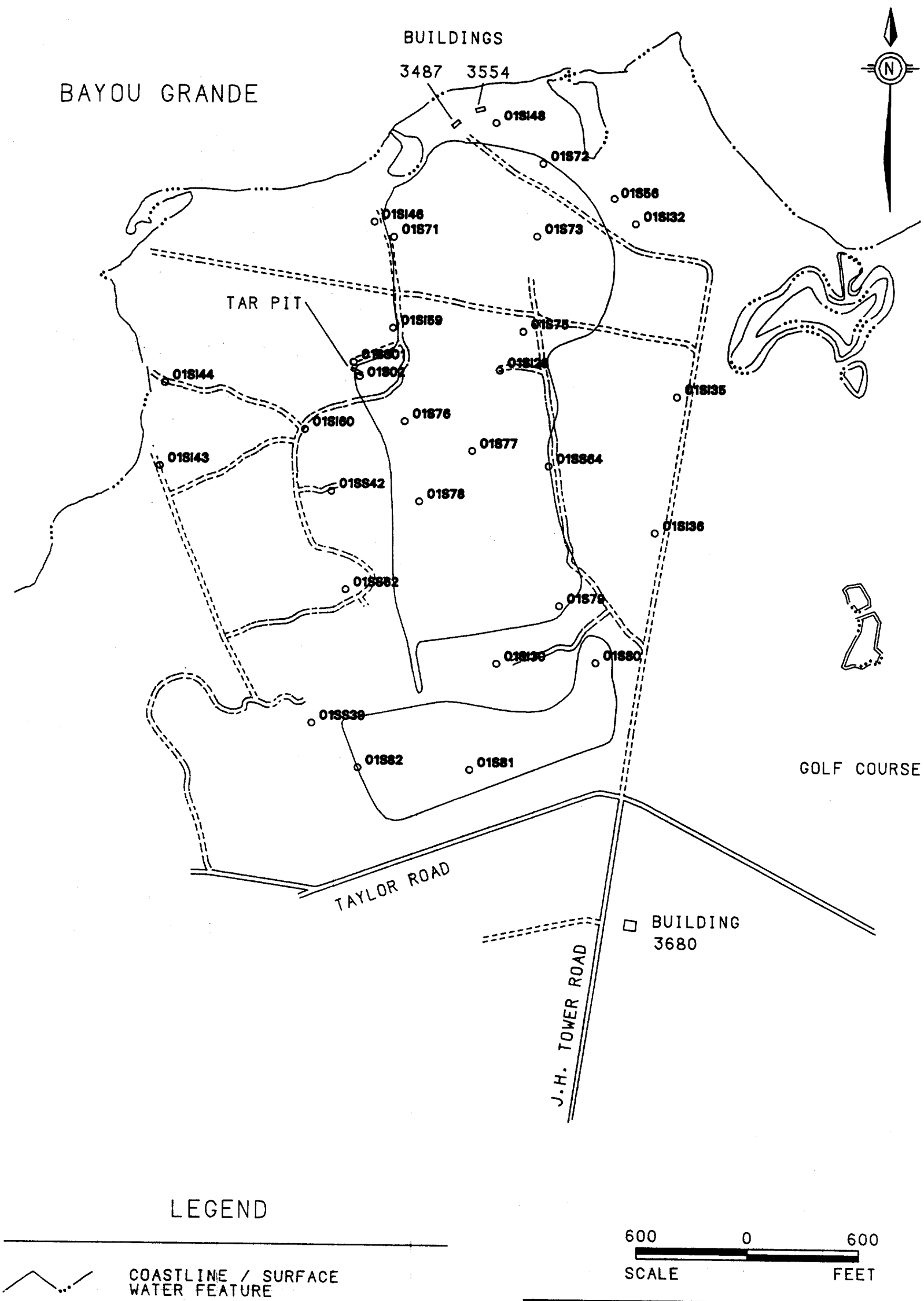
The identification code was used for all borings and locations from which groundwater, soil, or waste samples were collected. Hence, the eight digits of the code uniquely identify each sample by site, sample medium, and location. Borings for monitoring wells (from which no soil samples were collected) are identified by the well number (e.g., 01GI41) for convenience of association.

5.1 Soil

5.1.1 Contamination Assessment Sampling

Twenty-eight soil borings were completed between June 1 and August 27, 1993, in order to characterize the nature of surface soils at Site 1 for risk assessment. In addition to soil brings, subsurface soil and/or waste samples were collected during test trench excavation activities for contaminant characterization.

Soil boring and test trench locations for soil contamination assessment samples are presented in Figures 5-1 and 5-2 respectively. Samples were numbered using the eight-digit system documenting the site number, media, location (boring number), and sample depth. Borings were



LEGEND

COASTLINE / SURFACE WATER FEATURE

UNPAVED ROAD

SHALLOW SOIL BORING

600 0 600
SCALE FEET

REMEDIAL INVESTIGATION REPORT
SITE 1
NAS PENSACOLA

FIGURE 5-1
SHALLOW SOIL BORING LOCATIONS

DATE: 11/16/93 | DWG NAME: 59FIG5-1

BAYOU GRANDE

BUILDINGS
3487 3554

TRENCH 1
TRENCH 2
TRENCH 3
TRENCH 4
TRENCH 5
TAR PIT
TRENCH 6A
TRENCH 6B
TRENCH 6C
TRENCH 7
TRENCH 8
TRENCH 9
TRENCH 10A
TRENCH 10B
TRENCH 11
TRENCH 12
TRENCH 13A
TRENCH 13B

GOLF COURSE

TAYLOR ROAD

BUILDING
3680

J.H. TOWER ROAD

N

LEGEND

COASTLINE / SURFACE WATER FEATURE

UNPAVED ROAD

TEST TRENCH
(APPROXIMATE ORIENTATION
NOT TO SCALE)

600 0 600
SCALE FEET

REMEDIAL INVESTIGATION
REPORT
SITE 1
NAS PENSACOLA

FIGURE 5-2
TEST TRENCH LOCATIONS

DATE: 11/16/93 DWG NAME: 59FIG5-2

placed as specified by the SAP. However, boring placements were modified during fieldwork as proposed in Field Change Request forms. These modifications included the following:

- Replacement of soil borings originally proposed within the landfill boundary with test trenches.

- Addition of surface soil sampling (0 to 1 foot bls) at selected monitoring well locations (around the landfill perimeter) and test trench locations (within the landfill boundary) for risk assessment.

soil Borings

As shown on Figure 5-1, shallow borings were completed to collect soil samples from areas adjacent to 16 wells or well clusters near the landfill border, 11 test trenches within the landfill, and at a dry stream bed. Table 5-3 lists each soil boring, associated sample and analytical sample, and analytical parameters. Surface soil was not sampled at two test trenches due to their close proximity to locations where samples previously had been collected. Except for the stream bed, samples were collected from each of these borings across a 0- to 1-foot bls depth interval. A single sample of native soil was collected from the stream bed boring across a 1- to 2-foot bls depth interval. Additionally, because a solvent-like odor was encountered while installing well 01GL59, a single sample was collected below the water table (approximately 33 feet bls) for characterization purposes. Soil samples also were collected while installing two shallow background wells, one at each of the two functional deep supply wells shown on Figure 5-3. These samples were collected to obtain background soil quality data at NAS Pensacola. Soil sampling at these background locations was performed continuously from land surface at a frequency of 0 to 1 foot bls, then each 2-foot interval thereafter (1 to 3 feet bls, 3 to 5 feet bls, etc.) until the water table was encountered.

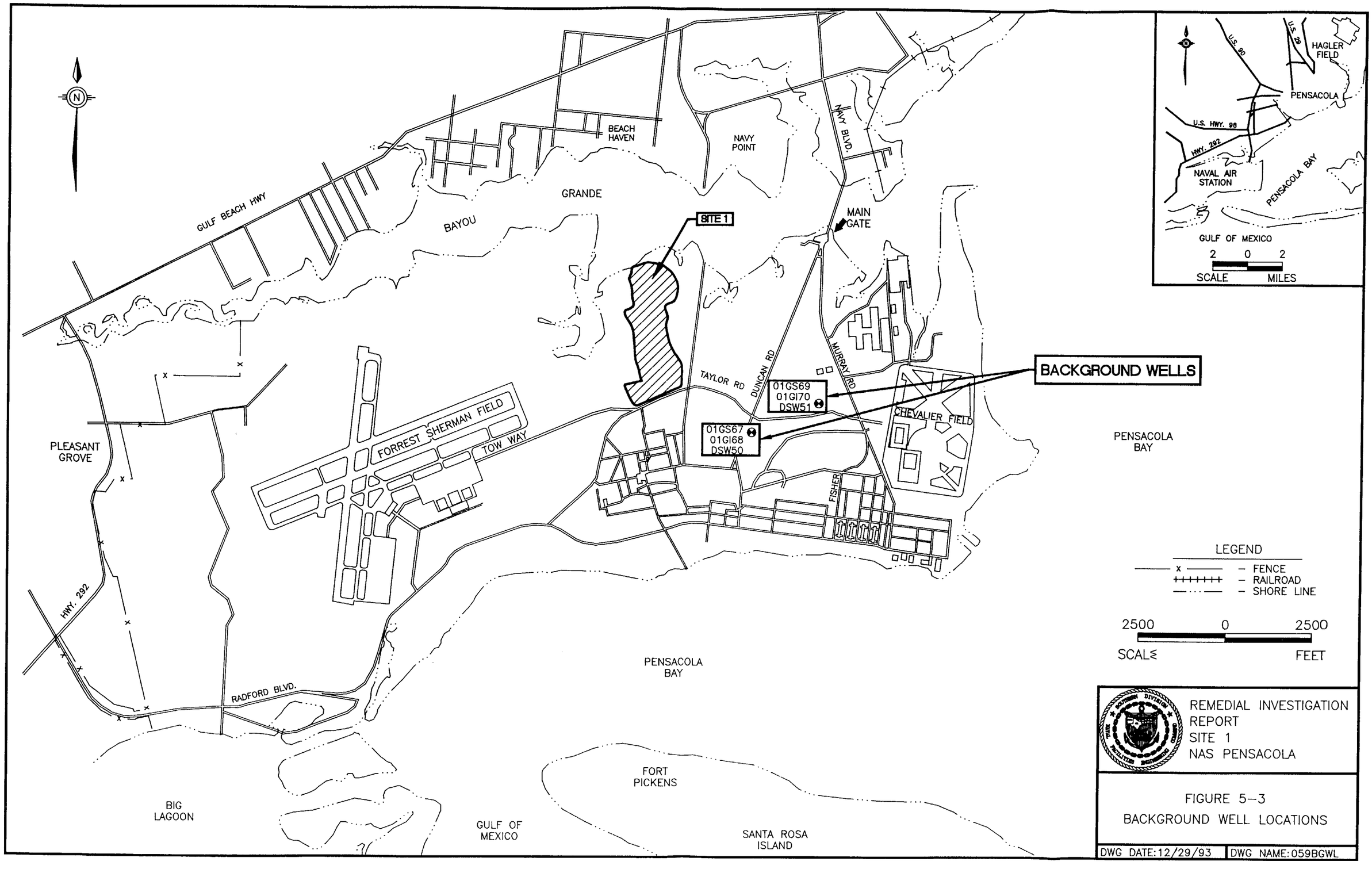

N
GULF BEACH HWY
BEACH HAVEN
NAVY POINT
NAVY BLVD.
GRANDE
BAYOU
SITE 1
MAIN GATE
TAYLOR RD
DUNCAN RD
MURRAY RD
BACKGROUND WELLS
01GS69
01GI70
DSW51
01GS67
01GI68
DSW50
CHEVALIER FIELD
FISHER
FORREST SHERMAN FIELD
TOW WAY
PLEASANT GROVE
HWY. 292
RADFORD BLVD.
PENSACOLA BAY
PENSACOLA BAY
FORT PICKENS
BIG LAGOON
GULF OF MEXICO
SANTA ROSA ISLAND
U.S. 90
U.S. 29
HAGLER FIELD
PENSACOLA
U.S. HWY. 98
HWY. 292
NAVAL AIR STATION
PENSACOLA BAY
GULF OF MEXICO
2 0 2
SCALE MILES
LEGEND
FENCE
RAILROAD
SHORE LINE
2500 0 2500
SCALE FEET
REMEDIAL INVESTIGATION REPORT
SITE 1
NAS PENSACOLA
FIGURE 5-3
BACKGROUND WELL LOCATIONS
DWG DATE:12/29/93
DWG NAME:059BGWL

Table 5-3
Site 1
Soil Borings, Associated Samples, and Analytical Parameters

Soil Boring	Location	Associated	Analytical
01SS01	Site Well 01GS01	01SS0101	TAL/TCL
01SI28	Site Well 01GI28	01SI2801 01SI2812	TAL/TCL PPS
01SI30	Site Well 01GI30	01SI3001 01SI3068	TAL/TCL ST
01SI32	Site Well 01GI32	01SI3201	TAL/TCL
01SI35	Site Well 01GI35	01SI3501 01SI3504	TAL/TCL PPS
01SI36	Site Well 01GI36	01SI3601	TAL/TCL
01SS39	Site Well 01GS39	01SS3901	TAL/TCL, Radiation, Hex.Chromium
01SS42	Site Well 01GS42	01SS4201	TAL/TCL
01SI43	Site Well 01GI43	01SI4301	TAL/TCL
01SI44	Site Well 01GI44	01SI4401	TAL/TCL
01SI46	Site Well 01GI46	01SI4601	TAL/TCL
01SI48	Site Well 01GI48	01SI4801	TAL/TCL
01S56	Dry Stream Bed	0135602	TCLP
01SI59	Site Well 01GI59	01SI5901 01SI5907 01SI5933 01SI5940	TAL/TCL, Radiation, Hex.Chromium PPS TAL/TCL ST
01SI60	Site Well 01GS60	01SI6001	TAL/TCL
01SI62	Site Well 01GS62	01SS6201	TAL/TCL
01SI64	Site Well 01GS64	01SS6401	TAL/TCL

Table 5-3
Site 1
Soil Borings, Associated Samples, and Analytical Parameters

Soil Boring	Location	Associated Sample	Analytical Parameters
01S167	Background Well 01GS67	01S6701	TAL/TCL
		01S6703	TAL/TCL
		01S6705	TAL/TCL
		01S6707	TAL/TCL
		01S6709	TAL/TCL
		01S6711	TAL/TCL
		01S6713	TAL/TCL
		01S6717	TAL/TCL, Radiation, Hex.Chromium
		01S6719	TAL/TCL
		01S6721	TAL/TCL
		01S6723	TAL/TCL
01S69	Background Well 01GS69	01S6901	TAL/TCL
		01S6903	TAL/TCL
		01S6905	TAL/TCL
		01S6907	TALKCL
		01S6909	TALTTCL
		01S6911	TALTTCL
		01S6913	TALTTCL
01S71	Trench 1	01S7101	TALKCL, Hex.Chromium
01S72	Trench 2	01S7201	TALKCL, Hex.Chromium
01s73	Trench 3	01S7301	TALKCL, Hex.Chromium
01S75	Trench 5	01S7501	TALTTCL, Hex.Chromium
01S76	Trench 6A	01S7601	TALKCL, Hex.Chromium
01s77	Trench 7	01S7701	TALTTCL, Hex.Chromium

Table 5-3
Site 1
Soil Borings, Associated Samples, and Analytical Parameters

Soil Boring	Location	Associated Sample	Analytical Parameters
01S78	Trench 8	01S7801	TALTTCL, Hex.Chromium
01s79	Trench 9	01S7901	TALKCL
01S80	Trench 10A	01S8001	TAL/TCL
01S81	Trench 11	01S8101	TALTTCL, Hex.Chromium
01S82	Trench 12	01S8201	TALKCL

Key:
TAL/TCL – Contract Laboratory Program Target Analyte List/Target Compound List
TCLP – Toxicity Characteristic Leaching Procedure
Radiation – Gross Alpha, Beta, Gamma Radiation
Hex. Chromium – Hexavalent Chromium
PPS – Chemical-Physical Characterization Parameters
ST – Physical Characterization Parameters

At each shallow boring location, a representative soil sample was collected across the designated sample interval, using either a stainless steel hand auger or a Xytech sampler. Soil samples were collected during monitoring well installation using 2-foot stainless steel split-barrel samplers advanced in front of the lead auger by the drill rig.

Soil was sampled with a hand auger as described in Section 4.4 of the *CSAP* by advancing the borehole and collecting soil cuttings from the desired depth interval into a stainless steel bowl. When the sample was collected from a subsurface depth interval (e.g., 1 to 2 feet bls), one auger advanced the borehole to the desired depth and a second auger collected soils from the sample interval. Once collected, soils were appropriately containerized, as described in Section 5.3.

Soil was sampled with the Xytech sampler as described in Section 4.5 of the *CSAP* by hammer driving stainless steel, 6-inch cylindrical sample sleeves into the subsurface to the required

depth. To collect the 0- to I-foot bls sample, two sample sleeves were driven consecutively to the desired depth. Upon retrieval, sample sleeves were covered at the ends with Teflon tape and capped.

Soil was sampled with split-barrel samplers without stainless steel liners, as described in Section 4.6 of the CSAP. Depending upon the given situation, the sampler was advanced either with the drill rig's hammer assembly or hydraulics to the desired depth. Upon retrieval, soil sample contents were screened with a photoionization detector (PID) for volatile organic vapors and described on soil boring logs before sample preparation. Soils collected with the sampler were appropriately containerized, as described in Section 5.3.

Except for the 0- to 1-footbls surface samples, information for soil boring sample collection was recorded on soil boring logs, complete with soil stratigraphy, PID responses, collected samples, and any other pertinent observations. Because soil boring logs were completed for monitoring well soil borings and trench excavations, documentation of surface soil sampling at these locations was recorded in a site log book. All sampling equipment was decontaminated between borings and sample intervals as described in Section 5.3. Samples collected from soil borings were processed as described in Section 5.3 and analyzed for CLP TAL/TCL parameters and radiation, except for the dry stream bed sample, which was analyzed for TCLP.

Test Trench Approach and Sample Collection

Site 1 trenching activities were performed during August 16 through 30, 1993. OHM Corporation from Orlando, Florida, was subcontracted to provide heavy-equipment operation and excavation services for these activities. Figure 5-2 illustrates the locations of Site 1 test trenches. In addition to the previously discussed shallow soil borings completed at test trench locations (shown on Figure 5-1), subsurface composite samples of trench waste and underlying native soils also were collected from several locations.

Test trenching was performed at 13 locations to confirm the presence of fill material in selected locations, and to generally characterize the landfill contents. Six of the 13 locations coincide with investigative areas previously identified from aerial photography analysis during the Phase I Investigation where soil borings and shallow monitoring wells were originally proposed (E&E 1991f). The remaining seven locations were chosen based on information gained during the CSS, or to provide additional lateral, unbiased coverage of likely filled areas. The rational for each location is explained below.

Location 1:	To investigate the filled area generally south of North Pond, where construction debris and rubble have reportedly been buried.
Locations 2 and 3:	To investigate areas where fill activities were performed during the early to mid 1960s.
Location 4:	To investigate the approximately 20-foot by 40-foot "tar pit" identified during the Phase I investigation.
Location 5:	To investigate the area where a creosote-soaked barge was reportedly buried (during the late 1960s/early 1970s).
Locations 6, 7, and 8:	To investigate visibly disturbed areas identified through review of aerial photographs.
Location 9:	To investigate the area where specific asbestos and chemical waste trenches were reportedly constructed during the late 1960s.
Locations 10 and 11:	To investigate the eastern and central portion of the 1950s fill area, where *irregular* surface indicates landfilling may have occurred.
Location 12:	To investigate the collapse feature identified during the Phase I investigation.
Location 13:	To investigate a zone between the 1950s and late 1960s fill area that was reportedly cleared but not filled.

At least one test trench was completed at each location. In most locations, these trenches were constructed in an approximate north-south orientation to bisect previously constructed (east to west) burial trenches. A trackhoe with an approximately 25-foot boom and 3-foot by 4-foot steel bucket was used to excavate each trench.

Trenching activities typically proceeded in the following order: The surface soil sample was collected as previously discussed before disturbing land surface; trench overburden was removed; trench contents/wastes were removed and sampled throughout the waste intend; and native underlying soils were sampled when encountered. Downward exploration stopped when unsaturated *(dry)* native soil was encountered below the waste interval to keep from mixing wastes with the underlying water table. Only one trench location contained groundwater within the waste intend; a groundwater sample was collected at this location as described in Section 5.2.3 (Groundwater Sampling).

Table 5-4 lists the trench localities, associated samples, and sample analysis performed, including the shallow soil boring samples previously discussed. Samples collected during the trenching process were analyzed for CLP TAL/TCL, TCLP, and physical-chemical parameters (PPS) as indicated. A surface soil sample was collected at each trench location except for locations 4 and 13, where samples had previously been collected in association with nearby well locations. Waste and native soil samples were collected at 11 of 13 trench locations. Because trench locations 10 and 13 contained no physical indications of waste fill, no subsurface samples were collected. To collect samples unaffected by the excavation process, soil or waste was retrieved from the center of each bucket so material did not come in contact with the bucket itself. Composite samples were collected in this manner from multiple buckets of material as they were removed from each trench. Sample material was collected with stainless steel spoons and bowls with a separate set of equipment used for each sample.

Table 5-4
Site 1
Trench Localities, Associated Samples, and Analytical Parameters

Test Trench	Associated Samples		Analytical Parameters
Trench 1	01S7101	Surface Soil	TAL/TCL, Hex. Cr.
	01S7108	Trench Contents	TAL/TCL, PPS, Hex. Cr.
	01S7112	Native Soil	TAVTCL, Hex. Cr.
Trench 2	01S7201	Surface Soil	TAVTCL, Hex. Cr.
	01S7209	Trench Contents	TAVTCL, PPS, TCLP, Hex. Cr.
	01S7211	Native Soil	TAWCL, PPS, Hex. Cr.
Trench 3	01S7301	Surface Soil	TAL//TCL, Hex. Cr.
	01S7310	Trench Contents	TAVTCL, PPS, TCLP, Hex. Cr.
	01S7313	Native Soil	TAVTCL, PPS. Hex. Cr.
Trench 4	01S0201	Tar Waste Sample	TCLP
	01S7402	Stained Soil	TAVTCL, PPS, TCLP, Hex. Cr.
	01S7404	Native Soil	TAVTCL, PPS, Hex. Cr.
Trench 5	01S7501	Surface Soil	TAVTCL, Hex. Cr.
	0187508	Trench Contents	TCL VOC
	01S7518	Trench Contents	TAVTCL, PPS, Hex. Cr.
Trench 6A	01S7601	Surface Soil	TAL/TCL, Hex. Cr.
Trench 6A, 6B, 6C	01S7610	Trench Contents	TAVTCL, PPS, TCLP, Hex. Cr.
Trench 7	01S7701	Surface Soil	TAWCL, Hex. Cr.
	01S7710	Trench Contents	TAVTCL, PPS, TCLP, Hex. Cr.
	0187715	Native Soil	TAVTCL, PPS, Hex. Cr.
Trench 8	01S7801	surface Soil	TAWCL, Hex. Cr.
	01S7806	Trench Contents	TAL/TCL, PPS, TCLP, Hex. Cr.
	01S7809	Native Soil	TAVTCL, PPS, Hex. Cr.
Trench 9	01S7901	surface Soil	TAL/TCL
	01S7914	Trench Contents	TCLP
	01G79	Groundwater	TAWCL. Hex. Cr.
Trench 10A	01S8001	Surface Soil	TAVTCL
Trench 11	01S8101	Surface Soil	TAWCL, Hex. Cr.
	01S8118	Trench Contents	TAWCL, PPS, TCLP, Hex. Cr.
	01S8120	Native Soil	TAWCL. PPS. Hex. Cr.
Trench 12	01S8201	Surface Soil	TAL/TCL
	01S8210	Trench Contents	TAVTCL, PPS, TCLP
	01S8214	Native Soil	TAWCL. PPS
Trench 13A, 138	None		

Key:
TAL/TCL = Contract Laboratory Program Target Analyte List/Target Compound List
PPS = Chemical-Physical Characterization Parameters
TCLP = Toxicity Characteristic Leaching Procedure
Hex. Cr. = Hexavalent Chromium

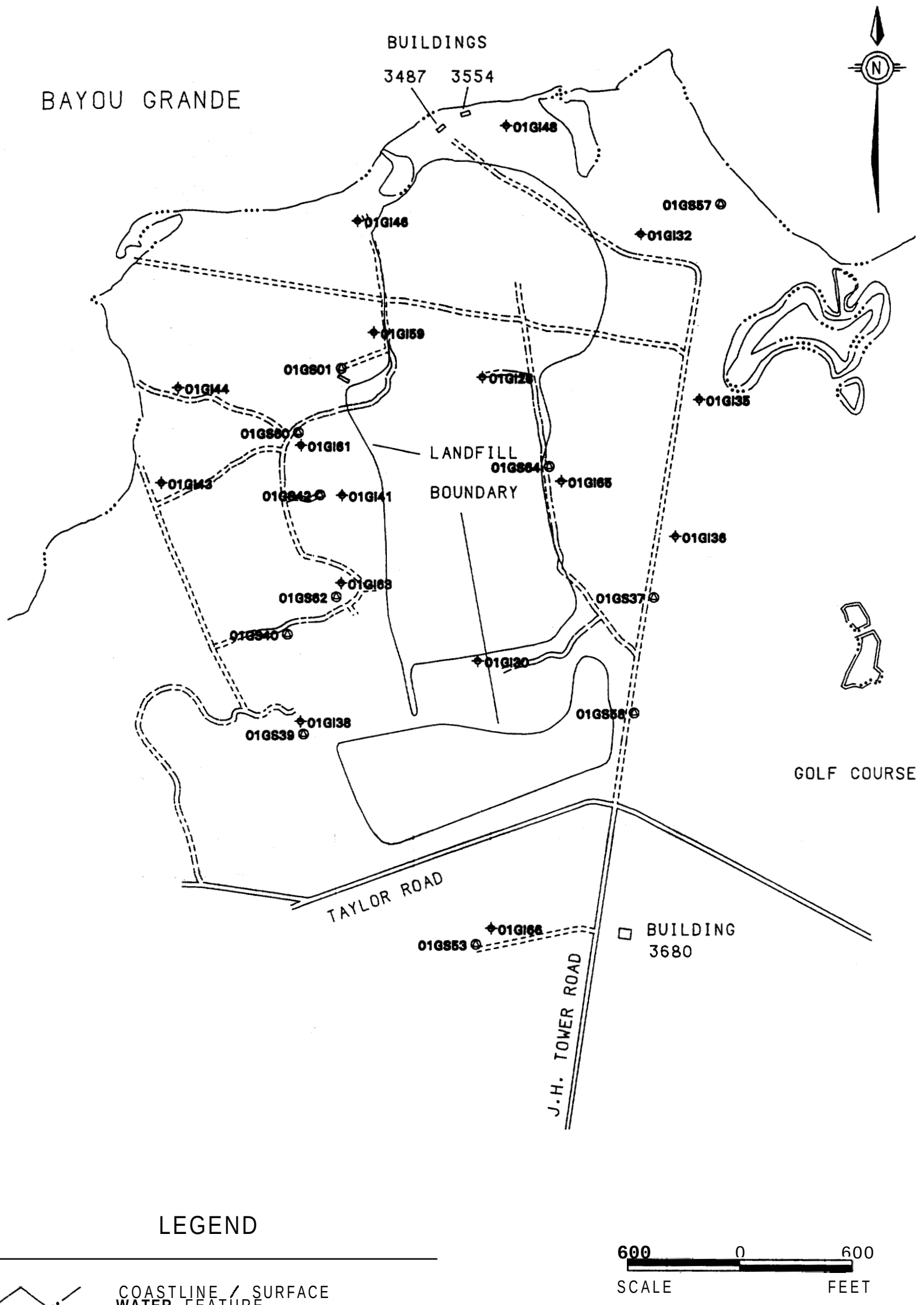
After completing sampling, all soils and trench wastes were returned into the excavation with no excess materials remaining. In most instances, the original overburden material was replaced on the excavated area. However, because overburden material was lacking at two locations, (trench locations 9 and 12) additional clean clayey-sandy soil was brought in by the subcontractor and added to the overburden cap. During the trenching process, a detailed log was maintained to document the contents of the trench, the thickness of the overburden, waste interval, underlying soils, and any notable observations regarding the process. Photographs also were taken throughout the trenching process.

All sampling equipment used during trenching was decontaminated as described in Section 5.3. Samples were processed as described in Section 5.3, and analyzed for CLP TAL/TCL, TCLP, and physical-chemical parameters.

5.1.2 Stratigraphic Exploration

Shallow soil boring and trenching activities provided stratigraphic information for soil above the water table. Deeper stratigraphic information of the shallow aquifer zone was obtained while installing 31 monitoring wells at Site 1 from May 27 through June 29, 1993. These included 11 shallow and 16 intermediate wells installed onsite, and a shallow and intermediate well pair installed at each of two deep supply well locations. Shallow wells were installed with well screens bracketing the water table. Intermediate depth wells were installed to the base of the surficial zone, with the target completion depth at the interface of the surficial zone and the underlying low permeability zone.

Figure 5-4 shows the locations of borings completed for monitoring well installation. Drilling methods for these borings are discussed in Sections 5.2.1. Four intermediate depth wells at strategic locations across the site were sampled for lithologic purposes. All other lithologic observations were based on cuttings brought to the surface during drilling. The interface of the surfical zone and low permeability zone was confirmed by split-barrel sampling at all intermediate depth wells as the estimated depth to the clay unit was approached.



LEGEND

COASTLINE / SURFACE WATER FEATURE

UNPAVED ROAD

SHALLOW MONITORING WELL

INTERMEDIATE MONITORING WELL

600 0 600
SCALE FEET

REMEDIAL INVESTIGATION REPORT
SITE 1
NAS PENSACOLA

FIGURE 5-4
NEWLY INSTALLED
SHALLOW AND INTERMEDIATE
MONITORING WELL LOCATIONS

DATE: 11/16/93 DWG NAME: 59FIG5-4

Monitoring well borings 01GI35, 01GI44, 01GI63, and 01GI66 were selected as locations for lithologic sampling. This process was performed using the split-barrel sampler and hammer method. One 2-foot sample per 5 feet of borehole depth was collected. Samples collected in this manner were logged for lithology and stratigraphic variation, providing a stratigraphic column of the surficial zone and the interface of the underlying confining clay unit across the site. Boring logs for all shallow and intermediate depth borings are provided in Appendix B.

5.1.3 Physical Characterization Sampling

Soil samples were collected during monitoring well installation for physical characterization. Unsaturated soils above the water table and the underlying clay unit beneath the surficial zone were sampled to provide information for the FS and hydrologic information on the site hydrogeologic units.

Unsaturated soils were composited from land surface to the water table from well borings 01GI28, 01GI35, and 01GI59. These samples were collected using a hammer-driven split-barrel sampler and analyzed for chemical-physical parameters (see Table 5-2). An undisturbed sample also was collected from this interval using a 2-foot, split-barrel sampler with 6-inch stainless steel sleeve inserts; it was analyzed for physical parameters only (see Table 5-2).

Undisturbed samples of the upper portion of the clay unit were taken from well borings 01GI30, 01GI48, and 01GI59 to determine the clay's permeability across the site. These samples were collected using either a 2-foot Shelby tube sampler or split-barrel sampler with stainless steel sleeve inserts. Each of these samplers was hydraulically driven by the drill rig. Undisturbed samples of the clay unit were analyzed for physical parameters.

All samples were processed as described in Section 5.3 and shipped to the appropriate laboratories for analysis. Undisturbed samples were capped and secured immediately upon retrieval, labeled as to their original orientation, and transported in an upright and stable position.

5.2 Groundwater

The groundwater investigation was performed at Site 1 from May 27 through August 13, 1993. This investigation included installing 31 monitoring wells, developing all newly installed wells, redeveloping existing site wells, collecting groundwater samples from all newly installed and existing wells, and conducting a hydrologic assessment.

5.2.1 Monitoring Well Installation

Eleven shallow and 16 intermediate wells were installed at Site 1 to expand the pre-existing well network to determine the nature and extent of potential groundwater contamination. Additionally, shallow and intermediate well pairs were installed at each of the two deep supply well locations to collect background groundwater quality data. A third well pair originally was proposed for a third deep supply well location; however, this well had been taken out of service several years prior to the investigation and was incapable of being sampled (Joyner, 1993, pers. comm.). Therefore, the third shallow and intermediate depth background well pair was not installed there. Monitoring well locations are shown on Figures 5-3 and 5-4.

Table 5-5 lists well construction information for all previously and newly installed monitoring wells at Site 1. Shallow wells were completed in the upper portion of the surficial zone of the Sand-and-Gravel Aquifer, with well screens bracketing the water table. Intermediate depth wells were installed into the lower portion of the surficial zone, with well screens set immediately above the low permeability clay unit. In general, wells were placed at, or as close as possible to, the locations proposed in the work plan and SAP, with only minor adjustments due to overhead power lines. Seven wells were added to the original scope of work to monitor areas or zones not covered by the proposed or existing well arrays: shallow wells 01GS60, 01GS62, 01GS64, and intermediate wells 01GI61, 01GI63, and 01GI65 were added to increase well network coverage around the landfill boundary; well 01GI66 was added to provide intermediate depth groundwater quality data from the upgradient well cluster.

Table 5-5
Construction Details for Newly Installed and Existing Site 1 Monitoring Wells[a]

Well Number	Well Depth (BLS)	Screened Interval[d] (BLS)
Shallow Wells		
01GS01	13.7	3.2 - 13.2
01GS37	13.3	2.8 - 12.8
01GS39	12.1	1.6- 11.6
01GS40	14.1	3.6 - 13.6
01GS42	14.2	3.7 - 13.7
01GS53	18.2	7.7 - 17.7
01GS57	21.5	11.0-21.0
01GS58	20.2	9.7 - 19.7
01GS60	14.3	3.8 - 13.8
01GS62	14.1	3.6 - 13.6
01GS64	13.9	3.4 - 13.4
01GS67[b]	32.6	22.1 - 32.1
01GS69[b]	20.2	9.7 - 19.7
01GS71[f]	13.5	3.0 - 13.0
GM-03	18.0	15.5 - 18.0
GM-04	17.2	14.5 - 17.0
GM-05	11.8	9.3 - 11.8
GM-31	11.3	8.8 - 11.3
GM-32	11.7	9.1 - 11.6
GM-33	11.5	9.0 - 11.5
GM-34	11.7	9.1 - 11.6
GM-35	11.5	9.0 - 11.5
GM-38	15.6	12.5 - 15.0

Table 5-5
Construction Details for Newly Installed and Existing Site 1 Monitoring Wells[a]

Well Number	Well Depth (BLS)	Screened Interval[d] (BLS)
GM-39	16.1	12.5 - 15.0
GM-41	16.0	12.5 - 15.0
GM-42	17.1	14.0 - 16.5
01GI28	30.0	19.5 - 29.5
01GI30	53.6	43.1 - 53.1
01GI32	35.5	25.0 - 35.0
01GI35	27.0	16.5 - 26.5
01GI36	35.5	25.0 - 35.0
01GI38	57.4	46.9 - 56.9
01GI41	40.0	29.5 - 39.5
01GI43	42.1	31.6 -41.6
01GI44	29.4	18.9 - 28.9
01GI46	29.5	19.0 - 29.0
01GI48	27.8	17.3 - 27.3
01GI59	28.6	18.1 - 28.1
01GI61	38.2	27.7 - 37.7
01GI63	46.1	35.6- 45.6
01GI65	37.7	27.2 - 37.2
01GI66	65.2	54.4 - 64.7
01GI68[b]	79.0	68.5 - 78.5
01GI70[b]	44.0	33.5 - 43.5
01GI72[f]	25.5	15.0 - 25.0

Table 5-5
Construction Details for Newly Installed and Existing Site 1 Monitoring Wells[a]

Well Number	Well Depth (BLS)	Screened Interval[d] (BLS)
Deep Wells		
GM-43	68.8	63 - 68
GM-44	58.2	53 - 58
GM-45	107.1	102 - 107
01GDWS50[c+e]	175.0	106 - 175
01GDSW51[c+e]	178.0	114 - 178

Key:

- = All well casino are 2 inches in diameter.
- b — Background well location.
- 8 — NASP deep supply well.
- — GM well screen interval taken from G&M 1984, 1986.
- — Well construction information for deep supply wells taken from Groundwater Technology 1993.
- f — Monitoring well installed June 1994.

BLS = Below land surface

Drilling Methods

Borehole drilling and monitoring well installation was performed by Kelly Environmental under the supervision of an E/A&H geologist. Hollow-stem auger drilling techniques were used to install all shallow and intermediate depth wells. Subsurface stratigraphy was noted by examining cuttings returned to the surface during the drilling process, and by split-barrel sampling (see Section 5.1.2., Stratigraphic Exploration). During drilling activities, all pertinent information was recorded in site logbooks and on boring log forms. The latter are provided in Appendix B.

Shallow and intermediate depth well boreholes were drilled using 4.25-inch internal diameter (ID) hollow-stem augers that created boreholes with a minimum diameter of 6.5 inches. Hollow-stem augers were used for Site 1 well installation to avoid introducing drilling mud into the aquifer. To prohibit flowing sands from entering the augers, a Teflon or PVC "knockout" plug commonly was placed in the lead end of the auger string before drilling. When drilling boreholes for shallow wells, augers with knockout plugs advanced the boring to approximately 6 to 8 feet below the water table where the well was set. When drilling boreholes for intermediate depth wells, the borehole was drilled twice. The first drilling was performed without a knockout plug so the split-barrel sampling could be performed to locate the confining clay's depth. Upon confirming the clay unit's depth, augers were removed from the borehole, and the hole was redrilled with knockout-plugged augers to set the well. In instances where running sands invaded the lower few feet of the auger string, it was necessary to tremie jet the augers clear with water to collect a representative split-barrel sample. Potable water from the NAS Pensacola water supply was used during drilling and well installation. Potable water was collected and transported to each well location in drill rig water tanks. A potable water field blank sample was collected from the tanks used each week during drilling. The results of these samples are discussed in Section 9, Data Validation.

Monitoring Well Construction

Groundwater monitoring wells were constructed to comply with all applicable federal, state, and local agency regulations. Well construction, installation, and development was executed in compliance with the Site 1 SAP and the CSAP.

All monitoring wells installed during the investigation were completed as 2-inch diameter wells. Well material correspondingly consisted of 2-inch diameter, flush threaded, PVC riser casing and 0.010 slot PVC screen. The screen size was determined to be suitable for site soil based on grain-size analysis (Appendix C). All wells uniformly included a 10-foot screened interval and were constructed through the annuli of the augers. Well specific construction details are contained on well completion diagrams in Appendix D.

Minimum borehole diameters of 6.5 inches for 2-inch wells resulted in a uniform minimum 2-inch annulus around the screens and risers. Silica sand (U.S. standard sieve size 20-30) was used to backfill around the screened intervals and to serve as a filter pack. Because all wells were constructed inside 4.25-inch ID augers, filter pack sand was poured into the auger annulus, which functioned as a tremie pipe for the even positioning of sand around the well screen. The filter sand was tagged for placement around the well screen with a weighted tape to verify thickness and uniformity. A minimal amount (estimated to be less than 10 gallons) of potable water occasionally was added to intermediate depth wells to promote the sand's flow down the auger annulus. All intermediate depth wells were sand-packed to at least 2 feet above the screened intervals. However, due to the shallow water table encountered at many well locations, approximately half of the shallow wells required installation with reduced thicknesses of sand above the well screen and bentonite seal. The thickness of each of these materials was generally reduced to 1 foot when conditions required.

A bentonite seal — either 3/8-inch round bentonite pellets or roughly .5-inch triangular chips — was emplaced above the sand pack to a thickness of approximately 2 feet or greater (except where shallow water table conditions required modification). For shallow wells in which the seal was placed above the water table, the bentonite was charged with approximately 5 to 10 gallons of potable water to promote hydration. A thick, pumpable, highdensity solids bentonite slurry was installed in place of bentonite pellets at most intermediate wells locations where the depth to the filter pack through the water table column was sufficient to inhibit the pellet placement (generally in wells with depths greater than 30 feet). At these locations, the filter pack was extended approximately 5 feet above the well screen and an approximate 5-foot thickness of bentonite slurry was tremie pumped slowly to the top of the filter pack.

Shallow and intermediate depth wells were grout-sealed above the bentonite to within 2 feet of land surface with a neat cement grout consisting of approximately 6 gallons of potable water per 94-pound bag of Portland type I cement. However, at shallow wells where the bentonite seal

was approximately 2 feet bls or less, a Portland cement-based concrete was added above the bentonite to form a stable base in which the protective well casing or cover was set. One shallow well, 01GS58, had to be abandoned due to the collapse of the PVC casing during the curing of the grout collar. This well was abandoned in accordance with Northwest Florida Water Management District (NFWMD) procedures and a replacement well given the same number was installed in an adjacent location.

All wells were *capped* with concrete surface pads that sealed the remaining annuli above the bentonite *seal* or grout. Surface pads measured either 3 feet by 3 feet by 6 inches or 2 feet by 2 feet by 4 inches at the ground surface, depending upon whether a stickup protective steel casing or a water-tight, bolt-down, flush-mount protective cover was installed, respectively (flush-mounted covers were installed at the request of NAS Pensacola Facility Management Department (FMD) for well locations along the golf course). Bolt-down covers were emplaced in concrete bases, approximately 1 foot into the ground. Approximately 2.5 feet of riser stickup was left above ground surface for non-flush mount wells. Each stickup, protective steel casing was emplaced in a base of concrete, approximately 2 feet into the ground. Both flush-mount and stickup well heads were equipped with locking caps. At stickup well locations in high-traffic areas, four protective steel concrete-filled bumper posts were installed at the concrete pads' corners in bases of concrete extending 2 feet bls.

5.2.2 Well Development

All newly installed and existing site monitoring wells were (re)developed by E/A&H from June 27 through July 20, 1993. Wells were developed by alternating surging and pumping. Existing site wells were redeveloped because of the length of time since their last use. A 5-horsepower centrifuge pump, PVC plastic tubing, and foot valve were used to develop most shallow and intermediate wells. A stainless steel submersible pump was used to develop wells where the depth to water or water level drawdown was too great to support using the centrifugal pump. Only wells 01GS67, 01GI68, GM-44, and GM-45 were developed with a submersible

pump. PVC surge blocks, 2 inches in diameter, and PVC extensions were used to surge the wells. Pumping and surging was reiterated, generally two or three times per well.

During development, discharge rate, pH, conductivity, temperature, and visible water quality were monitored. In accordance with the CSAP, SAP, and the SOP/QAM, development proceeded until pumped groundwater reached its maximum clarity, and pH, conductivity, and temperature stabilized. The clarity of most wells did improve during development; however, few newly installed wells near the landfill yielded "clear" groundwater. Most site wells produced tannic, dark brown groundwater with varying degrees of turbidity that did not clear for a considerable period after pH, conductivity, and temperature stabilized. In general, shallow wells yielded one 55-gallon drum of development water before acceptability, while intermediate and deep wells yielded two 55-gallon drums.

5.2.3 Groundwater Sampling

Initial sampling — 1993

Groundwater was sampled from 48 wells from July 13 through 26, 1993. These wells included the 27 newly installed site wells and 15 existing site wells. Additionally, to collect ambient or background water quality data for NAS Pensacola, the newly installed shallow and intermediate well pair at each of two NAS Pensacola deep supply well locations (total of four wells), and the two deep supply wells also were sampled. The two shallow and two intermediate background wells were resampled for TAL metals (unfiltered) on October 14, 1993. Resampling was done to confirm the detected metals concentrations in the background samples due to highly suspect analytical results originally received for sample 01GS69. Samples collected during this event were noted with a "R," as in 01GS69R. A third supply well originally was to be sampled; however, this well had been out of service for several years prior to the investigation and was not capable of being sampled (Joyner, 1993, pers. comm.). In addition, shallow groundwater was sampled from the bottom of one test trench during the trenching activities performed August 18, 1993. Table 5-6 lists all wells sampled, their depth levels, and the corresponding

Table 5-6
Monitoring Wells, Groundwater Samples, and Analytical Parameters
1993 Groundwater Sampling
Site 1

Level	Well Number	Sample Number	Analytical Parameters
Shallow	01GS01	01GS01	TALKCL
	01GS37	01GS37	TALITCL
	01GS39	01GS39	TALITCL
	01GS40	01GS40	TALKCL
	01GS42	01GS42	TALKCL
	01GS53	01GS53	TALKCL
	01GS57	01GS57	TAL/TCL
	01GS58	01GS58	TALKCL
	01GS60	01GS60	TALKCL
	01GS62	01GS62	TALKCL
	01GS64	01GS64	TAL/TCL
	01GS67[a]	01GS67	TALKCL
	01GS69[b]	01GS69	TALKCL
	GM03	01GGM03	TALITCL
	GM-04	01GGM04	TALKCL
	GM-05	01GGM05	TALKCL, PPW
	GM-31	01GGM31	TALKCL
	GM-32	01GGM32	TALKCL
	GM-33	01GGM33	TALKCL, Radiation, Hex. Chromium
	GM-38	01GGM34	TALITCL, PPW
		01GGM35	TALKCL, Radiation, Hex. Chromium
		01GGM38	TALKCL
		01GGM39	TALITCL
		01GGM41	TALITCL
	GM-42	01GGM42	TALKCL

Table 5-6
Monitoring Wells, Groundwater Samples, and Analytical Parameters
1993 Groundwater Sampling
Site 1

Level	Well Number	Sample Number	Analytical Parameters
Intermediate	01GI28	01GI28	TALKCL, Radiation, Hex. Chromium, PPW
	01GI30	01GI30	TALKCL
	01GI32	01GI32	TALKCL
	01GI35	01GI35	TALKCL
	01GI36	01GI36	TALKCL
	01GI38	01GI38	TAL/TCL
	01GI41	01GI41	TALITCL
	01GI43	01GI43	TAL/TCL
	01GI44	01GI44	TALITCL
	01GI46	01GI46	TALKCL
	01GI48	01GI48	TALKCL, PPW
	01GI59	01GI59	TALKCL, Radiation, Hex. Chromium
	01GI61	01GI61	TALKCL
	01GI63	01GI63	TAL/TCL
	01GI65	01GI65	TALKCL
	01GI66	01GI66	TALITCL
	01GI68[a]	01GI68	TALKCL
	01GI70[b]	01GI70	TALKCL
Deep	GM-43	01GGM43	TALITCL, PPW
	OM-44	01GGM44	TALKCL, Radiation, Hex. Chromium
	GM-45	01GGM45	TALITCL, PPW
	DSW50[c]	01GDSW50	TALKCL
	DSW51[d]	01GDSW51	TALKCL

Key:
- a = Background well located near deep supply well DSW50.
- b = Background well located near deep supply well DSW51.
- c = NAS Pensacola deep supply well located at Building 696.
- d = NAS Pensacola deep supply well located at Building 706.

TAL/TCL = Contract Laboratory Program Target Analyte List/Target Compound List
Radiation = Gross Alpha, Beta, Gamma Radiation and Gamma Spectroscopy
Hex. Chromium = Hexavalent Chromium
PPW = Physical Characterization Parameters

samples collected. The sampling event placed emphasis on the shallow and intermediate depth wells installed in the surficial zone above the confining clay unit. Three existing deep site wells— GM-43, GM-44, and GM-45 — that penetrate the confining unit were sampled to characterize deep groundwater conditions.

Prior to purging and sampling each well, water level and total well depth were measured with an electronic water-level indicator, and the volume of water within the well was calculated. The water table and well bottom were checked for floating and sinking non-aqueous phase liquids with either a product interface probe or a clear Teflon bailer lowered to the appropriate depth and retrieved for visual inspection. A minimum of three well volumes were then purged from each well using either a Teflon bailer or PVC submersible pump (at well location GM45 only) with a one-direction check valve. Where the submersible pump was used, an additional final well volume was removed with a Teflon bailer. The groundwater field parameters pH, specific conductivity, and temperature were measured with each removed well volume to monitor water stabilization. Water was considered stable and ready for sampling after three consecutive readings of pH, specific conductivity, and temperature within 10 percent of previous readings were obtained. Groundwater was sampled in 1993 using Teflon bailers with Teflon-coated stainless steel leader cables.

Groundwater percolating into the bottom of the test trench was sampled by placing a 10-foot length of 2-inch diameter, stainless steel well screen and 5-foot length of well casing into the open trench and collecting groundwater through the well screen with a Teflon bailer. No additional purging was performed to collect the sample. Only the water volume required for sample analysis was collected.

Samples from all wells and the test trench were collected for analysis of CLP TAL/TCL parameters, including total (unfiltered) TAL metals. One out of every 10 monitoring wells also was sampled for hexavalent chromium, in addition to gamma spectroscopy radiation (the test

trench sample also was analyzed for hexavalent chromium). Six wells (two shallow, two intermediate, and two deep) were analyzed for physical characterization parameters. Sample containers for VOC analysis were filled first, taking precautions to minimize water disturbance, followed by containers for semivolatiles and the remaining sample containers.

Weather conditions, initial water levels, purging and sampling times, purge volumes, groundwater temperature, pH, and specific conductance were recorded on groundwater sampling forms during purging and sampling activities.

5.3 Sampling Protocol

All sampling activities were conducted in accordance with the U.S. Navy-, FDEP- and U.S. EPA-approved SAP for Site 1, and the USEPA Region IV Standard Operations Procedures and Quality Assurance Manual (SOP/QAM) (USEPA 1991b). Where warranted by field conditions, deviations from the approved procedures were carried out and appropriately documented in accordance with the SOP/QAM. Specific sampling procedures varied with each task and are detailed in Sections 5.1 and 5.2 of this report.

Sample Handling

Handling of sampled materials was kept to a minimum. Where possible materials were directly sampled into their containers. Where it was necessary to transfer material from sampling devices to containers, the operation was conducted expediently in as clean an environment as possible. New gloves were donned prior to the collection of each sample. Empty containers were kept packaged until they were used. Sampling was not conducted in steady rain. Where sample aliquots were collected for separate analyses, those for volatile analyses were Containerized first from unhomogenized material to minimize any degassing. Containerized samples immediately were chilled and isolated from the environment in coolers.

QA/QC Samples

QA/QC samples were collected as quality checks on field and laboratory procedures to test for the level of reproducibility attainable in the sampling and analytical process, quality of equipment decontamination, quality of source waters and materials, sample exposure to ambient contamination during handling, and level of laboratory precision.

All field QA/QC samples were collected in accordance with the Site 1 SAP and the SOP/QAM. The samples taken are as follows.

Type and frequency:

- Duplicate samples were collected for every 10 samples for each sampling task.

- Equipment rinsates were collected from the sampling equipment specific to each task on a frequency of one for every batch decontamination of identical sampling devices.

- Material blanks were collected once for each accessory material used in drilling and well construction (filter sand, bentonite pellets, bentonite slurry, cement/bentonite grout mixture).

- One field blank per week was collected from a deionized, organic-removal water system at the E/A&H field trailer.

- Potable water source blanks were collected once a week from each rig-mounted drilling water source tank used.

- Matrix spike and matrix spike duplicate (MS/MSD) samples were collected at a frequency of one per every 20 for the groundwater sampling tasks. MS/MSD soil sample aliquots were chosen and separated in the laboratory from one of every 20 samples submitted.

- QA/QC samples were analyzed for the same contamination assessment parameters as the environmental samples.

Sample Containers and Preservation

Stainless steel sleeves were supplied by Envirotech, Inc. All other sample containers were supplied by CompuChem (for chemical analysis), and Savannah Laboratories (for chemical-physical analysis). The laboratory-provided containers were precleaned and certified. The stainless steel sleeves were cleaned by E/A&H staff at the field trailer and verified with QA/QC rinsate samples. Table 5-7 lists the sample containers, sample media, and analyses for which they were used. Sample preservation followed guidelines presented in the Site 1 SAP and the SOP/QAM, and is also included in Table 5-7.

Sample Packaging and Shipment

Shelby tube and other undisturbed samples for permeability analysis were packed in upright position and were relinquished to Thompson Engineering personnel for transport to their Mobile, Alabama, laboratory. All other samples were packed in sturdy coolers. Bagged and sealed ice was arranged within containers in sufficient volume to maintain uniform and appropriate preservation temperatures during shipment. Temperature strips were placed in all coolers.

Trip blanks were placed in coolers containing samples for VOC analysis. All sample coolers were lined with large plastic bags in which sample containers, double-bagged ice, and packing materials were placed. Vermiculite was used as a packing material to fill voids, keep breakable containers separated, and provide cushion during shipment. Chain-of-custody records were completed separately for each cooler and placed inside with the samples. The lids of the coolers were secured with strapping tape and sealed with a signed custody seal.

Table 5-7
Sample Containers and Preservation as per Medium and Analysis

Medium	Analysis	Sample Container	Preservative
Soil/Waste	CLP TAL/TCL	4 oz./8 oz. glass jars	4oc
Soil	Physical parameters	Shelby tube 6-inch s.s. sleeve	—
Soil/Waste	Chemical-physical parameters	1 liter Nalgene bottle	4°C
Groundwater	CLP TCL VOCs	40 ml. glass vial	4°C - HCL, pH < 2
Groundwater	CLP TCL SVOCs CLP TCL Pesticides/PCBs	1 liter amber bottle	4°C
Groundwater	CLP TAL Metals-unfiltered Hexivalent Chromium	1 liter Nalgene bottle 1 liter Nalgene bottle	4°C - HNO_3, pH < 2 4oc
Groundwater	Cyanide	1 liter amber bottle	4°C - NaOH, pH > [12]
Groundwater	Gross alpha, beta, gamma radiation Gamma spectroscopy	1 liter Nalgene bottle	4°C
Groundwater	BOD, TSS, Alkalinity, Nitrogen	1 liter polyethylene bottle	4oc
Groundwater	COD, Phosphorous, TKN	500 ml. polyethylene bottle	4°C - H_2SO_4, pH < 2
Groundwater	Hardness	500 ml. polyethylene bottle	4°C - HNO_3, pH < 2
Groundwater	Heterotrophic Plate Count	130 ml. sterile polyethylene bottle	4°C

Key:
VOC = Volatile organic compound
SVOCS = Semivolatile organic compound
BOD = Biological oxygen demand (5-day)
TSS = Total suspended solids
COD = Chemical oxygen demand
TKN = Total Kjeldahl nitrogen
S.S. = Stainless steel
ml = milliliter

[Bold items in brackets denote changes to the first draft of document.]

The packaged samples were shipped overnight via Federal Express Corporation priority service for next-morning delivery. The receiving laboratory was notified to expect a next-day delivery, and a follow-up phone call verified the shipments. With few exceptions, all samples were shipped to the laboratory on the same day of collection. However, when a long sampling day and large quantity of samples did not allow sufficient time for proper processing and packaging, a limited number of samples were stored overnight under refrigeration (4° C or less) inside the locked trailer and were shipped the following day with due notice to the laboratory about the delay. All sample shipments were reported to have arrived at the laboratory in good condition and at appropriate temperatures, and all samples were extracted and analyzed within the required holding times.

Chain-of-Custody

To ensure the integrity of the sample-transfer process, a strict chain-of-custody procedure was implemented for all samples collected. This procedure was initiated in the field for each sampling event and carried out through custody transfer to the contract laboratory. A chain-of-custody form was completed for each shipping cooler, itemizing sample numbers, containerization, preservative, analyses requested, date and time of sampling, and Federal Express shipment number. Custody transfers were recorded by signature, date and time of relinquishing or receipt of custody by the parties involved. Coolers or packages were sealed with custody seals during transport.

Auxiliary Data

Auxiliary data pertinent to sampling activities were collected for each sampling event. Field information included identifying personnel; time of sampling; describing location, weather conditions, and equipment/sample containers used; sampling methods and test equipment used; any physical/chemical parameters measured; soil lithology and stratigraphy; problems encountered; procedural deviations, etc. This information was recorded in appropriate field logbooks dedicated to specific sampling activities. Pertinent information also was recorded on

boring logs, well completion logs, groundwater sampling forms, and aquifer test data forms. Daily site activities were summarized in a site master log.

Decontamination

Equipment used in the field investigation was decontaminated in accordance with guidelines in the Site 1 SAP and the SOP/QAM. All exploration and sampling equipment was decontaminated prior to its use at each sampling station, while sampling equipment that came into contact with the actual sampled material was decontaminated between each sample collection at any given station. Decontamination was accomplished as follows.

Decontamination Procedures:

- Soap and water wash
- Tap water or analyte-free (deionized/organic-free) water rinse
- Analyte-free water rinse
- Two isopropanol rinses
- Analyte-free water rinse
- Air dry

Decontaminated sampling equipment was wrapped in aluminum foil if intended for transport or storage before use. Large equipment was decontaminated at a dedicated decontamination area set up on Site 1's outer boundary. The decontamination station of wood frame and heavy plastic groundcover funnelled decontamination water into a collection sump. A high-pressure steam-washing machine was used to spray down the large equipment and drill rig with water and soap. Small equipment was decontaminated at the E/A&H field trailer.

Investigation-Derived Wastes

Wastes derived from the field investigation included drill cuttings, well development and purge waters, decontamination water, used personal protective equipment (PPE), and well construction

material wrappings. Generated wastes were handled in a manner minimizing contact with the environment. Soil retrieved from hand-auger borings was contained in plastic sheeting. During rig drilling, plastic ground cover was laid down over the boring locations to contain drilling spoils. Waste water from activities at the decontamination area was contained within the plastic liner of the station and channelled into a plastic-lined sump that was pumped out regularly.

Wastes generated at each well site and at the decontamination Station were containerized in federal Department of Transportation *(DOT)* approved 55-gallon drums that are being maintained at their places of origin pending proper disposal by the U.S. Navy. All drums were marked with the sample location (well number, etc.), date, and type of investigationderived waste.

Drill cuttings from the shallow hand-auger borings were packed firmly back into the boreholes. PPE and well construction material wrapping were containerized in drums and appropriately labeled.

5.4 Hydrologic Investigation

The hydrologic investigations conducted during RI field work included measuring water levels in site monitoring wells and adjacent surface water bodies, piezometric surface mapping, and performing aquifer tests.

5.4.1 Water Level Measurements and Piezometric Mapping

Water level measurements were collected during consecutive low tide and high tide events on August 12 and 13, 1993. Measurements were taken at 42 site wells (15 existing and 27 newly installed wells), and 11 surface water staff gauges during *this* time period. Predicted tidal information for the Warrington area of Pensacola (near the main gate of NAS Pensacola) was obtained from tidal charts published by the U. S. Department of Agriculture, National Oceanic and Atmospheric Administration (NOM). Information concerning the areal distribution of tidal influence was generated by comparing the high and low tide water-level information described

below. Changes in water levels were plotted on site maps to analyze the distribution of tidal change. These maps and a discussion of tidal influenced groundwater level fluctuation are presented in Section 6.2.

Low tide measurements were recorded between 7 and 8 p.m. on August 12 and high tide measurements were recorded between 7 and 8 a.m. on August 13, 1993. Water levels were measured to the nearest 0.01 foot using electronic water-level measuring devices. Measurements were taken from a designated measuring point on the top of each well casing and directly from the scale printed on each staff gauge.

The top of each monitoring well casing and staff gauge was surveyed and referenced to National Geodetic Vertical Datum, 1929, by Northwest Florida Engineering and Surveying, Inc., to determine the elevations of these features above msl. Groundwater level elevations were calculated by subtracting each depth-to-water measurement from the top of the well casing elevation. Surface water level elevations were calculated by subtracting the length of the gauge above the water from the known top of gauge elevation. In this manner, the elevation of the piezometric surface for site groundwater and surf water was determined. Piezometric surface elevations were contoured to produce the piezometric maps presented and interpreted in Section 6.2.

5.4.2 Aquifer Tests

Specific capacity tests were conducted during the investigation to calculate first estimates of aquifer parameters for site characterization purposes. Aquifer parameters were calculated from specific data using a computer program developed by Bradbury and Rothschild (1985), based on equations presented in Lohman (1972). This program functions to correct specific capacity data for partial penetration and well loss, and through an iterative technique, estimates aquifer transmissivity and hydraulic conductivity.

Specific capacity tests were performed on 10 shallow and 15 intermediate depth site wells selected to provide beneficial areal coverage of the surficial aquifer across the site. Both existing and newly installed wells were tested by measuring the initial water level in the well and then withdrawing groundwater at a constant rate for a documented length of time. Water was withdrawn from each well using either a submersible battery-powered PVC pump or a centrifugal pump and suction line. Water level drawdown and discharge rate were recorded throughout the test. When the pumping water level stabilized, it was noted along with the elapsed time and confirmed discharge rate. Then pumping was ended and water level recovery was noted. Water levels were recorded with an electronic water-level indicator, and discharge rates were measured with a graduated bucket of known volume and a stopwatch.

For each well tested, a number of variables were input into the computer program that characterized the aquifer and the pumping system. For each well variables included initial water level, pumping (stabilized) water level, well construction information, the thickness of the aquifer, and the duration of pumping. Aquifer thickness was calculated as the approximate saturated thickness of the surficial aquifer above the confining clay at each well. The two assumed variables entered into the specific capacity program were the storage coefficient and well-loss coefficient. A storage coefficient of 0.25 was estimated for unconfined fine- to medium-grain sand aquifers from Todd (1980). A well-loss coefficient of 0.75 was selected from Todd (1980) to represent well screens and sand packs with mild deterioration and clogging (however, during sensitivity analysis the program was found to be relatively insensitive to these parameter). The program output includes estimates of specific capacity, transmissivity, and hydraulic conductivity. Copies of the input and output information for each tested well are presented in Appendix E.

Once hydraulic conductivity values were calculated, the geometric mean of the values for each zone (shallow vs. intermediate) were calculated using the following formula:

$$\text{Geometric Mean} = \text{nth } \sqrt{(X_1)(X_2)(X_3)\ldots(X_n)}$$

(the nth root of the product of n values)

Because hydrologic conductivity values frequently *can* vary by more than two orders of magnitude within the same hydrogeologic unit, and in that hydrologic data is typically log-normally distributed, the geometric mean offers a more representative value of the central tendency of these data (Fetter 1988).

Using the geometric mean for each depth zone, groundwater velocities were calculated using the following formula:

$$V = Ki/n_e$$

Where:

V	=	horizontal groundwater velocity
K	=	hydraulic conductivity
i	=	horizontal hydraulic gradient
n_e	=	effective porosity

An effective porosity of 0.25 was estimated for unconsolidated sand from Heath (1989).

A discussion of the hydrologic investigation results is contained in Section 6.2.

6.0 GEOLOGIC AND HYDROLOGIC RESULTS — 1993

6.1 Site Hydrogeological Setting

Findings from this investigation show a subsurface stratigraphy consistent with previous NAS Pensacola studies. All completed borings were limited to the Sand-and-Gravel Aquifer. Sixteen borings completed at Site 1 for intermediate depth wells penetrated the full thickness of the surficial zone and confirmed the depth to the top of the underlying low permeability zone. Results of split-barrel sampling allowed for the stratigraphic characterization of the surficial zone and the upper extent of the low permeability zone. Boring logs for all borings completed in this study are provided in Appendix B.

Figure 6-1 presents the map locations of two geologic cross-section *transects* across Site 1. Figures 6-2A and 6-2B present cross-sectional views of the subsurface along transects beneath the site. Geologic cross-sections were prepared using data from this investigation and available boring logs from previously installed wells. A-A′ extends roughly parallel to the landfill's north-south axis, and B-B′ extends west to east, roughly perpendicular to the landfill's long axis. As shown in the cross-section figures, the surficial zone is contiguous with land surface across the site, consisting of light tan to *dark* brown, fine-to medium-grain, poorly graded quartz sand. With the exception of color variations, this zone is relatively homogenous across the site. During this investigation, the observed thickness of the surficial zone ranged from approximately 27 feet along the site's northern and northeastern extent to approximately 57 feet along the southern and Southwestern extent. The apparent southward thickening of the surficial zone *can* be attributed to the general increase in land surface elevation to the south, and the slight southwestward dip of the underlying clay unit.

The low permeability zone was encountered beneath the surficial zone sands at all intermediate and deep borings for this and previous studies, indicating this zone is continuous beneath the site. Information collected while installing intermediate depth wells indicates the low

permeability zone is comprised of gray to blue gray, moderate to highly plastic clay, frequently containing shell fragments. A relatively thin transition zone was documented between the surficial zone sands and the top of the highly plastic clay. This transition zone varied from 1 to several feet in thickness and consisted of varying mixtures of gray to bluish gray, sandy clay and clayey sand. The cross-section shown on Figure 6-2A indicates the top elevation of the transition and low permeability zone is lowest at the site's southern end, and rises northward by as much as 15 feet beneath the central portion of the landfill at well location 01GI28. Figure 6-2B indicates the elevation of the upper portion of these units also increases from the site's western margin to its central portion. Based on lithologic information collected during the previous study deep well installation, the thickness of the low permeability zone decreases northward across the site, as shown on Figure 6-2A. However, because only three deep wells have been installed at Site 1, information on the total thickness and composition of the clay unit across the site is limited.

The low permeability zone was penetrated by three deep borings, GM-43, GM-44, and GM-45, completed during the 1986 Geraghty and Miller Characterization Study. Wells were installed through the confining clay into what is considered Site 1's deep zone. This interval has been interpreted as the uppermost portion of the main producing zone of the Sand-and-Gravel Aquifer. Lithologic information collected during the deep well installation shows the upper 10 to 20 feet of this zone contains medium- to fine-grain quartz sand, similar to the surficial zone.

6.2 Site Hydrologic Results

6.2.1 Water Level Elevations and Tidal Effects

Water level measurements were collected from all newly and previously installed site monitoring wells, and several surface water staff gauges during consecutive low and high tide events on August 12 and 13, 1993. The measurements and calculated water level elevations for these events are listed in Table 6-1.

Table 6-1
Site 1
Water Level Elevation Data

Well Number	Top of Casing Elevation[a]	Low Tide[b]		High Tide[c]		Low[d]-High Tide Water Level Elevation Variance (feet)
		Depth to Water (BTOC)	Water[a] Level Elevation	Depth to Water (BTOC)	Water[a] Level Elevation	
Shallow Wells						
01GS01	15.52	8.58	6.94	8.58	6.94	0.0
01GS37	17.18	5.17	12.01	5.18	12.00	-.01
01GS39	18.53	6.62	11.91	6.61	11.92	+.01
01GS40	20.91	9.92	10.99	9.93	10.98	-.01
01GS42	18.65	10.25	8.40	10.25	8.40	0.0
01GS53	31.53	15.79	15.74	15.81	15.72	-.02
01GS57	12.37	11.31	1.06	11.35	1.02	-.04
01GS58	25.71	11.79	13.92	11.80	13.91	-.01
01GS60	16.88	9.95	6.93	9.95	6.93	0.0
01GS62	20.51	9.25	11.26	9.25	11.26	0.0
01GS64	18.55	8.98	9.57	8.99	9.56	-.01
01GS67[e]	43.11	—	—	—	—	—
01GS69[e]	25.12	—	—	—	—	—
GM-03	19.78	18.26	1.52	18.27	1.51	-.01
GM-04	11.05	10.21	0.84	10.25	0.80	-.04
GM-05	8.03	6.91	1.12	6.88	1.15	+.03
GM-31	20.32	7.32	13.0	7.32	13.0	0.0
GM-32	19.20	6.71	12.49	6.71	12.49	0.0
GM-33	16.18	8.58	7.60	8.58	7.60	0.0
GM-34	16.14	8.66	7.48	8.67	7.47	-.01

Table 6-1
Site 1
Water Level Elevation Data

Well Number	Top of Casing Elevation[a]	Low Tide[b]		High Tide[c]		Low[d]-High Tide Water Level Elevation Variance (feet)
		Depth to Water (BTOC)	Water[a] Level Elevation	Depth to Water (BTOC)	Water[a] Level Elevation	
GM-35	16.14	8.85	7.29	8.85	7.29	0.0
GM-38	20.34	10.76	9.58	10.77	9.57	-.01
GM-39	7.66	4.83	2.83	4.76	2.90	+.07
GM-41	5.24	4.39	0.85	4.07	1.17	+.32
GM-42	14.83	11.95	2.88	11.95	2.88	0.0
Intermediate Depth Wells						
01GI28	16.96	9.78	7.18	9.79	7.17	-.01
01GI30	20.84	8.00	12.84	8.01	12.83	-.01
01GI32	20.49	18.99	1.50	19.00	1.49	-.01
01GI35	5.92	3.59	2.33	3.59	2.33	0.0
01GI36	17.83	8.51	9.32	8.52	9.31	-.01
01GI38	18.74	7.47	11.27	7.48	11.26	-.01
01GI41	18.42	10.04	8.38	10.05	8.37	-.01
01GI43	16.07	14.09	1.98	13.86	2.21	+.23
01GI44	**5.89**	***5.06***	0.83	4.69	**1.20**	+.37
01GI46	9.49	8.40	1.09	8.35	1.14	+.05
01GI48	11.50	10.65	0.85	10.70	0.80	-.05
01GI59	15.24	10.35	4.89	10.36	4.80	-.01
01GI61	17.04	10.15	6.89	10.15	6.89	0.0
01GI63	20.54	10.01	10.53	10.03	10.51	-.02
01GI65	18.50	10.48	8.02	10.51	7.99	-.03

Table 6-1
Site 1
Water Level Elevation Data

Well Number	Top of Casing Elevation[a]	Low Tide[b]		High Tide[c]		Low[d]-High Tide Water Level Elevation Variance (feet)
		Depth to Water (BTOC)	Water[a] Level Elevation	Depth to Water (BTOC)	Water[a] Level Elevation	
01GI66	31.79	18.03	13.76	18.02	13.77	+.01
01GI68[e]	42.74	—	—	—	—	—
01GI70[e]	25.06	—	—	—	—	—
Deep Wells						
GM-43	8.89	8.05	0.84	7.59	1.30	+.46
GM-44	20.56	19.53	1.03	19.47	1.09	+.06
GM-45	20.29	21.38	-1.09	21.38	-1.09	0.0
01GDWS50[f]	—	—	—	—	—	—
01GDSW51[f]	—	—	—	—	—	—
Staff Gauge	**Location**					
S.G.1-1	Creek flowing from beaver pond to golf course pond	NA	2.03	NA	2.05	+.02
S.G.1-2	Golf course pond	NA	0.74	NA	1.14	+.40
S.G.1-3	Bayou Grande north of golf course pond	NA	-0.06	NA	1.41	+1.47
S.G.1-4	Bayou Grande Pond	NA	0.68	NA	0.68	0.0
S.G.1-5	Bayou Grande east of picnic area	NA	-0.11	NA	1.42	+1.53
S.G.1-6	North Pond	NA	0.59	NA	1.47	+.88

Table 6-1
Site 1
Water Level Elevation Data

Well Number	Top of Casing Elevation[a]	Low Tide[b]		High Tide[c]		Low[d]-High Tide Water Level Elevation Variance (feet)
		Depth to Water (BTOC)	Water[a] Level Elevation	Depth to Water (BTOC)	Water[a] Level Elevation	
S.G.1-7	Bayou Grande north of north pond	NA	-.04	NA	1.48	+1.52
S.G.1-8	Needle-rush inlet west of site	NA	1.15	NA	1.45	+.30
S.G.1-9	Bayou Grande west of site	NA	*-0.08*	NA	1.45	1.53
S.G. 1-10	Intermittent creek south of beaver pond/marsh	NA	6.45	NA	6.46	+.01
S.G.1-11	Tidal Inlet at western extent of Powerline Road	NA	0.20	NA	1.49	+1.29

Key:

[a]	=	In feet above mean seal level (MSL).
[b]	=	Water level measured 8/12/93 at approximately 1750 hours.
[c]	=	Water level measured 8/13/93 at approximately 0720 hours.
[d]	=	Positive variance indicates water level increase from low to high tide.
[e]	=	Background well location, water level not measured.
[f]	=	NAS Pensacola deep supply well, water level not measured.
NA	=	Not applicable
BTOC	=	Below top of well casing

Generally, water level elevations in shallow and intermediate depth wells mimic local topography across the site, sloping north toward the bayou. Water level elevations varied across the site from approximately 16 feet above msl at the southernmost shallow well (01GS53) upgradient of the landfill, to less than 1 foot above msl at several shallow and intermediate wells (GM-04, GM-41, 01GI44, and 01GI48) near the Bayou Grande shoreline. Contrastingly, deep well water level elevations do not follow topography, but rather slope generally to the south across the site, toward the Gulf of Mexico. All deep water level elevations were significantly higher than the elevation of the top of the confining clay (see Section 6.1, Site Hydrogeological Setting), indicating the deep interval is confined across the site.

Notable variations in water levels (.03 foot or greater) from low to high tide were observed at wells located within approximately 300 feet of the shoreline or sizable surface water features (see Table 6-1). Water level variation observed in shallow and intermediate depth wells were similar in magnitude (-.01 to + .37 feet). The largest water level variation was measured in deep well GM-43 (+ .46 feet). Most water level variations were in phase with the changing tide, increasing during rising tide and decreasing during low tide. However, out-of-phase variations occurred in both shallow and intermediate depth wells. Specifically, out-of-phase water level variations occurred in shallow wells 01GS57 and GM-04, and intermediate well 01GI48, near the coastline. The reason for these out-of-phase water level variations is not known. During high tide, surface water levels in Bayou Grande (staff gauge locations 1-3, 1-5, 1-7, and 1-9) were greater than groundwater levels measured in wells closest to the coastline (01GS57, GM-04, GM-05, and GM-41), indicating there is potential for temporary surface water flow from the bayou inland into the nearshore portion of surficial zone during high tide. No significant tidal effects on groundwater were noted farther inland.

Surface water flow was observed between the golf course pond and the bayou, and between north pond and the bayou during the tidal cycle. Surface was observed flowing into theses ponds at high tide and from these ponds during low tide. However, flow was not observed

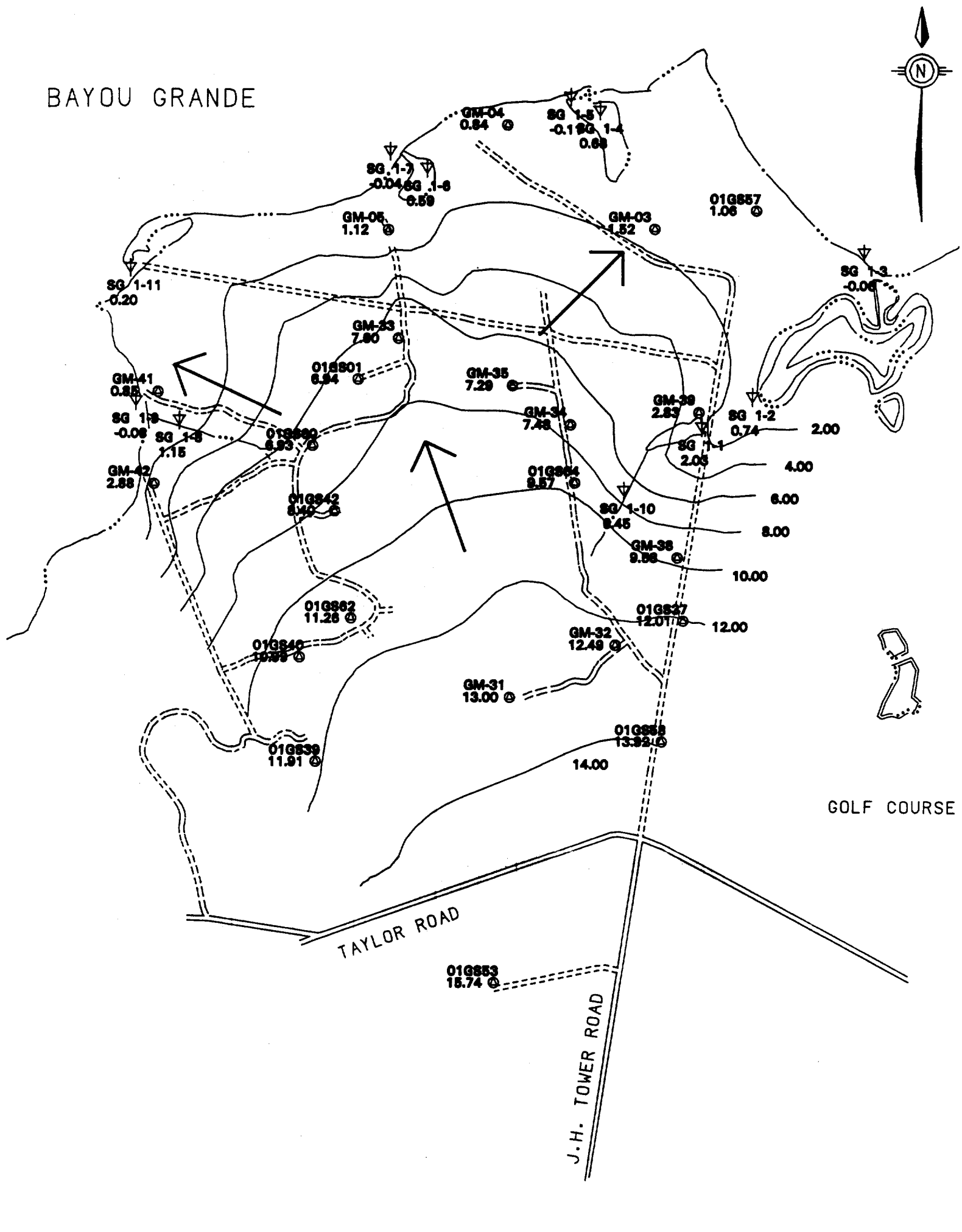
between Bayou Grande Pond and the bayou during the study because a berm comprised of sand and silty pond sediment effectively closed off the pond's inlet channel. Notable variations in water levels due to tidal effects were observed in all surface water features except Bayou Grande Pond and the inland intermittent creek staff gauge (S.G. 1-10) location. However, the magnitude of these variations was controlled by the degree of connection or height of the silty-sandy berm between the surface water body and the bayou (e.g. berms at the mouths of most tidal inlets maintained a minimum water level in them).

6.2.2 Groundwater Flow, Gradients, and Vertical Permeabilities

Groundwater Flow

Water level measurements collected during low and high tide events were used to construct piezometric surface diagrams across the site. Figures *6-3* through *6-8* illustrate the piezometric surface for shallow, intermediate, and deep well depths during each tidal event. Potential groundwater flow directions, perpendicular to equipotential water level contour lines, are shown on each figure.

The piezometric surface diagrams show groundwater in the shallow and intermediate well depths flowing in essentially the same pattern, indicating that these two depth intervals should be considered part of the same general flow system. As shown on Figures *6-3* through *6-6*, the potential for shallow and intermediate depth groundwater flow is in an overall northward direction during both low and high tide, with components of flow to the north-northwest, northwest, and northeast toward Bayou Grande and other surface water features. This flow pattern generally mimics site topography, which is characteristic of unconfined surficial aquifers with high transmissivities. Shallow and intermediate depth groundwater flow toward Bayou Grande and other site surface waters indicates groundwater is discharging to these water bodies. However, except for the previously discussed out-of-phase water level variations, rising groundwater levels within approximately *300* feet of the coastline during high tide indicate that



LEGEND

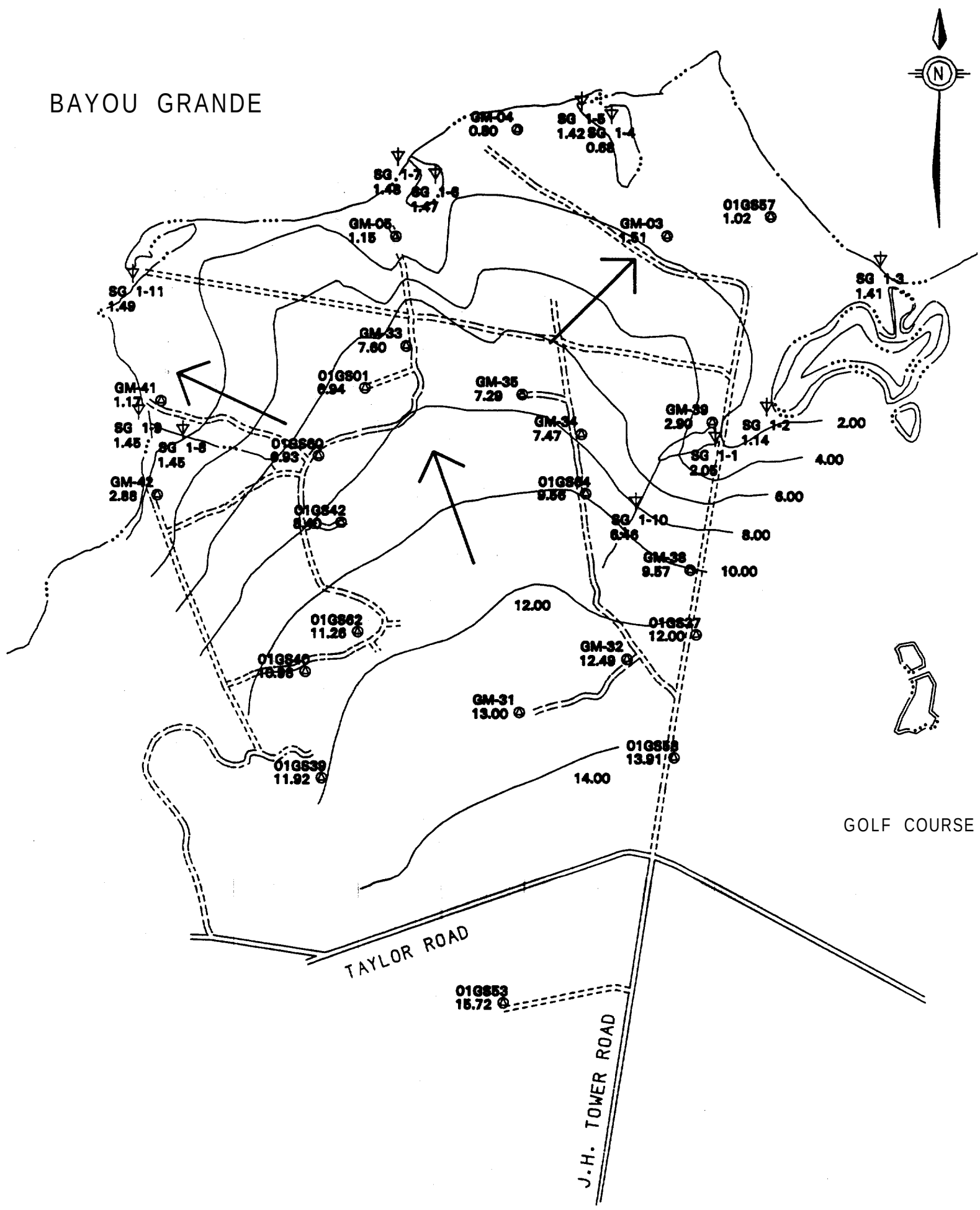
- COASTLINE / SURFACE WATER FEATURE
- UNPAVED ROAD
- SHALLOW MONITORING WELL
- STAFF GAUGE
- 2.88 — WATER LEVEL ELEVATION IN FEET ABOVE MSL
- POTENTIAL GROUNDWATER FLOW DIRECTION

600 0 600
SCALE FEET

REMEDIAL INVESTIGATION REPORT
SITE 1
NAS PENSACOLA

FIGURE 6-3
PIEZOMETRIC SURFACE 8/12/93
SHALLOW MONITORING WELLS
LOW TIDE

DATE: 11/18/93 DWG NAME: 59FIG6-3



LEGEND

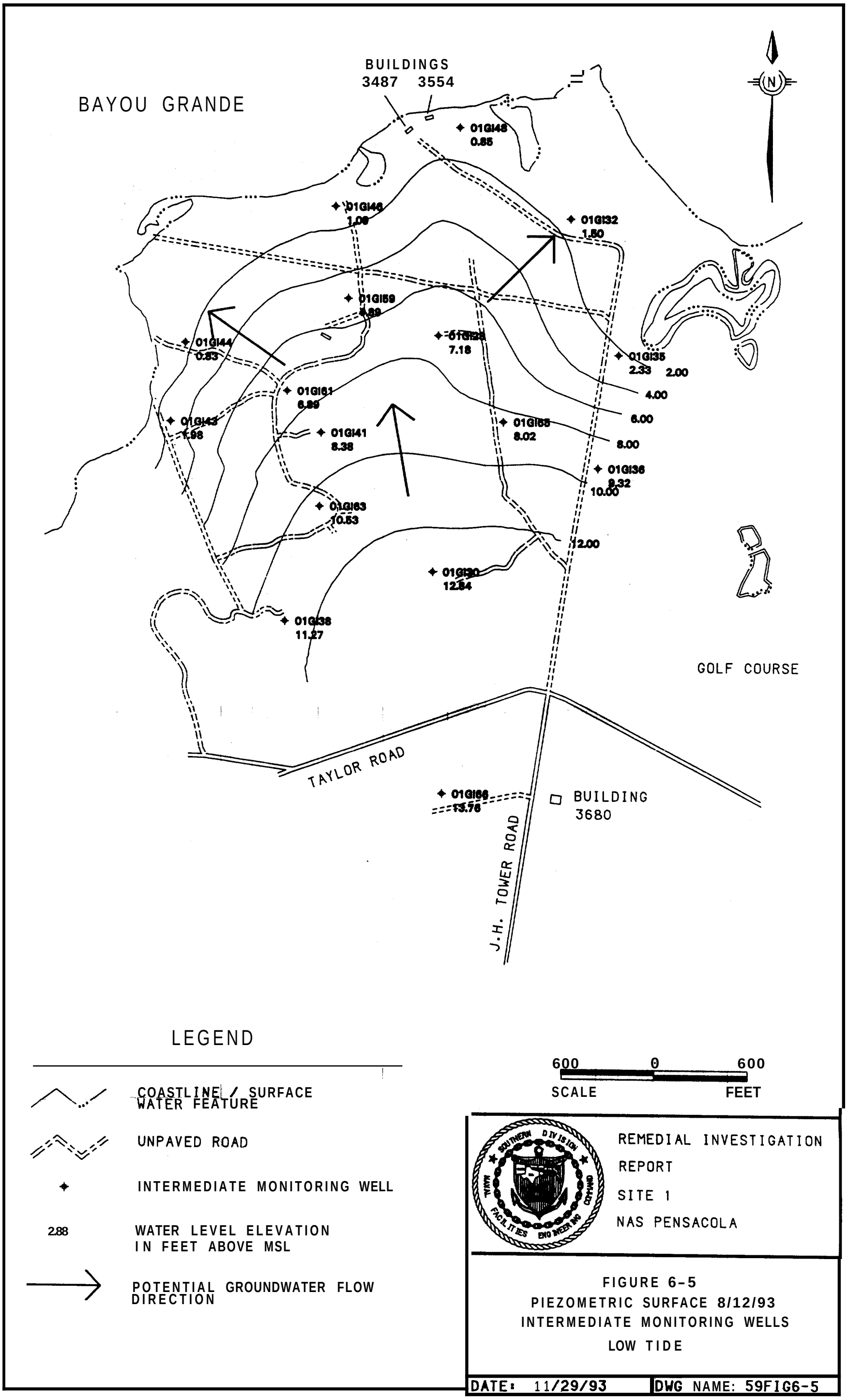
- COASTLINE / SURFACE WATER FEATURE
- UNPAVED ROAD
- SHALLOW MONITORING WELL
- STAFF GAUGE
- 2.88 — WATER LEVEL ELEVATION IN FEET ABOVE MSL
- POTENTIAL GROUNDWATER FLOW DIRECTION

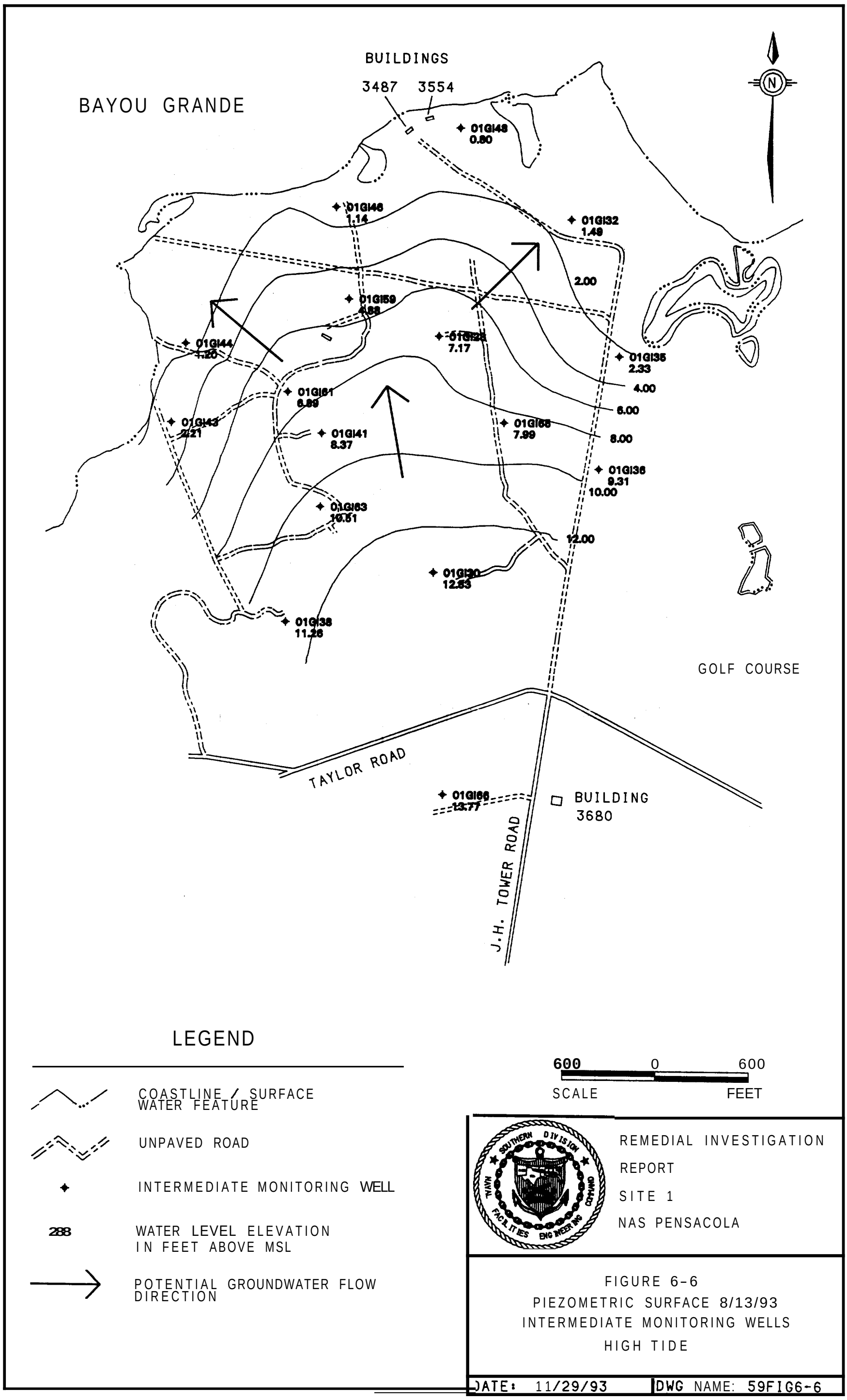
600 0 600
SCALE FEET

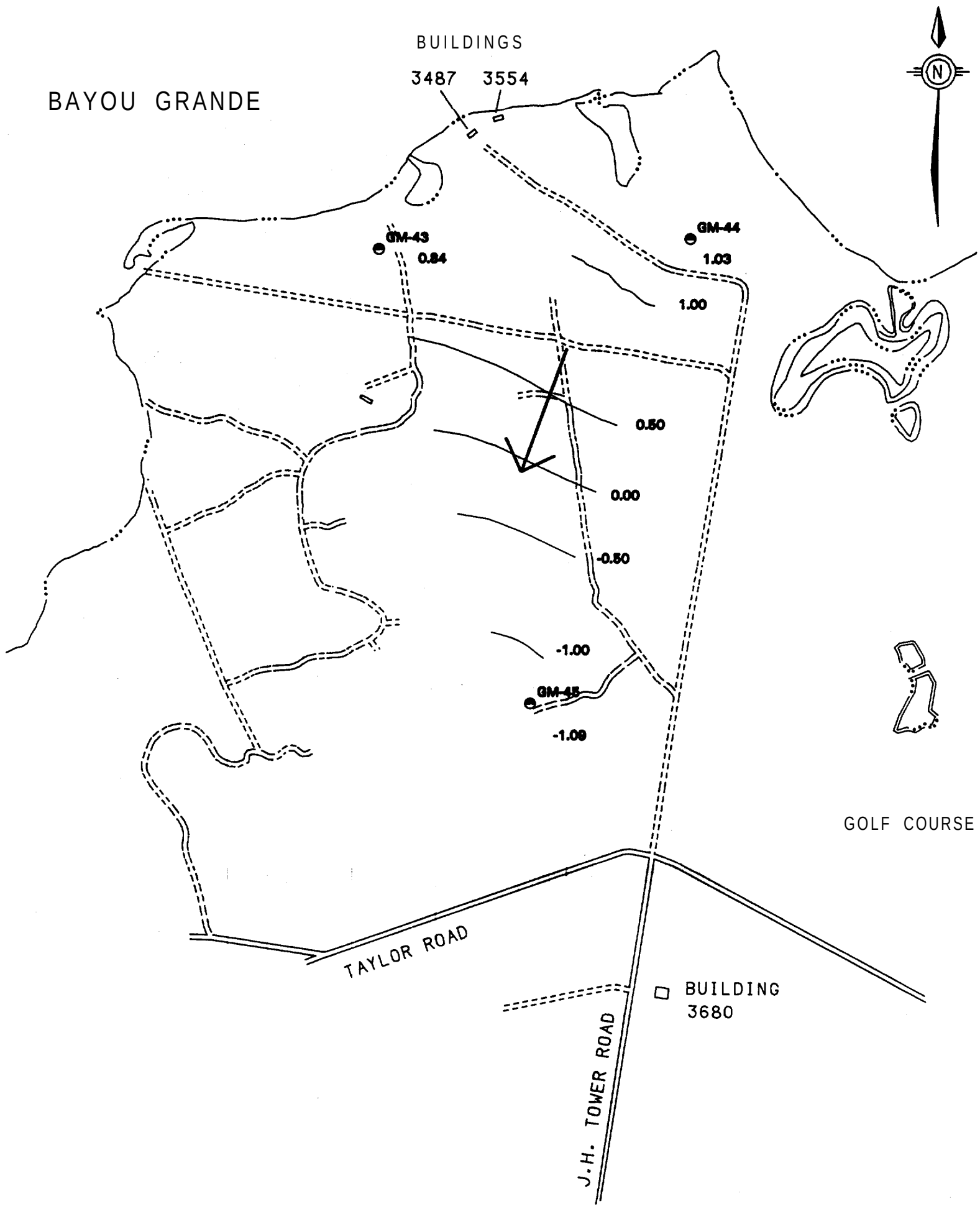
REMEDIAL INVESTIGATION
REPORT
SITE 1
NAS PENSACOLA

FIGURE 6-4
PIEZOMETRIC SURFACE 8/13/93
SHALLOW MONITORING WELLS
HIGH TIDE

DATE: 11/29/93 | DWG NAME: 59FIG6-4


BAYOU GRANDE
BUILDINGS
3487 3554
N
01GI48
0.85
01GI46
1.09
01GI32
1.50
01GI59
4.89
01GI44
0.83
01GI28
7.18
01GI35
2.33
2.00
4.00
6.00
8.00
10.00
12.00
01GI61
6.89
01GI43
1.98
01GI41
8.38
01GI55
8.02
01GI36
9.32
01GI63
10.53
01GI30
12.84
01GI38
11.27
GOLF COURSE
TAYLOR ROAD
01GI66
13.76
BUILDING
3680
J.H. TOWER ROAD
LEGEND
COASTLINE / SURFACE WATER FEATURE
UNPAVED ROAD
INTERMEDIATE MONITORING WELL
2.88
WATER LEVEL ELEVATION IN FEET ABOVE MSL
POTENTIAL GROUNDWATER FLOW DIRECTION
600 0 600
SCALE FEET
SOUTHERN DIVISION NAVAL FACILITIES ENGINEERING COMMAND
REMEDIAL INVESTIGATION
REPORT
SITE 1
NAS PENSACOLA
FIGURE 6-5
PIEZOMETRIC SURFACE 8/12/93
INTERMEDIATE MONITORING WELLS
LOW TIDE
DATE: 11/29/93
DWG NAME: 59FIG6-5


BUILDINGS
3487
3554
BAYOU GRANDE
N
01GI48
0.80
01GI46
1.14
01GI32
1.49
2.00
01GI59
4.88
01GI44
1.20
01GI25
7.17
01GI35
2.33
4.00
01GI61
6.89
6.00
01GI43
2.21
01GI41
8.37
01GI65
7.99
8.00
01GI36
9.31
10.00
01GI63
10.51
12.00
01GI30
12.53
01GI38
11.26
GOLF COURSE
TAYLOR ROAD
01GI66
13.77
BUILDING
3680
J.H. TOWER ROAD
LEGEND
COASTLINE / SURFACE WATER FEATURE
UNPAVED ROAD
INTERMEDIATE MONITORING WELL
288
WATER LEVEL ELEVATION IN FEET ABOVE MSL
POTENTIAL GROUNDWATER FLOW DIRECTION
600
0
600
SCALE
FEET
SOUTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
REMEDIAL INVESTIGATION
REPORT
SITE 1
NAS PENSACOLA
FIGURE 6-6
PIEZOMETRIC SURFACE 8/13/93
INTERMEDIATE MONITORING WELLS
HIGH TIDE
DATE: 11/29/93
DWG NAME: 59FIG6-6



LEGEND

COASTLINE / SURFACE WATER FEATURE

UNPAVED ROAD

DEEP MONITORING WELL

2.88 WATER LEVEL ELEVATION IN FEET ABOVE MSL

POTENTIAL GROUNDWATER FLOW DIRECTION

600 0 600

SCALE FEET

REMEDIAL INVESTIGATION REPORT

SITE 1

NAS PENSACOLA

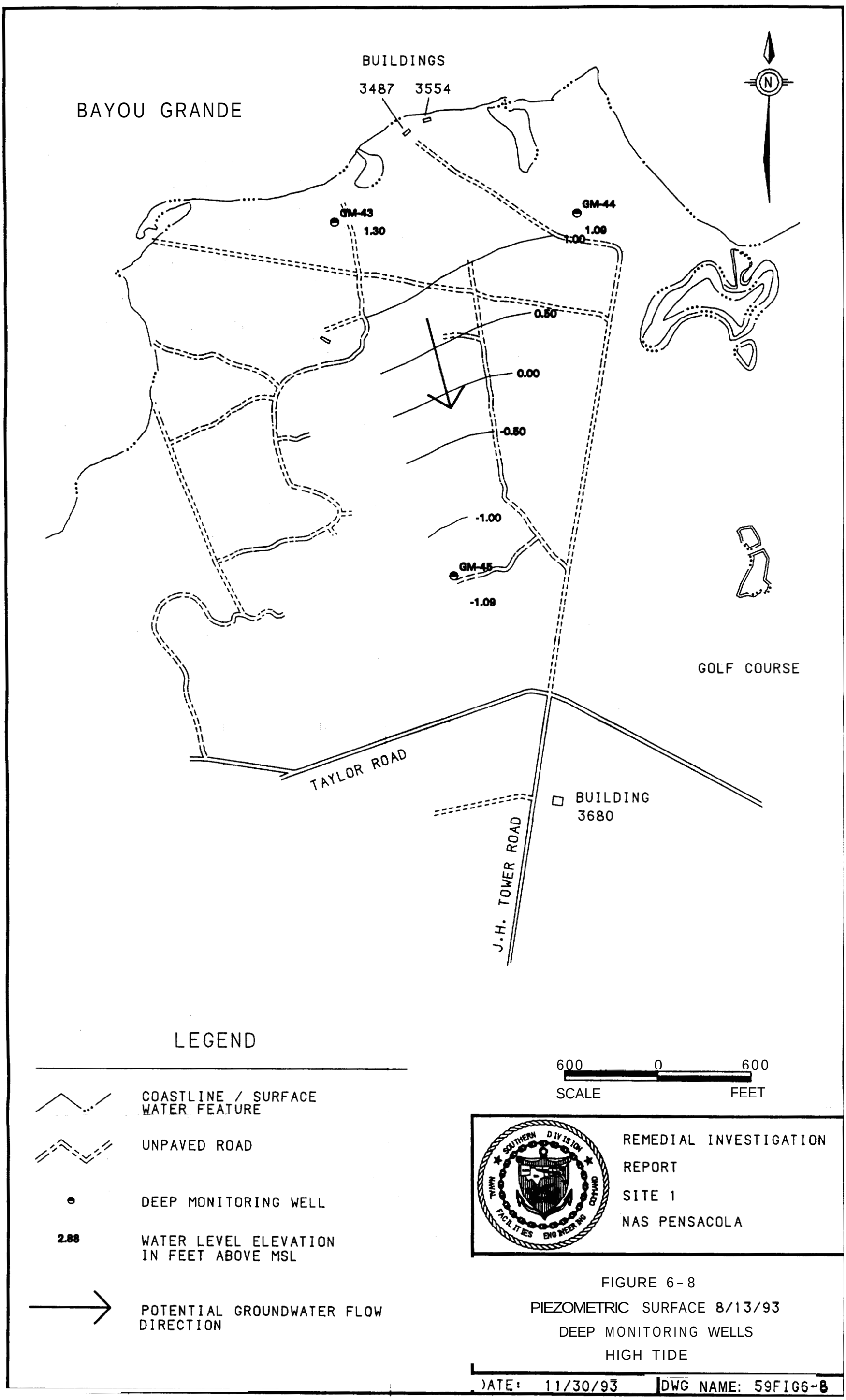
FIGURE 6-7

PIEZOMETRIC SURFACE 8/12/93

DEEP MONITORING WELLS

LOW TIDE

DATE: 11/30/93 DWG NAME: 59FIG6-7


BAYOU GRANDE
BUILDINGS
3487
3554
N
GM-43
1.30
GM-44
1.09
1.00
0.50
0.00
-0.50
-1.00
GM-45
-1.09
GOLF COURSE
TAYLOR ROAD
BUILDING
3680
J.H. TOWER ROAD
LEGEND
COASTLINE / SURFACE WATER FEATURE
UNPAVED ROAD
DEEP MONITORING WELL
2.88
WATER LEVEL ELEVATION IN FEET ABOVE MSL
POTENTIAL GROUNDWATER FLOW DIRECTION
600
0
600
SCALE
FEET
SOUTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
REMEDIAL INVESTIGATION
REPORT
SITE 1
NAS PENSACOLA
FIGURE 6-8
PIEZOMETRIC SURFACE 8/13/93
DEEP MONITORING WELLS
HIGH TIDE
DATE: 11/30/93
DWG NAME: 59FIG6-8

some degree of groundwater mounding or bank storage effect may be occurring near the coastline during high tide, as groundwater discharge to the bayou is slowed, impeded, or temporarily reversed by the rising surface water level.

Figures 6-7 and 6-8 illustrate the piezometric surface and potential groundwater flow direction for the deep well depths. Based on the limited water level data for this interval (e.g., only three deep wells exist at Site 1), the potential for groundwater flow in this depth interval is generally to the south toward Pensacola Bay and the Gulf of Mexico. As discussed in the water level elevation section, deep water level fluctuations were observed in the northernmost two deep wells during the tidal cycle. The greatest water level change was at well GM-43, in the site's northwestern portion. Due to these water level fluctuations, the potential groundwater flow direction shifts slightly from south-southwest during low tide to south-southeast during high tide. However, this flow apparent direction shift is likely exaggerated in these diagrams due to the Limited number of data points available.

Horizontal Hydraulic Gradients

Table 6-2 presents horizontal hydraulic gradients for selected well pairs at Site 1. Generally, these well pairs were selected to determine the horizontal hydraulic gradient along the predominant flow directions across the site. Horizontal gradient was calculated approximately perpendicular to isopleth (equipotential) lines by dividing the difference between selected well pair water levels (in feet) by the distance between the two wells (also in feet) to produce a unit-less gradient value.

The piezometric surface diagrams indicate overall shallow and intermediate depth well groundwater flow may be divided into three flow direction components: a central (to the site) north-northwest flow, a northwest flow, and a northeast flow. Shallow well pairs GM-31\ GM-33, 01GS60/GM-41, and GM-35/GM-03, and intermediate well pairs 01GI30/01GI59,

Table 6-2
Horizontal Hydraulic Gradient
Site 1

Well Pair	Distance Between Wells (feet)	Difference Between Water Levels (feet)		Horizontal Gradient	
		Low Tide	High Tide	Low Tide	High Tide
Shallow					
GM-31/GM-33	1,885	5.40	5.40	.0029	.0029
01GS60/GM-41	785	6.08	5.76	.0077	.0073
GM-35/GM-03	1,090	5.77	5.78	.0053	.0053
Intermediate					
01GI30/01GI59	1,885	7.95	7.95	.0042	.0042
01GI61/01GI44	790	6.06	5.69	.0077	.0072
01GI28/01GI32	1,100	5.68	5.68	.0052	.0052
Deep					
GM-45/GM-43	2,500	1.93	2.39	.0008	.0010
GM-45/GM-44	2,520	2.11	2.18	.0008	.0009

01GI61/01GI44, and 01GI28/01GI32 approximately coincide with these flow direction components, respectively. As shown on Table 6-2, the shallow and intermediate well depth flow gradients are relatively similar in magnitude ranging from .0027 to .0077, again indicating the two depth intervals are part of the same flow system. The central flow direction contains the lowest gradient of the three, at both depth intervals. Gradients along the two remaining flow directions are slightly steeper than the central flow direction, likely a result of steeper topographic gradients along the site's margin as the coastline is approached. The highest gradient of the three is the northwestern gradient in both depth intervals, again likely reflecting the relatively steeper topographic gradient along the western margin of the site.

Based on limited deep well water level data, hydraulic gradients calculated for this interval are significantly lower (approximately three to seven times) than those observed in the overlying shallow and intermediate depth intervals. As is indicated by the deep interval potentiometric surface diagrams, potential flow direction, and gradients, this well interval represents a distinct and separate flow system underlying the low permeability zone at the site.

Vertical Hydraulic Gradients

Table 6-3 presents the estimated vertical hydraulic gradients between each of the shallow intermediate, intermediate/deep, and shallow/deep well pairs. Vertical hydraulic gradients were calculated for each well cluster by dividing the difference between the groundwater level elevations by the difference of the well completion depths, for each tidal event. In this manner, the elevation difference (measured in feet) was divided by the well depth difference (measured in feet) to produce a unit-less gradient value. Positive gradients indicate a potential for downward vertical flow at the well location and negative gradients indicate a potential for upward vertical flow. Except for two well pairs, all of the shallow/intermediate pairs have a downward (positive) hydraulic gradient, indicating there is potential for groundwater to flow from shallow to intermediate depths. A downward gradient in a highly permeable surficial aquifer is indicative of a recharge area.

The gradients between the intermediate and deep well pairs, and the shallow and deep well pairs primarily are positive, indicating a general downward potential for groundwater flow between each of these zones, respectively. However, the positive vertical gradients at deep well location GM-43 reverses to negative during high ti& due to the relatively large increase (+.46 ft) in the deep well water level elevation. These negative gradients indicate potential for upward vertical flow between the top of the confined aquifer and the overlying unconfined aquifer during high tide. Although not large enough to reverse the vertical gradient direction, an increase in water level elevation also occurred during high tide at deep well GM-44. These fluctuations in deep

Table 6-3
Vertical Hydraulic Gradients
Site 1

Well Pair	Well Depths (Feet)	Difference Between Water Levels (Feet)		Vertical Hydraulic Gradients	
		Low Tide	High Tide	Low Tide	High Tide
Shallow/Intermediate					
01GS39/01GI38	12/57	.64	.66	.0142	.0147
01GS42/01GI41	14/40	.02	.03	.0008	.0012
01GS53/01GI66	18/65	1.98	1.95	.0421	.0415
01GS60/01GI61	14/38	.04	.04	.0017	.0017
01GS62/01GI63	14/46	.73	.75	.0228	.0234
01GS64/01GI65	14/38	1.55	1.57	.0646	.0654
GM-03/01GI32	18/36	.02	.02	.0011	.0011
GM-04/01GI48	17/28	-.01	.00	-.0009	**.0000**
GM-05/01GI46	12/30	.03	.01	.0017	.0006
GM-31/01GI30	11/54	.16	.17	.0037	.0039
GM-33/01GI59	12/29	2.71	2.72	.1594	.1600
GM-35/01GI28	11/30	.11	.12	.0058	.0063
GM-38/01GI36	16/36	.26	.26	.0130	.0130
GM-39/01GI35	16/27	.50	.57	.0455	.0518
GM-41/01GI44	16/29	**.02**	**-.03**	.0015	**-.0023**
GM-42/01GI43	**17/42**	**.90**	**.67**	**.0360**	**.0268**
Intermediate/Deep					
01GI46/GM-43	30/69	.25	-.16	.0064	-.0041
01GI32/GM-44	36/58	.47	.40	.0214	.0182
01GI30/GM-45	54/107	13.93	13.92	.2628	.2626
GM-05/GM-43	12/69	.28	-.15	.0049	-.0026

Table 6-3
Vertical Hydraulic Gradients
Site 1

Well Pair	Well Depths (Feet)	Difference Between Water Levels (Feet)		Vertical Hydraulic Gradients	
		Low Tide	High Tide	Low Tide	High Tide
GM-05/GM-44	18/58	.49	.42	.0123	.0105
GM-31/GM-45	11/107	14.09	14.09	.1468	.1468

Note: Positive vertical gradient indicates downward groundwater flow potential. Negative vertical gradient indicates upward groundwater flow potential.

zone water levels during the tidal cycle are likely indicative of hydrostatic pressure changes in the confined deep zone due to overlying bayou surface water volume increases and decreases during the tidal cycle. The relatively strong and consistent positive vertical gradient at deep well GM-45 indicates the potential for downward groundwater movement from the surficial zone to the main producing zone is greater in the southern portion of the site.

Vertical Permeabilities

While drilling wells 01GI28, 01GI35, and 01GI59, undisturbed subsurface samples of the unsaturated soils were collected. Based on visual inspection during collection, these samples consisted of fine- to medium-grain quartz sand. Additionally, while drilling wells 01GI30, 01GI48, and 01GI59, undisturbed samples of the clayey material from the upper extent of the low permeability zone were collected. All undisturbed samples were submitted for permeability analysis. Vertical permeabilities of the unsaturated soil samples from 2 to 5 feet bls ranged from 2.923×10^{-2} centimeters per second (cm/sec) to 9.793×10^{-2} cm/sec (or 82.87 feet per day [ft/day] to 277.63 ft/day). Vertical permeabilities of two low permeability zone clayey material samples from approximately 40 feet bls ranged from 6.524×10^{-7} cm/sec to 8.19×10^{-7} cm/sec

(or .0018 ft/day to .0023 ft/day). The third low permeability sample (01SI3068) proved to be too disturbed to perform the permeability analysis. However, based on the grain-size distribution for this sample, permeability was estimated to be 10^{-8} cm/sec or less (Doug Beach 1993, pers. comm.). The laboratory results for these samples are presented in Appendix C.

According to Fetter (1988), sediments with permeabilities of 10^{-5} cm/sec or less can be considered confining units. The extremely low permeabilities found in the clay material of the low permeability zone indicate the potential is extremely low for groundwater movement through the clay.

6.2.3 Aquifer Parameter Estimation

Specific Capacity Test Results

Specific capacity tests were performed at 25 Site 1 monitoring wells as described in Section 5.4.2. Five of these were newly installed shallow depth wells, five were existing shallow wells, and the remaining 15 were newly installed intermediate depth wells. Approximately half of the specific capacity tests were performed immediately after well development (or redevelopment in the case of existing wells), after pumping water levels had stabilized and fine sediments had been minimized. The remaining tests were performed following well development and groundwater sampling. Table 6-4 presents the results of the specific capacity tests performed at Site 1.

Using the data from Table 6-4, the geometric mean for hydraulic conductivity was calculated for shallow and intermediate well depth intervals. As discussed in Section 5.4.2, because hydrologic conductivity data are generally log-normally distributed, the geometric mean offers

the most representative value of the central tendency of these data. The range of hydraulic conductivity values and the geometric mean for each of these depth intervals is as follows:

Well Depth	Hydraulic Conductivity (Feet/Day)	
	Range of Values	Geometric Mean
shallow	14.57 - 162.73	47.93
Intermediate	4.77 - 109.83	24.19

Table 6-4
Specific Capacity Test Results
Site 1

Well Number	Well Depth (BLS)	Specific Capacity (GPM/Ft)	Transmissivity (Ft^2/Day)	Hydraulic Conductivity (Ft/Day)
Shallow				
01GS53	18.2	4.47	6323.78	(126.47)
01GS57	21.5	8.83	4068.20	(162.73)
01GS60	14.3	7.61	4741.33	(148.17)
01GS62	14.1	2.47	1758.07	(45.081
01GS64	13.9	5.86	3155.10	(101.781
GM-04	17.2	0.99	293.85	(14.69)
GM-05	11.7	0.66	364.21	(14.57)
GM-31	11.3	1.29	1357.26	(28.88)
GM-33	11.5	0.69	336.73	16.03
GM-38	15.6	2.52	1155.55	(46.22)
Intermediate				
01GI28	30.0	0.67	172.01	7.81
01GI30	53.6	0.68	450.77	9.39
01GI32	35.5	7.67	2196.57	(109.83)

Table 6-4
Specific Capacity Test Results
Site 1

Well Number	Well Depth (BLS)	Specific Capacity (GPM/Ft)	Transmissivity (Ft^2/Day)	Hydraulic Conductivity (Ft/Day)
01GI35	27.0	1.61	445.85	20.27
01GI36	35.5	2.09	673.03	26.92
01GI38	57.4	0.58	402.29	7.89
01GI41	40.0	3.66	1645.13	49.85
01GI44	29.4	2.10	682.28	27.29
01GI46	29.5	3.16	987.46	41.14
01GI48	27.8	3.74	972.79	48.64
01GI59	28.6	1.29	326.54	15.55
01GI61	38.2	4.17	1861.76	58.18
01GI63	46.1	2.31	1236.47	31.70
01GI65	37.7	.36	143.23	(4.77)
01GI66	65.2	3.14	2210.40	44.21

Note: Except where noted, specific capacity test performed during well development. Data in parenthesis are from tests performed after well development and sampling.

Key: BLS = Below land surface.
GPM = Gallons per minute.
Ft = Feet

This information indicates the lower extent (intermediate well depth) of the surficial zone of the Sand-and-Gravel Aquifer has lower hydraulic conductivity than its upper portion (shallow well depth). Because each intermediate depth well was installed at or near the top of the low permeability zone, the generally lower conductivities in intermediate well specific capacity data are most likely a result of the relatively more abundant finer-grain material (silty-clayey sand and/or sandy clay) present at or near the base of the surficial zone.

Overall, the specific capacity results indicate the following:

- The site hydraulic conductivity values are typical of those for aquifers comprised of fine-to medium-grain, unconsolidated sands. The range of observed values is relatively small given that hydraulic conductivity values for aquifers comprised of unconsolidated sandy sediments *can* be highly variable.

- As indicated by the individual well and geometric mean hydraulic conductivity values, the shallow interval of the surficial zone is characterized by higher hydraulic conductivities than the intermediate depth interval. This trend is likely the result of the finer-grain material comprising this depth interval.

- Few distinct areal trends are apparent in the hydraulic conductivity data. However, the shallow depth interval along the site's north-northwestern portion exhibits relatively lower conductivities, compared to the remainder of the site's shallow interval. Additionally, the intermediate depth interval along the eastern and southern portion of the site exhibits relatively lower conductivities, compared to the remainder of the site's intermediate interval. The highest conductivity values were in the northeastern and central portions of the site for shallow depth wells, and in the northeastern and western portions for intermediate depth wells.

Groundwater Velocity Estimates

Groundwater velocity estimates were calculated for the three component flow directions observed in the shallow and intermediate well intervals at Site 1 (see Section 6.2.1 for discussion of flow direction and horizontal hydraulic gradients). Groundwater velocity estimates were calculated for each flow direction and well depth interval using the lowest and highest hydraulic conductivity values (obtained from specific capacity data), and the horizontal gradient values calculated for low and high tide. Consequently, a low and high groundwater velocity value was

calculated for each tide event (low tide and high tide), and each depth interval. However, due to the limited data available, velocity values were not calculated for deep wells. Groundwater velocity values, as well as hydraulic conductivities and horizontal gradients used in the calculations, are presented in Table 6-5.

Based on the given range of hydraulic conductivity values, groundwater velocity estimates range from 0.17 feet per day (ft/day) to 5.01 ft/per day in the shallow well depth interval, and 0.08 Wday to 3.38 Wday in the intermediate well depth interval. Overall, the northwestern flow direction along the site's western portion had the highest velocity estimates due to the relatively steeper horizontal gradients for this direction. Additionally, the north-northwestern flow direction calculated for the central portion had the lowest velocity estimates due to the relatively lower horizontal gradient.

6.3 Conclusions

1. Boring logs indicate the low permeability clay unit Separating the deep well interval and shallow/intermediate well interval is laterally persistent across the site. The depth of occurrence for this unit increases to the west and south.

2. Water levels in all monitored groundwater depths are affected by tidal fluctuations. However, significant tidal effect is observed only within approximately 300 feet of the coastline along the northeastern, northern, and northwestern perimeters of the site. All deep water level elevations were significantly higher than the top of the confining clay, indicating the deep interval is confined across the site.

Table 6-5
Groundwater Velocity Results

Flow Direction	Hydraulic[a] Conductivity (feet/day)			Horizontal Hydraulic Gradient		Groundwater Velocity[b] (feet/day)					
						Low Tide			High Tide		
	Low Value	High Value	Average Value	Low Tide	High Tide	Low Value	High Value	Average Value	Low Value	High Value	Average Value
Shallow Wells											
North-Northwestern Flow	14.57	162.73	47.93	.0029	.0029	0.17	1.89	0.55	0.17	1.89	0.55
Northwestern Flow	14.57	162.73	47.93	.0077	.0073	0.45	5.01	1.48	0.43	4.75	1.40
Northeastern Flow	14.57	162.73	47.93	.0053	.0053	0.31	3.45	1.02	0.31	3.45	1.02
Intermediate Wells											
North-Northwestern Flow	4.77	109.83	24.19	.0042	.0042	0.08	1.86	0.41	0.08	1.85	0.41
Northwestern flow	4.77	109.83	24.19	.0077	.0072	0.15	3.38	0.75	0.14	3.18	0.70
Northeaetern Flow	4.77	109.83	24.19	.0052	.0052	0.10	2.28	0.60	0.10	2.28	0.50

Key:

= Low and high hydraulic conductivity values represent the lowest and higheet values calculated besed on specific capacity test data for each well interval; averags conductivity values are the geometric mean values calculated for each well depth.

b = Groundwater velocities calculated using respective hydraulic conductivities, horizontal gradiente, and an effective porosity estimate of .25.

3. Groundwater flow directions in the shallow and intermediate well depth intervals are essentially the same; consequently groundwaters at these two depths should be considered part of the same flow system. Additionally, except for water level variations near the coastline during high tide, flow and horizontal hydraulic gradients at these depths does not appear to be significantly impacted by tidal fluctuations.

4. Groundwater flow in the surficial zone (shallow and intermediate monitored depths) is influenced by an area of high water level and topography in the site's south central portion. How components off this high mimic local topography, with flow to the northwest, north-northeast, and northeast, discharging to Bayou Grande and site surface water features. Elevated water levels in Bayou Grande relative to groundwater levels at wells closest to the coastline indicate the potential for temporary surface water recharge to the surficial zone during high tide.

5. The vertical gradients between shallow and intermediate well pairs, intermediate and deep well pairs, and shallow and deep well pairs are consistently positive, indicating the potential for downward groundwater movement at Site 1. However, during high tide the water level in deep well GM-43 rose significantly. This deep well water level variation was sufficient to create a negative vertical gradient between the deep and shallow well pair and the deep and intermediate well pair at this location during high tide.

6. The steepest measured horizonal hydraulic gradients in the surficial zone (shallow and intermediate well depths) are to the northwest and northeast, and the shallowest is to the north-northeast across the site's central portion. Values were in agreement for both the shallow and intermediate well intervals, ranging from 0.0029 to 0.0077.

7. Hydraulic conductivities (K) derived from specific capacity tests are typical of values observed for aquifers comprised of fine- to medium-grain, unconsolidated sands. The

variation in the range of observed values is relative small given that hydrologic conductivity values *can* be highly variable in this type of aquifer. The average K (geometric mean) for the shallow well interval of the surficial aquifer was 47.93 ft/day, indicating fairly high permeabilities. Average K in the intermediate well interval was 24.19 Wday, indicating relatively lower permeabilities. This trend is likely the result of the finer-grain material present at or near the bottom of this aquifer zone.

8. Using the specific capacity test data and the horizontal gradients for the three observed site flow directions at low and high tide, groundwater flow velocities calculated for the shallow and intermediate depth well intervals indicate fairly high velocity regimes in the northwestern and northeastern directions, ranging from 0.10 Wday (37 ft/yr) to 5.01 Wday (1,800 ft/yr). The estimated groundwater flow velocity for the central north-northwestern flow direction was relatively lower, ranging from 0.08 ft/day (30 ft/yr) to 1.89 Wday (690 ft/year).

7.0 NATURE AND EXTENT OF CONTAMINATION — 1993

The nature and extent discussion will be organized by media. The sampling approach, methodology, and sample locations for this investigation were discussed in Sections 5.1 through 5.3 of this report.

Establishment of Reference Concentrations

Before beginning this investigation, locations were selected to collect data on soil and groundwater quality that are representative of reference or ambient conditions at NAS Pensacola (referred to in Section 5 as background sample locations). For comparison, reference sample results have been used in the following discussion to define a range of concentrations for each detected inorganic parameter considered representative of ambient conditions. Further, a "reference concentration" (RC) has been calculated for each inorganic parameter, equal to two times it's mean concentration, to approximate the upper extent of the ambient concentration range. In instances where an analyzed parameter was not detected above the quantitation limit, a value of one-half the reported detection limit was used to calculate the mean concentration for the RC. Parameters detected in site groundwater and soil samples are discussed in the following sections relative to RCs. Detected concentrations exceeding RCs are generally referred to as "elevated" in these discussions. Analytical results for soil and groundwater reference samples are also summarized in the following respective discussions. The complete analytical results for reference samples are contained in Appendices F and G.

7.1 Soil

Twenty-seven samples were collected from across the site during 1993 field work activities to assess the impact of landfii activities on surface and near-surface soil. Sixteen surface (0 to 1 foot bls) soil samples were collected from undisturbed areas around the landfii's perimeter, near the monitoring well clusters. Another 11 surface soil samples were collected from selected locations within the landfill boundary, where test trenching occurred. Full TAL/TCL analyses were performed on all surface soil samples. TCLP, radiation, and hexavalent chromium

analyses were performed on selected surface soil samples as listed on Table 5-3. Subsurface soil samples were collected within the landfill during test trenching. The results of these samples are presented in Section 7.2.

Two near-surface samples, 01S5602 and 01S0201, collected during the investigation were analyzed for TCLP. Sample 0185602 was collected from the native soil of a nearby streambed that intermittently drains surface water runoff from the site's northeastern portion. Sample 01S0201 was collected from the tar pit. No leachable analytical parameters were detected in those samples. Because a solvent-like odor was detected at depth while installing well 01GI59, soil sample 01SI5933 was collected from below the water table to determine if contamination was associated with aquifer media. The sample of groundwater-saturated clayey-sand material was retrieved from approximately 33 feet bls from the side of the lead auger after its removal from the borehole. No significant concentrations of organic compounds were detected in the sample, indicating the odor was associated with local groundwater (see Section 7.3, Groundwater). The complete results for these soil samples are in Appendix F.

The study area's surface soil generally comprised silty, sandy soil with varying amounts of decaying plant matter (leaves, straw, and twigs) at the surface. Lithologic descriptions for soil borings, nearby well borings, and test trench excavations are presented in Appendix B.

7.1.1 Analytical Results

Summary analytical results for reference soil samples used to determine ambient parameter concentrations at NAS Pensacola are presented in Table 7-1. As discussed in Section 5.1, the soil reference data consist of 18 samples from soil borings 01S67 and 01S69 collected while installing shallow monitoring wells at the two NAS Pensacola deep supply well locations (Buildings 696 and 706; Figure 5-3). Concentrations of several inorganic constituents and pesticides were detected in reference samples. While many inorganics naturally occur in area soil, the low concentrations of pesticides detected in reference samples are likely associated with historical facility-wide pesticide and herbicide application.

Table 7-1
Summary Analytical Results for Reference Soil Samples
Site 1

Parameter	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration (MC)	Reference Concentration (2 X MC)
Metals (mg/kg)				
Aluminum	95.20	12,400.00	1,916.68	3,833.36
Arsenic	1.70	2.40	0.78	1.56
Barium	1.20	10.10	2.32	4.63
Beryllium	0.20U	0.21U	0.21	0.41
Cadmium	0.50U	0.50U	0.50	1.00
Calcium	35.70	6,740.00	456.18	912.37
Chromium (total)	2.40	11.80	3.07	6.13
Cobalt	0.90U	0.95U	0.93	1.87
Copper	5.10	5.10	2.87	5.74
Cyanide	0.25U	0.26U	0.26	0.52
iron	205.00	9.180.00	1,372.5	2,745.00
Lead	0.44	28.00	3.66	7.32
Magnesium	365.00	365.00	66.67	133.33
Manganese	1.70	63.70	10.68	21.36
Mercury	0.05U	0.05U	0.05	0.10
Nickel	3.10U	3.25U	3.19	6.38
Potassium	225	233	230.34	460.67
Selenium	0.30	0.31	0.31	0.62
Silver	1.00	1.05	1.04	2.07
Sodium	97.20	108.00	53.93	107.85
Vanadium	1.60	20.60	2.91	5.83
Zinc	3.30	29.00	8.43	16.87

Key:
mg/kg = Milligram per kilogram
U = Parameter not detected, vdue reported equals onahdf the detection limit.
RC = Reference concentration, calculated as two times the mean concentration (MC).

Tables 7-2 and 7-3 summarize analytical results for parameters detected in soil samples collected generally around the landfill's perimeter and from test trench locations within the landfill boundary, respectively. Radiation and PPS analyses results are presented in Section 7.4. Appendix F contains the complete analytical results for soil samples. For inorganic results, bold type indicates the reported value exceeded the RC calculated from reference data for the parameter. Concentrations of several inorganic constituents, volatiles, semivolatiles, pesticides, and PCBs were detected in Site 1 soil. The following results discussion is presented by parameter group.

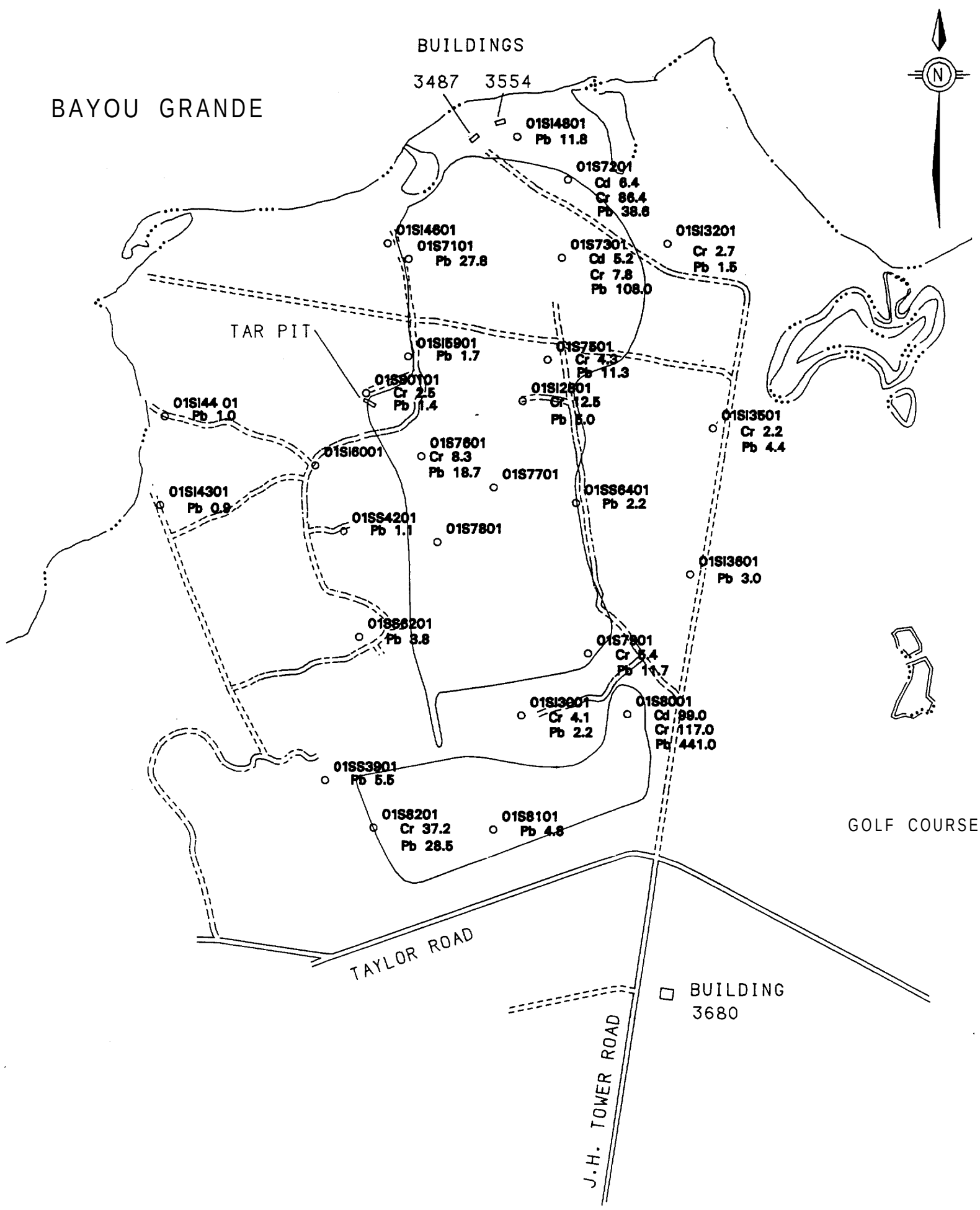
Inorganics

Concentrations of aluminum, barium, calcium, chromium, iron, lead, manganese, vanadium, and zinc were frequently detected in both reference and site surface soil samples. Arsenic, copper, magnesium, and sodium also were detected in both sample groups, but much less frequently. Detectable concentrations of beryllium, cadmium, cobalt, cyanide, mercury, nickel, selenium, and silver were present in site soil, but not in reference samples.

With only few exceptions, metals concentrations reported for surface soil samples collected around the perimeter of the landfill were consistent with those in reference soil. Perimeter samples exceeding RCs were as follows (Figures 7-1 and 7-2 illustrate selected metals concentrations detected in surface samples):

- 01SS0101 collected just northeast of the tar pit contained lead (5.0 mg/kg) and zinc (34.0 mg/kg) slightly exceeding the RC.

- 01SI2801 from the site's central portion contained aluminum (13,600 mg/kg), chromium (12.5 mg/kg), iron (9760 mg/kg), and vanadium (23.0 mg/kg) exceeding their respective RCs.



LEGEND

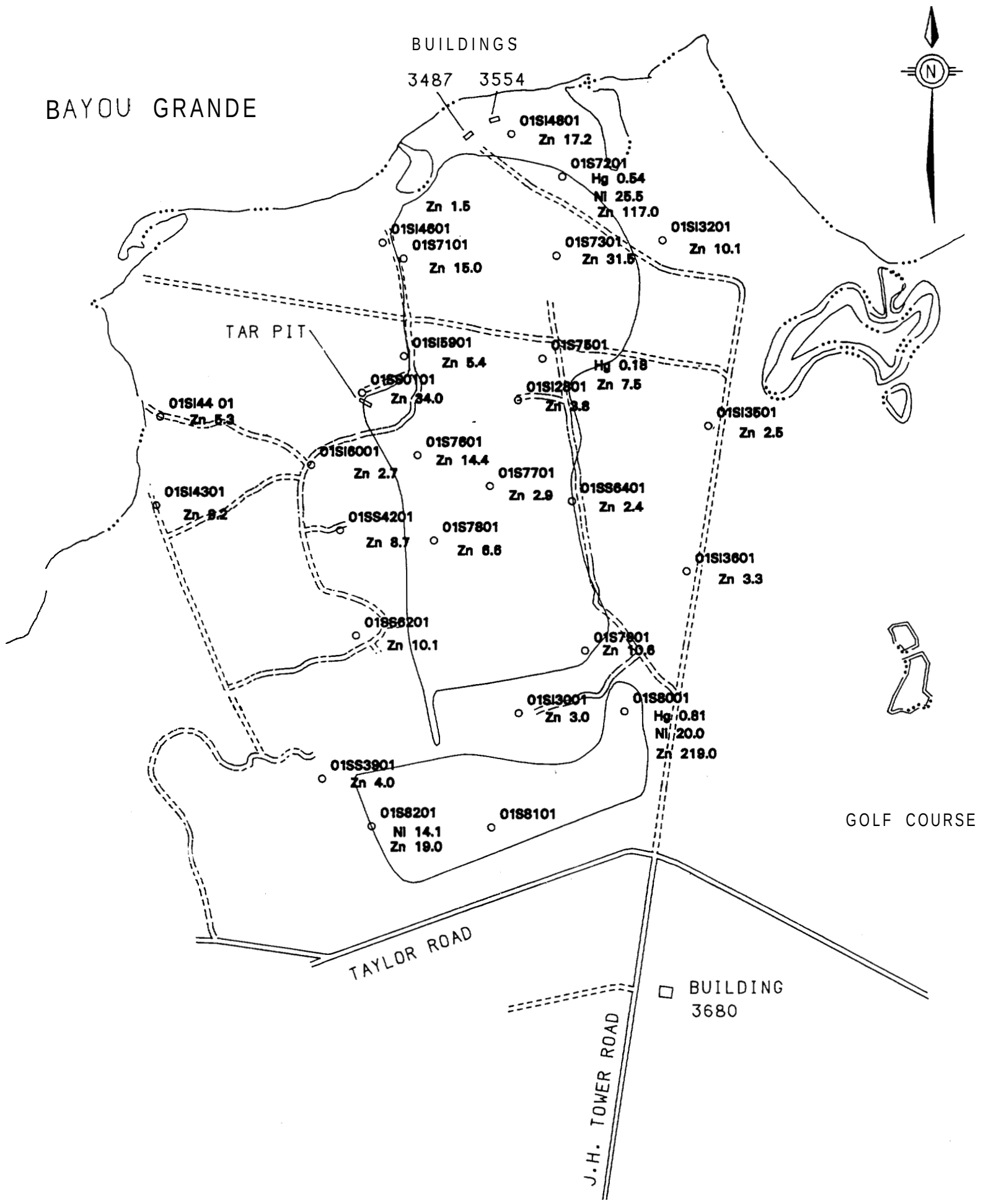
	COASTLINE / SURFACE WATER FEATURE
	UNPAVED ROAD
o	SURFACE SOIL SAMPLE
Cd 0.4	CADMIUM CONCENTRATION IN MG/KG
Cr 86.4	CHROMIMUM CONCENTRATION IN MG/KG
Pb 38.6	LEAD CONCENTRATION IN MG/KG

600 0 600
SCALE FEET

REMEDIAL INVESTIGATION
REPORT
SITE 1
NAS PENSACOLA

FIGURE 7-1
CADMIUM. CHROMIUM, AND LEAD
DETECTED IN SURFACE SOIL SAMPLES

DATE: 11/16/93 | DWG NAME: 59FIG7-1



LEGEND

	COASTLINE / SURFACE WATER FEATURE
	UNPAVED ROAD
o	SURFACE SOIL SAMPLE
Hg 16.0	MERCURY CONCENTRATION IN MG/KG
Ni 6.8	NICKEL CONCENTRATION IN MG/KG
Zn 7.2	ZINC CONCENTRATION IN MG/KG

600 0 600
SCALE FEET

REMEDIAL INVESTIGATION
REPORT
SITE 1
NAS PENSACOLA

FIGURE 7-2
MERCURY, NICKEL, AND ZINC
DETECTED IN SURFACE SOIL SAMPLES

DATE: 11/16/93 DWG NAME: 59FIG7-2

Table 7-2
Summary Analytical Results for Surface Soil Samples Collected Around the Perimeter of the Landfill Site 1

		Sample Identification Number			
Parameter	**RC**	**01SS0101**	**01SI2801**	**01SI3001**	**01SI3201**
Inorganics (mg/kg)					
Aluminum	3,833	2,810.000	**13,600.000**	2,640.000	2,450.000
Arsenic	1.56	—	—	—	—
Barium	4.63	**5.000**	—	—	2.600
Beryllium	0.41	—	—	**0.610**	—
Calcium	912.37	51.200	56.700	90.000	105.000
Chromium (total)	6.13	2.500	**12.500**	4.100	2.700
Cobalt	1.87	—	—	—	—
Copper	5.74	3.100	—	—	3.100
Iron	2,745	1,820.000	**9,760.000**	333.000	1,670.000
Lead	7.32	1.400	5.000	2.200	1.500
Magnesium	133.33	92.700	—	108.000	97.800
Manganese	21.36	—	10.200	2.900	7.100
Nickel	6.38	—	—	—	—
Potassium	460.67	—	—	—	—
Selenium	0.62	—	—	—	—
Sodium	107.85	—	38.800	42.000	—
Vanadium	5.83	3.800	**23.000**	2.200	3.800
Zinc	16.87	**34.000**	3.800	3.000	10.100

Table 7-2
Summary Analytical Results for Surface Soil Samples Collected Around the Perimeter of the Landfill Site 1

		Sample Identification Number			
Parameter	**RC**	**01SI3501**	**01SI3601**	**01SS3901**	**01SS4201**
Inorganics (mg/kg)					
Aluminum	3,833	1,430.00	2,100.000	1,760.00	1,810.00
Arsenic	1.56	—	—	—	—
Barium	4.63	—	—	1.900	1.800
Beryllium	0.41	—	—	—	—
Calcium	912.37	**1,720.000**	536.000	43.500	85.900
Chromium (total)	6.13	2.200	—	—	—
Cobalt	1.87	—	—	—	—
Copper	5.74	—	—	3.200	3.600
Iron	2,745	1,260.000	1,380.000	365.000	958.000
Lead	7.32	4.400	3.000	5.500	1.100
Magnesium	133.33	—	—	—	—
Manganese	21.36	12.000	6.000	—	—
Nickel	6.38	—	—	—	—
Potassium	460.67	—	—	—	—
Selenium	0.62	—	—	**0.730**	—
Sodium	107.85	77.900	51.600	—	—
Vanadium	5.83	2.800	2.800	—	—
Zinc	16.87	2.500	3.300	4.000	8.700

Table 7-2
Summary Analytical Results for Surface Soil Samples Collected Around the Perimeter of the Landfill Site 1

		Sample Identification Number			
Parameter	**RC**	**01SI4301**	**01SI4401**	**01SS4601**	**01SI4801**
Inorganics (mg/kg)					
Aluminum	3,833	2,050.000	—	1,860.000	1,290.000
Arsenic	1.56	—	—	—	—
Barium	4.63	2.200	—	—	3.400
Beryllium	0.41	—	—	—	—
Calcium	912.37	33.100	60.200	—	**1,050.000**
Chromium (total)	6.13	—	—	—	—
Cobalt	1.87	—	—	—	—
Copper	5.74	—	—	—	3.100
Iron	2,745	1,200.000	46.400	1,320.000	1,230.000
Lead	7.32	0.900	1.000	—	**11.800**
Magnesium	133.33	—	—	—	—
Manganese	21.36	—	—	8.800	—
Nickel	6.38	—	—	—	—
Potassium	460.67	—	—	—	—
Selenium	0.62	—	—	—	—
Sodium	107.85	—	—	29.000	—
Vanadium	5.83	2.100	—	2.400	2.700
Zinc	16.87	9.200	5.300	1.500	**17.200**

Table 7-2
Summary Analytical Results for Surface Soil Samples Collected Around the Perimeter of the Landfill Site 1

		Sample Identification Number			
Parameter	**RC**	**01SI5901**	**01SI6001**	**01SS6201**	**01SS6401**
Inorganics (mg/kg)					
Aluminum	3,833	1,760.W	1,920.000	1,770.000	733.000
Arsenic	1.56	—	—	—	—
Barium	4.63	2.300	—	2.900	—
Beryllium	0.41	—	—	—	—
Calcium	912.37	72.900	—	35.600	80.500
Chromium (total)	6.13	—	—	—	—
Cobalt	1.87	—	—	—	—
Copper	5.74	—	—	3.200	—
Iron	2,745	1,010.000	944.000	856.000	556.000
Lead	7.32	1.700	—	3.800	2.200
Magnesium	133.33	—	—	—	—
Manganese	21.36	—	12.200	—	6.000
Nickel	6.38	—	—	—	—
Potassium	460.67	—	—	—	—
Selenium	0.62	—	—	—	—
Sodium	107.85	—	30.700	—	47.600
Vanadium	5.83	3.000	2.500	2.400	—
Zinc	16.87	5.400	2.700	10.100	2.400

Table 7-2
Summary Analytical Results for Surface Soil Samples
Collected Around the Perimeter of the Landfill
Site 1

		Sample Identification Number			
Parameter	**RC**	**01SS0101**	**01SI2801**	**01SI3001**	**01SI3201**
Volatiles (µg/kg)					
Acetone	NA	—	—	—	—
Toluene	NA	—	—	—	—
Pesticides (µg/kg)					
4,4'-DDD	NA	—	0.078 J	—	—
4,4'-DDE	NA	—	—	—	—
4.4'-DDT	NA	—	0.480 J	0.570 J	—
Aldrin	NA	—	—	—	—
Endosulfan sulfate	NA	—	0.540 J	0.120 J	—
Endrin	NA	—	0.100 J	—	—
Endrin aldehyde	NA	—	—	—	—
Endrin ketone	NA	—	—	—	—
Heptachlor epoxide	NA	—	—	—	—
alpha-Chlordane	NA	—	0.120 J	—	—
beta-BHC	NA	—	—	—	—
delta-BHC	NA	—	—	—	—

Table 7-2
Summary Analytical Results for Surface Soil Samples Collected Around the Perimeter of the Landfill Site 1

		Sample Identification Number			
Parameter	**RC**	**01SI3501**	**01SI3601**	**01SS3901**	**01SS4201**
Volatiles (µg/kg)					
Acetone	NA	—	—	—	—
Toluene	NA	—	—	—	—
Pesticides (µg/kg)					
4,4'-DDD	NA	4.300	0.270 J	—	—
4,4'-DDE	NA	40.000	2.700 J	—	—
4,4'-DDT	NA	19.000	0.410 J	—	—
Aldrin	NA	—	—	—	—
Endosulfan sulfate	NA	1.000	—	—	—
Endrin	NA	0.580 J	—	—	—
Endrin aldehyde	NA	—	—	—	—
Endrin ketone	NA	—	—	—	—
Heptachlor epoxide	NA	—	—	—	—
alpha-Chlordane	NA	—	—	—	—
beta-BHC	NA	—	—	—	—
delta-BHC	NA	—	—	—	—

Table 7-2
Summary Analytical Results for Surface Soil Samples Collected Around the Perimeter of the Landfill Site 1

		Sample Identification Number			
Parameter	**RC**	**01SI4301**	**01SI4401**	**01SS4601**	**01SI4801**
Volatiles (µg/kg)					
Acetone	NA	—	—	—	—
Toluene	NA	—	—	—	—
Pesticides (µg/kg)					
4,4'-DDD	NA	—	—	0.280 J	—
4,4'-DDE	NA	—	—	1.100 J	1.600 J
4,4'-DDT	NA	—	—	1.900 J	2.200 J
Aldrin	NA	—	—	—	—
Endosulfan sulfate	NA	—	—	—	0.410 J
Endrin	NA	—	—	—	—
Endrin aldehyde	NA	—	—	—	0.190 J
Endrin ketone	NA	—	—	—	0.270 J
Heptachlor epoxide	NA	—	—	—	—
alpha-Chlordane	NA	—	—	—	—
beta-BHC	NA	—	—	0.200 J	—
delta-BHC	NA	—	—	0.130 J	—

Table 7-2
Summary Analytical Results for Surface Soil Samples Collected Around the Perimeter of the Landfill Site 1

		Sample Identification Number			
Parameter	**RC**	**01SI5901**	**01SI6001**	**01SS6201**	**01SS6401**
Volatiles (µg/kg)					
Acetone	NA	—	—	—	280.000 J
Toluene	NA	—	—	—	—
Pesticides (µg/kg)					
4,4'-DDD	NA	—	—	—	0.400 J
4.4'-DDE	NA	—	—	0.120 J	—
4.4'-DDT	NA	—	—	—	0.360 J
Aldrin	NA	—	—	0.120 J	—
Endosulfan sulfate	NA	—	—	0.280 J	0.270 J
Endrin	NA	—	—	0.120 J	0.099 J
Endrin aldehyde	NA	—	—	—	—
Endrin ketone	NA	—	—	—	—
Heptachlor epoxide	NA	—	—	—	0.081 J
alpha-Chlordane	NA	—	—	—	—
beta-BHC	NA	—	—	—	—
delta-BHC	NA	—	—	0.064 J	—

Table 7-3
Summary Analytical Results for Surface Soil Samples
Collected from Test Trench Locations
Site 1

		Sample Identification Number			
Parameter	**RC**	**01S7101**	**01S7201**	**01S7301**	**01S7501**
Inorganics (mg/kg)					
Aluminum	3,833	1,200.000	2,370.000	2,440.000	1,460.000
Arsenic	1.56	—	1.100	—	—
Barium	4.63	3.600	20.400	7.800	3.100
Cadmium	1.0	—	6.400 J	5.200	—
Calcium	912.37	931.000	1,370.000	560.000	—
Chromium (total)	6.13	—	86.400	7.800	4.300
Cobalt	1.87	—	—	—	—
Copper	5.74	—	32.300	—	—
Cyanide	0.52	—	0.620	—	—
Iron	2,745	850.000	1,690.000	2,300.000	1,300.000
Lead	7.32	27.800	38.600	108.000 J	11.300 J
Magnesium	133.33	174.000	119.000	79.700	—
Manganese	21.36	19.900	19.800	20.600	5.500
Mercury	0.10	—	0.540	—	0.180
Nickel	6.38	—	25.500	—	—
Silver	2.07	—	6.200	—	—
Sodium	107.85	32.400	40.100	—	—
Vanadium	5.83	—	4.300	4.900	—
Zinc	16.87	15.000	117.000	31.500	7.500

Table 7-3
Summary Analytical Results for Surface Soil Samples
Collected from Test Trench Locations
Site 1

		Sample Identification Number			
Parameter	RC	01S7601	01S7701	01S7801	01S7901
[illegible]					
Aluminum	3,833	1,510.000	1,000.000	1,870.000	1,540.000
Arsenic	1.56	—	—	0.900	—
Barium	4.63	3.400	1.500	7.400	2.400
Cadmium	1.0	—	—	—	—
Calcium	912.37	1,180.000	41.400	2,910.000	—
Chromium (total)	6.13	8.300	—	—	5.400
Cobalt	1.87	—	—	—	—
Copper	5.74	—	—	—	—
Cyanide	0.52	—	—	—	—
Iron	2,745	1,020.000	685.000	1,230.000	653.000
Lead	7.32	18.700	—	—	11.700 J
Magnesium	133.33	127.000	—	246.000	—
Manganese	21.36	14.300	2.400	24.100	2.300
Mercury	0.10	—	—	—	—
Nickel	6.38	—	—	—	—
Silver	2.07	—	—	—	—
Sodium	107.85	38.300	30.000	45.900	—
Vanadium	5.83	3.100	—	3.600	—
Zinc	16.87	14.400	2.900	6.600	10.600

Table 7-3
Summary Analytical Results for Surface Soil Samples
Collected from Test Trench Locations
Site 1

		Sample Identification Number		
	RC	01S8001	01S8101	
Inorganics (mg/kg)				
Aluminum	3,833	4,830.000	1,140.000	985.000
Arsenic	1.56	—	—	—
Barium	4.63	18.000	2.200	1.400
Cadmium	1.0	99.000	—	—
Calcium	912.37	355.000	—	38.700
Chromium (total)	6.13	117.000	—	*37.200*
Cobalt	1.87	2.100	—	2.800
Copper	5.74	54.900	—	39.200
Cyanide	0.52	—	—	—
Iron	2,745	3,580.000	1,030.000	42,300.000
Lead	7.32	441.000 J	4.800 J	28.500 J
Magnesium	133.33	140.000	—	—
Manganese	21.36	18.500	2.300	191.000
Mercury	0.10	0.810	—	—
Nickel	6.38	20.000	—	14.100
Silver	2.07	6.300	—	—
Sodium	107.85	35.400	—	—
Vanadium	5.83	—	—	—
Zinc	16.87	219.000	—	19.000

Table 7-3
Summary Analytical Results for Surface Soil Samples
Collected from Test Trench Locations
Site 1

		Sample Identification Number			
Parameter	**RC**	**01S7101**	**01S7201**	**01S7301**	**01S7501**
Volatiles (µg/kg)					
1,1,1-Trichloroethane	NA	—	—	—	1.000 J
Acetone	NA	—	—	—	—
Chloroform	NA	—	—	—	—
Tetrachloroethene	NA	—	—	—	—
Toluene	NA	—	—	—	16.000
Semivolatiles (µg/kg)					
2,4-Dimethylphenol	NA	—	—	—	—
4-methyl phenol	NA	—	—	—	—
Benzo(a)anthracene	NA	—	55.000 J	—	—
Benzo(a)pyrene	NA	—	50.000 J	—	—
Benzo(b)fluoranthene	NA	—	130.000 J	60.000 J	—
Benzo(g,h,i)perylene	NA	—	48.000 J	—	—
Benzo(k)fluoranthene	NA	—	130.000 J	60.000 J	—
Butylbenzylphthalate	NA	—	—	—	—
Chrvsene	NA	—	57.000 J	—	—
Di-n-butyl phthalate	NA	—	—	—	—
Fluoranthene	NA	—	110.000 J	—	—
Indeno(1,2,3-cd)pyrene	NA	—	47.000 J	—	—
Phenanthrene	NA	—	38.000 J	—	—
Pyrene	NA	—	73.000 J	—	—
bis(2-Ethlyhexy)phthalate	NA	—	—	—	—
bis(2-chloroethyl)ether	NA	—	—	—	—
Pesticides and PCBs (µg/kg)					
4,4'-DDD	NA	—	—	2.400 J	—

Table 7-3
Summary Analytical Results for Surface Soil Samples
Collected from Test Trench Locations
Site 1

		Sample Identification Number			
Parameter	**RC**	**01S7101**	**01S7201**	**01S7301**	**01S7501**
4,4'-DDE	NA	—	19.000	20.000	—
4,4'-DDT	NA	—	6.700	22.000	—
Aldrin	NA	1.400 J	—	—	—
Aroclor 124%	NA	—	—	—	—
Aroclor 1254	NA	310.000	—	—	—
Aroclor 1260	NA	—	130.000	—	—
					0.910 J
					0.061 J
					—
Endosulfan sulfate	NA	—	—	—	—
Endrin	NA	—	—	—	0.250 J
Endrin aldehyde	NA	—	—	0.920 J	—
Endrin ketone	NA	—	—	—	—
Heptachlor	NA	—	—	—	—
Heptachlor epoxide	NA	0.410	0.500 J	—	—
Methoxychlor	NA	—	—	—	—
alpha-BHC	NA	—	—	—	—
alpha-Chlordane	NA	—	1.800	—	1.400 J
delta-BHC	NA	—	—	0.061 J	0.200 J
gamma-BHC (lindane)	NA	—	—	—	—
gamma-Chlordane	NA	—	1.500 J	0.160 J	0.570 J

Table 7-3
Summary Analytical Results for Surface Soil Samples
Collected from Test Trench Locations
Site 1

		Sample Identification Number			
Parameter	**RC**	**01S7601**	**01S7701**	**01S7801**	**01S7901**
Volatiles (µg/kg)					
1,1,1-Trichloroethane	NA	—	—	—	—
Acetone	NA	—	—	—	—
Chloroform	NA	—	—	—	—
Tetrachloroethene	NA	—	—	—	—
Toluene	NA	—	1.000 J	—	—
Semivdatiles (µg/kg)					
2,4-Dimethylphenol	NA	—	—	—	—
4-methyl phenol	NA	—	—	—	—
Benzo(a)anthracene	NA	—	—	—	—
Benzo(a)pyrene	NA	—	—	—	—
Benzo(b)fluoranthene	NA	—	—	55.000 J	—
Benzo(g,h,i)perylene	NA	—	—	—	—
Benzo(k)fluoranthene	NA	—	—	55.000 J	—
Butylbenzylphthalate	NA	71.000 J	—	—	—
Chrysene	NA	—	—	—	—
Di-n-butylphthalate	NA	—	—	—	—
Fluoranthene	NA	—	—	—	—
Indeno(1,2,3-cd)pyrene	NA	—	—	—	—
Phenanthrene	NA	—	—	—	—
Pyrene	NA	—	—	—	—
bis(2-Ethlyhexy)phthalate	NA	—	—	—	—
bis(2-chloroethyl)ether	NA	—	—	230.000 J	—
Pesticides and PCBs (µg/kg)					
4,4'-DDD	NA	—	—	0.210 J	0.430 J

Table 7-3
Summary Analytical Results for Surface Soil Samples
Collected from Test Trench Locations
Site 1

		Sample Identification Number			
Parameter	**RC**	**01S7601**	**01S7701**	**01S7801**	**01S7901**
4,4'-DDE	NA	0.160 J	—	—	—
4,4'-DDT	NA	—	—	—	—
Aldrin	NA	—	—	—	—
Aroclor 1248	NA	—	—	190.000 J	—
Aroclor 1254	NA	—	—	—	—
Aroclor 1260	NA	9.100 J	—	—	4.700 J
Dieldrin	NA	0.620 J	—	—	0.190 J
Endosulfan I	NA	—	—	—	—
Endosulfan II	NA	—	0.340 J	—	—
Endosulfan sulfate	NA	—	—	—	—
Endrin	NA	—	—	—	—
Endrin aldehyde	NA	—	—	—	0.170 J
Endrin ketone	NA	—	—	—	—
Heptachlor	NA	—	—	—	—
Heptachlor epoxide	NA	—	—	—	—
Methoxychlor	NA	—	—	—	—
alpha-BHC	NA	—	—	—	—
alpha-Chlordane	NA	—	—	—	0.064 J
delta-BHC	NA	—	—	—	—
gamma-BHC (lindane)	NA	—	—	—	—
gamma-Chlordane	NA	0.280 J	0.250 J	—	—

Table 7-3
Summary Analytical Results for Surface Soil Samples
Collected from Test Trench Locations
Site 1

		Sample Identification Number		
Parameter	**RC**	**01S8001**	**01S8101**	**01S8201**
Volatiles (µg/kg)				
1,1,1-Trichloroethane	NA	—	—	—
Acetone	NA	—	—	—
Chloroform	NA	—	—	2.000 J
Tetrachloroethene	NA	—	—	6.000 J
Toluene	NA	—	—	14.000
2,4-Dimethylphenol	NA	—	—	3,500.000 J
4-methyl phenol	NA	—	—	1,200.000 J
Benzo(a)anthracene	NA	—	—	—
Benzo(a)pyrene	NA	—	—	—
Benzo(b)fluoranthene	NA	—	—	—
Benzo(g,h,i)perylene	NA	—	—	—
Benzo(k)fluoranthene	NA	—	—	—
Butylbenzylphthalate	NA	—	—	—
Chrysene	NA	—	—	—
Di-n-butylphthalate	NA	—	—	—
Fluoranthene	NA	—	—	—
Indeno(1,2,3-cd)pyrene	NA	—	—	—
Phenanthrene	NA	—	—	—
	NA	—	—	—
bis(2-Ethlyhexy)phthalate	NA	—	—	—
bis(2-chloroethyl)ether	NA	—	—	—
Pesticides and PCBs (µg/kg)				

Table 7-3
Summary Analytical Results for Surface Soil Samples
Collected from Test Trench Locations
Site 1

		Sample Identification Number		
Parameter	**RC**	**01S8001**	**01S8101**	**01S8201**
4,4'-DDE	NA	66.000	0.220 J	39.000 J
4,4'-DDT	NA	92.000	0.340 J	99.000 J
Aldrin	NA	—	—	0.200
Aroclor 1248	NA	—	—	—
Aroclor 1254	NA	—	—	—
Aroclor 1260	NA	—	—	—
Dieldrin	NA	6.400 J	—	—
Endosulfan I	NA	—	—	—
Endosulfan II	NA	—	—	3.700
Endosulfan sulfate	NA	—	—	—
Endrin	NA	0.400 J	—	—
Endrin aldehyde	NA	2.900 J	—	—
Endrin ketone	NA	—	—	1.600 J
Heptachlor	NA	—	—	—
Heptachlor epoxide	NA	1.400 J	—	0.300 J
Methoxychlor	NA	—	—	—
alpha-BHC	NA	—	—	0.130 J
alpha-Chlordane	NA	130.000	—	13.000
delta-BHC	NA	0.450 J	—	1.500 J
gamma-BHC (lindane)	NA	—	—	0.210 J
gamma-Chlordane	NA	110.000	—	—

Key:
mg/kg = Milligrams per kilogram
µg/kg = Micrograms per kilogram
— = Indicates parameter analyzed but not detected above the method detection limit.
NA = Not applicable, RCs calculated for inorganics only.
J = Parameter present below CRQL but above IDL: reported concentration is approximate.
RC = Reference concentration calculated from reference data as two times the mean concentration.
Bold = The reported value exceeds the RC calculated for this parameter.

- 01SI3001 from the southcentral portion contained beryllium (0.61 mg/kg) exceeding the RC.

- 01SI3501 from the eastern margin contained calcium (1,720 mg/kg) exceeding the RC.

- 01SS3901 from the southwestern portion contained relatively low concentrations of selenium (0.73 mg/kg) exceeding the RC.

- 01SI4801 from the northern portion contained calcium (1,050 mg/kg), lead (11.8 mg/kg), and zinc (17.2 mg/kg) exceeding their respective RCs.

Concentrations of aluminum, barium, calcium, chromium (total), copper, iron, lead, magnesium, manganese, and zinc exceeding RCs were detected in one or more surface soil samples collected from within the landfill boundary. Additionally, cadmium, cobalt, cyanide, mercury, and nickel were detected in one or more of these samples, but not in reference samples. Figures 7-1 and 7-2 illustrate the distributions of selected metals concentrations in surface soil across the landfill area that were most frequently elevated. As shown in the figures, the highest and most frequently reported elevated metals concentrations were detected in samples 01S7201 and 01S7301 from the landfill's northern portion, sample 01S7501 from the east central portion, and samples 01S8001 and 01S8201 from the southeastern and southwestern portions, respectively.

Concentrations of cadmium were detected only in samples 01S7201, 01S7301, and 01S8001, within the landfill boundary. Detected concentrations, all of which exceeded the 1.0 mg/kg RC, ranged from 5.2 mg/kg to 99.0 mg/kg. The highest cadmium concentration was detected in sample 01S8001 from the southeastern portion.

Chromium (total) was reported for several samples from outside, as well as inside, the landfill boundary at concentrations ranging from 2.2 mg/kg to 117.0 mg/kg. Chromium concentrations

exceeding the 6.13 mg/kg RC were detected in samples 01SI2801 (12.5 mg/kg), 01S7201 (86.4 mg/kg), 01S7301 (7.8 mg/kg), 01S7601 (8.3 mg/kg), 01S8001 (117.0 mg/kg), and 01S8201 (37.2 mg/kg).

Lead was detected commonly in surface soil samples with concentrations ranging from 0.9 mg/kg to 441.0 mg/kg. Most reported lead concentrations were within those observed in reference samples; however, concentrations commonly exceeded the 7.32 mg/kg RC. The highest concentrations of lead were detected within the landfii boundary in samples 01S7201 (38.6 mg/kg), 01S7301 (108.0 mg/kg), and 01S8001 (441.0 mg/kg).

Detectable concentrations of mercury, each exceeding the 0.10 RC, were present only in samples 01S7201, 01S7501, and 01S8001, collected within the landfill boundary. Concentrations ranged from 0.18 mg/kg to 0.81 mg/kg, with the highest in sample 01S8001.

Detectable nickel concentrations, each exceeding the 6.38 RC mg/kg, were present only in samples 01S7201, 01S8001, and 01S8201, collected within the landfii boundary. Detected concentrations ranged from 14.1 mg/kg to 25.5 mg/kg, with the highest in sample 01S7201.

Zinc was detected commonly in surface soil samples with concentrations ranging from 1.5 mg/kg to 219.0 mg/kg. Most reported zinc concentrations were within those observed in reference samples; however, concentrations of zinc exceeding the 16.87 mg/kg RC were detected in samples 01SS0101 (34.0 mg/kg), 01SI4801 (17.2 mg/kg), 01S7201 (117.0 mg/kg), 01S7301 (31.5 mg/kg), 01S8001 (219.0 mg/kg), and 01S8201 (19.0 mg/kg).

Less frequently detected inorganics (not shown on Figures 7-1 and 7-2) that were elevated or not detected in reference samples include aluminum, barium, copper, magnesium, manganese, cobalt, cyanide, and silver. Most of these were detected in surface soil samples collected within

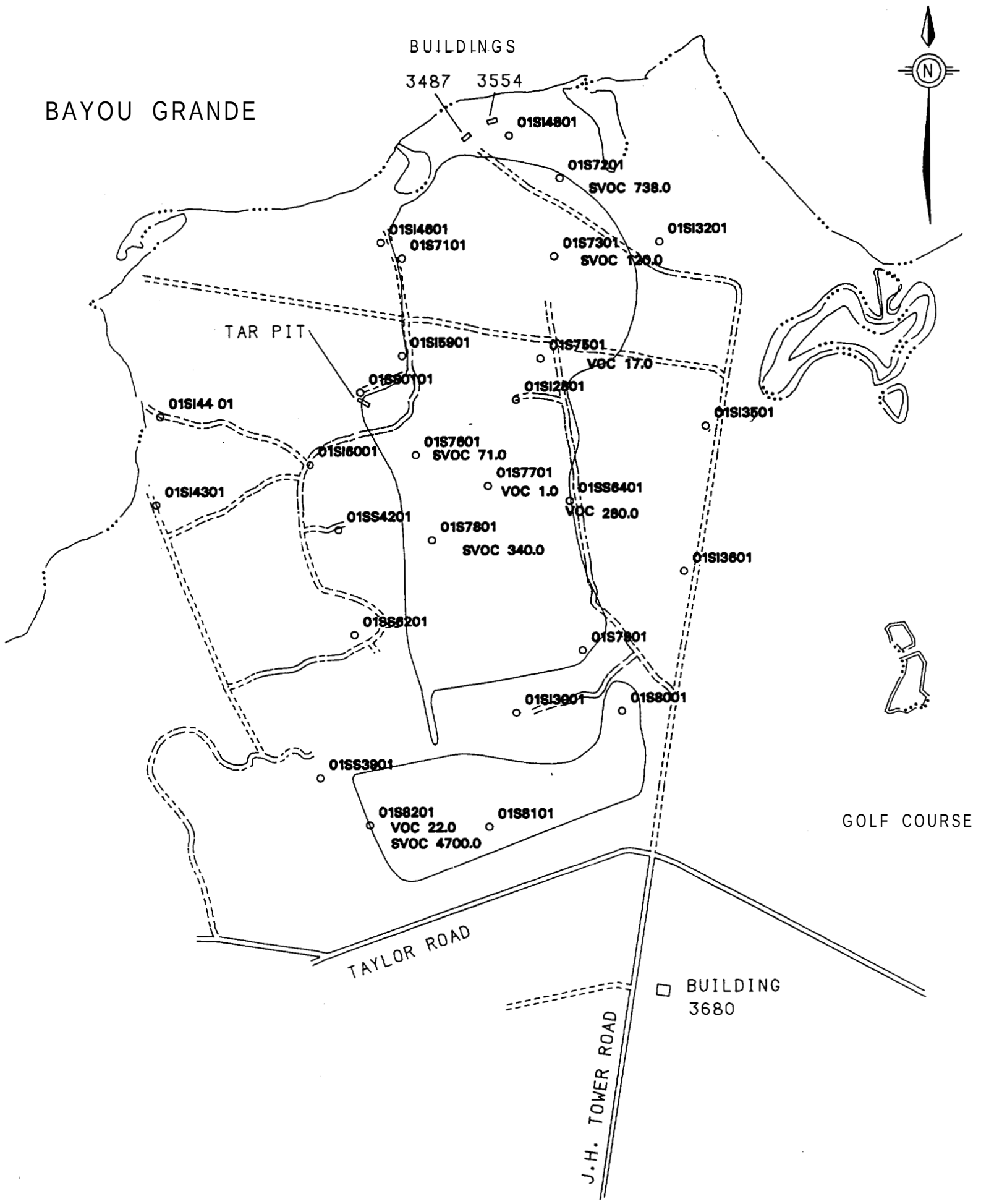
the landfill boundary; however, RCs occasionally were exceeded in perimeter location soil samples. All RC exceedences are noted on Tables 7-2 and 7-3 in bold print.

Volatiles

As shown on Tables 7-2 and 7-3, relatively low concentrations of five VOCs (acetone, chloroform, 1,1,1-trichloroethane, tetrachloroethene, and toluene) were detected in a limited number of surface soil samples. Figure 7-3 illustrates the distribution of the total VOC concentrations in these samples. The highest detected VOC concentration, 280 μg/kg of acetone, was present in sample 01SS6401, collected immediately outside of the landfill's eastern border. However, due to the highly volatile nature of this compound and the apparent lack of a nearby source, the presence of acetone in this sample is suspect. Samples 01S7501 and 01S7701, from the central portion of the landfill, and 01S8201 from the southwestern portion each contained detectable concentrations of one or more VOCs. Total VOC concentrations detected in each of these samples were 17.0 μg/kg, 1.0 μg/kg, and 22 μg/kg, respectively.

Semivolatiles

As shown on Table 7-3, semivolatile compounds were detected only in surface soil samples collected at test trench locations within the landfill boundary. Semivolatiles detected in these samples included several phenol, aromatic, phthalate, and pyrene compounds. Figure 7-3 also illustrates the distribution of total semivolatile concentrations detected at these locations. Several trench surface samples exhibited concentrations of semivolatile compounds. The highest concentrations were detected in samples 01S7201 (738.0 μg/kg) and 01S8201 (4,700.0 μg/kg) from the site's northern and southern extents, respectively. Primarily aromatic and pyrene compounds were in sample 01S7201, while sample 01S8201 exhibited only phenols.



LEGEND

COASTLINE / SURFACE WATER FEATURE

UNPAVED ROAD

o SURFACE SOIL SAMPLE

VOC 66.0 TOTAL VOC CONCENTRATION IN µG/KG

SVOC 7.0 TOTAL SEMIVOLATILE CONCENTRATION IN µG/KG

600 0 600
SCALE FEET

REMEDIAL INVESTIGATION REPORT
SITE 1
NAS PENSACOLA

FIGURE 7-3

TOTAL VOCS AND TOTAL SEMIVOLATILES DETECTED IN SURFACE SOIL SAMPLES

DATE: 11/16/93 DWG NAME: 59FIG7-3

Pesticides and PCBs

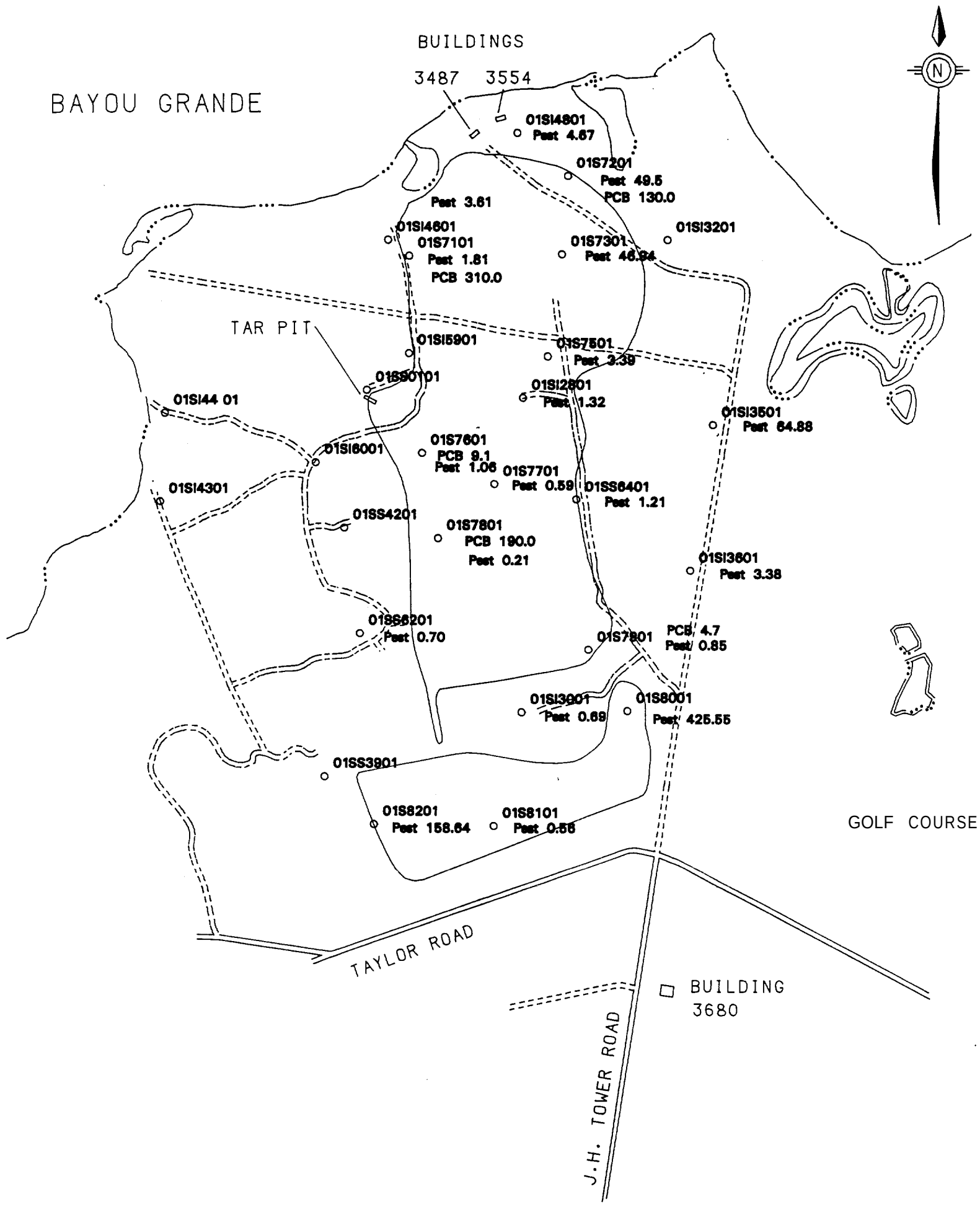
Pesticides were detected in surface soil samples collected across most of the site. Figure 7-4 illustrates the distribution of total pesticide and PCB concentrations detected in surface soil samples at Site 1.

As shown on Table 7-2, several pesticides were detected in surface soil samples collected outside the landfiill boundary. With few exceptions, these pesticides concentrations were comparable with those reported for reference samples. Sample 01SI3501, from the eastern margin adjacent to the golf course, contained elevated concentrations of the pesticides 4'4 DDD, 4'4 DDE, and 4'4 DDT. Additionally, relatively low concentrations (1.0 µg/kg or less) of one or more of the pesticides endosulfan sulfate, endrin ketone, beta-BHC, and delta-BHC were detected in samples 01SI2801, 01SI3001, 01SI3501, 01SI4601, 01SS6201, and 01SS6401. These pesticides were not detected in reference samples.

As shown on Table 7-3, elevated concentrations of numerous pesticides and PCBs were detected in surface soil samples collected from test trenches within the landfill boundary. The highest concentrations of total pesticides were reported for samples 01S7201 (49.5 pglkg) and 01S7301 (46.94 pglk), collected from the landfiill's northern portion, and samples 01S8001 (425.55 µg/k) and 01S8201 (158.64 pglkg), from the southemmost portion. Elevated concentrations of the PCBs Aroclor 1248, 1254, and 1260 also were detected in interior samples. Samples exhibiting PCB concentrations included 01S7101 (310.0 µg/kg) and 01S7201 (130.0 pglkg), collected from the landfill's northern portion; samples 01S7601 (9.1 pglkg) and 01S7801 (190.0 µg/kg), from the central portion; and sample 01S7901 (4.7 pglkg), from the southeastern portion.

7.1.2 Summary and Conclusions

Soil samples were collected across Site 1 to characterize the nature of surface soil for risk assessment purposes. Ecological and human health risk assessments are presented in Section 11 of this report. Based on the sample results, soil outside the landfill's perimeter does not appear to have been greatly impacted by landfill activities. Parameters detected in these samples



LEGEND

	COASTLINE / SURFACE WATER FEATURE
	UNPAVED ROAD
○	SURFACE SOIL SAMPLE
Pest 1.0	TOTAL PESTICIDE CONCENTRATIONS IN μG/KG
PCB 3.0	TOTAL PCB CONCENTRATIONS IN μG/KG

600 0 600
SCALE FEET

REMEDIAL INVESTIGATION
REPORT
SITE 1
NAS PENSACOLA

FIGURE 7-4
TOTAL PESTICIDES AND TOTAL PCBS
DETECTED IN SURFACE SOIL SAMPLES

DATE: 11/16/93 | DWG NAME: 59FIG7-4

included metals and pesticides, which occurred at concentrations generally comparable to RCs. A single concentration of acetone was also detected in perimeter soil sample 01SS6401. However, because this compound's occurrence was isolated and it is a common laboratory artifact, its presence is suspect.

In contrast to the soil sampled outside the landfill, analytical results indicate elevated concentrations of inorganics and organic compounds are present in the 0- to 1-foot depth interval of the landfill. Surface soil samples collected from the test trenches within the landfill boundary commonly exhibited concentrations of inorganics and pesticides exceeding those detected in reference (and perimeter) samples. Furthermore, concentrations of VOCs, semivolatiles, and PCBs, while not detected in perimeter or reference samples, were reported for interior soil samples. VOCs were detected in only a limited number of surface samples at generally low concentrations and do not represent significant contamination. Therefore, based on an evaluation of the analytical data, elevated parameters detected in landfill surface soil include various metals, semivolatiles, pesticides, and PCBs.

In summary, elevated concentrations of metals and organics were detected in Site 1 surface soil samples as follows:

Concentrations of one or more of the metals barium, cadmium, chromium, lead, mercury, nickel, silver, and zinc were detected in samples from trenches 2, 3, 5, 10, and 12. However, samples from trenches 2, 10, and 12, in the landfill's northern, southeastern, and southwestern portions, respectively, contained the highest concentrations of metals relative to all other site samples.

Semivolatiles, including several aromatic, phenol, and pyrene compounds, were detected in samples collected from trenches 2, 3, 5, 6, 8, and 10. The highest concentrations of

semivolatiles were reported in the samples from trenches 2 and 12, in the landfill's northernmost and southwestern portions, respectively.

Pesticides were detected in the majority of the surface soil samples from outside and inside the landfill boundary. Most concentrations of pesticides detected at the site are comparable to those in reference samples. The highest concentrations were reported for samples collected outside the landfill along the golf course's margin, and from trenches 2, 3, 10, and 12. Trenches 2 and 3 are in the landfill's northern portion; trenches 10 and 12 are in the southern portion.

PCBs were detected in samples from trenches 1, 2, 6; 8, and 9. Relatively higher concentrations were reported for the samples from trench 1, along the landfill's northwestern margin; trench 2, in the northemmost portion; and trench 8, in the center.

Except for trenches 10 and 12, the interval sampled at each test trench consisted of the overburden/cover material (as determined during test trench activities, see Section 7.2) that was reworked and graded into place during landfill activities. During the grading and waste burial/covering process, it is possible that landfill wastes were co-mingled to some degree with the cover material, potentially scattering relatively lower concentrations of waste contaminants during grading. The exceptions, test trenches 10 and 12, are areas where no significant overburden material was encountered at land surface. Trench 12 was constructed across a collapse feature where waste materials were partially exposed; therefore, waste material was collected along with surface soil. The sample from trench 10 was retrieved from a mounded area of soil that originally was believed to overlie a filled area. However, no subsurface waste interval was encountered below the mound during excavation. Based on this information and the results of the soil analyses, it is now believed the mounded soil, which exhibited the highest concentrations of metals and pesticides onsite, may represent impacted material transported to the site for disposal after completion of landfill activities. Based on this information, only trenches 10 and 12 should be considered discrete areas of surface soil contamination. Due to

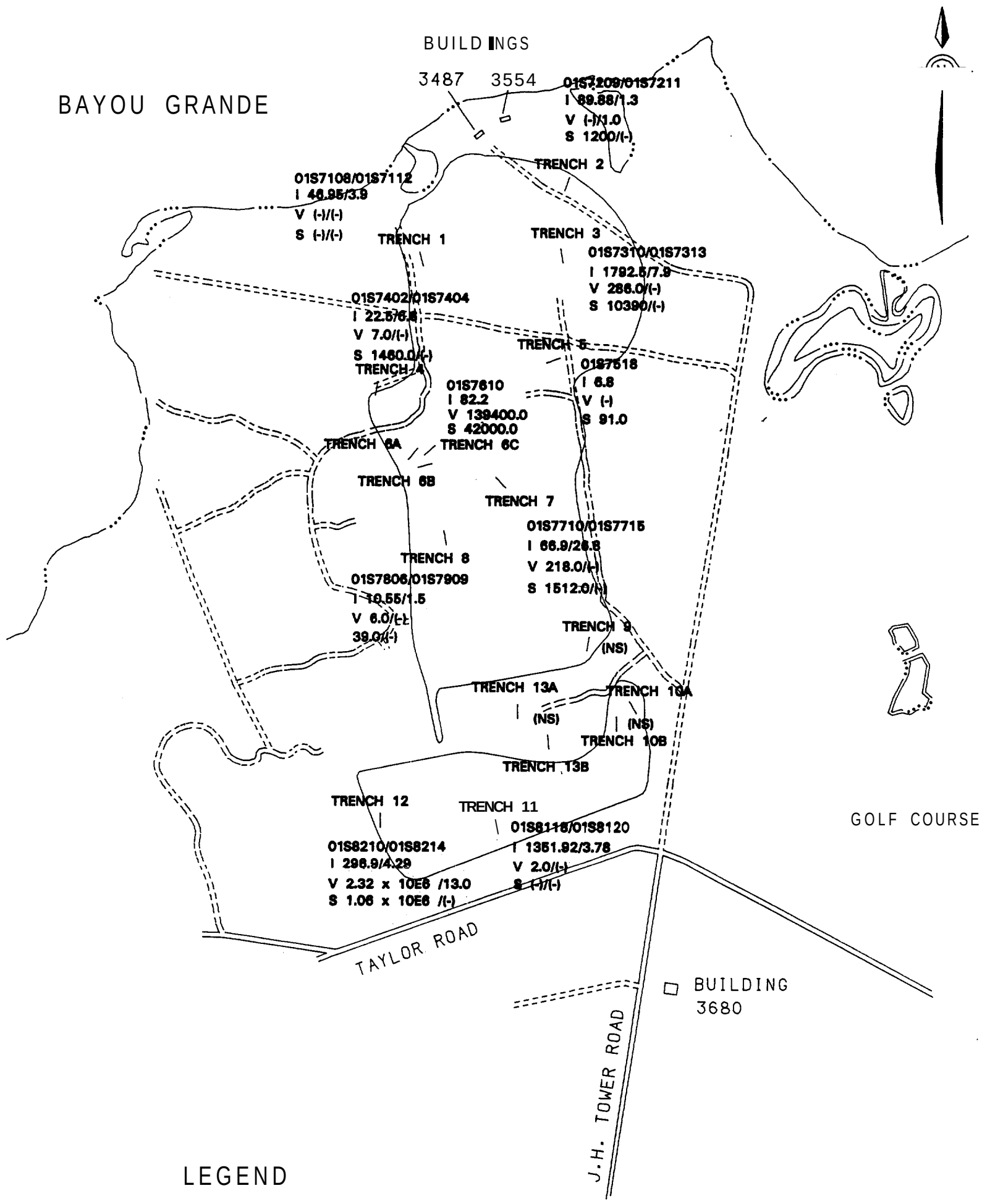
the distribution of sample locations across the full extent of the landfill and the potential scattering of co-mingled waste/cover material across significant portions of the landfill, the remaining parameter concentrations reported for surface samples from trench locations should be considered representative of general surface soil conditions within its boundary.

7.2 Test Trench Activities

Test trenching was performed at 13 locations across the landfill, as discussed in Section 5.1.1, to confirm the presence of waste material in selected locations, and to generally characterize the landfill's contents. It should be noted that delineating contaminant extent was not an objective of the trench activities due to the expansive (approximately 80 acres) of the landfill and the anticipated heterogeneous nature of the wastes.

In addition to the previously discussed surface soil samples collected at the trenches (see Section 7.1), subsurface samples of trench contents and/or underlying native soil were collected from most test trenches (as stated in Section 5.0, trenches 10 and 13 contained no indication of waste/fill below land surface, so no subsurface samples were collected). Full CLP TAL/TCL, TCLP, PPS, and hexavalent chromium analyses were performed on trench samples, as Table 5-4 indicates.

The following sections discuss the findings of test trench activities, organized by trench location. Included in this discussion are the analytical results for the test trench samples, as well as the physical observations (thickness of overburden, excavation depth, description of waste material encountered, etc.) noted during test trench activities. Trench samples contained detectable concentrations of several inorganic constituents, volatiles, semivolatiles, pesticides, and PCBs. Table 7-4 summarizes analytical results for parameters detected in these samples (PPS analyses results are presented in Section 7.4). The complete analytical results for trench samples are contained in Appendix F. Figure 7-5 illustrates the distribution of select total inorganics, which include eight metals (the RCRA metals arsenic, barium, cadmium, chromium, lead, mercury,



LEGEND

	COASTLINE / SURFACE WATER FEATURE
	UNPAVED ROAD
—	TEST TRENCH (APPROXIMATE ORIENTATION NOT TO SCALE)
I	TOTAL METALS (8 RCRA) PLUS CYANIDE IN MG/KG
V	TOTAL VOCS IN µG/KG
S	TOTAL SEMIVOLATILE COMPOUNDS IN µG/KG
01S7108	SAMPLE IDENTIFICATION NUMBER
10.5/1.5	TRENCH CONTENTS / NATIVE SOIL SAMPLE SAMPLE
(-)	PARAMETER NOT DETECTED
INS)	TRENCH NOT SAMPLED FOR TAL/TCL

600 0 600
SCALE FEET

REMEDIAL INVESTIGATION
REPORT
SITE 1
NAS PENSACOLA

FIGURE 7-5
TOTAL INORGANICS, VOCS,
AND SEMIVOLATILES DETECTED IN
TEST TRENCH SOIL SAMPLES

DATE: 12/3/93 | DWG NAME: 59FIG7-5

Table 7-4
Summary Analytical Results for Subsurface Soil Samples Collected during Test Trenching Activities
Site 1

	Sample Identification Number			
Parameter	**01S7108**	**01S7112**	**01S7209**	**01S7211**
Inorganics (mg/kg)				
Aluminum	1,370.000	1,380.000	2,410.000	286.000
Antimony	—	—	—	—
Arsenic	0.850	1.100	1.300	—
Barium	5.700	1.700	12.800	1.300
Cadmium	—	—	2.200 J	—
Calcium	863.000	195.000	718.000	50.000
Chromium (total)	4.800	—	12.500	—
Cobalt	—	—	—	—
Copper	3.300	—	23.000	—
Cyanide	—	—	0.680	—
Iron	989.000	963.000	2,140.000	111.000
Lead	35.600	1.100	60.200	—
Magnesium	—	89.600	115.000	—
Manganese	11.600	4.800	26.400	—
Mercury	—	—	0.200	—
Nickel	—	—	11.100	—
Selenium	—	—	—	—
Silver	—	—	—	—
Sodium	36.800	29.900	28.100	34.200
Vanadium	3.000	2.400	4.100	—
Zinc	16.700	3.400	5,930.000	211.000
Volatiles (µg/kg)				
1,1-Dichloroethene	—	—	—	—

Table 7-4
Summary Analytical Results for Subsurface Soil Samples
Collected during Test Trenching Activities
Site 1

	Sample Identification Number			
Parameter	**01S7108**	**01S7112**	**01S7209**	**01S7211**
1,2-Dichloroethene (total)	—	—	—	—
1,1,1-Trichloroethane	—	—	—	1.000 J
Acetone	—	—	—	—
Benzene	—	—	—	—
Chlorobenzene	—	—	—	—
Chloroform	—	—	—	—
Ethylbenzene	—	—	—	—
Methylene Chloride	—	—	—	—
Tetrachloroethene	—	—	—	—
Toluene	—	—	—	—
Trichloroethene	—	—	—	—
Xylene (total)	—	—	—	—
Semivolatiles (µg/kg)				
1,2,4-Trichlorobenzene	—	—	—	—
1,2-Dichlorobenzene	—	—	—	—
1,4-Dichlorobenzene	—	—	—	—
2,4-Dimethylphenol	—	—	—	—
2,4-Dinitrotoluene	—	—	—	—
2-Chlorophenol	—	—	—	—
2-Methylnaphthalene	—	—	—	—
2-Methylphenol	—	—	—	—
2-Nitrophenol	—	—	—	—
4-Chloro-3-methylphenol	—	—	—	—
4-Methylphenol	—	—	—	—
4-Nitrophenol	—	—	—	—

Table 7-4
Summary Analytical Results for Subsurface Soil Samples
Collected during Test Trenching Activities
Site 1

	Sample Identification Number			
Parameter	**01S7108**	**01S7112**	**01S7209**	**01S7211**
Acenaphthene	—	—	—	—
Anthracene	—	—	—	—
Benzo(a)anthracene	—	—	—	—
Benzo(a)pyrene	—	—	—	—
Benzo(b)fluoranthene	—	—	—	—
Benzo(g,h,i)perylene	—	—	—	—
Benzo(k)fluoranthene	—	—	—	—
Butylbenzylphthalate	—	—	—	—
Chrysene	—	—	—	—
Din-butylphthalate	—	—	1,200.000	—
Din-octylphthalate	—	—	—	—
Diethylphthalate	—	—	—	—
Fluoranthene	—	—	—	—
Fluorene	—	—	—	—
Indeno(1,2,3-cd)pyrene	—	—	—	—
Naphthalene				
N-Nitroso-di-n-propylamine	—	—		—
Pentachlorophenol	—	—	—	—
Phenanthrene	—	—	—	—
Phenol	—	—	—	—
Pyrene	—	—	—	—
bis(2-Ethlyhexy)phthalate	—	—	—	—
esticid (µg/kg)				
4,4'-DDD	0.420	—	3.600	—

Table 7-4
Summary Analytical Results for Subsurface Soil Samples
Collected during Test Trenching Activities
Site 1

	Sample Identification Number			
Parameter	01S7108	01S7112	01S7209	01S7211
4,4'-DDE	2.600 J	—	—	—
4,4'-DDT	2.400 J	—	0.320J	—
Aldrin	—	—	—	—
Aroclor 1242	—	—	—	—
Aroclor 1248	—	—	—	—
Aroclor 1254	—	—	50.000	—
Aroclor 1260	—	—	63.000	—
Dieldrin	0.580	—	—	—
Endosulfan I	—	—	—	—
Endosulfan II	—	—	—	—
Endosulfan sulfate	—	—	—	—
Endrin	—	—	—	—
Endrin aldehyde	—	—	—	—
Endrin ketone	—	—	—	—
Heptachlor	—	—	0.190 J	—
Heptachlor epoxide	—	—	—	—
Methoxychlor	—	—	—	—
alpha-BHC	—	—	—	—
alpha-Chlordane	—	—	0.420 J	—
beta-BHC	—	—	—	—
delta-BHC	—	—	—	—
gamma-BHC (lindane)	—	—	—	—
gamma-Chlordane	—	—	0.570 J	—

Table 7-4
Summary Analytical Results for Subsurface Soil Samples Collected during Test Trenching Activities
Site 1

	Sample Identification Number			
Parameter	**01S7310**	**01S7313**	**01S7402**	**01S7404**
Inorganics (mg/kg)				
Aluminum	2,760.000	455.000	5,140.000	2,420.000
Antimony	—	—	—	—
Arsenic	2.500	—	1.500	1.400
Barium	392.000	1.300	12.200	4.100
Cadmium	214.000 J	1.500 J	—	—
Calcium	2,230.000	42.300	48.100	2.400
Chromium (total)	915.000	2.900	4.000	—
Cobalt	—	—	—	—
Copper	212.000	—	—	—
Cyanide	5.400	—	—	—
Iron	2,810.000	310.000	2,970.000	760.000
Lead	142.000	2.200	4.800	1.100
Magnesium	253.000	—	173.000	94.700
Manganese	20.700	1.900	9.800	2.400
Mercury	4.400	—	—	—
Nickel	18.600	—	—	—
Selenium	1.200	—	—	1.400 R
Silver	116.000	—	—	—
Sodium	55.800	30.000	46.400	25.200
Vanadium	5.000	—	11.200	2.600
Zinc	454.000	10.200	6.000	2.900
Volatiles (µg/kg)				
1,1-Dichloroethene	—	—	—	—
1,2-Dichloroethene (total)	3.000	—	—	—

Table 7-4
Summary Analytical Results for Subsurface Soil Samples Collected during Test Trenching Activities
Site 1

	Sample Identification Number			
Parameter	01S7310	01S7313	01S7402	01S7404
1,1,1-Trichloroethane	—	—	—	—
Acetone	—	—	—	—
Benzene	—	—	—	—
Chlorobenzene	27.000	—	—	—
Chloroform	—	—	—	—
Ethylbenzene	10.000 J	—	—	—
Methylene Chloride	—	—	—	—
Tetrachloroethene	16.000	—	—	—
Toluene	100.000	—	7.000 J	—
Trichloroethene	—	—	—	—
Xylene (total)	130.000	—	—	—
1,2,4-Trichlorobenzene	480.000 J	—	—	—
1,2-Dichlorobenzene	810.000 J	—	—	—
1.4-Dichlorobenzene	3,300.000	—	—	—
2,4-Dimethylphenol	—	—	—	—
2,4-Dinitrotoluene	1,500.000	—	—	—
2-Chlorophenol	—	—	—	—
2-Methylnaphthalene	—	—	—	—
2-Methylphend	—	—	—	—
2-Nitrophend	—	—	—	—
4-Chloro-3-methylphenol	—	—	—	—
4-methyl phenol	—	—	—	—
4-Nitrophenol	—	—	—	—
Acenaphthene	—	—	—	—

Table 7-4
Summary Analytical Results for Subsurface Soil Samples Collected during Test Trenching Activities
Site 1

	Sample Identification Number			
Parameter	**01S7310**	**01S7313**	**01S7402**	**01S7404**
Anthracene	—	—	—	—
Benzo(a)anthracene	—	—	—	—
Benzo(a)pyrene	—	—	—	—
Benzo(b)fluoranthene	—	—	—	—
Benzo(g,h,i)perylene	—	—	490.000	—
Benzo(k)fluoranthene	—	—	—	—
Butylbenzylphthalate	—	—	—	—
Chrysene	240.000 J	—	470.000	—
Di-n-butylphthalate	—	—	160.000 J	—
Di-n-octylphthalate	—	—	—	—
Diethylphthalate	—	—	—	—
Fluoranthene	480.000 J	—	—	—
Fluorene	180.000 J	—	—	—
Indeno(1,2,3-cd)pyrene	—	—	—	—
Naphthalene	2,500.000	—	—	—
N-Nitroso-di-n-propylamine	—	—	—	—
Pentachlorophenol	—	—	—	—
Phenanthrene	580.000 J	—	—	—
Phenol	—	—	—	—
Pyrene	320.000 J	—	340.000 J	—
bis(2-Ethlyhexy)phthalate	—	—	—	—
bis(2-chloroethyl)ether	—	—	—	—
Pesticides and PCBs (µg/kg)				
4,4'-DDD	—	—	0.800 J	—
4,4'-DDE	110.000 J	0.850 J	—	—

Table 7-4
Summary Analytical Results for Subsurface Soil Samples Collected during Test Trenching Activities
Site 1

	Sample Identification Number			
Parameter	01S7310	01S7313	01S7402	01S7404
4.4'-DDT	—	—	2.300 J	—
Aldrin	—	—	—	—
Aroclor 1242	—	—	—	—
Aroclor 1248	—	—	—	—
Aroclor 1254	—	—	—	—
Arodor 1260	7,900.000	30.000 J	—	—
Dieldrin	72.000 J	0.780 J	—	—
Endosulfan I	—	—	—	—
Endosulfan II	—	—	—	—
Endosulfan sulfate	—	—	—	—
Endrin	—	—	—	—
Endrin aldehyde	—	—	—	—
Endrin ketone	—	—	3.000 J	2.400 J
Heptachlor	—	—	—	—
Heptachlor epoxide	11.000 J	—	—	—
Methoxychlor	—	—	12.000 J	—
alpha-BHC	—	—	—	—
alpha-Chlordane	3.400 J	—	—	—
beta-BHC	—	—	—	—
delta-BHC	—	—	—	—
gamma-BHC (lindane)	—	—	—	—
gamma-Chlordane	4.000 J	—	—	—

Table 7-4
Summary Analytical Results for Subsurface Soil Samples Collected during Test Trenching Activities
Site 1

	Sample Identification Number			
Parameter	**01S7508**	**01S7518**	**01S7610**	**01S7710**
Inorganics (mg/kg)				
Aluminum	NA	1,420.000	1,320.000	3,800.000
Antimony	NA	—	—	—
Arsenic	NA	1.000	—	1.200
Barium	NA	3.100	2.700	18.200
Cadmium	NA	—	—	26.100 J
Calcium	NA	180.000	136.000	196.000
Chromium	NA	2.700	79.500	5.500
Cobalt	NA	—	—	—
Copper	NA	—	—	3.700
Cyanide	NA	—	—	—
Iron	NA	1,170.000	481.000	2,520.000
Lead	NA	—	—	15.900
Magnesium	NA	—	—	119.000
Manganese	NA	8.000	2.200	7.600
Mercury	NA	—	—	—
Nickel	NA	—	—	—
Selenium	NA	—	—	—
Silver	NA	—	—	—
Sodium	NA	27.200	27.600	31.600
Vanadium	NA	—	—	5.800
Zinc	NA	18.100	9.700	37.600
Volatiles (µg/kg)				
1,1-Dichloroethene	—	—	—	—
1,2-Dichloroethene (total)	—	—	—	—

Table 7-4
Summary Analytical Results for Subsurface Soil Samples Collected during Test Trenching Activities
Site 1

	Sample Identification Number			
Parameter	**01S7508**	**01S7518**	**01S7610**	**01S7710**
1,1,1-Trichloroethane	—	—	—	—
Acetone	—	—	—	—
Benzene	—	—	—	—
Chlorobenzene	—	—	—	150.000
Chloroform	—	—	—	—
Ethylbenzene	—	—	16,000.000	40.000
Methylene Chloride	—	—	—	—
Tetrachloroethene	—	—	2,400.000 J	—
Toluene	—	—	72,000.000	6.000 J
Trichloroethene	—	—	—	—
Xylene (total)	—	—	49,000.000	22.000
Semivolatiles (µg/kg)				
1,2,4-Trichlorobenzene	NA	—	—	43.000 J
1,2-Dichlorobenzene	NA	—	16,000.000	—
1,4-Dichlorobenzene	NA	—	—	420.000
2,4-Dimethylphenol	NA	—	1,700.000 J	—
2,4-Dinitrotoluene	NA	—	—	—
2-Chlorophenol	NA	—	—	—
2-Methylnaphthalene	NA	—	6,800.000	220.000 J
2-Methylphenol	NA	—	—	—
2-Nitrophenol	NA	—	—	—
4-Chloro-3-methylphenol	NA	—	—	—
4-methyl phenol	NA	—	—	—
4-Nitrophenol	NA	—	—	—
Acenaphthene	NA	—	—	41.000 J

Table 7-4
Summary Analytical Results for Subsurface Soil Samples Collected during Test Trenching Activities
Site 1

	Sample Identification Number			
Parameter	**01S7508**	**01S7518**	**01S7610**	**01S7710**
Anthracene	NA	—	—	47.000 J
Benzo(a)anthracene	NA	—	—	—
Benzo(a)pyrene	NA	—	—	—
Benzo(b)fluoranthene	NA	—	—	—
Benzo(g,h,i)perylene	NA	—	—	—
Benzo(k)fluoranthene	NA	—	—	—
Butylbenzylphthalate	NA	—	—	—
Chrysene	NA	—	—	54.000 J
Diethylphthalate	NA	—	—	—
Di-n-butylphthalate	NA	—	—	—
Di-n-octylphthalate	NA	—	—	—
Diethylphthalate	NA	—	—	—
Fluoranthene	NA	—	—	69.000 J
Fluorene	NA	—	—	58.000 J
Indeno(1,2,3-cd)pyrene	NA	—	—	—
Naphthalene	NA	—	16,000.000	320.000 J
N-Nitroso-di-n-propylamine	NA	—	—	—
Pentachlorophenol	NA	91.000 J	—	—
Phenanthrene	NA	—	1,500.000 J	120.000 J
Phenol	NA	—	—	—
Pyrene	NA	—	—	120.000
bis(2-Ethlyhexy)phthalate	NA	—	—	—
bis(2-chloroethyl)ether	NA	—	—	—
Pesticides and PCBs (µg/kg)				
4,4'-DDD	NA	3.500 J	—	—

Table 7-4
Summary Analytical Results for Subsurface Soil Samples
Collected during Test Trenching Activities
Site 1

	Sample Identification Number			
Parameter	01S7508	01S7518	01S7610	01S7710
4,4'-DDE	NA	3.200 J	—	4.200
4,4'-DDT	NA	0.860 J	—	—
Aldrin	NA	—	0.790 J	—
Aroclor 1242	NA	—	—	—
Aroclor 1248	NA	—	—	1,700.000
Aroclor 1254	NA	—	—	1,000.000
Aroclor 1260	NA	—	76.000 J	—
Dieldrin	NA	1.100 J	1.100 J	—
Endosulfan I	NA	—	0.200 J	—
Endosulfan II	NA	—	—	0.890 J
Endosulfan sulfate	NA	—	—	—
Endrin	NA	1.000 J	—	—
Endrin aldehyde	NA	—	—	—
Endrin ketone	NA	—	—	—
Heptachlor	NA	—	—	—
Heptachlor epoxide	NA	—	—	—
Methoxychlor	NA	—	—	0.440 J
alpha-Chlordane	NA	5.200	—	15.000 J
beta-BHC	NA	—	—	—
delta-BHC	NA	—	—	0.300 J
gamma-BHC (Lindane)	NA	—	0.075 J	0.075 J
gamma-Chlordane	NA	5.600	0.800 J	0.240 J

Table 7-4
Summary Analytical Results for Subsurface Soil Samples
Collected during Test Trenching Activities
Site 1

	Sample Identification Number			
Parameter	**01S7715**	**01S7806**	**01S7809**	**01G79***
Inorganics (mg/kg)				**(µg/L)**
Aluminum	9,140.000	3,290.000	279.000	218,000.000 J
Antimony	—	—	—	52.400
Arsenic	1.500	0.950	—	14.500
Barium	15.700	6.900	1.500	1,030.000
Beryllium	—	—	—	1.600
Cadmium	—	—	—	353.000
Calcium	126.000	212.000	26.600	76,200.000
Chromium (total)	9.600	2.700	—	425.000
Cobalt	—	—	—	82.700
Copper	—	—	—	171.000
Cyanide	—	—	—	66.500
Iron	4,700.000	1,440.000	90.600	181,000.000
Lead	—	—	—	1,060.000 J
Magnesium	272.000	120.000	—	14,000.000
Manganese	8.200	5.100	—	750.000
Mercury	—	—	—	7.200
Nickel	—	—	—	280.000
Potassium	—	—	—	14,000.000
Selenium	—	—	—	—
Silver	—	—	—	18.200
Sodium	48.000	33.400	30.100	8,210.000
Vanadium	9.500	5.200	—	209.000
Zinc	8.900	29.100	27.600	8,120.000

Table 7-4
Summary Analytical Results for Subsurface Soil Samples
Collected during Test Trenching Activities
Site 1

	Sample Identification Number			
Parameter	**01S7715**	**01S7806**	**01S7809**	**01G79***
Volatiles (µg/kg)				**(µg/L)**
1,1-Dichloroethene	—	—	—	—
1,2-Dichloroethene (total)	—	—	—	—
1,1,1-Trichloroethane	—	—	—	—
Acetone	—	—	—	—
Benzene	—	—	—	9.000 J
Carbon Disulfide	—	—	—	2.000 J
Chlorobenzene	—	6.000 J	—	—
Chloroethane	—	—	—	2.000 J
Chloroform	—	—	—	—
Ethylbenzene	—	—	—	—
Methylene Chloride	—	—	—	—
Tetrachloroethene	—	—	—	—
Toluene	—	—	—	3.000 J
Trichloroethene	—	—	—	—
Xylene (total)	—	—	—	—
Semivolatiles (µg/kg)				**(µg/L)**
1,2,4-Trichlorobenzene	—	—	—	—
1,2-Dichlorobenzene	—	—	—	—
1,4-Dichlorobenzene	—	—	—	10.000 J
2,4-Dimethylphenol	—	—	—	—
2,4-Dinitrotoluene	—	—	—	—
2-Chlorophenol	—	—	—	—
2-Methylnaphthalene	—	—	—	13.000 J
2-Methylphenol	—	—	—	—

Table 7-4
Summary Analytical Results for Subsurface Soil Samples Collected during Test Trenching Activities
Site 1

	Sample Identification Number			
Parameter	01S7715	01S7806	01S7809	01G79*
2-Nitrophenol	—	—	—	—
4-Chloro-3-methylphenol	—	—	—	—
4-methyl phenol	—	—	—	—
4-nitro phenol	—	—	—	—
Acenaphthene	—	—	—	—
Anthracene	—	—	—	—
Benzo(a)anthracene	—	—	—	—
Benzo(a)pyrene	—	—	—	—
Benzo(b)fluoranthene	—	—	—	—
Benzo(g,h,i)perylene	—	—	—	—
Benzo(k)fluoranthene	—	—	—	—
Butylbenzylphthalate	—	—	—	—
Chrysene	—	—	—	—
Di-n-butylphthalate	—	39.000 J	—	—
Di-n-octylphthalate	—	—	—	—
Diethylphthalate	—	—	—	8.000 J
Fluoranthene	—	—	—	—
Fluorene	—	—	—	—
Indeno(1,2,3-cd)pyrene	—	—	—	—
Naphthalene	—	—	—	—
N-Nitrosodiphenylamine	—	—	—	18.000 J
N-Nitroso-di-n-propylamine	—	—	—	—
Pentachlorophenol	—	—	—	—
Phenanthrene	—	—	—	—
Phenol	—	—	—	—

Table 7-4
Summary Analytical Results for Subsurface Soil Samples Collected during Test Trenching Activities
Site 1

	Sample Identification Number			
Parameter	**01S7715**	**01S7806**	**01S7809**	**01G79***
Pyrene	—	—	—	—
bis(2-Ethlyhexy)phthalate	—	—	—	—
bis(2-chloroethyl)ether	—	—	—	—
Pesticides and PCBs (µg/kg)				**(µg/L)**
4,4'-DDD	—	—	—	—
4,4'-DDE	—	1.300 J	—	0.024 J
4,4'-DDT	—	—	—	0.015 J
Aldrin	—	—	—	—
Aroclor 1242	—	840.000	—	—
Aroclor 1248	—	—	—	—
Aroclor 1254	—	—	—	—
Aroclor 1260	—	—	—	—
Dieldrin	—	—	—	—
Endosulfan I	—	—	—	—
Endosulfan II	—	—	—	—
Endosulfan sulfate	—	—	—	0.035 J
Endrin	—	—	—	—
Endrin aldehyde	—	—	—	—
Endrin ketone	—	—	—	—
Heptachlor	—	—	—	0.059 J
Heptachlor epoxide	—	—	—	—
Methoxychlor	—	—	3.300 J	—
alpha-BHC	—	—	—	—
alpha-Chlordane	—	—	—	0.005 J
beta-BHC	—	—	—	0.033 J

Table 7-4
Summary Analytical Results for Subsurface Soil Samples Collected during Test Trenching Activities
Site 1

	Sample Identification Number			
Parameter	**01S7715**	**01S7806**	**01S7809**	**01G79***
delta-BHC	—	—	—	—
gamma-BHC (lindane)	0.090 J	—	—	—
gamma-Chlordane	—	—	—	0.033 J

	Sample Identification Number			
Parameter	**01S8118**	**01S8120**	**01S8210**	[illegible]
Inorganics (mg/kg)				
Aluminum	3,100.000	141.000	1,340.000	721.000
Antimony	15.100	—	—	—
Arsenic	0.990	—	—	—
Barium	1,050.000	3.000	1.100	0.690
Cadmium	14.500	—	—	—
Calcium	819.000	—	—	—
Chromium (total)	19.400	—	276.000	—
Cobalt	—	—	—	—
Copper	209.000	—	—	—
Cyanide	—	—	—	—
Iron	4,000.000	102.000	15,900.000	1,830.000
Lead	241.000 J	0.780 J	19.800 J	3.600 J
Magnesium	117.000	—	—	—
Manganese	76.000	2.500	46.000	6.700
Mercury	0.130	—	—	—
Nickel	55.700	—	—	—
Selenium	—	—	—	—
Silver	25.900	—	—	—

Table 7-4
Summary Analytical Results for Subsurface Soil Samples
Collected during Test Trenching Activities
Site 1

	Sample Identification Number			
Parameter	**01S8118**	**01S8120**	**01S8210**	**01S8214**
Sodium	—	—	406.000	—
Vanadium	3.200	—	—	2.900
Zinc	473.000	12.300	15.600	—
Volatiles (µg/kg)				
1.1-Dichloroethene	—	—	—	—
1.2-Dichloroethene (total)	—	—	—	—
1,1,1-Trichloroethane	—	—	—	—
Acetone	—	—	—	11.000
Benzene	—	—	—	—
Chlorobenzene	—	—	—	—
Chloroform	—	—	—	—
Ethylbenzene	—	—	—	—
Methylene Chloride	—	—	—	—
Tetrachloroethene	—	—	26,000.000 J	—
TCLP (µg/L)	—	NA	367.000	—
Toluene	—	—	2,300,000.000	2.000 J
Trichloroethene	2.000 J	—	—	—
Xylene (total)	—	—	—	—
es (µg/kg)				
1,2,4-Trichlorobenzene	—	—	—	—
1,2-Dichlorobenzene	—	—	62,000.000	—
1.4-Dichlorobenzene	—	—	4,300.000 J	—
2,4-Dimethylphenol	—	—	610,000.000	—
2,4-Dinitrotoluene	—	—	—	—
2-Chlorophenol	—	—	—	—

Table 7-4
Summary Analytical Results for Subsurface Soil Samples
Collected during Test Trenching Activities
Site 1

	Sample Identification Number			
Parameter	01S8118	01S8120	01S8210	01S8214
2-Methylnaphthalene	—	—	3,800.000 J	—
2-Methylphenol	—	—	19,000.000	—
2-Nitrophenol	—	—	—	—
4-Chloro-3-methylphenol	—	—	1,400.000 J	—
4-Methylphenol	—	—	360,000.000	—
4-Nitrophenol	—	—	—	—
Acenaphthene	—	—	—	—
Anthracene	—	—	—	—
Benzo(a)anthracene	—	—	—	—
Benzo(a)pyrene	—	—	—	—
Benzo(b)fluoranthene	—	—	—	—
Benzo(g,h,i)perylene	—	—	—	—
Benzo(k)fluoranthene	—	—	—	—
Butylbenzylphthalate	—	—	—	—
Chrysene	—	—	—	—
Di-n-butylphthalate	—	—	—	—
Di-n-octylphthalate	—	—	—	—
Diethylphthalate	—	—	—	—
Fluoranthene	—	—	—	—
Fluorene	—	—	—	—
Indeno(1,2,3-cd)pyrene	—	—	—	—
Naphthalene	—	—	2,800.000 J	—
N-Nitroso-di-n-propylamine	—	—	—	—
Pentachlorophenol	—	—	—	—
Phenanthrene	—	—	—	—

Table 7-4
Summary Analytical Results for Subsurface Soil Samples Collected during Test Trenching Activities
Site 1

	Sample Identification Number			
Parameter	**01S8118**	**01S8120**	**01S8210**	**01S8214**
Phenol	—	—	5,000.000 J	—
Pyrene	—	—	—	—
bis(2-Ethlyhexy)phthalate	—	—	—	—
bis(2-chloroethyl)ether	—	—	—	—
Pesticides and PCBs (µg/kg)				
4,4'-DDD	—	—	—	—
4,4'-DDE	2.500	—	10.000 J	5.100
4,4'-DDT	—	—	10.000 J	36.000
Aldrin	1.000 J	—	—	—
Aroclor 1242	—	—	—	—
Aroclor 1248	—	—	—	—
Aroclor 1254	260.000	—	—	—
Aroclor 1260	—	—	—	—
Dieldrin	—	—	1.600 J	—
Endosulfan I	—	—	—	—
Endosulfan II	—	—	8.600 J	—
Endosulfan sulfate	—	—	13.000 J	—
Endrin	0.350 J	—	—	0.076 J
Endrin aldehyde	—	—	0.920 J	—
Endrin ketone	—	—	0.780 J	—
Heptachlor	—	—	—	—
Heptachlor epoxide	0.350 J	—	—	—
Methoxychlor	—	—	—	—
alpha-BHC	—	—	0.440 J	—
alpha-Chlordane	0.290 J	—	14.000	—

Table 7-4
Summary Analytical Results for Subsurface Soil Samples Collected during Test Trenching Activities
Site 1

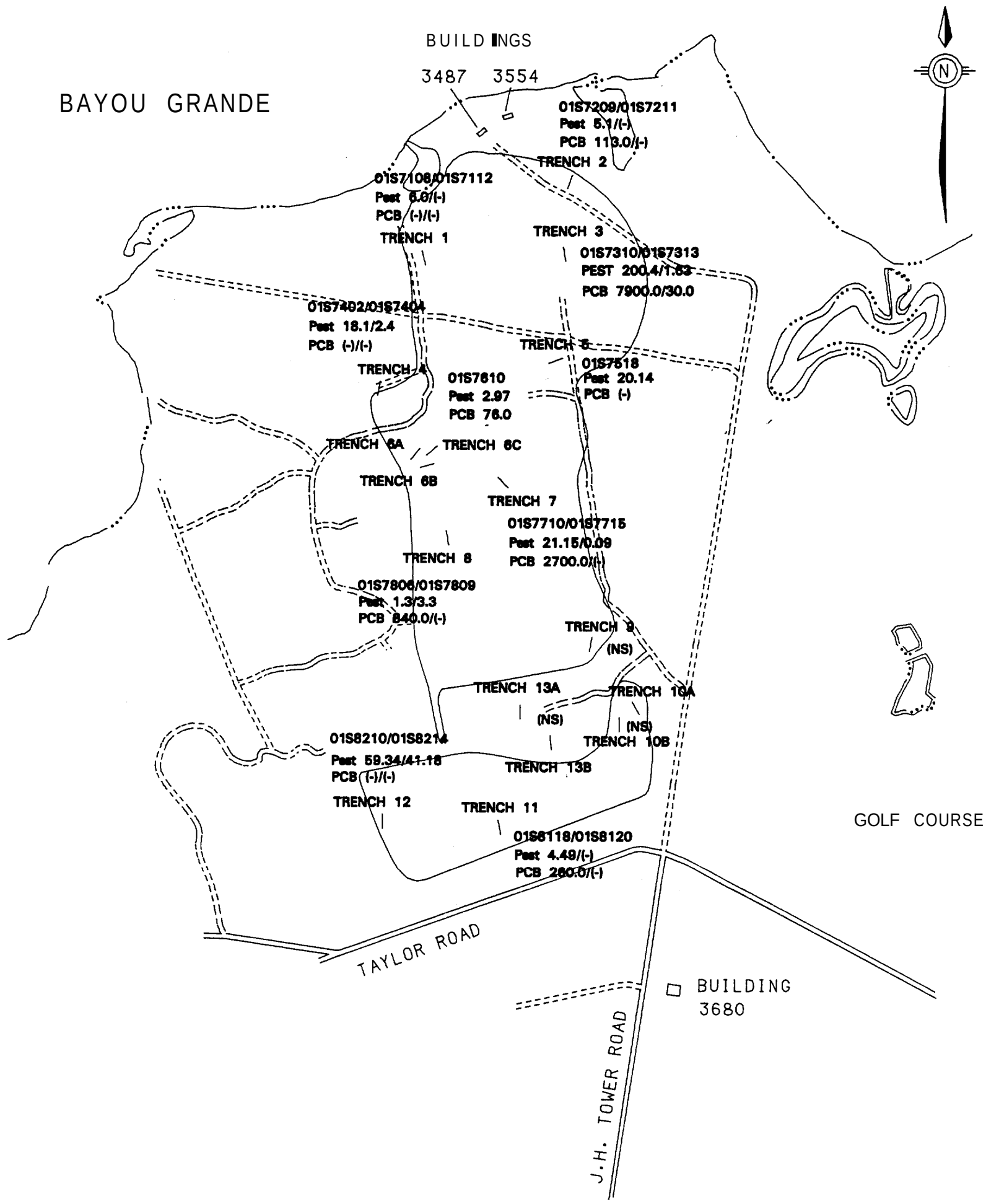
	Sample Identification Number			
Parameter	**01S8118**	**01S8120**	**01S8210**	**01S8214**
beta-BHC	—	—	—	—
delta-BHC	—	—	—	—
gamma-BHC (lindane)	—	—	—	—
gamma-Chlordane	—	—	—	—

Key:

	=	Groundwater sample 01679 collected from test trench 9
mg/kg	=	Milligrams per kilogram
µg/kg	=	Micrograms per kilograms
µg/L	=	Micrograms per liter
TCLP	=	Toxicity characteristic leaching procedure
—	=	Indicates parameter analyzed but not detected above method detection limit.
B	=	Parameter positively detected; however reported concentration is approximate.
	=	Reported results *are* rejected due to QC deficiencies, the presence of the compound cannot be verified.
NA	=	Parameter not analyzed.

selenium, and silver) plus cyanide detected in subsurface trench samples. In the following discussion, the term "total inorganics" will refer to these eight metals and cyanide.

Additionally, references to organic parameter group (VOCs, semivolatiles, pesticides, and PCBs) concentrations will also indicate "total" concentrations, unless specified otherwise. Also shown on Figure 7-5 are total VOC and total semivolatiles concentrations detected in these samples. Total pesticides and total PCBs concentrations detected in subsurface samples are illustrated on Figure 7-6. Because numerous analytical parameters were commonly present in test trench samples, only the most predominantly detected contaminants (in terms of magnitude) will be specifically discussed. Additionally, the terms low, moderate, and high will be used to describe the detected parameter concentrations, in order to relatively compare these results.



LEGEND

	COASTLINE / SURFACE WATER FEATURE
	UNPAVED ROAD
—	TEST TRENCH (APPROXIMATE ORIENTATION NOT TO SCALE)
Pest	TOTAL PESTICIDES IN µG/KG
PCB	TOTAL PBCS IN µG/KG
01SE7108	SAMPLE IDENTIFICATION NUMBER
1.3/3.3	TRENCH CONTENTS / NATIVE SOIL SAMPLE SAMPLE
(-)	PARAMETER NOT DETECTED
(NS)	TRENCH NOT SAMPLED FOR TAL/TCL

600 0 600

SCALE FEET

REMEDIAL INVESTIGATION REPORT

SITE 1

NAS PENSACOLA

FIGURE 7-6

TOTAL PESTICIDES AND PCBS DETECTED IN TEST TRENCH SOIL SAMPLES

DATE: 12/3/93 | DWG NAME: 59FIG7-6

Native subsurface soil within the landfill generally comprised silty, fme- to medium-grained quartz sand, light tan to brown in color. Lithologic descriptions of all test trench excavations are presented in Appendix B.

Test Trench 1

Test trench 1 was excavated in the northwestern portion of the landfill where construction debris was reported to have been disposed. The area excavated was a mound of soil cresting at approximately 5 feet above the surrounding land. Construction debris mixed with soil was encountered within the first foot of the excavation and continued to approximately 8 feet bls. Sample 01S7108 was collected from the interval with debris consisting of concrete, rebar, wood, and brick rubble with a small amount of what appeared to be coal fragments. No physical indication of contamination was present through the excavated debris interval. Native soil underlying the debris interval was encountered at approximately 8 feet bls. The test trench was terminated in dry native soil at approximately 12 feet bls. Sample 01S7112 was collected from the native soil interval.

As illustrated on Figures 7-5 and 7-6, relatively low concentrations of total inorganics (46.95 mg/kg) and pesticides (6.0 μg/kg) were detected in the sample 01S7108 from the debris interval. Metals detected in this sample included arsenic (0.85 mg/kg), barium (5.7 mg/kg), chromium (4.8 mg/kg), and lead (35.6 mg/kg). Pesticides detected in this sample included 4,4'-DDE (2.6 μg/kg) and 4,4'-DDT (2.4 μg/kg). Sample 01S7112, from the native soil interval, contained only low concentrations of total inorganics (3.9 mg/kg).

Based on the analytical results of subsurface samples collected from test trench 1, the trench contents presently do not appear to be a source of contamination that would affect site groundwater quality.

Test Trench 2

Test trench 2 was excavated in the northeastem-most portion of the landfill in an area clear of trees, with level land surface and scrub underbrush vegetative cover. Approximately 3 feet of sandy soil overburden was removed before penetrating landfill waste. At this depth, an interval of waste material was encountered that extended to 9 feet bls. Sample 0187209 was collected from the waste interval. The waste appeared to be partially domestic in nature, consisting of plastic, paper, metal, and glass mixed with sandy soil. Portions of the waste may have been bumed before burial, as dark, charred material indicated. An empty, ruptured 55-gallon metal drum was in the waste interval at approximately 5 feet bls. Dry native soil was encountered immediately below the waste interval at approximately 9 feet bls. The test trench terminated in moist native soil at approximately 11 feet bls; however, the water table was not reached. Sample 01S7211 was collected from the native soil interval.

As illustrated on Figures 7-5 and 7-6, concentrations of total inorganics (89.88 mg/kg), the semivolatile di-n-butylphthalate (1,200 μg/kg), PCBs (113 μg/kg), and low concentrations of pesticides (5.1 μg/kg) were detected in the waste interval sample 01S7209. Inorganics detected in this sample included all eight RCRA metals and cyanide, except selenium and silver. Of this group, barium (12.8 mg/kg), chromium (12.5 mg/kg), and lead (60.2 mg/kg) occurred at the highest concentrations. The predominant pesticide in this sample was 4,4'-DDD (3.6 μg/kg). The PCBs aroclor 1254 (50 μg/kg) and Aroclor 1260 (63 μg/kg) were also detected in this sample. Only reduced concentrations of total inorganics (1.3 mg/kg) and the VOC 1,1,1 trichloroethane (1.0 μg/kg) were detected in the native soil sample 01S7211.

Observations made during trenching indicate the bottom of the waste interval here is not in direct contact with the water table. TCLP analysis conducted on the waste interval sample 0187209 exhibited no leachable constituents above TCLP reporting limits. Based on the analytical results of subsurface samples and the proximity of the waste interval to the water table, the contents of

this trench presently do not appear to be a source of contamination that would greatly impact site groundwater quality.

Test Trench 3

Test trench 3 was excavated in the north-northeastern portion of the landfill in an area clear of trees, with slightly irregular land surface and scrub underbrush vegetation cover. Approximately 4 feet of sandy soil overburden was removed before penetrating landfill waste. At this depth, an interval of waste material was encountered that extended to 10 feet bls. Sample 01S7310 was collected from the waste interval. The waste was a dark gray to black clayey material that appeared to be burned moist ash residue mixed with sandy soil. A distinct fuel odor was noted from the waste and PID readings of up to 80 ppm were noted. Dry native soil was encountered immediately below the waste interval at approximately 10 feet bls. The test trench was terminated in dry native soil at approximately 13 feet bls. Sample 01S73213 was collected from the native soil interval.

As illustrated on Figures 7-5 and 7-6, concentrations of total inorganics (1,792.5 mg/kg), VOCs (286 μg/kg), semivolatiles (10,390 μg/kg), pesticides (200.4 μg/kg), and the PCB Aroclor 1260 (7,900 μg/kg) were detected in sample 01S7310 collected from the waste interval. Inorganics detected in this sample included all eight RCRA metals and cyanide. Barium (392 mg/kg), cadmium (214 mg/kg), and chromium (915 mg/kg) occurred at the highest concentrations. Several VOCs were detected in this sample. Chlorobenzene (27 μg/kg), tetrachloroethene (16 μg/kg), toluene (100 μg/kg), and xylenes (130 μg/kg) were the VOCs detected at the highest concentrations. Numerous semivolatiles were detected in the waste sample. Detected semivolatile compounds included 1,2-dichlorobenzene (810 μg/kg), 1,4-dichlorobenzene (3,300 μg/kg), 2,4-dinitrotoluene (1,500 μg/kg), naphthalene (2,500 μg/kg), and phenanthrene (580 μg/kg). Several pesticides were detected in the waste sample, including 4,4'-DDE (110 μg/kg), dieldrin (72 μg/kg), and heptachlor epoxide (11 μg/kg). Sample 0187313, from

the native soil interval, contained reduced concentrations of total inorganics (7.9 mg/kg), pesticides (1.63 μg/kg), and the PCB Aroclor 1260 (30.0 μg/kg).

The analysis of the waste interval sample 01S7310 exhibited no leachable constituents above TCLP reporting limits. As noted during trenching, the bottom of the waste interval here is at least 3 feet above the water table. Based on this information and the analytical results of subsurface samples from the test trench, relatively high concentrations of contaminants do not appear to be leaching from trench wastes at this location. However, the significant concentrations of inorganics and organics in the waste interval indicate this area of the landfill previously may have been a source of contamination, and potentially may be leaching lower concentrations (below TCLP reporting limits) of these contaminants or non-TCLP parameters to the groundwater system.

Test Trench 4

Test trench 4 was excavated adjacent to the northern side of the tar pit, near the west-central landfill boundary, to sample the soil adjacent to and immediately below the pit. In doing so, a trench was excavated alongside and extending beneath the bottom of the pit, exposing stained and unstained native soil below. A horizontal/angled boring was performed with a stainless-steel hand auger to collect soil below the pit. The tar pit is approximately 1.5 feet deep, with stained soil extending approximately 1 foot below the pit (approximately 2.5 feet bls). Sample 01S7402 was collected from the interval of stained soil alongside and below the tar pit. Sample 01S7404 was collected from the unstained native soil beneath the tar pit, immediately below the stained soil interval.

As illustrated on Figures 7-5 and 7-6, relatively low concentrations of total inorganics (22.5 mg/kg), the VOC toluene (7.0 μg/kg), and pesticides (18.1 μg/kg), and moderate Concentrations of semivolatiles (1460 μg/kg) were detected in sample 0187402 from the stained soil interval. Inorganics detected in this sample included arsenic (1.5 mg/kg), barium

(12.2 mg/kg), and chromium (4.0 mg/kg). Semivolatiles present in the stained soil included benzo(g,h,i)perylene (490 μg/kg), chrysene (470 μg/kg), and pyrene (340 μg/kg). Pesticides detected in this sample included 4,4'-DDT (2.3 μg/kg), endrin ketone (3.0 μg/kg), and methoxychlor (12.0 μg/kg). Sample 01S7404 from the underlying native soil contained reduced concentrations of total inorganics (6.6 mg/kg) and pesticides (2.4 μg/kg of endrin ketone).

TCLP analysis conducted on a sample of the tar waste, 01S0201, and the stained soil interval, 0187402, exhibited no leachable constituents above TCLP reporting limits. Based on the analytical results of the waste and subsurface samples, the tar pit does not appear to be a source of contamination that would affect site groundwater quality. ,However, the potential exists for lower concentrations (below TCLP detection limits) of detected contaminants or non-TCLP parameters to leach to the groundwater system.

Test Trench 5

Test trench 5 was excavated in the northcentral portion of the landfill, where a creosote-soaked wooden barge reportedly was buried. The trenching was performed in an area with a slightly elevated, *irregular* land surface, planted pine trees, and scrub underbrush vegetation cover. A distinct interval of waste material and the wooden barge were not encountered here during trenching. Instead, small amounts of plastic and wood fragments mixed with the sandy soil were scattered within the first several feet of the excavation. Additionally, a single, empty ruptured 55-gallon drum and an acetylene gas cylinder (partially full) were found approximately 8 feet and 10 feet bls, respectively. Dark gray to black potentially *stained* and/or organic-rich soil was encountered at 15 feet bls; however, no elevated PID readings were observed from *this* material. The excavation was terminated at approximately 18 feet bls in moist, dark gray soil above the water table. Sample 0187508 was collected from the soil immediately adjacent to the ruptured drum (analyzed for VOCs only), and sample 0187518 was collected as a composite of the entire excavated interval.

As illustrated on Figures 7-5 and 7-6, concentrations of total inorganics (6.8 mg/kg), the semivolatile pentachlorophenol (91.0 μg/kg), and pesticides (20.14 μg/kg) were detected in sample 0187518 from the excavated interval. Inorganics detected in this sample included arsenic (1.0 mg/kg), barium (3.1 mg/kg), and chromium (2.7 mg/kg). Pesticides in this sample included 4,4'-DDD (3.5 μg/kg), 4,4'-DDE (3.2 μg/kg), alpha-Chlordane (5.2 μg/kg), and gamma-Chlordane (5.6 μg/kg). Sample 0187508, collected from soil adjacent to the ruptured drum, contained no detectable VOCs.

Based on the analytical results of subsurface samples, except for pentachlorophenol, the contents of this trench presently do not appear to be a source of contamination that would affect site groundwater quality. Because no discrete interval of waste was encountered in this trench, no TCLP analyses were performed on sample 01S7518; therefore, the leachability of pentachlorophenol in this soil was not determined.

Test Trenches 6A, 6B, and 6C

Test trenches 6A, 6B, and 6C were excavated in the west-central portion of the landfill, where aerial photographs indicated intense landfill activities had occurred during the 1960s. All excavations were performed in an area approximately 100 feet in diameter. This area is generally clear of trees, with slightly irregular land surface and scrub underbrush vegetation cover. A thin, highly weathered veneer of asphaltic material was observed across most of the clearing's land surface where the trenching was performed. Three trenches were excavated to thoroughly explore the area's subsurface. No waste material was encountered in any of the three test trenches. However, heavily stained soil emitting a strong fuel odor was encountered at depths that varied from approximately 6 to 8 feet bls (depending on land surface elevation). The stained soil extended into the water table, becoming saturated at approximately 8 to 10 feet bls. A composite sample, 01S7510, was collected from the stained soil interval of all three trenches.

As illustrated on Figures 7-5 and 7-6, concentrations of total inorganics (82.2 mg/kg), VOCs (139,400 μg/kg), semivolatiles (42,000 μg/kg), pesticides (2.97 μg/kg), and the PCB Aroclor 1260 (76.0 μg/kg) were detected in sample 01S7610 from the stained soil interval. The predominant inorganic in this sample was chromium (79.5 μg/kg). Detected VOCs included ethylbenzene (16,000 μg/kg), tetrachloroethene (2,400 μg/kg), toluene (72,000 μg/kg), and xylenes (49,000 μg/kg). Several semivolatiles were detected in the stained soil, including 1,2-dichlorobenzene (16,000 μg/kg), 2-methylnapthalene (6,800 μg/kg), and naphthalene (16,000 μg/kg). Several pesticides were detected in the sample, the highest concentration of which was dieldrin (1.1 μg/kg).

As noted during trenching, the interval of stained soil here extends into the water table. It is not clear whether the stained soil interval is the result of fuel and or other waste liquids having been discharged into a burial trench and then covered, or the remnants of a floating (primarily organics/hydrocarbons) contaminant plume migrating through the area from an upgradient location. Based on this information and the analytical results of subsurface samples from the three trenches, the stained soil in this area appears to be a probable source of contamination that is likely impacting shallow groundwater.

Test Trench 7

Test trench 7 was excavated in the central portion of the landfill, where aerial photographs indicated intense activities had occurred during the 1960s. The trenching was performed in a level area densely planted in pine trees, which has little to no vegetation cover due to a thick pine straw floor. Approximately 4 feet of sandy soil overburden was removed before penetrating landfill waste. At this depth, an interval of waste material extending to 10 feet bls was encountered. Sample 01S7710 was collected from the waste interval. The waste consisted of paper, plastic, and glass intermingled with soil and industrial wastes, including rubber and cloth gloves, rubber hoses, and ignitable flares. Plastic containers of medical waste also were

identified. PID readings of up to 90 ppm were recorded from the waste interval. Dry native soil was encountered immediately below it at approximately 10 feet bls. This soil consisted of gray, silty, clayey, sandy material that appeared stained by leachate from the overlying wastes. The test trench was terminated in dry native soil at approximately 15 feet bls. Sample 01S7715 was collected from the native soil interval.

As Figures 7-5 and 7-6 show, concentrations of total inorganics (66.9 mg/kg), VOCs (218.0 μg/kg), semivolatiles (1,12.0 μg/kg), pesticides (21.15 μg/kg), and PCBs (2,700.0 μg/kg) were detected in sample 01S7710 from the waste interval. Inorganics in this sample included the five of the eight RCRA-metals, minus mercury, selenium, and silver. Of this group, barium (18.2 mg/kg) and lead (15.9 mg/kg) occurred at the highest concentrations. VOCs in the waste sample included chlorobenzene (150 μg/kg), ethylbenzene (40 μg/kg), toluene (6.0 μg/kg), and xylene (22 μg/kg). Several semivolatile compounds were present in the sample, including 1,4-dichlorobenzene (420 μg/kg), 2-methynapthalene (220 μg/kg), naphthalene (320 μg/kg), phenanthrene (120 μg/kg), and pyrene (120 μg/kg). Pesticides in this sample included 4,4'-DDE (4.2 μg/kg) and alpha-Chlordane (15 μg/kg). The PCBs detected in sample 01S7710 were Aroclor 1248 (1,700 μg/kg) and Aroclor 1254 (1000 μg/kg). Sample 0187715 from the underlying native soil contained only reduced concentrations of total inorganics (26.8 mg/kg) and pesticides (0.09 μg/kg of gamma-BHC).

Sample 01S7710 exhibited no leachable constituents above TCLP reporting limits. As noted during trenching, the bottom of the waste interval at this location is at least 5 feet above the water table. Based on this information and the analytical results of subsurface samples from the trench, relatively high concentrations of contaminants presently do not appear to be leaching from trench wastes at this location. However, due to the concentrations of organics (VOCs and semivolatiles) in the waste, this area of the landfill previously may have been a source of

contamination, and potentially may be leaching lower concentrations (below TCLP detection limits) of these contaminants or non-TCLP parameters to the groundwater system.

Test Trench 8

Test trench 8 was excavated in the central portion of the landfill, where aerial photographs indicated intense landfill activities had occurred during the 1960s. The trenching was performed in an area which is generally planted in pine trees; however, no trees were present in the immediate area of the excavation. Land surface in this location was slightly irregular, with sizable chunks of concrete rubble exposed through a grassy vegetative cover. Approximately 2 feet of sandy soil overburden was removed before penetrating landfill waste. At this depth, an interval of waste material extending to approximately 6 feet bls was encountered. Sample 01S7806 was collected from the waste interval. The waste contained paper, plastic, and metal debris intermingled with soil and industrial wastes, including paint cans and empty, crushed 55-gallon drums. PID readings of up to 30 ppm were recorded from the waste. Dry native soil was encountered immediately below the waste interval at approximately 6 feet bls. This soil consisted of buff white quartz sand. The test trench terminated in moist native soil at approximately 9 feet bls; however, the water table was not reached. Sample 0187809 was collected from the native soil interval.

As Figures 7-5 and 7-6 show, concentrations of total inorganics (10.55 mg/kg), and VOC (6.0 μg/kg), semivolatile (39.0 μg/kg), pesticide (1.3 μg/kg), and PCB (840.0 μg/kg) compounds were detected in sample 01S7806 from the waste interval. Inorganics detected included arsenic (0.95 mg/kg), barium (6.9 mg/kg), and chromium (2.7 mg/kg). The only VOCs, semivolatiles, pesticides, and PCBs detected in this sample were chlorobenzene (6.0 μg/kg), di-n-butylphthalate (39 μg/kg), 4,4'-DDE (1.3 μg/kg), and Aroclor 1242 (840 μg/kg), respectively. Sample 0187809 from the underlying native soil contained only

reduced concentrations of inorganics (1.5 mg/kg) and a slightly higher concentration of the pesticide methoxychlor (3.3 μg/kg).

Sample 01S7806 exhibited no leachable constituents above TCLP reporting limits. Based on the analytical results of the subsurface samples, the contents of this trench do not appear to be a source of contamination that would affect site groundwater quality. However, because PCBs were not analyzed during the TCLP, the leachability of the detected Aroclor 1242 was not determined.

Test Trench 9

Test trench 9 was excavated in the southeastern portion of the landfill, where asbestos and chemical wastes were reportedly buried during the 1960s. The trenching was performed in a level area of the landfill densely planted in pine trees that has little to no vegetative cover due to a thick pine straw floor. Approximately 2 feet of sandy soil overburden was removed before penetrating landfill waste. At this depth, an interval of waste material that extended into the water table was encountered. The water table was noted at approximately 14 feet bls. Sample 0187914 was collected from the waste interval. The waste contained paper, plastic, glass, wood, and metal debris intermingled with soil and a small amount of what appeared to be plastic medical product wastes. PID readings of up to 56 ppm were recorded. Because the waste interval was in contact with the water table, groundwater sample 01G79 was collected from the bottom of the excavation. The test trench terminated at approximately 15 feet bls.

Waste interval sample 0187914 was analyzed for TCLP. No leachable constituents above TCLP reporting limits were detected. As listed on Table 7-4, concentrations of several inorganic constituents, VOCs, semivolatiles, and pesticides were detected in shallow groundwater sample 01G79 from the trench. Specifically, the metals antimony (52.4 μg/L), cadmium (353 μg/L), chromium (425 μg/L), lead (1,060 μg/L), mercury (7.2 μg/L), and nickel

(280 μg/L), and the VOC benzene (9.0 μg/L) were present in this sample at concentrations exceeding FPDWS MCLs. However, the groundwater sample from the trench was highly turbid, which likely contributed to the elevated metal concentrations that were detected. Based on these analytical results, shallow groundwater here may have been impacted either by the contents of this test trench or some other upgradient contamination source.

Test Trenches 10A and 10B

Test trenches 10A and 10B were excavated in the southeastern portion of the landfill where irregular land surface indicated landfill activities had occurred. Several mounds of soil cresting at approximately 3 feet above the surrounding surface were present in the excavation area. However, no physical indication of subsurface fill or waste material was observed in either of the two test trenches during the excavation process. Only dry native soil consisting of light tan to gray, fine- to medium-grained quartz sand was encountered approximately 14 feet bls, where the trenches terminated.

Because no indication of subsurface waste or contamination was observed during excavation, no subsurface samples were collected from either of these trenches. However, the results of surface soil sample 01S8001 from this location indicate that concentrations of inorganics and pesticides are in the mounded surface soil (see Section 5.1 for a discussion of surface soil results). Based on this information, the mounded soil there may be impacted material transported to the site for disposal.

Test Trench 11

Test trench 11 was excavated in the southern portion of the landfill, where aerial photographs indicated landfill activities had occurred during the 1950s. The trenching was performed in an area with a regrowth of sizable pine trees and scrub underbrush vegetation. No trees were present in the immediate area of the excavation. Topographically, land surface elevation here

is level and notably higher (approximately 25 feet above msl) than the remaining landfill area. Approximately 4 feet of sandy soil overburden was removed before penetrating landfill waste. At this depth, an interval of waste material was encountered that extended to approximately 18 feet bls. The waste interval occurred in three layers, each approximately 2 to 3 feet in thickness separated by 2 to 3 feet of sandy soil. Sample 01S8118 was collected from the waste interval. The waste contained significant amounts of apparently burned and charred paper, plastic, and glass intermingled with soil and industrial wastes including empty 5-gallon buckets and other metal debris. Additionally, small amounts of a light blue, crusty oxidized material was discovered that could not be identified. PID readings of up to 60 ppm were recorded. Dry native soil was encountered immediately below the waste interval at approximately 18 feet bls. This soil consisted of buff white quartz sand. The test trench terminated in dry native soil at approximately 20 feet bls. Sample 01S8120 was collected from the native soil interval.

As Figures 7-5 and 7-6 show, concentrations of total inorganics (1,351.92 mg/kg), the VOC trichloroethene (2.0 μg/kg), pesticides (4.49 μg/kg), the PCB Aroclor 1254 (260.0 μg/kg) were detected in sample 01S8118 from the waste interval. Inorganics detected in this sample included all eight RCRA metals, except selenium. Barium (1,050 mg/kg), lead (241 mg/kg), and silver (25.9 mg/kg) occurred at the highest concentrations. Several pesticides were detected with 4,4'-DDE (2.5 μg/kg) and aldrin (1.0 μg/kg) occurring at the highest concentrations. Sample 01S8120 from the underlying native soil only contained reduced concentrations of inorganics (3.78 mg/kg).

The waste interval sample 01S8118 exhibited no leachable constituents above TCLP reporting limits. Based on the analytical results of the subsurface samples, the trench's contents presently do not appear to be a source of contamination that would affect site groundwater quality. However, because PCBs were not analyzed during the TCLP, the leachability of the detected Aroclor 1254 was not determined.

Test Trench 12

Test trench 12 was excavated in the southwestern portion of the landfill, where a collapse feature had been located during the 1991 Phase I survey. Aerial photographs indicate landfill activities occurred here during the 1950s. The trenching was performed in an area with a regrowth of sizable pine trees and scrub underbrush vegetation; however, few trees were present in the excavation's immediate area. Topographically, land surface elevation in this area is generally level, except for approximately 30-foot-by-10-foot collapsed area. A crusty iron oxidized hardpan-like substance, along with a dark tar-like material, was exposed at land surface within the collapse. During excavation, additional waste material was encountered (within 1 foot of the surface) extending to approximately 10 feet bls. Sample 01S8210 was collected from the waste interval. The wastes consisted primarily of a dark tar-like or sludge material intermingled with soil, ruptured 5-gallon buckets, and wooden pallets. A strong organic odor was present, along with PID readings of up to 2,400 ppm. Dry native soil consisting of yellow-orange to light gray quartz sand were encountered immediately below the waste interval at 10 feet bls. The test trench terminated in dry native soil at approximately 14 feet bls. Sample 01S8214 was collected from the native soil interval.

As Figures 7-5 and 7-6 show, concentrations of total inorganics (296.9 mg/kg), VOCs (2.32 x 10^6 μg/kg), semivolatiles (1.06 x 10^6 μg/kg), and pesticides (59.34 μg/kg) were detected in sample 01S8210 from the waste interval. The predominant inorganic in this sample was chromium (276.0 mg/kg). The only VOCs detected in this sample were tetrachloroethene (26,000 μg/kg) and toluene (2.3 x 10^6 μg/kg). Several semivolatiles were detected in the waste sample. Those at the highest concentrations were 1,2-dichlorobenzene (62,000 μg/kg), 2,4-dimethylphenol (610,000 μg/kg), 2-methylphenol (19,000 μg/kg), and 4-methylphenol (360,000 μg/kg). Several pesticides were detected in the sample, the highest concentrations of which were 4,4'-DDE (10 μg/kg), 4,4'-DDT (10 μg/kg), endosulfan II (8.6 μg/kg), endosulfan sulfate (13 μg/kg), and alpha-Chlordane (14 μg/kg). Sample 01S8214 from the native soil

interval contained reduced concentrations of inorganics (4.29 mg/kg) and VOCs (13.0 μg/kg; however, different compounds, acetone and toluene, were detected), and slightly lower concentrations of pesticides (41.18 μg/kg).

Sample 01S8210 exhibited only leachable concentrations of tetrachloroethene (376.0 μg/L) above TCLP reporting limits. As noted during trenching, the bottom of the waste interval is at least 4 feet above the water table. Based on this information and the analytical results of subsurface samples collected from the test trench, except for tetrachloroethene, relative high concentrations of contaminants do not appear to be leaching from these wastes. However, detected concentrations of chromium and organic compounds in the waste interval indicate this portion of the landfill previously may have been a source of contamination, and potentially may be leaching lower concentrations (below TCLP detection limits) of these contaminants or non-TCLP parameters to the groundwater system.

Test Trenches WA and 13B

Test trenches 13A and 13B were excavated in the southcentral portion of the landfill to confirm the absence of subsurface fill in this general area. Land surface in the immediate areas of trenching were level and generally clear of trees and underbrush. A small amount of wood debris was at land surface near trench 13B. During excavation no physical indication of subsurface fill or waste material was observed in either of the two test trenches. Only dry native soil consisting of light tan to orange to gray, fine- to medium-grained quartz sand was encountered approximately 11 feet bls, where the trenches terminated in saturated, dark organic stained (water table) soil. Because no indication of subsurface waste or contamination was observed, no samples were collected from these trenches.

7.3 Groundwater

To assess the impact of landfill activities on site groundwater quality, unfiltered groundwater samples were collected using Teflon bailers (see Groundwater Sampling Methodology, Section 5.2.3) during 1993 sampling activities from 23 shallow depth (11 newly installed and 12 existing), 16 intermediate depth (newly installed), and three deep (existing) monitoring wells. Full CLP TAL/TCL analyses were performed on all groundwater samples. Radiation, hexavalent chromium, and physical characterization analyses (PPW) were performed on selected groundwater samples, as indicated in Table 5-6. An additional round of groundwater sampling was performed in 1994 using low-flow sampling techniques. Section 8 discusses this sampling event, which compares 1993 and 1994 results.

In the following sections, groundwater quality will be discussed by depth intervals corresponding to the shallow, intermediate, and deep well intervals monitored onsite. It should be noted no physical separation between the shallow and intermediate depth intervals is apparent, other than relative vertical position, and that these two intervals should be considered part of the same hydrologic system — the surficial zone. However, as discussed in Section 6.2, notable differences generally were observed in the hydraulic properties (i.e., hydraulic conductivities) of the two zones. Following the analytical results sections will be a concluding discussion of groundwater quality incorporating all monitored intervals. Additionally, the conclusion section will present any apparent temporal trends in the current groundwater analytical data as compared to available historical analytical information for Site 1 groundwater.

7.3.1 Analytical Results

Summary analytical results for reference groundwater samples collected in 1993 and used to determine ambient groundwater quality at NAS Pensacola are presented in Tables 7-5 (shallow and intermediate) and 7-9 (deep, see Section 7.3.1.3). Because shallow and intermediate wells are each screened in the same surficial aquifer, samples from these wells have been grouped together for RC calculations. The resulting RCs calculated from this data set will be applied to both the shallow and intermediate well intervals for the site groundwater quality evaluation. Additionally, site groundwater samples will be discussed in the following sections relative to FPDWS/USEPA or FSDWS MCLs, and Florida Groundwater Guidance Concentrations (FGGCs).

As discussed in Section 5.2, shallow and intermediate reference monitoring wells 01GS67, 01GI68, 01GS69, and 01GI70, as well as (potable water) deep supply wells 01DSW50 and 01DSW51, were sampled to obtain the reference data. Notably, shallow and intermediate groundwater samples collected in 1993 from Site 1 and reference well locations were turbid to varying degrees. The results of grain-size analyses conducted on shallow subsurface soil samples indicate 6 to 9 percent of the surficial zone comprises silt to clay-size material while the remaining portion is generally a fine- to medium-grained sand (grain-size analysis results are contained in Appendix C). The finer material produces the turbidity in surficial zone groundwater samples. Given the aquifer lithology, concentrations of many soluble metals in site and reference samples are naturally occurring to NAS Pensacola-area groundwater. However, metals concentrations in turbid unfiltered groundwater samples are affected by added concentrations of metals entrained with and adsorbed to fine-grained aquifer matrix. Metals adsorbed to these sediments are leached during sample preservation. Greatly reduced metal concentrations observed in low turbidity site and reference samples collected in 1994 confirm this effect (see Section 8). Consequently, some of the metals concentrations detected in both 1993 site and reference samples are not indicative of truly solubilized metals concentrations. However, because reference wells are in apparently unaffected areas, concentrations of metals

Table 7-5
Summary Analytical Results for Shallow and Intermediate Reference Groundwater Samples
Site 1
1993
(All results in µg/L)

Parameter	Sample Number								Mean Concentration	RC (2xMC)
	01GS67	01GS67R	01GI68	01GI68R	01GS69	01GS69R	01GI70	01GI70R		
Aluminum	202000.0	273000.W	149000.0	13800.0J	61.6	248000.W	121000.0	70100.W	134618.95	269237.90
Antimony	17.5U	17.35UJ	17.5U	17.35UJ	17.5U	17.35UJ	17.5U	17.35U	17.43	34.86
Arsenic	4.7	R	84.8	R	2.0U	—	27.3	R	28.7	69.4
Barium	237.0	304.0	248.0	40.4	1.0U	442.0	122.0	70.2	182.83	386.88
Beryllium	4.1	6.6	6.3	2.1U	0.5U	6.8	2.9	2.1U	3.79	7.58
Cadmium	1.5U	2.4UJ	2.05U	2.4UJ	1.5U	2.4U	1.5U	2.4UJ	2.02	4.04
Calcium	11300.0	15100.0	31000.0	7980.0	57.5U	9630.0	8860.0	7270.0	11373.44	22748.88
Chromium	266.0J	333.0	268.0J	26.4	4.0U	271.0	224.W	122.0	187.80	376.60
Cobalt	16.4	18.0	32.8	3.65U	4.5U	42.3	21.9	7.8	18.03	38.08
Copper	103.0	160.0	82.2	6.1U	2.0U	121.0	82.0	61.8	72.24	144.48
Cyanide	5.0U	—	5.0U	—	11.7	—	5.0U	—	8.88	13.38
Iron	41100.0J	62100.0	74100.0J	9300.0	43.6J	189000.0	91100.w	63200.0	64992.95	129986.90
Lead	78.9	112.0	32.6	2.95U	1.0U	46.6	38.4	27.1	42.29	84.58
Magnesium	7580.0	9900.0	15400.0	2770.0	24.0U	12400.0	8300.0	6880.0	7766.76	16613.60
Manganese	303.0	434.0	368.0	67.7	1.6	1460.0	197.0	106.0	364.53	729.06
Mercury	2.2	4.0	0.3	0.1U	1.1	1.2	0.76	0.64	1.28	2.56
Nickel	66.4	66.1	102.0J	18.3U	9.0U	121.0	67.4J	18.3U	66.81	111.62

Table 7-5
Summary Analytical Results for Shallow and Intermediate Reference Groundwater Samples
Site 1
1993
(All results in µg/L)

Parameter	Sample Number								Mean Concentration	RC (2xMC)
	01GS67	01GS672	01GI68	01GI68R	01GS69	01GS69R	01GI70	01GI70R		
Potassium	8450.0	9050.0	14600.0	4360.0	836.W	12900.0	7760.0	6840.0	8073.14	16146.28
Selenium	15.0U	90.0U	7.5U	1.8U	1.5U	R	7.5U	R	20.66	41.1
Silver	2.0U	2.5U	2.0U	2.5U	2.0U	2.5U	2.0U	2.5U	2.26	4.60
Sodium	9800.0	7980.0	19400.0	8170.0	70.0U	8610.0	9910.0	10600.0	9317.60	18635.00
Thallium	1.5U	***2.4UJ***	1.5U	***2.4UJ***	1.5U	***2.4UJ***	1.5U	***2.4UJ***	1.91	3.82
Vanadium	179.0	183.0	389.0	36.8	3.0U	306.0	227.0	140.0	183.48	386.08
Zinc	146.0	257.0J	313.0	96.9J	60.3	490.0J	176.0	116.0J	206.63	411.06

Key:

—	=	Parameter not analyzed
µg/L	=	Micrograms per liter
U	=	Parameter not detected, value reported equals one-half detection limit.
R	=	Indicates reported value was rejected due to QA/QC deficiencies.
RC	=	Reference Concentration, calculated as two times the mean concentrations(MC).
Bold Italics	=	The reported value exceeds the FPDWS/USEPA or FSDWS MCL.

in these reference samples will be considered representative of ambient ones for the purpose of the 1993 site groundwater quality discussion.

Table 7-6 lists final stabilization values for temperature, pH, and conductivity measured during well purging prior to sampling. Observed pH values ranged from 4.15 to 7.25 across the site, with the majority of them falling within 5.5 to 6.5 units. Conductivity values varied widely from less than 100 micromhos to more than 500 micromhos. Measured groundwater temperatures were approximately 22 to 23 degrees Celsius. Except for the relatively higher specific conductivity values (greater than 150 micromhos), final stabilization parameters were consistent with those observed for regional surficial zone reference samples collected in southern Escambia County (Florida Geological Survey 1992).

Radiation and physical parameter sample results are discussed in Section 7.4. The complete analytical report for all groundwater samples is contained in Appendix G. Summary analytical results tables for parameters detected in shallow, intermediate, and deep groundwater samples are presented in the following discussions. For these tables, results in bold underline type exceeded RCs calculated from reference data. Bold italic type indicates reported result exceeded a FPDWS/USEPA or FSDWS MCL, or FGGC. Bold, italic, and underline type indicates reported result exceeded both criteria.

7.3.1.1 Shallow Groundwater

Analytical results for shallow groundwater samples are summarized in Table 7-7 at the end of the section. Concentrations of inorganic constituents, volatiles, semivolatiles, and pesticides were detected in shallow groundwater.

Table 7-6
Groundwater Field Parameters
Site 1

Well ID	pH Units	Conductivity (µmhos)	Temperature (°C)
Shallow Wells			
01GS01	5.39	88	22.5
01GS37	5.08	141	23.1
01GS39	5.70	121	22.2
01GS40	4.15	64	21.6
01GS42	6.28	47	22.7
01GS53	6.46	150	23.3
01GS57	5.99	151	22.2
01GS58	4.83	72	23.4
01GS60	4.48	41	21.5
01GS62	5.43	237	21.6
01GS64	5.89	440	24.7
01GS67[a]	5.82	72	22.8
01GS69[b]	4.95	138	21.9
GM03	6.24	102	22.5
GM04	6.49	291	21.5
GM05	5.06	75	21.6
GM31	5.88	177	23.1
GM32	5.76	105	22.6
GM33	6.23	511	21.3
GM34	6.12	406	23.7
GM35	6.04	335	24.1
GM38	6.74	215	21.9
GM39	5.91	418	22.0
GM41	4.92	90	22.1
GM42	5.89	144	21.4
Intermediate Wells			
01GI28	6.02	386	22.4

Table 7-6 Groundwater Field Parameters Site 1			
Well ID	pH Units	Conductivity (μmhos)	Temperature (°C)
01GI30	7.03	317	21.6
01GI32	6.40	842	21.6
01GI35	5.55	316	22.3
01GI36	6.74	102	22.5
01GI38	6.02	121	21.7
01GI41	6.40	377	21.7
01GI43	5.60	156	21.6
01GI44	5.99	266	21.8
01GI46	6.10	302	21.2
01GI48	6.37	364	21.3
01GI59	6.06	527	21.6
01GI61	5.62	337	21.3
01GI63	6.00	230	22.3
01GI65	5.28	276	23.3
01GI66	6.37	203	23.9
01GI68[a]	6.05	161	23.5
01GI70[b]	4.69	141	22.9
Deep Wells			
GM43	6.46	147	22.7
GM44	7.25	268	22.7
GM45	5.85	107	22.0
DSW50[c]	6.58	190	21.3
DSW51[d]	5.56	159	23.2

Key:

- – Reference well located near deep supply well DSWSO.
- – Reference well located near deep supply well DSW51.
- – NAS Pensacola deep supply well located at Building 696.
- = NAS Pensacola deep supply well located at Building 706.

Table 7-7
Site 1
Summary Analytical Results for Shallow Groundwater Samples
(All results in µg/L)

		Sample Identification Number			
Parameter	**FPDWS/RC**	**01GS01**	**01GS37**	**01GS39**	**01GS40**
Inorganics					
Aluminum	200*/269,237	211.000.000 J	320,000.000	91,600.000	51,700.000
Antimony	6/34	—	36.600	—	—
Arsenic	50159	13.600 J	9.200	—	5.800 J
Barium	2,0001365	251.000	391.000	154.000	46.700
Beryllium	4ff	2.300	6.200	—	1.000
Cadmium	5/4	—	—	21.900	—
Calcium	—/2,2746	13,900.000	30.600.000	15,100.000	1,030.000
Chromium (total)	1001375	232.000	429.000 J	65.400	69.100
Cobalt	—/36	41.600	37.400	9.600	—
Copper	1,000*/144	89.900	166.000	22.800	48.500
Iron	300*/129,985	51,600.000	117,000.000 J	11,900.000	8,110.000
Lead	15/84	59.100 J	104.000	36.300 J	31.800 J
Magnesium	—115,513	8,520.000	11,000.000	4,690.000	1,560.000
Manganese	50*/729	148.000	245.000	60.300	47.900
Mercury	212.56	1.600	2.300	—	—
Nickel	100/111	72.300	144.000 J	44.200 J	—
Potassium	—/16.146	4,890.000	7,350.000	2,730.000	1,620.000
Sodium	160.000I18.635	5,770.000	7,000.000	3,860.000	5,030.000
Vanadium	49**/366	186.000	426.000	84.500	71.300
Zinc	5,000*/411	112.000	272.000	173.000	50.900

Table 7-7
Site 1
Summary Analytical Results for Shallow Groundwater Samples
(All results in µg/L)

		Sample Identification Number			
Parameter	**FPDWS/RC**	**01GS42**	**01GS53**	**01GS57**	**01GS58**
Inorganics					
Aluminum	200*/269,237	136,000.000 J	321,000.000	333,000.000	189,000.000
Antimony	6134	—	—	—	—
Arsenic	50/59	10.700 J	—	—	—
Barium	2,000/365	158.000	332.000	491,000	231.000
Beryllium	417	3.000	4.200	6.200	5.100
Cadmium	5/4	—	—	—	—
Calcium	—122,746	3,030.000	55,900.000	15,700.000	9,340.000
Chromium (total)	1001375	217.000	346.000 J	361.000	267.000 J
Cobalt	—/36	29.800	39.700	61.800	27.300
Copper	1,000*/144	177.000	164.000	142.000	84.800
Iron	300*/129,985	73,400.000	76,600.000 J	200,000.000	57,900.000 J
Lead	15/84	55.100 J	62.200	36.200 J	79.500
Magnesium	—/15.513	5,950.000	11,200.000	18.100.000	6.850.000
Manganese	50*/729	178.000	307.000	2,020.000	184.000
Mercury	212.56	2.000	2.100	1.300	2.000
Nickel	1001111	69.400	136.000 J	158.000 J	95.700 J
Potassium	—/16,146	3,970.000	7,590.000	11,100.000	5,550.000
Sodium	160,000/18,635	2,820.000	2,580.000	8,710.000	3,410.000
Vanadium	49**/366	202.000	262.000	386.000	178.000
Zinc	5,000*/411	113.000	275.000	332.000	163.000

Table 7-7
Site 1
Summary Analytical Results for Shallow Groundwater Samples
(All results in µg/L)

		Sample Identification Number			
Parameter	**FPDWS/RC**	**01GS60**	**01GS62**	**01GS64**	**01GGM03**
Inorganics					
Aluminum	200*/269,237	***255,000.000***	***183,000.000***	***104,000.000 J***	***25,400.000***
Antimony	6134	—	—	—	—
Arsenic	50/59	—	—	18.500 J	5.100 J
Barium	2,000/365	***364.000***	125.000	***348.000***	112.000
Beryllium	4/7	—	3.600	1.700	1.300
Cadmium	5/4	—	—	**5.000**	—
Calcium	—/22,746	—	1,840.000	**42,900.000**	17,200.000
Chromium (total)	100/375	***252.000***	***197.000***	***126.000***	9.300
Cobalt	—/36	—	15.700	22.500	—
Copper	1,000*/144	***135.000***	***127.000***	***231.000***	10.100
Iron	300*/129,985	***132,000.000***	***20,000.000***	***103,000.000***	***19,700.000***
Lead	15/84	***39.900***	***77.500 J***	***55.900 J***	***74.100 J***
Magnesium	—/15,513	9,840.000	3,160.000	6,220.000	5,900.000
Manganese	50*/729	327.000	43.800	474.000	***793.000***
Mercury	2/2.56	1.700	1.900	—	0.240 J
Nickel	100/111	***106.000***	43.200	63.400	—
Potassium	—/16,146	5,470.000	15,500.000	4,900.000	1,840.000
Sodium	160,000/18,635	3,610.000	**28,900.000**	4,270.000	8,190.000
Vanadium	49**/366	***242.000***	***226.000***	***109.000***	7.100
Zinc	5,000*/411	189.000	86.000	**527.000**	127.000

Table 7-7
Site 1
Summary Analytical Results for Shallow Groundwater Samples
(All results in µg/L)

		Sample Identification Number			
Parameter	**FPDWS/RC**	**01GGM04**	**01GGM05**	**01GGM31**	**01GGM32**
Inorganics					
Aluminum	200*/269,237	***519.000***	***4,910.000***	***30,300.000***	***1,110.000***
Antimony	6/34	—	—	—	—
Arsenic	50/59	—	—	—	—
Barium	2,000/365	48.400	16.800	***223.000***	14.400
Beryllium	4/7	—	—	—	—
Cadmium	5/4	—	—	—	—
Calcium	—/22,746	**57,400.000**	1,510.000	**22,800.000**	10,300.000
Chromium (total)	100/375	—	—	41.100	—
Cobalt	—/36	—	—	—	—
Copper	1,000*/144	—	5.400	13.500	—
Iron	300*/129,985	***6,740.000***	***3,920.000***	***17,100.000***	***2,360.000***
Lead	15/84	—	—	13.900 J	—
Magnesium	—/15,513	2,160.000	1,440.000	4,160.000	2,200.000
Manganese	50*/729	122.000	123.000	236.000	48.100
Mercury	2/2.56	—	—	—	—
Nickel	100/111	—	—	23.700 J	—
Potassium	—/16,146	—	—	1,800.000	—
Sodium	160,000/18,635	3,600.000	6,350.000	6,690.000	4,410.000
Vanadium	49**/366	—	—	46.800	—
Zinc	5,000*/411	30.700	23.900	155.000	38.100

Table 7-7
Site 1
Summary Analytical Results for Shallow Groundwater Samples
(All results in µg/L)

		Sample Identification Number			
Parameter	**FPDWS/RC**	**01GGGM33**	**01GGM34**	**01GGM35**	**01GGM38**
Inorganics					
Aluminum	200'1269,237	***4,510.000 J***	***2,090.000***	***1,270.000 J***	***30,300.000***
Antimony	6/34	—	—	—	—
Arsenic	50159	41.700 J	—	6.300 J	20.000 J
Barium	2,0001365	20.400	290.000	55.600	55.400
Beryllium	4/7	—	—	—	—
Cadmium	514	—	—	—	—
Calcium	—122,746	61.900.000	46,800.000	40.100.000	38,600.000
Chromium (total)	100/375	—	12.000	—	36.500
Cobalt	—136	9.600	—		
Copper	1,000'11 44	5.000	4.800	—	13.600
Iron	300'11 29.985	***48,100.000***	***50,700.000***	***41,500.000***	*31,000.000*
Lead	15/84	4.80 J	6.000 J	—	14.600 J
Magnesium	—11 5.513	3,710.000	3,490.000	3,360.000	4,160.000
Mangenese	50*/729	301.000	267.000	362.000	45.500
Mercury	212.56	—	—	—	—
Nickel	1001111	—	—	—	—
Potassium	—/16.146	2,980.000	3,040.000	3,550.000	3,450.000
Sodium	160,000/18,635	4,620.000	5,490.000	4,780.000	5.970.000
Vanadium	49**/366	—	—	—	*121.000*
Zinc	5.000'1411	35.500	285.000	35.200	52.500

Table 7-7
Site 1
Summary Analytical Results for Shallow Groundwater Samples
(All results in µg/L)

		Sample Identification Number		
Parameter	**FPDWS/RC**	**01GGGM39**	**01GGM41**	**01GGM42**
Inorganics				
Aluminum	200*/269,237	*29,300.000*	*12,100.000*	***15,400.000 J***
Antimony	6/34	—	—	—
Arsenic	50/59	26.700 J	—	*97.700 J*
Barium	2,0001365	48.300	30.000	25.700
Beryllium	4ff	—	—	—
Cadmium	5/4	—	—	—
Calcium	—/22,746	31.600.000	967.000	507.000
Chromium (total)	1001375	32.600	12.800	24.300
Cobalt	—/36	—	—	—
Copper	1,000*/144	15.400	7.400	10.600
Iron	300*/129,985	*79,800.000*	***8,200.000***	*52,200.000*
Lead	15/84	11.200 J	—	8.900 J
Magnesium	—/15.513	5,730.000	1,590.000	1,060.000
Manganese	50*/729	***532.000***	*877.000*	107.000
Mercury	212.56	—	0.260	0.250
Nickel	100/111	—	—	—
Potassium	—/16,146	—	1,550.000	2,230.000
Sodium	160,000l18.635	8,010.000	9,450.000	6,460.000
Vanadium	49**/366	30.400	14.400	25.400
Zinc	5,000*/411	59.200	—	24.000

Table 7-7
Site 1
Summary Analytical Results for Shallow Groundwater Samples
(All results in µg/L)

		Sample Identification Number			
Parameter	**FPDWS**	**01GS01**	**01GS37**	**01GS39**	**01GS40**
Volatiles					
1,1-Dichloroethane	700**	—	—	—	—
1.2-Dichloroethena (total)	70	—	—	—	—
Benzene	1	—	—	—	—
Chlorobenzene	100	—	—	—	—
Chloroform	6**	—	—	—	—
Ethylbenzene	700	—	—	—	*2.000* J
Tetrachloroethene	3	—	—	*4.000 J*	—
Toluene	1,000	—	—	—	—
Trichloroethene	3	—	—	—	—
Vinyl Chloride	1	—	—	—	—
Xylene (total)	10,000	—	—	—	—
Semivolatiles					
1,2-Dichlorobenzene	600	—	—	—	—
1,4-Dichlorobenzene	75	—	—	—	—
2-Methylnaphthalene	—	—	—	—	—
2,4-Dimethylphenol	400**	—	—	—	—
2-Chlorophenol	35**	—	—	—	—
4-Chloro-3-methylphenol	—	—	—	—	—
Diethylphthalate	5,600**	—	—	—	—
N-Nitrosodiphenylamine	7**	—	—	—	—
Naphthalene	6.8**	—	—	—	—
Phenol	10**	—	—	—	—
Pesticides					
4.4'-ODE	0.1**	—	—	—	—
4.4'-DDT	0.1**	—	—	—	—
Alpha-Chlordane	2	—	—	—	—

Table 7-7
Site 1
Summary Analytical Results for Shallow Groundwater Samples
(All results in µg/L)

		Sample Identification Number			
Parameter	**FPDWS**	**01GS42**	**01GS53**	**01GS57**	**01GS58**
[illegible]					
[illegible]	700	—	—	—	—
1,2-Dichloroethene (total)	70	—	—	—	—
Benzene	1	—	—	—	—
Chlorobenzene	100	4.000 J	—	—	—
Chloroform	6**	—	—	1.000 J	—
Ethylbenzene	700	—	—	—	—
Tetrachloroethene	3	—	—	—	—
Toluene	1.000	—	—	—	—
Trichloroethene	3	—	—	—	—
Vinyl Chloride	1	—	—	—	—
Xylene (total)	10.000	—	—	—	—
Semivolatiles					
1.2-Dichlorobenzene	600	—	—	—	—
1.4-Dichlorobenzene	75	—	—	—	—
2-Methylnaphthalene	—	—	—	—	—
2.4-Dimethylphenol	400**	—	—	—	—
2-Chlorophenol	35**	—	—	—	—
4-Chloro-3-methylphenol	—	—	—	—	—
Diethylphthalate	5,600**	—	—	—	—
N-Nitrosodiphenylemine	7**	—	—	—	—
Naphthalene	6.8**	—	—	—	—
Phenol	10**	—	—	—	—
Pesticides					
4,4'-DDE	0.1**	—	—	—	0.064 J
4,4'-DDT	0.1**	—	—	—	0.014 J
Alpha-Chlordane	2	—	—	—	—

Table 7-7
Site 1
Summary Analytical Results for Shallow Groundwater Samples
(All results in µg/L)

		Sample Identification Number			
Parameter	**FPDWS**	**01GS60**	**01GS62**	**01GS64**	**01GGM03**
Volatiles					
1,1-Dichloroethane	700**	2.000	3.000 J	—	—
1,2-Dichloroethene (total)	70	9.000	—	—	—
Benzene	1	***9.000***	***12.000***	***13.000***	—
Chlorobenzene	100	98.000	6.000 J	***120.000***	—
Chloroform	6**	—	—	—	2.000 J
Ethylbenzene	700	—	62.000	—	—
Tetrachloroethene	3	—	—	—	—
Toluene	1,000	—	2.000 J	—	—
Trichloroethene	3	—	—	2.000 J	—
Vinyl Chloride	1	***9.000 J***	—	—	—
Xylene (total)	10,000	—	130.000	1.000 J	—
Semivolatiles					
1,2-Dichlorobenzene	600	—	—	2.000 J	—
1,4-Dichlorobenzene	75	—	—	21.000	—
2-Methylnaphthalene	—	—	—	4.000 J	—
2,4-Dimethylphenol	400**	—	5.000 J	—	—
2-Chlorophenol	35**	—	—	2.000 J	—
4-Chloro-3-methylphenol	—	—	—	18.000	—
Diethylphthalate	5,600**	—	—	—	—
N-Nitrosodiphenylamine	7**	—	—	—	—
Naphthalene	6.8**	—	—	*16.000*	—
Phenol	10**	—	—	—	—
Pesticides					
4.4'-DDE	0.1**	—	—	—	—
4,4'-DDT	0.1**	—	—	—	—
Alpha-Chlordane	2	—	—	—	—

Table 7-7
Site 1
Summary Analytical Results for Shallow Groundwater Samples
(All results in µg/L)

		Sample Identification Number			
Parameter	**FPDWS**	**01GGM04**	**01GGM05**	**01GGM31**	**01GGM32**
Volatiles					
1.l-Dichloroethane	700**	—	2.000 J	—	—
1.2-Dichloroethene (total)	70	—	3.000 J	—	—
Benzene	1	—	—	—	—
Chlorobenzene	100	14.000	5.000 J	—	—
Chloroform	6**	—	—	—	—
Ethylbenzene	*700*	—	—	—	—
Tetrachloroethene	3	—	—	—	—
Toluene	1,000	—	—	—	—
Trichloroethene	3	—	—	—	—
Vinyl Chloride	1	—	*3.000 J*	—	—
Xylene (total)	10,000	—	—	—	—
Semivolatiles					
1.2-Dichlorobenzene	600	3.000 J	—	—	—
1.4-Dichlorobenzene	75	6.000 J	—	—	—
2-Methylnaphthalene	—	—	—	—	—
2,4-Dimethylphenol	400**	—	—	—	—
2-Chlorophenol	35**	—	—	—	—
4-Chloro-3-methylphenol	—	—	—	—	—
Diethylphthalate	5,600**	—	—	—	—
N-Nitrosodiphenylamine	7**	—	—	—	—
Naphthalene	6.8**	—	—	—	—
Phenol	10**	—	—	—	—
Pesticides					
4.4'-DDE	0.1*	—	—	—	—
4,4'-DDT	0.1	—	—	—	—
Aloha-Chlordane	2	—	—	—	—

Table 7-7
Site 1
Summary Analytical Results for Shallow Groundwater Samples
(All results in µg/L)

		Sample Identification Number			
Parameter	**FPDWS**	**01GGGM33**	**01GGM34**	**01GGM35**	**01GGM38**
Volatiles					
1,1-Dichloroethane	700**	—	—	—	—
1,2-Dichloroethene (total)	70	—	1.000 J	—	—
Benzene	1	***3.000 J***	***55.000***	***5.000 J***	—
Chlorobenzene	100	35.000	21.000	21.000	—
Chloroform	6**	—	—	—	—
Ethylbenzene	700	—	11.000	—	—
Tetrachloroethene	3	—	—	—	—
Toluene	1,000	—	2.000 J	—	—
Trichloroethene	3	—	—	—	—
Vinyl Chloride	1	—	***5.000 J***	—	—
Xylene (total)	10,000	—	11.000	—	1.000 J
Semivolatiles					
1,2-Dichlorobenzene	600	—	—	3.000 J	—
1,4-Dichlorobenzene	75	8.000 J	6.000 J	10.000	—
2-Methylnaphthalene	—	—	9.000 J	—	—
2,4-Dimethylphenol	400**	—	—	—	—
2-Chlorophenol	35**	—	—	—	—
4-Chloro-3-methylphenol	—	—	—	—	—
Diethylphthalate	5,600**	—	—	1.000 J	—
N-Nitrosodiphenylamine	7**	—	1.000 J	—	—
Naphthalene	6.8**	2.000 J	***16.000***	—	—
Phenol	10**	—	—	—	—
Pesticides					
4.4'-DDE	0.1**	—	—	—	—
4.4'-DDT	0.1**	—	—	—	—
Alpha-Chlordane	2	—	—	0.004 J	—

Table 7-7
Site 1
Summary Analytical Results for Shallow Groundwater Samples
(All results in µg/L)

		Sample Identification Number		
Parameter	**FPDWS**	**01GGGM39**	**01GGM41**	**01GGM42**
Volatiles				
1,1-Dichloroethane	700**	1.000 J	—	1.000 J
1,2-Dichloroethene (total)	70	1.000 J	—	5.000 J
Benzene	1	***6.000 J***	—	***2.000 J***
Chlorobenzene	100	15.000	—	1.000 J
Chloroform	6**	—	—	—
Ethylbenzene	700	—	—	1.000 J
Tetrachloroethene	3	—	—	—
Toluene	1,000	—	—	—
Trichloroethene	3	—	—	—
Vinyl Chloride	1	—	—	—
Xylene (total)	10.000	2.000 J	—	—
Semivolatiles				
1,2-Dichlorobenzene	600	—	2.000 J	—
1,4-Dichlorobenzene	75	2.000 J	2.000 J	2.000 J
2-Methylnaphthalene	—	—	—	—
2,4-Dimethylphenol	400**	—	—	—
2-Chlorophenol	35**	—	—	—
4-Chloro-3-methylphenol	—	—	—	—
Diethylphthalate	5,600**	—	—	—
N-Nitrosodiphenylamine	7**	—	—	—
Naphthalene	6.8**	—	—	—
Phenol	10**	2.000 J	—	2.000 J

Table 7-7
Site 1
Summary Analytical Results for Shallow Groundwater Samples
(All results in µg/L)

		Sample Identification Number		
Parameter	**FPDWS**	**01GGGM39**	**01GGM41**	**01GGM42**
Pesticides				
4,4'-DDE	0.1**		—	—
4,4'-DDT	0.1**		—	—
Alpha-Chlordane	2		—	—

Key:

µg/L	=	Micrograms per liter
—	=	Indicates parameter analyzed but not detected above the method detection limit.
J	=	Parameter positively detected; however reported concentration is approximate.
FPDWS	=	Florida and/or USEPA Primary Drinking Water Standard (lower of the two)
*	=	Florida Secondary Drinking Water Standard
**	=	Florida Groundwater Guidance Concentration (FGGC)
RC	=	Reference concentration calculated from reference data as two times the mean concentration.
Bold Underline	=	The reported value exceeds the RC calculated for this parameter.
Bold Italic	=	The reported value exceeds the USEPAIFPDWS, FSDWS or FGGC for this parameter.
Bold Underline and Italic	=	The reported value exceeds both the RC and the USEPA/FPDWS or FSDWS for this parameter.

Inorganics

Concentrations of numerous metals were detected frequently in reference samples, and Site 1 shallow groundwater samples (see Tables 7-5 and 7-7). The following six metals were detected detected in both groups of samples at concentrations exceeding FPDWS and USEPA MCLs: arsenic, beryllium, chromium, lead, mercury, and nickel. Additionally, antimony and cadmium infrequently were detected in site groundwater samples at concentration levels exceeding MCLs, but were not detected in reference samples.

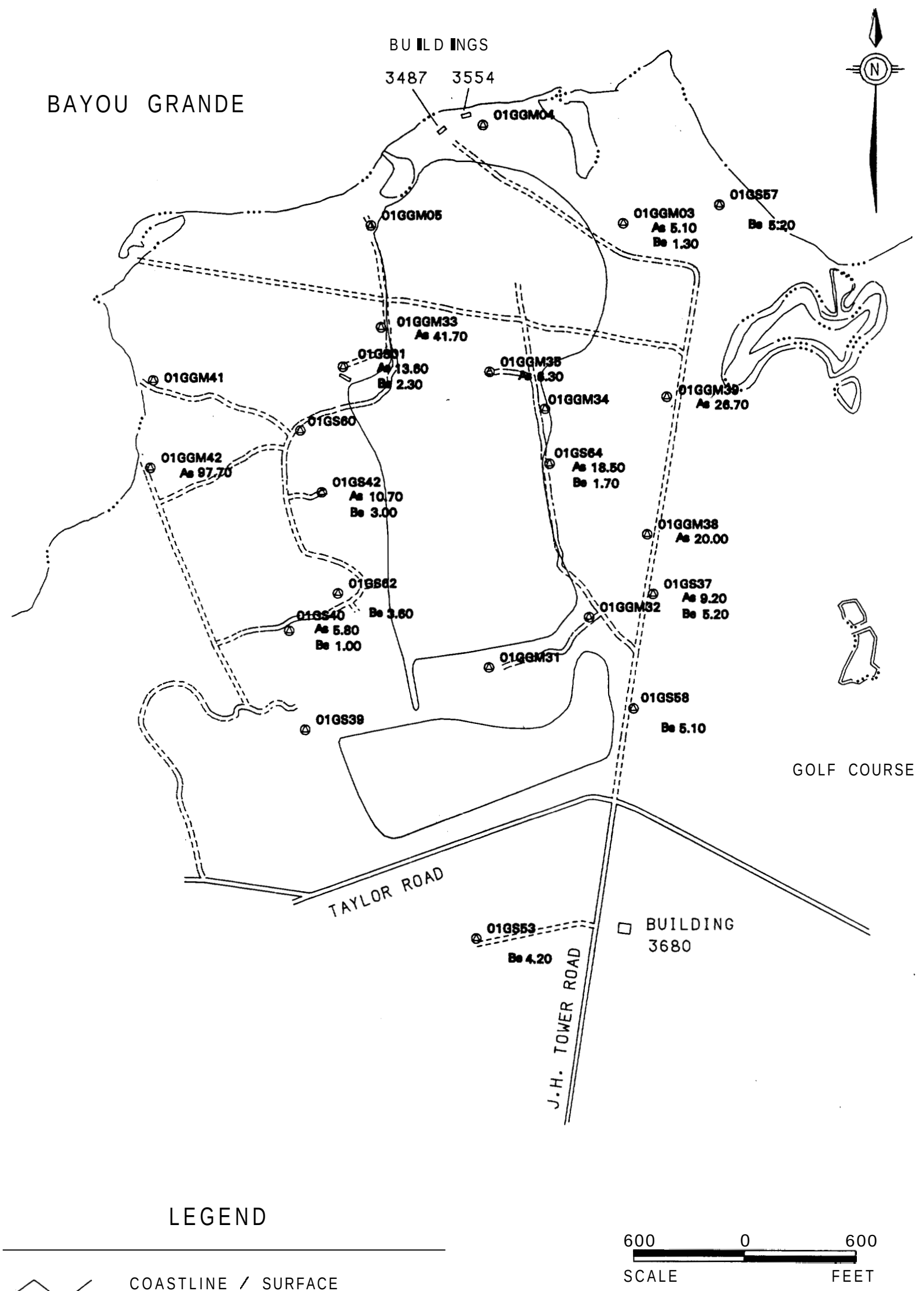
In general, metals concentrations in site samples were within the range those detected in reference samples. However, several samples, including upgradient (of Site 1) shallow well sample 01GS53, contained concentrations of one or more metals exceeding respective RCs. Due to the number of metals detected in groundwater samples, this discussion will focus on metals

to the number of metals detected in groundwater samples, this discussion will focus on metals frequently exceeding MCLs, RCs, and/or metals not detected in reference samples. Figures 7-7 through 7-9 illustrate the distribution of selected metals detected in shallow groundwater samples at Site 1 exceeding FPDWS MCLs.

Antimony (not shown on figures and not detected in reference samples) was detected only in sample 01GS37, from the southeastern margin of the site along the edge of the golf course. This detected concentration, 36.6 μg/L, exceeded the 6.0 μg/L MCL and the 34 μg/L RC for this metal.

Arsenic was commonly detected in site groundwater samples. The distribution of arsenic concentrations in shallow groundwater is illustrated in Figure 7-7. Arsenic was detected across most of the site at concentrations ranging from 5.1 μg/L (01GGM03) to 97.7 μg/L (01GGM42). With one exception, reported arsenic concentrations were below the 50 μg/L MCL and 59 μg/L RC for this parameter. Only sample 01GGM42, from at the westernmost margin of the site, contained arsenic at a concentration exceeding the MCL and RC. Most arsenic concentrations were within the range of those in reference samples.

Beryllium concentrations were reported for approximately half the shallow groundwater samples collected across the site. Figure 7-7 illustrates the distribution of detected beryllium's distribution in shallow groundwater. Beryllium concentrations ranged from 1.0 μg/L (01GGS40) to 5.2 μg/L (01GS37 and 01GS57). All detected beryllium concentrations were below the 7 μg/L RC. Most reported concentrations were below the 4.0 μg/L MCL for this parameter. However, concentrations slightly exceeding the MCL were detected in four samples: 01GS53, collected south (upgradient) of the site; samples 01GS37 and 01GS58, collected along the eastern site margin; and sample 01GS57, from the northeastern extent of the site. All concentrations of beryllium reported for site groundwater samples were within the range of those in reference samples.



LEGEND

COASTLINE / SURFACE WATER FEATURE

UNPAVED ROAD

SHALLOW MONITORING WELL

9.2 ARSENIC CONCENTRATION IN µG/L

6.2 BERYLLIUM CONCENTRATION IN µG/L

600 0 600

SCALE FEET

REMEDIAL INVESTIGATION REPORT

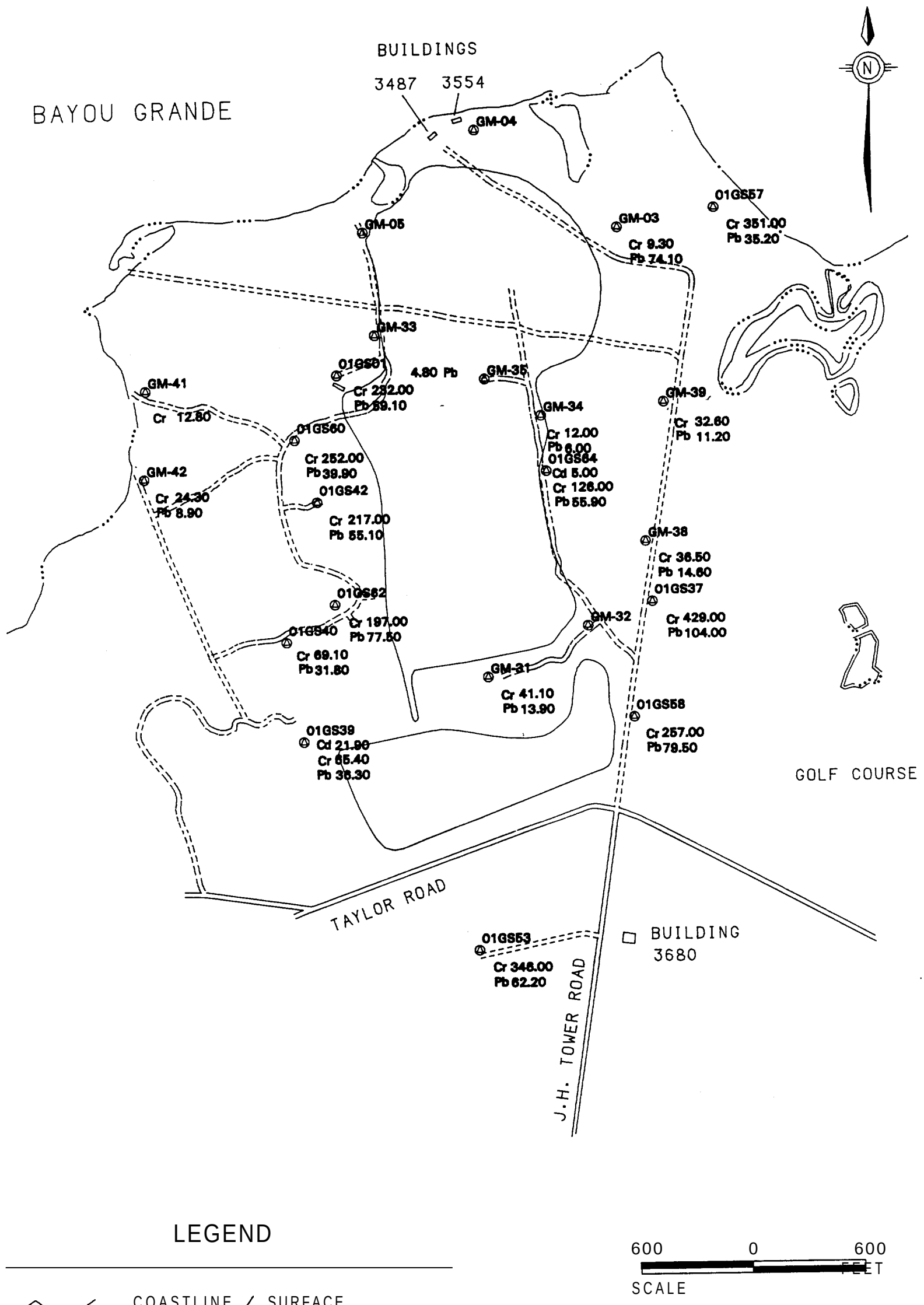
SITE 1

NAS PENSACOLA

FIGURE 7-7

ARSENIC AND BERYLLIUM DETECTED IN SHALLOW GROUNDWATER SAMPLES

DATE: 11/19/93 DWG NAME: 59FIG7-7



LEGEND

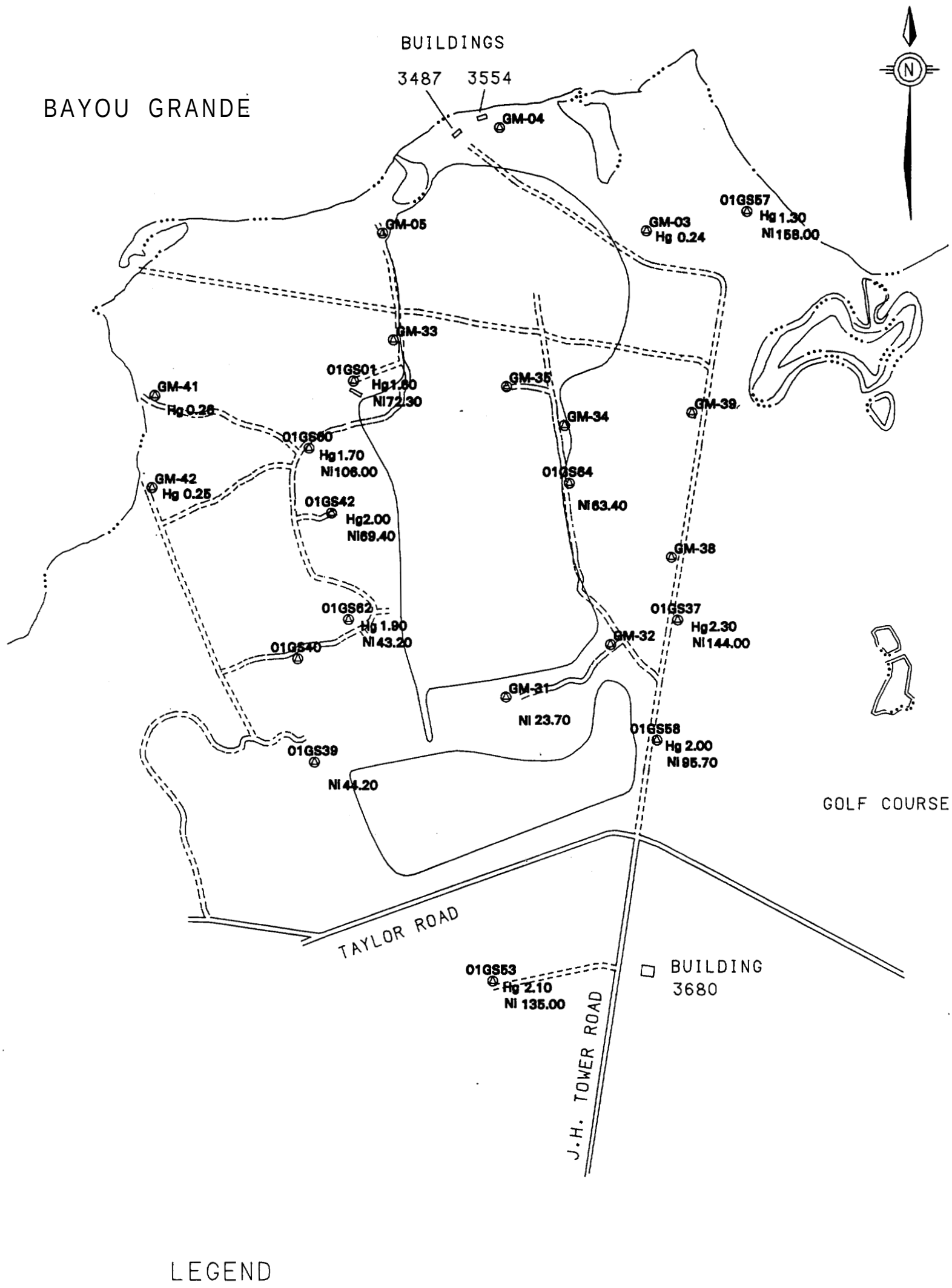
	COASTLINE / SURFACE WATER FEATURE
	UNPAVED ROAD
⊙	SHALLOW MONITORING WELL
Cd 6.4	CADMIUM CONCENTRATION IN µG/KG
Cr 36.1	CHROMIUM CONCENTRATION IN µG/KG
Pb 36.2	LEAD CONCENTRATION IN µG/KG

600 0 600
FEET
SCALE

REMEDIAL INVESTIGATION
REPORT
SITE 1
NAS PENSACOLA

FIGURE 7-a
CADMIUM, CHROMIUM. AND LEAD
DETECTED IN SHALLOW GROUNDWATER SAMPLES

DATE: 11/19/93 | DWG NAME: 59FIG7-8



LEGEND

	COASTLINE / SURFACE WATER FEATURE
	UNPAVED ROAD
⊙	SHALLOW MONITORING WELL
Hg 6.8	MERCURY CONCENTRATION IN µG/L
Ni 7.2	NICKEL CONCENTRATION IN µG/L

600 0 600

SCALE FEET

REMEDIAL INVESTIGATION REPORT

SITE 1

NAS PENSACOLA

FIGURE 7-9

MERCURY AND NICKEL

DETECTED IN SHALLOW GROUNDWATER SAMPLES

DATE: 11/22/93 DWG NAME: 59FIG7-9

Cadmium (not detected in reference samples) was detected in only two shallow Site 1 groundwater samples. These included sample 01GS39, from in the southwestern portion of the site, and sample 01GS64, collected along the landfill's eastern border. Figure 7-8 illustrates the locations and concentrations of cadmium detected in site groundwater samples. The concentrations of cadmium in samples 01GS39 and 01GS64, 21.9 and 5.0 μg/L, respectively, equaled or exceeded the 5.0 μg/L MCL and the 4 μg/L RC for this parameter.

Chromium (total) was detected in most shallow groundwater samples. Figure 7-8 illustrates the chromium distribution in shallow groundwater at Site 1. Chromium concentrations ranged from 9.3 μg/L (01GGM03) to 429 μg/L (01GS37). Approximately half the detected concentrations exceeded the 100 μg/L MCL for chromium. The highest reported concentrations (exceeding 300 μg/L) were detected in sample 01GS53, collected south (upgradient) of the site, and samples 01GS37 and 01GS57, from the eastern and northeastern site margins, respectively. Only the highest concentration detected in sample 01GS37 exceeded the 375 μg/L RC. However, most concentrations of chromium in site samples were within the range of those detected in the reference samples.

Lead was detected in most shallow groundwater samples. Figure 7-8 illustrates lead's distribution in shallow groundwater at Site 1. Reported lead concentrations ranged from 4.8 μg/L (01GGM33) to 104 μg/L (01GS37). Approximately half of these concentrations exceed the 15 μg/L MCL for this parameter. The highest reported concentrations (exceeding 50 μg/L) were in sample 01GS53, collected south (upgradient) of the site; samples 01GS64, 01GS37, and 01GS58, from along the eastern site margin; and sample 01GGM03 from the northeastern extent of the site; and samples 01GS01, 01GS42, and 01GS62, from the western landfill boundary. Only the highest concentration detected in sample 01GS37 exceeded the 84 μg/L RC. However, all lead concentrations in site samples were within the range of those observed in reference samples.

Mercury concentrations were reported for approximately half the shallow groundwater samples, ranging from 0.24 μg/L (01GGM03) to 2.3 μg/L (01GS37). Figure 7-9 illustrates mercury's distribution in shallow groundwater at Site 1. While mercury was detected primarily in samples from the west-central portion of the site, samples collected south (upgradient) of the site, along the southeastem margin, and at the northeastern extent also contained mercury. Mercury concentrations equal to or slightly exceeding the 2.0 μg/L MCL for this parameter were detected in samples 01GS42, 01GS53, 01GS37, and 01GS58, collected west, south, and southeast of the landfill, respectively. However, site mercury concentrations were below the 2.56 μg/L RC, and within the range of those in reference samples.

Nickel concentrations were reported for approximately half the shallow groundwater samples. Figure 7-9 illustrates nickel's distribution in shallow groundwater. Concentrations of nickel ranging from 23.7 μg/L (01GGM31) to 158 μg/L (01GS57) were detected in samples from across most of the site. Sample 01GS60, collected near the western landfill boundary; sample 01GS53, collected south (upgradient) of the landfill; sample 01GS37, from the southeastern site margin; and sample 01GS57, from northeastern extent of the site, each contained nickel concentrations exceeding the 100 μg/L MCL for this parameter. Except for sample 01GS60, each of these samples also exceeded the 111 μg/L RC. However, most nickel concentrations detected at the site were within the range of those in reference samples.

Vanadium concentrations (not shown) were reported for most shallow groundwater samples collected across the site ranging from 7.1 μg/L (01GGM03) to 426 μg/L (01GS37). Twelve samples contained vanadium exceeding the 49 μg/L FGGC. However, only the two highest concentrations detected in samples 01GS37 (426 μg/L) and 01GS57 (385 μg/L) exceeded the 366 μg/L RC for this parameter.

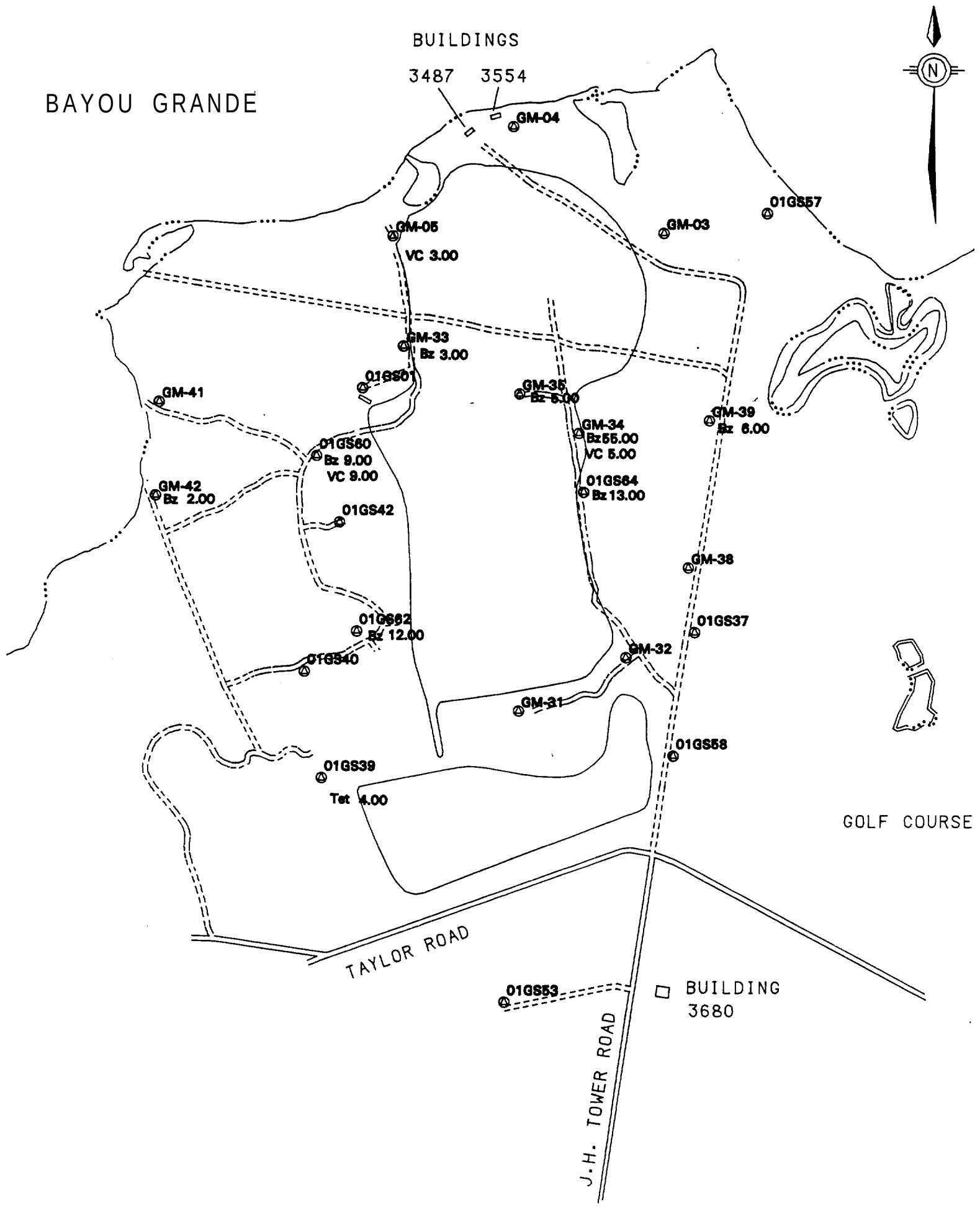
All shallow groundwater samples collected from Site 1 exceeded the FSDWS MCLs for aluminum (200 μg/L) and iron (300 μg/L). Additionally, the FSDWS MCL for manganese (50 μg/L) was exceeded by most sample concentrations. However, concentrations of these parameters detected in site samples are comparable to those in reference samples. As previously stated, groundwater samples were high in turbidity and inorganics detected may in part be representative of total suspended solids.

Volatiles

As shown on Table 7-7 shows, 12 VOCs (six aromatic hydrocarbon and six aliphatic hydrocarbon compounds) were detected in shallow groundwater samples. Most of these compounds were detected infrequently and at relatively low concentrations. In addition, the distribution of VOC concentrations in the shallow interval is generally spatially sporadic and without significant areal trend. Figures 7-10 and 7-11 illustrate the distribution of selected VOCs exceeding MCLs and total VOC groups (aromatic and aliphatic hydrocarbons) detected in shallow groundwater samples, respectively.

As shown on Figure 7-10 shows, one or more detected concentrations of the aromatic VOC benzene, and the aliphatic VOCs tetrachloroethene and vinyl chloride exceeded FPDWS MCLs of 1.0 μg/L, 3.0 μg/L, and 1.0 μg/L, respectively. Except for benzene, concentrations of these compounds were below 10.0 μg/L. Additionally, a single chlorobenzene concentration (not shown) detected in sample 01GS64 (120 μg/L) exceeded the 100 μg/L MCL for this parameter.

Benzene was the most frequently detected of the three VOCs, occurring in eight shallow samples across the site's central and western portions. The highest benzene concentrations, 55.0 μg/L, 13.0 μg/L, and 12.0 μg/L, respectively, were detected in samples 01GGM34 and 01GS64 collected along the landfill's eastern boundary, and sample 01GS62 from the landfill's southwestern boundary. Vinyl chloride was detected in samples 01GGM34 (5.0 μg/L) and



LEGEND

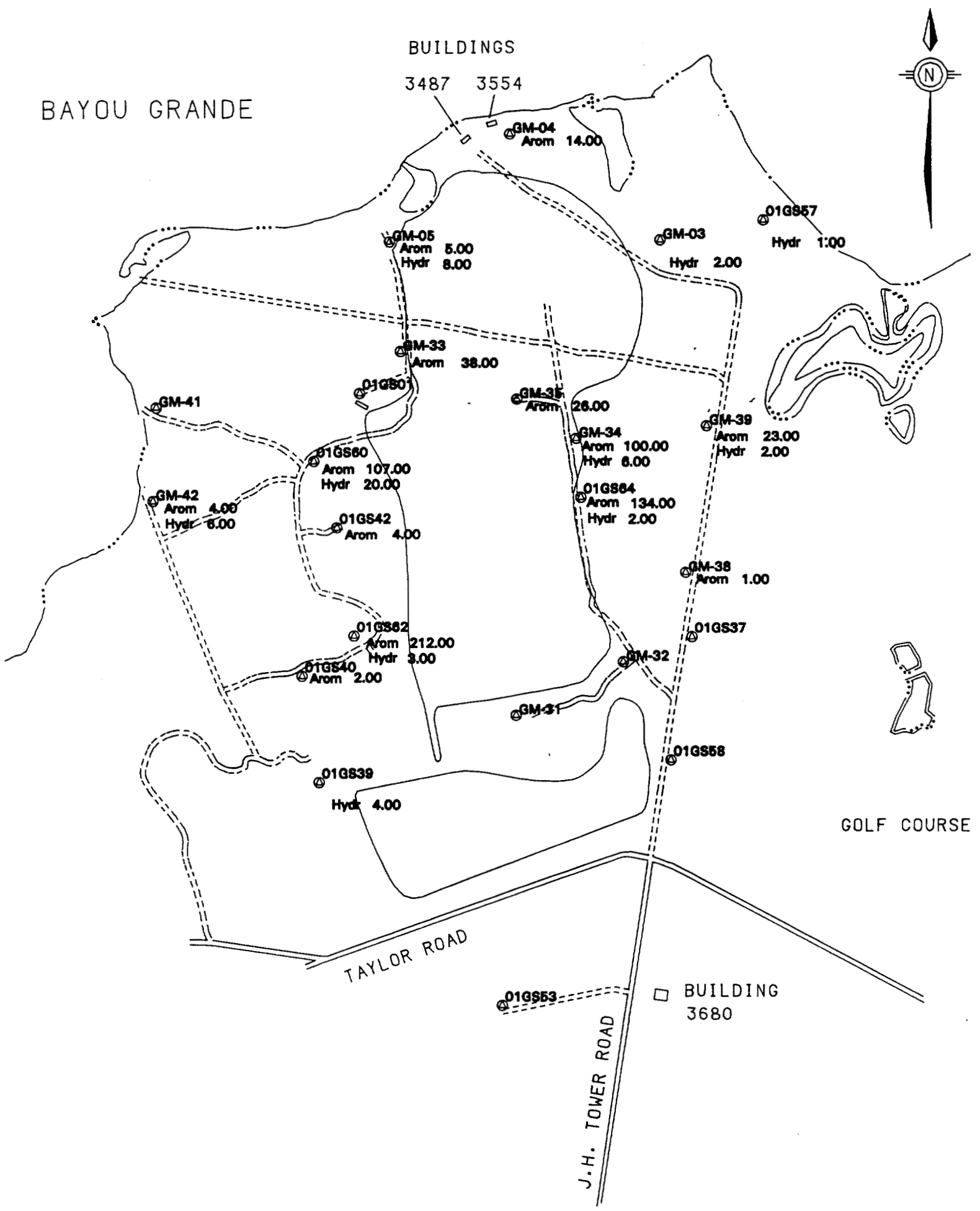
	COASTLINE / SURFACE WATER FEATURE
	UNPAVED ROAD
⊙	SHALLOW MONITORING WELL
Bz 6.8	BENZENE CONCENTRATION IN μG/L
Tet 7.0	TETRACHLOROETHENE CONCENTRATION IN μG/L
VC 7.2	VINYL CHLORIDE CONCENTRATION IN μG/L

600 0 600
SCALE FEET

REMEDIAL INVESTIGATION REPORT
SITE 1
NAS PENSACOLA

FIGURE 7-10
VOCS DETECTED IN SHALLOW GROUNDWATER SAMPLES EXCEEDING MAXIMUM CONTAMINANT LEVELS

DATE: 11/22/93 DWG NAME: 59FIG7-10



LEGEND

COASTLINE / SURFACE WATER FEATURE

UNPAVED ROAD

SHALLOW MONITORING WELL

Arom 5.0 — TOTAL AROMATIC HYDROCARBON VOC CONCENTRATION IN μG/L

Hydr 10.0 — TOTAL ALIPHATIC HYDROCARBON VOC CONCENTRATION IN μG/L

600 0 600

SCALE 1333

REMEDIAL INVESTIGATION REPORT
SITE 1
NAS PENSACOLA

FIGURE 7-11

TOTAL AROMATIC AND TOTAL ALIPHATIC HYDROCARBON VOCS DETECTED IN SHALLOW GROUNDWATER SAMPLES

DATE: 11/22/93 | DWG NAME: 59FIG7-11

01GS60 (9.0 μg/L) collected from the central portion of the site, and sample 01GGM05 (3.0 μg/L) from the northern portion. Sample 01GS39 from the southwestern portion contained tetrachloroethene (4.0 μg/L) exceeding the MCL for this compound.

In addition to the previously discussed compounds, VOCs which were detected most frequently and at the highest concentrations in shallow groundwater samples were the aromatics chlorobenzene, ethylbenzene, and xylenes, and the aliphatics 1,1 dichloroethane, and 1,2 dichloroethene (total). Chlorobenzene was most frequently detected in 11 samples collected across the site at concentrations ranging up to 120 μg/L (01GS64). Ethylebenzene, xylenes, 1,1 dichloroethane, and 1,2 dichloroethene each were detected in five or fewer samples at concentrations up to 62 μg/L, 130 μg/L, 3.0 μg/L and 9.0 μg/L, respectively. Figure 7-11 illustrates concentrations of total aromatic and total aliphatic hydrocarbon VOCs detected in shallow samples. Also included in these "total" concentrations are the VOCs that exceeded MCLs, the infrequently detected aromatic toluene, and the infrequently detected aliphatics chloromethane and chloroform.

In general, aromatic VOCs occurred at higher concentrations than aliphatics in shallow groundwater. The highest concentrations of total aromatics were detected in samples 01GGM34 (100 μg/L) and 01GS64 (134 μg/L) from the landfill's eastern boundary; 01GS60 (107 μg/L) from the western boundary; and 01GS62 (212 μg/L) from the southwestern boundary. With one exception, concentrations of total aliphatic VOCs in shallow samples were below 10.0 μg/L. The highest concentration of total aliphatic VOCs, 20.0 μg/L, was detected in sample 01GS60.

Semivolatiles

As Table 7-7 shows, several semivolatile compounds were detected in shallow groundwater samples. Detected semivolatiles predominantly included two chlorinated aromatics (1,2-dichlorobenzene and 1,4-dichlorobenzene), two PAHs (2-methylnaphthalene and naphthalene), and four phenols (2,4-dimethylphenol, 2-chlorophenol, 4-chloro-3-methylphenol,

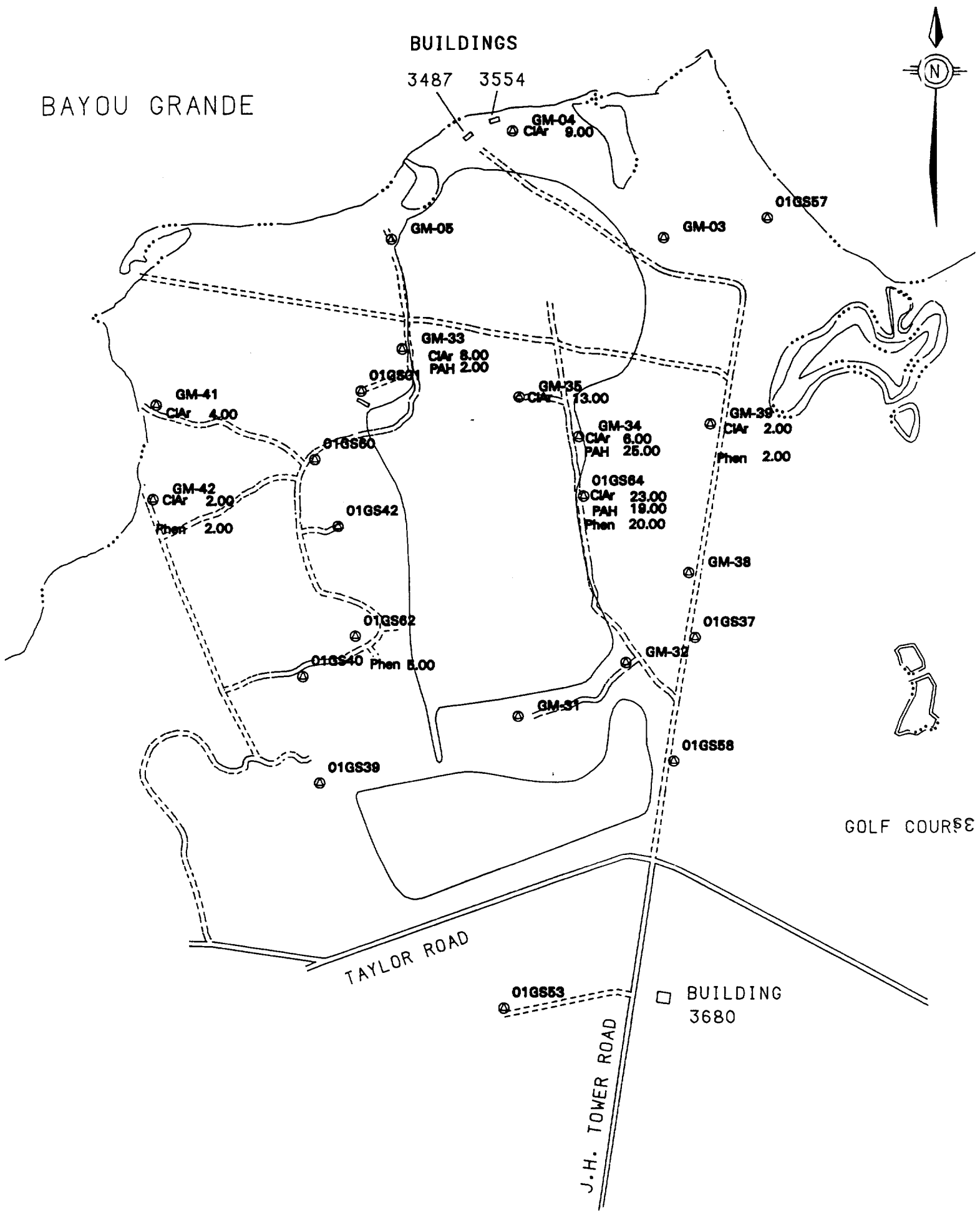
and phenol). These compounds were detected primarily across the central and northern portions of the site. Concentrations of individual compounds were generally below 10 μg/L. However, the highest concentrations of semivolatiles included 21 μg/L of 1,4-dichlorobenzene, 18 μg/L of 4-chloro-3-methylphenol, and 15 μg/L of naphthalene each in sample 01GS64, and 16 μg/L of naphthalene in sample 01GGM34. Only the naphthalene concentrations detected in samples 01GS64 and 01GGM34 exceeded a FGGC (6.8 μg/L for naphthalene). Figure 7-12 illustrates the distribution of total chlorinated aromatics, PAHs, and phenols detected in shallow groundwater samples.

As Figure 7-12 shows, chlorinated aromatics were detected in eight samples collected across the central and northern portions of the site. The distribution of these detected concentrations is somewhat scattered; however the highest concentrations, up to 23.0 μg/L total chlorinated aromatics in sample 01GS64, occur primarily in the central and east-central portions of the site, near the landfill boundary.

As Table 7-7 shows, PAHs and phenols were detected relatively infrequently (four or less detected concentrations for each group). Concentrations of PAHs were detected in samples from the central and east-central portion of the site. Phenols were detected across a slightly wider area than PAHs, including the western, southwestern, and eastern extents of the site. The highest concentrations of each compound group, up to 25 μg/L total PAHs and 20 μg/L total phenols in samples 01GGM34 and 01GS64, were detected in samples collected along the landfill's eastern boundary.

Pesticides

As on Table 7-7 and Figure 7-13 shows, three pesticides (4,4'-DDE, 4,4'-DDT, and alpha-Chlordane) were detected in shallow groundwater samples. Concentrations of 4,4'-DDE (0.064 μg/L) and 4,4'-DDT (0.014 μg/L) were detected only in sample 01GS58, collected at the site's southeastern margin on the fringe of the golf course. A single concentration of



LEGEND

COASTLINE / SURFACE WATER FEATURE

UNPAVED ROAD

SHALLOW MONITORING WELL

ClAr 30.0 — TOTAL CHLORINATED AROMATIC CONCENTRATIONS IN µG/L

PAH 25.0 — TOTAL PAH CONCENTRAIONS IN µG/L

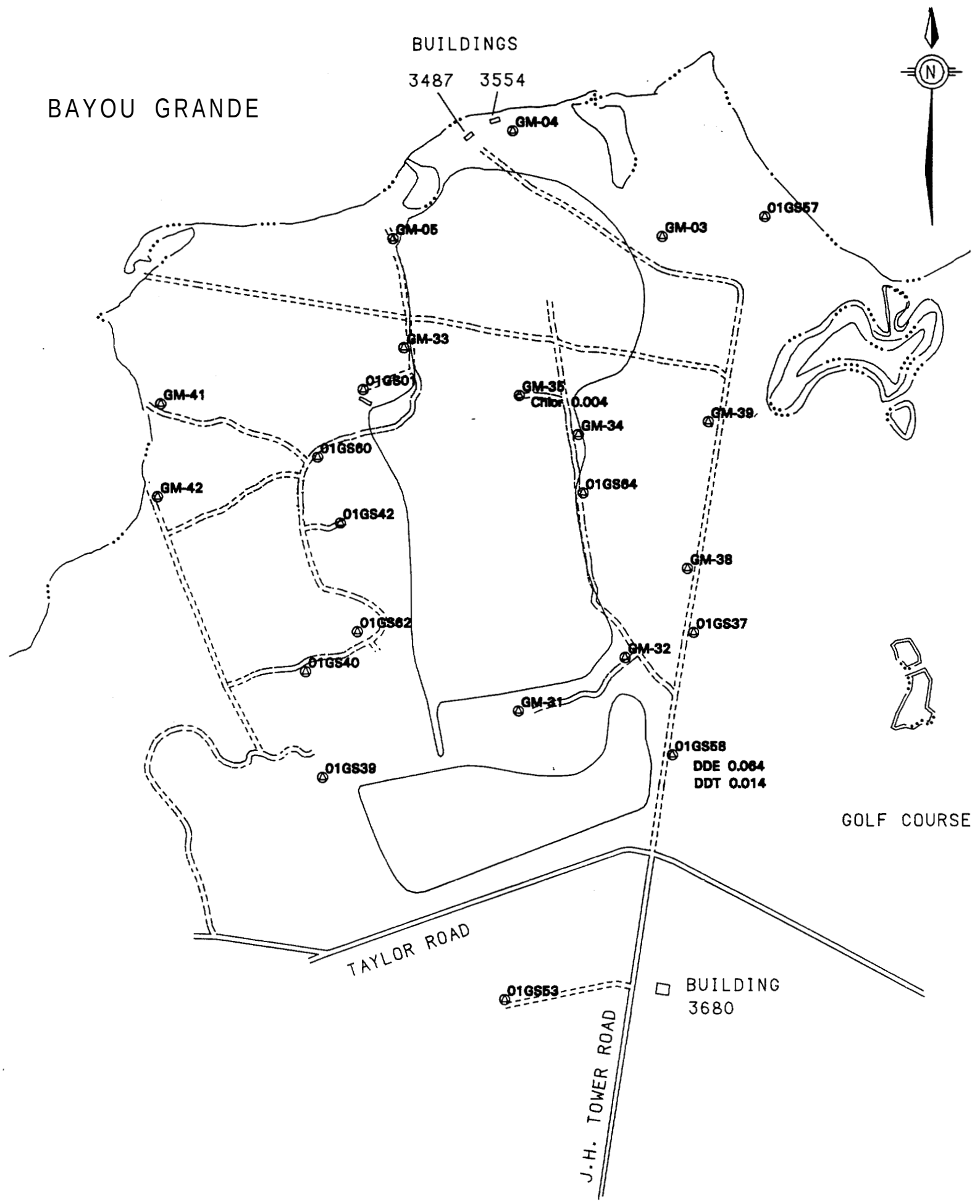
Phen — TOTAL PHENOL CONCENTRAIONS IN µG/L

600 0 600
SCALE FEET

REMEDIAL INVESTIGATION REPORT
SITE 1
NAS PENSACOLA

FIGURE 7-12
TOTAL CHLORINATED AROMATIC, TOTAL PAH, AND TOTAL PHENOL SEMIVOLATILES IN SHALLOW GROUNDWATER SAMPLES

DATE: 11/23/93 | DWG NAME: 59FIG7-12



LEGEND

	COASTLINE / SURFACE WATER FEATURE
	UNPAVED ROAD
⊙	SHALLOW MONITORING WELL
DDE 1.0	4,4 DDE CONCENTRATION IN μG/L
DDT 2.5	4,4 DDT CONCENTRATION IN μG/L
Chlor 3.0	ALPHA CHLORDANE CONCENTRATION IN μG/L

600 0 600
SCALE FEET

REMEDIAL INVESTIGATION REPORT
SITE 1
NAS PENSACOLA

FIGURE 7-13
PESTICIDES DETECTED IN SHALLOW GROUNDWATER SAMPLES

DATE: 11/23/93 DWG NAME: 59FIG7-13

alpha-Chlordane (0.004 µg/L) was detected in sample 01GGM35, from the center of the site, inside the landfill boundary.

7.3.1.2 Intermediate Depth Groundwater

Analytical results for intermediate groundwater samples are summarized in Table 7-8 at the end of the section. Concentrations of inorganic constituents, volatiles, and semivolatiles were detected in intermediate groundwater.

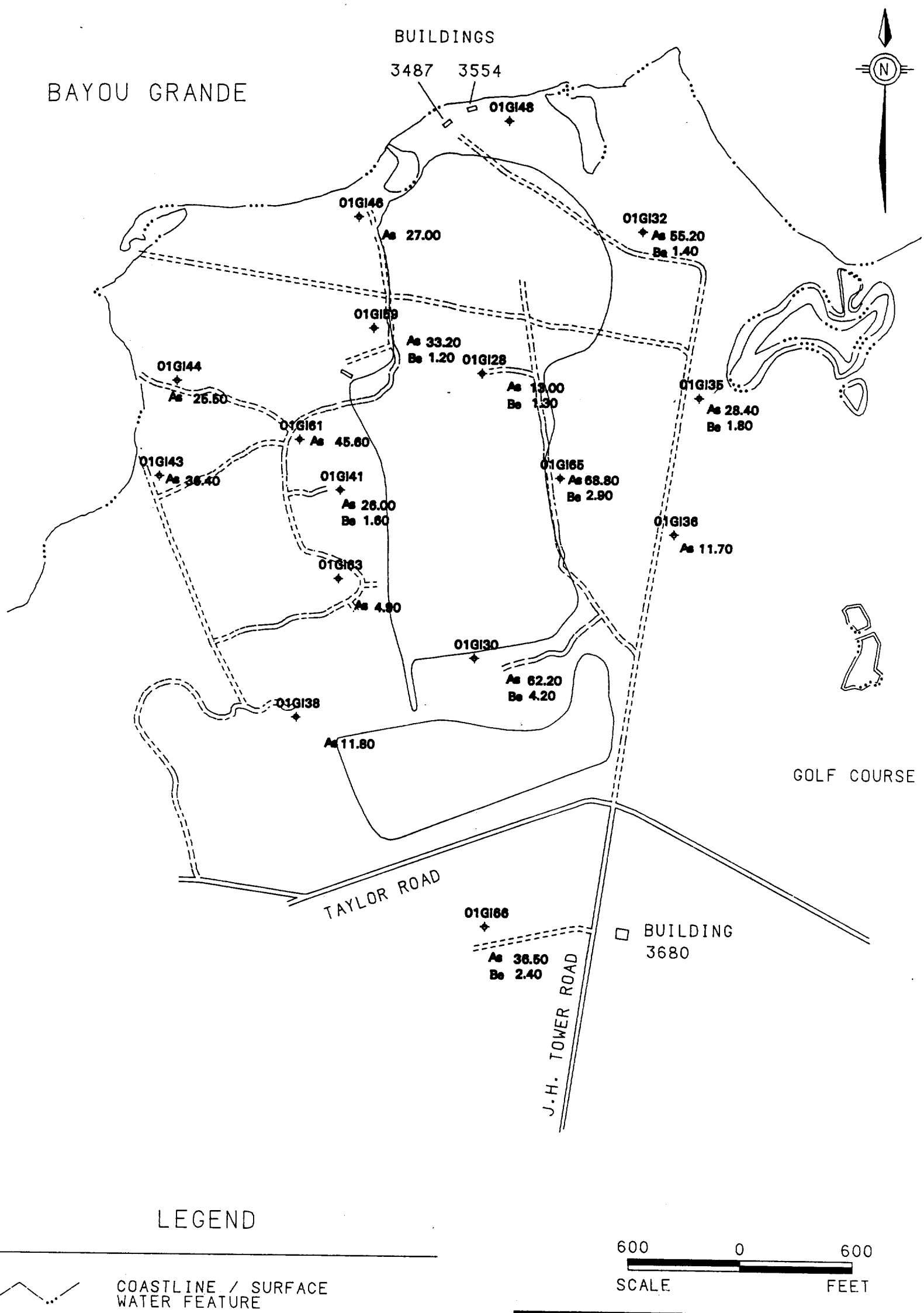
Inorganics

Concentrations of numerous metals were detected frequently in reference samples, and intermediate groundwater samples collected from Site 1 (see Tables 7-5 and 7-7). Six metals were detected in both sample groups at concentrations exceeding FPDWS MCLs: arsenic, beryllium, chromium, lead, mercury, and nickel. Additionally, antimony was frequently detected in site groundwater samples (also at concentrations exceeding MCLs), but was not detected in reference samples.

Due to the number of metals detected in groundwater samples, this results discussion will focus on those exceeding MCLs, RCs, and/or metals not detected in reference samples. Figures 7-14 through 7-16 illustrate the distribution of selected metals detected in intermediate groundwater samples exceeding FPDWS MCLs.

Antimony (not shown on figures and not detected in reference samples) was detected only in sample 01GI66, from the upgradient intermediate well south of the site. The concentration for this sample, 36.5 µg/L, exceeded the 6.0 µg/L MCL and 34 µg/L RC for this parameter.

Arsenic concentrations were reported for all but one intermediate groundwater sample. Figure 7-14 illustrates the distribution of detected arsenic concentrations in intermediate samples. Arsenic concentrations ranged from 4.9 µg/L (01GI63) to 68.8 µg/L (01GI65), but most were



LEGEND

COASTLINE / SURFACE WATER FEATURE

UNPAVED ROAD

INTERMEDIATE MONITORING WELL

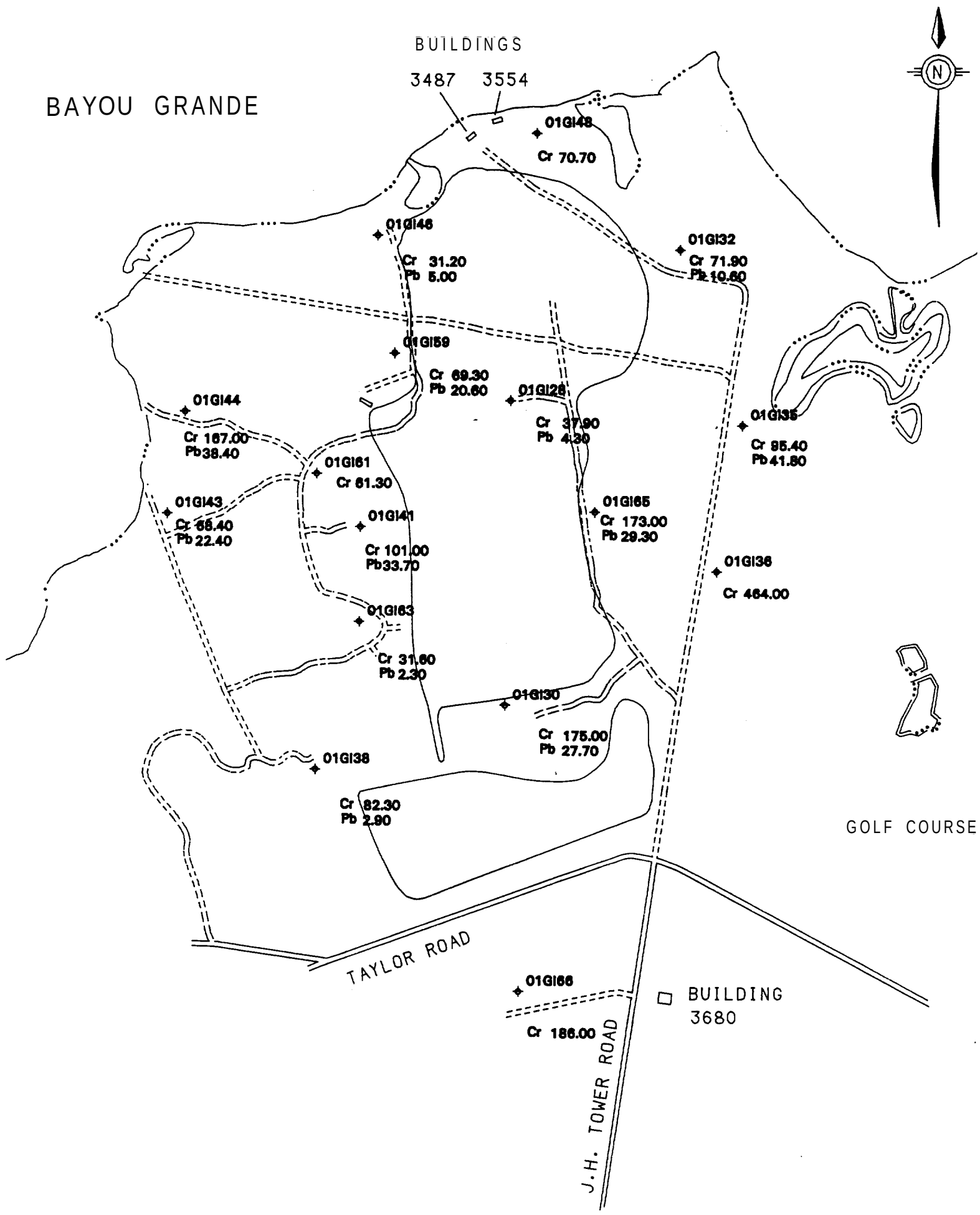
As 3.0 — ARSENIC CONCENTRATION IN μG/L

Be 7.2 — BERYLLIUM CONCENTRATION IN μG/L

REMEDIAL INVESTIGATION REPORT
SITE 1
NAS PENSACOLA

FIGURE 7-14
ARSENIC AND BERYLLIUM DETECTED IN INTERMEDIATE GROUNDWATER SAMPLES

DATE: 11/23/93 | DWG NAME: 59FIG7-14



LEGEND

COASTLINE / SURFACE WATER FEATURE

UNPAVED ROAD

INTERMEDIATE MONITORING WELL

Cr 40 — CHROMIUM CONCENTRATION IN µG/L

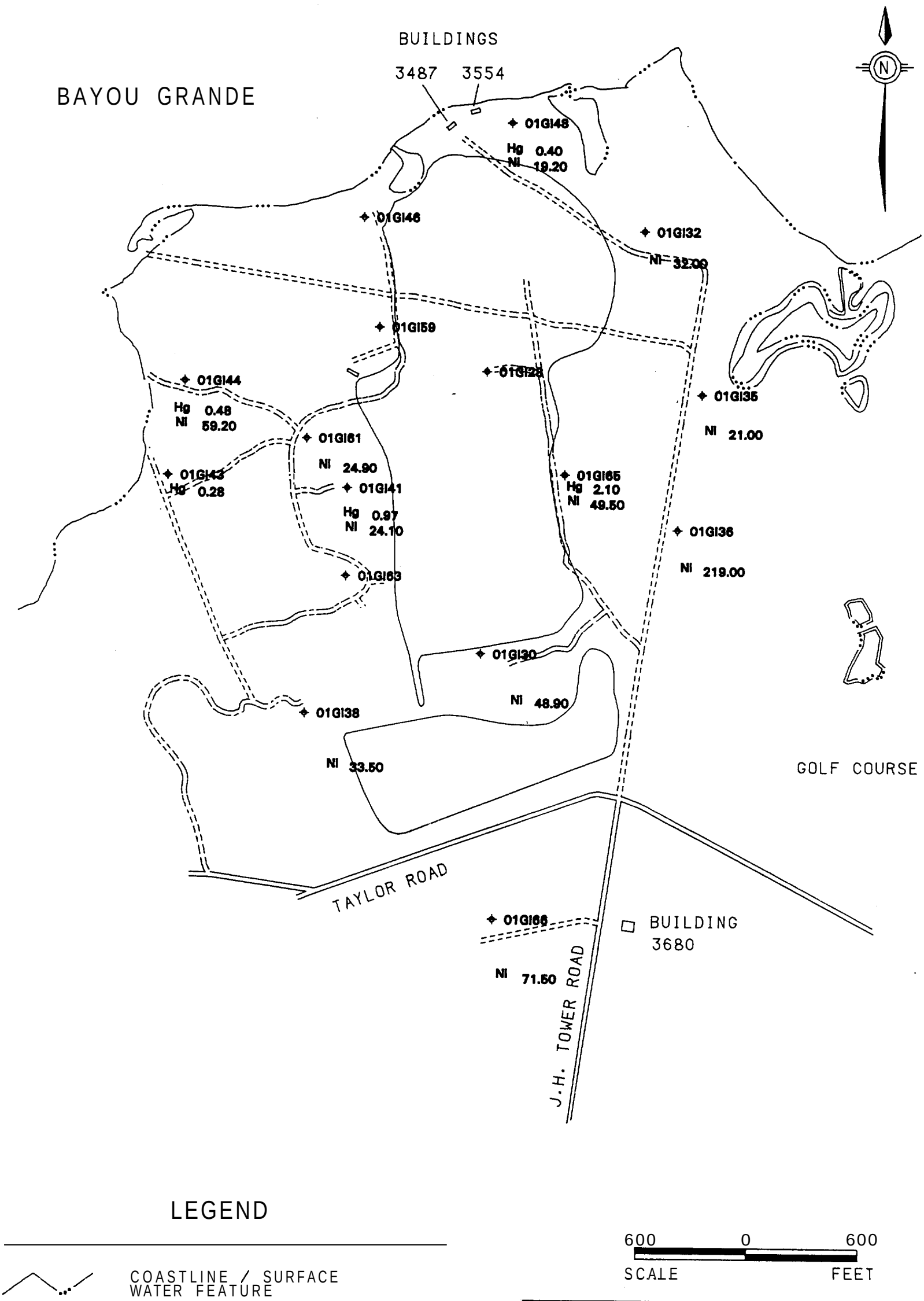
Pb 5.0 — LEAD CONCENTRATION IN µG/L

600 0 600
SCALE FEET

REMEDIAL INVESTIGATION REPORT
SITE 1
NAS PENSACOLA

FIGURE 7-15
CHROMIUM AND LEAD DETECTED IN INTERMEDIATE GROUNDWATER SAMPLES

DATE: 11/23/93 | DWG NAME: 59FIG7-15



LEGEND

COASTLINE / SURFACE WATER FEATURE

UNPAVED ROAD

INTERMEDIATE MONITORING WELL

Hg 20 — MERCURY CONCENTRATION IN µG/L

Ni 6.0 — NICKEL CONCENTRATIOM IN µG/L

600 0 600
SCALE FEET

REMEDIAL INVESTIGATION
REPORT
SITE 1
NAS PENSACOLA

FIGURE 7-16
MERCURY AND NICKEL DETECTED IN
INTERMEDIATE GROUNDWATER SAMPLES

DATE: 11/24/93 DWG NAME* 59FIG7-16

Table 7-8
Site 1
Summary Analytical Results for Intermediate Groundwater Samples
(All results in µg/L)

		Sample Identification Number			
Parameter	**FPDWS/RC**	**01GI28**	**01GI30**	**01GI32**	**01GI35**
Inorganics					
Aluminum	200*/269,237	*1,510.000* J	*75,700.000*	*48,100.000* J	*51,400.000*
Antimony	6/34	—	—	—	—
Arsenic	50159	13.000 J	*62.200* J	*66.200* J	28.400 J
	2,0001365	61.100	118.000	85.500	84.000
	4/7	1.300	*4.200*	1.400	1.800
			000	173,000	
Chromium (total)	1001375	37.900	*175.000*	71.900	95.400
Cobalt	—136	—	23.000	17.400	10.700
Copper	1,000*/144	9.300	32.300	24.900	27.600
Iron	300*/129,985	*34,700.000*	*66,200.000*	*65,900.000*	*62,300.000*
Lead	15/84	4.300 J	*27.700* J	10.600 J	*41.800* J
Magnesium	—/15.513	7,470.000	13,000.000	14,300.000	5,300.000
Manganese	50*/729	*316.000*	*243.000*	*487.000*	*282.000*
Mercury	212.56	—	—	—	—
Nickel	1001111	—	48.900 J	32.000	21.000 J
Potassium	—/16.146	15,100.000	6,600.000	9.010.000	5,460.000
Selenium	50141	—	—	—	—
Sodium	160,000/18635	12,900.000	14,000.000	14,000.000	16,500.000
Vanadium	49**/366	44.200	*243.000*	*89.400*	*143.000*
Zinc	5,000*/411	50.600	154.000	83.200	65.300

Table 7-8
Site 1
Summary Analytical Results for Intermediate Groundwater Samples
(All results in µg/L)

		Sample Identification Number			
Parameter	**FPDWS/RC**	**01GI36**	**01GI38**	**01GI41**	**01GI43**
Inorganics					
Aluminum	200*/269,237	*13,100.000*	*13,700.000*	*65,900.000 J*	*33,600.000 J*
Antimony	6134	—	—	—	—
Arsenic	50/59	11.700	11.800 J	26.000 J	36.400 J
Barium	2.0001365	—	25.400	70.400	47.800
Beryllium	4t7	—	—	1.600	—
Calcium	–122.746	6,820.000	14,000.000	**37,700.000**	8.280.000
Chromium (total)	1001375	*464.000 J*	82.300	*107.000*	68.400
Cobalt	—/36	—	—	17.400	9.600
Copper	1,000*/144	32.800	8.700	68.100	24.400
Iron	300*/129,985	*11,100.000 J*	*9,780.000*	*78.100.000*	*31.600.000*
	15/84	—	2.900 J	*33.700 J*	*22.400 J*
Magnesium	–115,513	2,280.000	2,800.000	5,700.000	3.320.000
Manganese	50*/729	*74.100*	37.000	*542.000*	*71.100*
Mercury	212.56	—	—	0.970	0.280
Nickel	1001111	*219.000 J*	*33.500* J	24.100	—
Potassium	—/16,146	2,280.000	1,930.000	5,130.000	4,010.000
Selenium	50/41	—	—	—	9.700 J
Sodium	160,000118635	7,420.000	6160.000	8,740.000	9,450.000
Vanadium	49**/366	29.400	47.300	*127.000*	*96.500*
Zinc	5,000*/411	91.100	54.100	49.900	56.600

Table 7-8
Site 1
Summary Analytical Results for Intermediate Groundwater Samples
(All results in µg/L)

		Sample Identification Number			
Parameter	**FPDWS/RC**	**01GI44**	**01GI46**	**01GI48**	**01GI59**
Inorganics					
Aluminum	200*/269,237	***116,000.000***	***14,400.000 J***	***31,700.000***	***30,900.000 J***
Antimony	6/34	—	—	—	—
Arsenic	50/59	25.500	27.000 J	—	33.200 J
Barium	2,000/365	152.000	30.000	46.800	50.600
Beryllium	4/7	—	—	—	1.200
Calcium	—/2,2746	2,100.000	16,200.000	8,240.000	**76,600.000**
Chromium (total)	100/375	***167.000***	31.200	70.700	69.300
Cobalt	—/36	31.500	9.600	11.100	13.500
Copper	1,000*/144	71.200	11.100	24.800	18.600
Iron	300*/129,985	***179,000.000***	***49,300.000***	***22,500.000***	***54,900.000***
Lead	15/84	***38.400***	5.000 J	—	***20.600 J***
Magnesium	—/15,513	5,800.000	4,560.000	1,950.000	8,490.000
Manganese	50*/729	***1300.00***	***356.000***	***138.000***	***352.000***
Mercury	2/2.56	0.480	—	0.400	—
Nickel	100/111	59.200	—	19.200	—
Potassium	—/16,146	6,570.000	5,270.000	1,820.000	7,710.000
Selenium	50/41	—	—	—	8.800 J
Sodium	160,000/18,635	12,900.000	10,200.000	**29,800.000**	9,630.000
Vanadium	49**/366	260.000	*29.600*	—	*70.000*
Zinc	5,000*/411	128.000	*35.200*	80.000	42.900

Table 7-8
Site 1
Summary Analytical Results for Intermediate Groundwater Samples
(All results in µg/L)

		Sample Identification Number			
Parameter	**FPDWS/RC**	**010161**	**01GI63**	[illegible]	[illegible]
Inorganics					
Aluminum	200'1269,237	31,700,000	3,630,000	70,700.000	58,300.000
Antimony	6134	—	—	—	36.600
Arsenic	50/59	45.600	4.900 J	68,800 J	36.500
Barium	2,000/365	49.700	31.100	102.000	85.100
Beryllium	4ff	—	—	2.900	2.400
Calcium	—122.746	25,400.000	17,800.000	10,300.000	19,300.000
Chromium (total)	1001375	61.300	31.600	173.000	186.000J
Cobalt	—136	—	—	25.300	13.000
Copper	1,000*/144	27.900	6.100	38.700	35.800
Iron	300*/129,985	51,100.000	3.530.000	55,400.000	35,600.000 J
Lead	15184	—	2.300 J	29.300 J	—
Magnesium	—11 5.51 3	7,610.000	4.3 10.000	4,170.000	5,440.000
Manganese	50*/729	330.000	69.700	132.000	126.000
Mercury	2/2.56	—	—	2.100	—
Nickel	1001111	24.900	—	49.500	71.500 J
Potassium	—116,146	7,9 10.000	5,430.000	14.000.000	37,800.000
Selenium	50141	—	—	—	—
Sodium	160,000/18,635	14,600.000	15,400.000	32,400.000	15,100.000
Vanadium	49**/366	—	11.300	273.000	154.000
Zinc	5,000*/41 1	56.100	24.000	203.000	221.000

Table 7-8
Site 1
Summary Analytical Results for Intermediate Groundwater Samples
(All results in µg/L)

		Sample Identification Number			
Parameter	**FPDWS**	**01GI28**	**01GI30**	**01GI32**	**01GI35**
Volatiles					
1,1-Dichloroethane	700**	1.000 J	—	—	1.000
1,2-Dichloroethene (total)	70	3.000 J	—	4.000 J	4.000 J
Benzene	1	***9.000 J***	1.000 J	***2.000 J***	***15.000***
Chlorobenzene	100	23.000	—	4.000 J	5.000 J
Chloromethane	2.7**	—	—	—	2.000 J
Ethylbenzene	700	27.000	—	—	5.000 J
Toluene	1,000	1.000 J	—	—	—
Trichloroethene	3	—	—	—	—
Vinyl Chloride	1	—	—	—	***3.000 J***
Xylene (total)	10,000	27.000	—	—	17.000
Semivolatiles					
1,2-Dichlorobenzene	600	4.000 J	—	—	—
1,4-Dichlorobenzene	75	6.000 J	—	—	2.000 J
2-Methylnaphthalene	—	9.000 J	—	—	—
2,4-Dimethylphenol	400**	63.000	—	—	6.000 J
2-Chlorophenol	35**	—	—	—	—
2-Methylphenol	350**	—	—	—	—
4-Chloro-3-methylphenol	—	—	—	11.000	—
4-Methylphenol	35**	—	—	—	—
4-Nitrophenol	15**	—	—	3.000 J	—
Di-n-butylphthalate	700**	—	—	—	—
Diethylphthalate	5,600**	—	—	—	—
Isophorone	40**	—	—	—	—
Naphthalene	6.8**	***31.000***	—	—	—
Pentachlorophenol	1	—	***1.000 J***	—	—
Phenol	10**	—	—	—	—

Table 7-8
Site 1
Summary Analytical Results for Intermediate Groundwater Samples
(All results in µg/L)

		Sample Identification Number			
Parameter	**FPDWS**	**01GI36**	**01GI38**	**01GI41**	**01GI43**
Volatiles					
1,1-Dichloroethane	700**	—	—	2.000 J	2.000 J
1,2-Dichloroethene (total)	70	8.000 J	3.000 J	3.000 J	6.000 J
Benzene	1	***2.000 J***	—	***74.000***	***3.000 J***
Chlorobenzene	100	—	—	***120.000***	2.000 J
Chloromethane	2.7**	—	—	—	—
Ethylbenzene	700	—	—	8.000 J	2.000 J
Toluene	1,000	—	—	—	—
Trichloroethene	3	***5.000 J***	—	—	—
Vinyl Chloride	1	—	—	—	—
Xylene (total)	10,000	—	—	—	—
Semivolatiles					
1,2-Dichlorobenzene	600	—	—	5.000 J	—
1,4-Dichlorobenzene	75	—	—	14.000	1.000 J
2-Methylnaphthalene	—	—	—	—	—
2,4-Dimethylphenol	400**	—	—	—	—
2-Chlorophenol	35**	—	—	—	—
2-Methylphenol	350**	—	—	—	—
4-Chloro-3-methylphenol	—	—	—	—	—
4-Methylphenol	35**	—	—	—	—
4-Nitrophenol	15**	—	—	—	—
Di-n-butylphthalate	700**	—	—	1.000 J	—
Diethylphthalate	5,600**	—	—	6.000 J	—
Isophorone	40**	—	—	—	—
Naphthalene	6.8**	—	—	***8.000 J***	—
Pentachlorophenol	1	—	—	—	—
Phenol	10**	—	—	5.000 J	—

Table 7-8
Site 1
Summary Analytical Results for Intermediate Groundwater Samples
(All results in µg/L)

		Sample Identification Number			
Parameter	**FPDWS**	**01GI44**	**01GI46**	**01GI48**	**01GI59**
Volatiles					
1,1-Dichloroethane		—	3.000 J	—	1.000 J
1.2-Dichloroethene (total)	70	3.000 J	1.000 J	1.000 J	—
Benzene	1	***3.000 J***	***3.000 J***	2.000 J	8.000
Chlorobenzene	100	32.000	18.000	17.000	45.000
Chloromethane		—	—	—	—
Ethylbenzene	700	—	—	—	4.000 J
Toluene	1,000	—	—	—	**1.000 J**
Trichloroethene	3	—	—	—	—
Vinyl Chloride	1	—	***19.000***	—	—
Xylene (total)	10,000	—	—	—	5.000 J
Semivolatiles					
1,2-Dichlorobenzene	600	3.000 J	3.000 J	2.000 J	1.000 J
1,4-Dichlorobenzene	75	5.000 J	3.000 J	5.000 J	12.000
2-Methylnaphthalene	—	—	—		—
2.4-Dimethylphenol	**400****	—	—	—	3.000 J
2-Chlorophenol	35**	1.000	—	—	—
2-Methylphenol	350**	—	—	—	—
4-Chloro-3-methylphenol	—	—	—	—	—
4-Methylphenol	35**	—	—	—	—
4-Nitrophenol	15**	—	2.000 J	—	—
Di-n-butylphthalate	**700****	—	—	—	—
Diethylphthalate	5,600**	—	—	—	—
Isophorone	**40****	—	—	—	—
Naphthalene	6.8 **	—	—	—	1.000 J
Pentachlorophenol	1	—	—	—	—
Phenol	10**	—	—	—	—

Table 7-8
Site 1
Summary Analytical Results for Intermediate Groundwater Samples
(All results in µg/L)

		Sample Identification Number			
Parameter	**FPDWS**	**01GI61**	**01GI63**	**01GI65**	**01GI66**
Volatiles					
1,1-Dichloroethane		—	—	11.000	—
1,2-Dichloroethane	3	—	—	1.000 J	—
1,2-Dichloroethene (total)	70	—	—	***170.000***	—
4-Methyl-2-Pentanone		—	—	140.000	—
Benzene	1	—	***5.000***	***11.000***	—
Chlorobenzene	100	2.000 J	—	7.000	—
Chloromethane		—	—	—	—
Ethylbenzene	700	—	—	2.000 J	—
Toluene	1,000	—	—	27.000	—
Trichloroethene	3	—	—	—	2.000 J
Vinyl Chloride	1	—	—	***23.000***	—
Xylene (total)	10,000	—	9.000 J	2.000 J	—
Semivolatiles					
1,2-Dichlorobenzene	600	3.000 J	—	—	—
1,4-Dichlorobenzene	75	12.000	—	3.000 J	—
2-Methylnaphthalene	—	—	—		—
2,4-Dimethylphenol	400**	1.000 J	—	3.000 J	—
2-Chlorophenol	35**	1.000 J	—		—
2-Methylphenol	350**	—	—	12.000	—
4-Chloro-3-methylphenol	—	—	—	3.000 J	—
4-Methylphenol	35**	—	—	7.000 J	—
4-Nitrophenol	15**	—	—	—	—
Di-n-butylphthalate	700**	—	—	—	—
Diethylphthalate	5,600**	—	—	—	—
Isophorone	40**	—	—	1.000 J	—
Naphthalene	6.8**	6.000 J	2.000 J	1.000 J	—
Pentachlorophenol	1	—	—	—	—

Table 7-8
Site 1
Summary Analytical Results for Intermediate Groundwater Samples
(All results in µg/L)

		Sample Identification Number			
Parameter	**FPDWS**	**01GI61**	**01GI63**	**01GI65**	**01GI66**
Phenol	10**	3.000	—	***76.000***	—

Notes:

µg/L	=	Micrograms per liter
—	=	Indicates parameter analyzed but not detected above the method detection limit.
J	=	Parameter positively detected; however reported concentration is approximate.
FPDWS	=	Florida and/or USEPA Primary Drinking Water Standard (lower of the two)
*	=	Florida Secondary Drinking Water Standard
**	=	Florida Groundwater Guidance Concentration (FGGC).
RC	=	Reference concentration calculated from reference data as two times the mean concentration.
Bold Underline	=	The reported value exceeds the RC calculated for this parameter.
Bold Italic	=	The reported value exceeds the USEPA/FPDWS, FSDWS or FGGC for this parameter.
Bold Underline and Italic	=	The reported value exceeds both the RC and the USEPA/FPDWS or FSDWS for this parameter.

below the 50 µg/l MCL for this parameter. However, arsenic exceeded the MCL in sample 01GI32, collected at the northeastern extent of the site; sample 01GI65, from the landfill's eastern boundary; and sample 01GI30, from the south-central portion of the site. Only the two highest concentrations detected in samples 01GI30 (62.2 µg/L) and 01GI65 (68.8 µg/L) exceeded the 59 µg/L RC. All arsenic concentrations detected in site samples were within the range of those in reference samples.

Concentrations of beryllium occurred in several intermediate groundwater samples. The distribution of beryllium detected in intermediate samples is illustrated in Figure 7-14. Beryllium concentrations ranging from 1.2 µg/L (01GI59) to 4.2 µg/L (01GI30) were detected in samples collected primarily from the central portion of the site along the landfill boundary, and from the northeastern portion of the site. Additionally, beryllium was detected in sample 01GI66 (2.4 µg/L) from the upgradient well south of the site. Only sample 01GI30 from the south-central portion of the site contained beryllium at a concentration exceeding the 4.0 µg/L MCL for this parameter. All beryllium concentrations in site samples were below the

4.0 μg/L MCL for this parameter. All beryllium concentrations in site samples were below the 7 μg/L RC and within the range of those reported for reference samples.

Concentrations of chromium (total) were detected in all intermediate groundwater samples. Figure 7-15 illustrates the distribution of detected chromium concentrations in intermediate samples. Samples collected across the site contained chromium concentrations ranging from 31.2 μg/L (01GI46) to 464 μg/L (01GI36). Several samples exceeded the 100 μg/L MCL for this parameter. Sample 01GI44, from the western extent of the site; samples 01GI41, 01GI30, and 01GI65, from the central portion around the landfill boundary; sample 01GI36, from the eastern margin; and sample 01GI66 collected south (upgradient) of the site, contained the highest chromium concentrations exceeding the MCL. Only the highest chromium concentration detected in sample 01GI36, collected along the eastern margin of the site adjacent to the golf course, exceeded the range of chromium concentrations in reference samples, and the 375 μg/L RC.

Lead was detected in most intermediate groundwater samples. The distribution of lead concentrations detected in intermediate samples is illustrated in Figure 7-15. Lead concentrations ranged from 2.3 μg/L (01GI63) to 41.8 μg/L (01GI35). Approximately half of these concentrations exceed the 15 μg/L MCL for lead. Samples 01GI43 and 01GI44, from the westernmost extent of the site; samples 01GI59, 01GI41, 01GI65, and 01GI30, from the central portion around the landfill boundary; and sample 01GI35, from the eastern margin, contained the highest concentrations of lead, exceeding the 15 μg/L MCL. However, lead concentrations at the site did not exceed the 84 μg/L RC, and were well within the range of those in reference samples.

Mercury concentrations were reported for less than half of the intermediate groundwater samples. Figure 7-16 illustrates the distribution of detected mercury in intermediate samples. Mercury concentrations ranged from 0.28 μg/L (01GI43) to 2.1 μg/L (01GI65). Most were

detected in samples from the western portion of the site; however, samples from the eastern boundary of the landfill and the northern extent of the site also contained mercury. Only sample 01GI65, from the eastern boundary of the landfill, contained mercury (2.1 μg/L) at a concentrations slightly exceeding the 2.0 μg/L MCL for this parameter. However, all mercury concentrations in site samples were below the 2.56 μg/L RC and within the range of those in reference samples.

Nickel was detected in most intermediate groundwater samples. Figure 7-16 illustrates the distribution of reported nickel concentrations in intermediate samples. Samples collected across the site contained nickel concentrations ranging from 19.2 μg/L (01GI48) to 219 μg/L (01GI36). The highest reported nickel concentrations (exceeding 50 μg/L) were in sample 01GI44, from the westernmost extent of the site; sample 01GI66, collected south (upgradient) of the site; and sample 01GI36, collected along the eastern site margin. Only sample 01GI36 contained nickel at a concentration exceeding the 100 μg/L MCL and the 111 μg/L RC for this parameter. However, except for sample 01GI36, all nickel concentrations in site samples were within the range of those in reference samples.

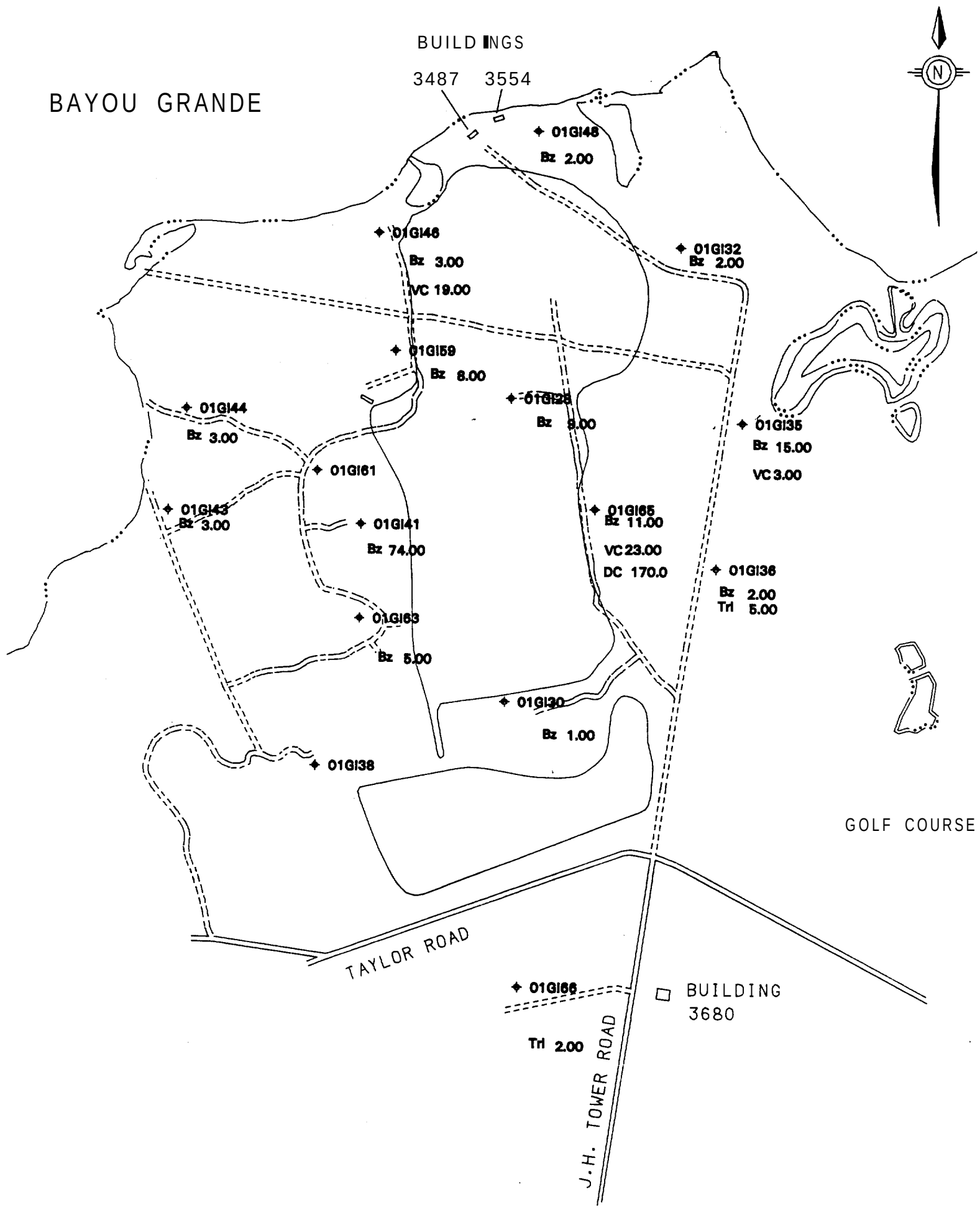
Vanadium concentrations (not shown) were reported for most intermediate samples collected across the site ranging from 11.3 μg/L (01GI63) to 273 μg/L (01GI65). Vanadium exceeded the 49 μg/L FGGC in approximately half of the intermediate samples. However, all intermediate sample vanadium concentrations were below the 366 μg/L RC calculated for this parameter.

All Site 1 intermediate groundwater samples exceeded the FSDWS MCLs for aluminum (200 μg/L), and iron (300 μg/L). Additionally, the FSDWS MCL for manganese (50 μg/L) was exceeded by most sample concentrations. However, concentrations of these metals in site samples were within the range of those in reference samples for these respective metals. As previously stated, groundwater samples were high in turbidity and inorganics detected may in part be representative of total suspended solids.

As Table 7-8 shows, 12 VOCs (five aromatic hydrocarbons, six aliphatic hydrocarbons, and one ketone) were detected in intermediate groundwater samples. VOCs were detected across much of the site, with each intermediate sample exhibiting concentrations of one or more compounds. Figures 7-17 and 7-18 illustrate the distribution of selected individual VOCs exceeding MCLs and total VOC groups (aromatic and aliphatic hydrocarbons) in intermediate groundwater samples, respectively.

As shown on Figure 7-17, the aromatic VOC benzene, and the aliphatic VOCs trichloroethane, vinyl chloride, and 1,2-dichloroethene were detected at concentrations exceeding their respective FPDWS MCLs of 1.0 μg/L, 3.0 μg/L, 1.0 μg/L, and 70 μg/L. Most concentrations of these compounds were below 10.0 μg/L. Additionally, a single chlorobenzene concentration (not shown) detected in sample 01GI41 (120 μg/L) exceeded the 100 μg/L MCL for this parameter.

Benzene was the most frequently detected of these VOCs, occurring in 13 intermediate samples collected across all but the southwestern portion of the site. The highest concentrations of benzene were detected in samples 01GI35 (15.0 μg/L), collected along the eastern site margin; sample 01GI65 (11.0 μg/L), from the landfill's eastern boundary; and sample 01GI41 (74.0 μg/L), from the landfill's western boundary. Concentrations of trichloroethene, vinyl chloride, and 1,2-dichloroethene were infrequently detected in intermediate samples. Trichloroethene was detected only at two locations: in sample 01GI36 (5.0 μg/L), from the eastern site margin, and sample 01GI66 (2.0 μg/L), from the upgradient intermediate depth well approximately 700 feet south of the landfii. Vinyl chloride concentrations were detected in sample 01GI46 (19.0 μg/L) from the northwestern extent of the landfill, and 01GI65 (23 μg/L), from the landfill's eastern border. The only detected concentration of 1,2-dichloroethene (170 μg/L) also was reported in sample 01GI65.



LEGEND

	COASTLINE / SURFACE WATER FEATURE
	UNPAVED ROAD
4	INTERMEDIATE MONITORING WELL
Bz 3.0	BENZENE CONCENTRATION IN µG/L
Tri 6.0	TRICHLOROETHENE CONCENTRATION IN µG/L
VC 7.2	VINYL CHLORIDE CONCENTRATION IN µG/L
DC 170.0	1,2 DICHLOROETHENE (TOTAL) IN µG/L

600 0 600
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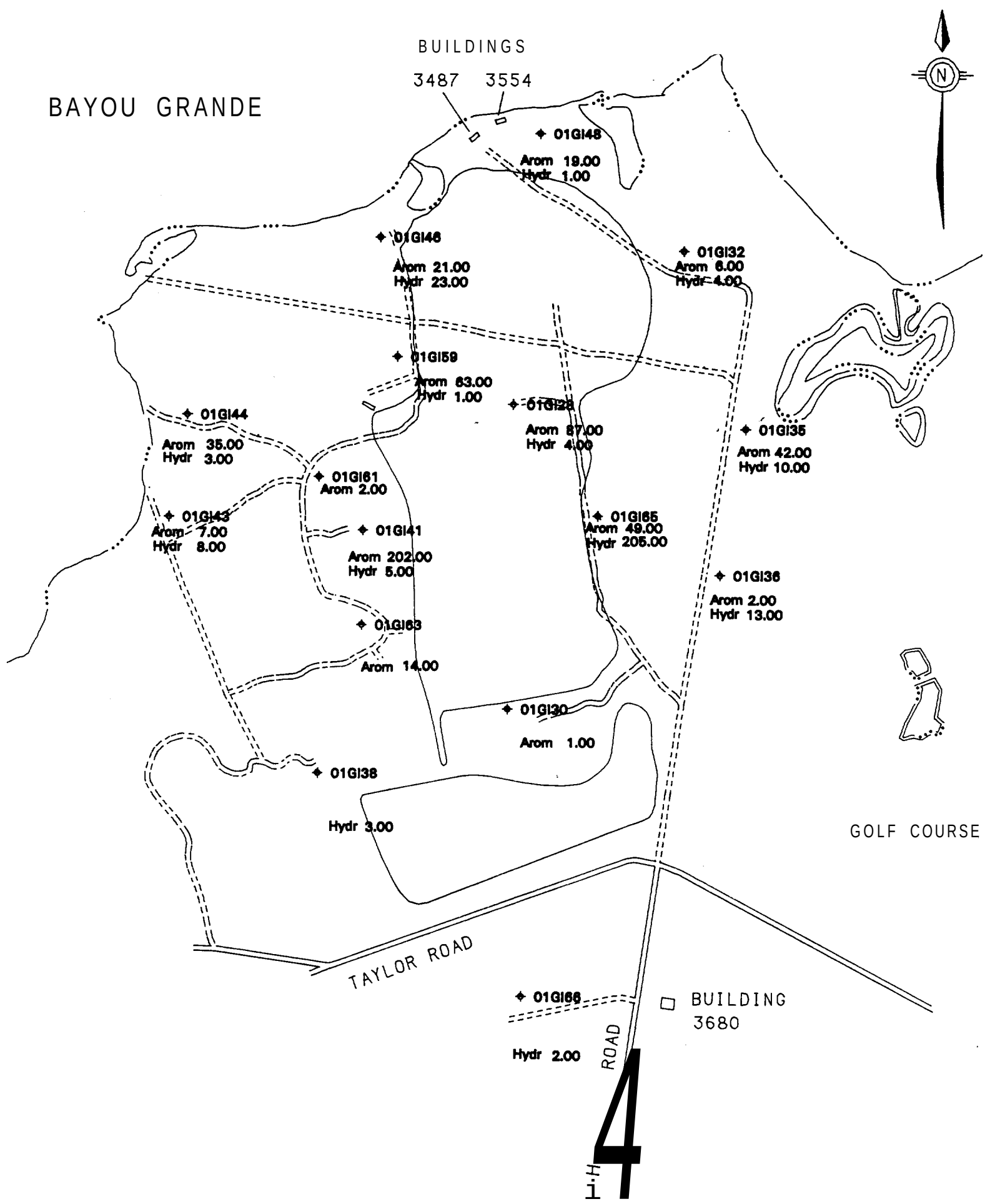
FIGURE 7-17
VOCS DETECTED IN INTERMEDIATE GROUNDWATER SAMPLES EXCEEDING MAXIMUM CONTAMINANT LEVELS

DATE: 11/24/93 DWG NAME: 59FIG7-17



LEGEND

COASTLINE / SURFACE WATER FEATURE

UNPAVED ROAD

4 — INTERMEDIATE MONITORING WELL

Arom 6.0 — TOTAL AROMATIC HYDROCARBON VOC CONCENTRATION IN µG/L

Hydr 7.2 — TOTAL ALIPHATIC HYDROCARBON VOC CONCENTRATION IN µG/L

600 0 600
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FIGURE 7-18
TOTAL AROMATIC AND ALIPHATIC HYDROCARBON VOCS DETECTED IN INTERMEDIATE GROUNDWATER SAMPLES

DATE: 11/24/93 | DWG NAME: 59FIG7-18

In addition to the previously discussed compounds, VOCs which were detected frequently and at the highest concentrations in intermediate groundwater samples were the aromatics chlorobenzene, ethylbenzene, and xylenes, and the aliphatics 1,1-dichloroethane, and 1,2-dichloroethene (total). Except for benzene, the most frequently detected VOCs were 1,2 dichloroethene and chlorobenzene in intermediate groundwater, with concentrations of up to 170 μg/L (01GI65) and 120 μg/L (01GI41), respectively, reported in 11 samples. Ethylbenzene, xylene, and 1,1-dichloroethane each were detected in seven or fewer samples at concentrations of up to 27 μg/L, 27 μg/L, and 11 μg/L, respectively. Figure 7-18 illustrates the detected concentrations of total aromatic and total aliphatic hydrocarbon VOCs. Also included in these "total" concentrations are the VOCs exceeding MCLs, the infrequently detected aromatic toluene, and the infrequently detected aliphatic chloromethane. However, a single concentration of the ketone 4-methyl-2-pentanone (140 μg/L) detected along the landfill's eastern boundary in sample 01GI65 is not included in these "total" VOC concentrations.

In general, aromatics occurred at higher concentrations than aliphatics in intermediate samples. The highest concentrations of total aromatics were detected in samples 01GI28 (87.0 μg/L), 01GI59 (63.0 μg/L), 01GI65 (49.0 μg/L), and 01GI41 (202.0 μg/L) from the site's central portion, around the eastern and western boundary of the landfill. With only two exceptions, concentrations of total aliphatic VOCs below 15 μg/L. The highest concentrations of total aliphatics were detected in samples 01GI65 (205.0 μg/L) and 01GI46 (23 μg/L), from the landfill's eastern and northwestern boundaries, respectively.

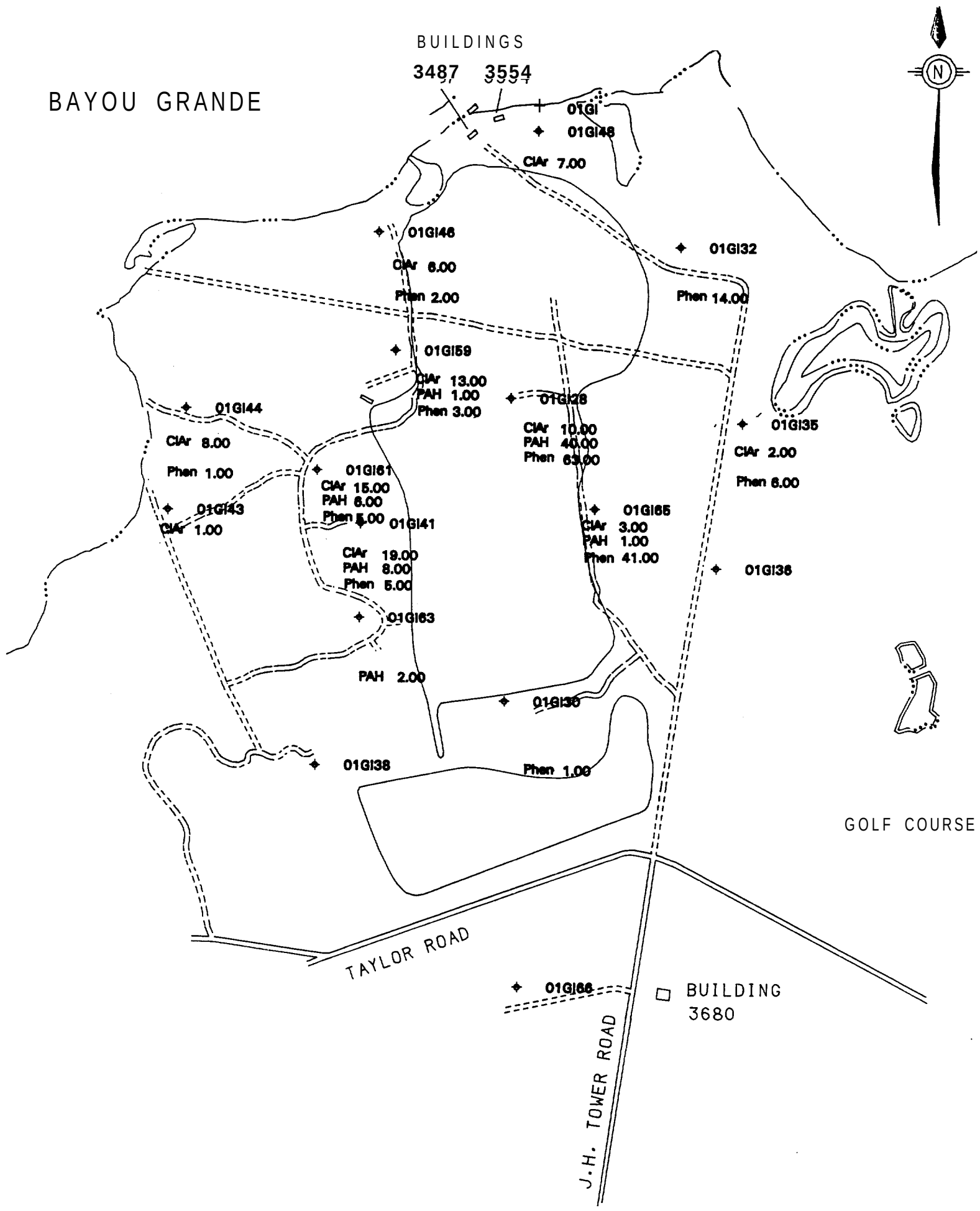
Semivolatiles

As shown on Table 7-8, 15 semivolatile compounds were' detected in intermediate groundwater samples, predominantly including two chlorinated aromatics (1,2-dichlorobenzene and 1,4-dichlorobenzene), two PAHs (2-methylnapthalene and naphthalene), and eight phenols (2,4-dimethylphenol, 2-chlorophenol, 2-methylphenol, 4-chloro-3-methylphenol, 4-methylphenol, 4-nitrophenol, pentachlorophenol, and phenol). These compounds were detected primarily

across the central and northern portions of the site, generally at concentrations of 10 μg/L or less. The highest concentrations of semivolatiles included 14 μg/L of 1,4-dichlorobenzene in sample 01GI41, 63 μg/L of 2,4-dimethylphenol and 31 μg/L of naphthalene in sample 01GI28, and 12 μg/L of 2-methylphenol in sample 01GI65. The two highest concentrations of napthalene, detected in samples 01GI28 (31 μg/L) and 01GI41 (8 μg/L), exceeded the 6.8 μg/L FGGC for this parameter. Figure 7-19 illustrates the distribution of total chlorinated aromatics, PAHs, and phenols detected in intermediate groundwater samples.

As Figure 7-19 shows, chlorinated aromatics were detected in 10 samples collected across the site's central and northern portions. The distribution of these detected concentrations is somewhat scattered, although the highest concentrations (up to 19.0 μg/L in sample 01GI41) occur in samples from the site's central and southwest portions, along the landfill's western boundary.

Most individual PAHs and phenols were detected relatively infrequently (less than six detected concentrations of each individual compound). As Figure 7-19 shows, detected PAH compounds were limited to the central portion of the site, around the landfill boundary. Phenols were detected across a wider area than PAHs, including the western, eastern, and northern extents of the site. The highest total concentrations of each compound group were detected in sample 01GI28 from the site's central portion within the landfill boundary. This sample exhibited concentrations of 40 μg/L and 63 μg/L of total PAHs and phenols, respectively. Nearby sample 01GI65 from the landfill's eastern boundary, also contained a relatively high concentration of total phenols, 41 μg/L. Included in this total phenol concentration is a 16 μg/L phenol concentration exceeding the 10 μg/L FGGC for this parameter. Additionally, a single concentration of pentachlorophenol was detected in sample 01GI30, equaling the FPDWS MCL of 1.0 μg/L for this compound.



LEGEND

COASTLINE / SURFACE WATER FEATURE

UNPAVED ROAD

INTERMEDIATE MONITORING WELL

ClAr *6.0* — TOTAL CHLORINATED AROMATICS CONCENTRATION IN μG/L

PAH *6.8* — TOTAL PAH CONCENTRATION IN μG/L

Phen *7.2* — TOTAL PHENOL CONCENTRATION IN μG/L

600 0 600

SCALE FEET

REMEDIAL INVESTIGATION REPORT

SITE 1

NAS PENSACOLA

FIGURE 7-19

TOTAL CHLORINATED AROMATIC, PAH, AND PHENOL SEMIVOLATILES DETECTED IN INTERMEDIATE GROUNDWATER SAMPLES

DATE: 11/24/93 | DWG NAME: 59FIG7-19

7.3.1.3 Deep Groundwater

Summary analytical results for deep groundwater samples collected from reference locations and Site 1 are presented in Tables 7-9 and 7-10, respectively. No organic compounds were detected in deep samples from the site.

Inorganics

Numerous metals concentrations were detected in groundwater samples collected from the three deep wells — GM-43, GM-44, and GM-45 — installed during the 1986 Characterization Study (Section 2.2.2 details previous investigations). All metals concentrations in deep groundwater samples were below FPDWS MCLs. However, all deep samples exceeded FSDWS MCLs for aluminum, iron, and manganese.

Deep groundwater sample metal concentrations generally exceeded those in reference samples from the two deep supply wells. Concentrations of aluminum, calcium, iron, lead, mercury, and manganese detected in site samples exceeded the respective RCs calculated from reference data. In addition, concentrations of arsenic, barium, lead, and mercury in site samples were not detected in reference samples. Figure 7-20 illustrates the distribution of arsenic, barium, lead, and mercury concentrations detected in Site 1's deep groundwater samples.

7.3.2 Summary and Conclusions

To organize the following discussion of Site 1 groundwater quality, this section will evaluate the previously discussed analytical results by parameter group (inorganics vs. organics, etc.) for all monitored intervals combined. Additionally, previous investigation groundwater quality data results will be compared to the results of this investigation to note any apparent temporal trends in site groundwater quality.

BAYOU GRANDE

BUILDINGS
3487 3554

GM-43
As 4.10
Ba 10.90
Pb 2.80
Hg 0.24

GM-44
Ba 11.90

GM-45
Ba 15.30

GOLF COURSE

TAYLOR ROAD

BUILDING
3680

J.H. TOWER ROAD

N

LEGEND

COASTLINE / SURFACE WATER FEATURE

UNPAVED ROAD

DEEP MONITORING WELL

As 2.5 — ARSENIC CONCENTRATION IN μG/L

Ba 3.5 — BARIUM CONCENTRATION IN μG/L

Pb 6.8 — LEAD CONCENTRATION IN μG/L

Hg 7.2 — MERCURY CONCENTRATION IN μG/L

600 0 600
SCALE FEET

SOUTHERN DIVISION NAVAL FACILITIES ENGINEERING COMMAND

REMEDIAL INVESTIGATION REPORT
SITE 1
NAS PENSACOLA

FIGURE 7-20
ARSENIC, BARIUM, LEAD, AND MERCURY DETECTED IN DEEP GROUNDWATER SAMPLES

DATE: 11/24/93 | DWG NAME: 59FIG7-20

Table 7-9
Site 1
Summary Analytical Results for Deep Reference Groundwater
(All results in µg/L)

Parameter	FPDWS	Sample Identification Number		Mean Concentration	RC (2 x MC)
		01GDSW50	01GDSW51		
Aluminum	200*	***345.000***	91.900	***218.45***	***436.9***
Arsenic	50	2.5 U	2.0 U	2.25	4.5
Barium	2,000	6.55 U	7.6 U	7.07	14.15
Calcium	-	3,260.000	8,240.000	5,750	11,500
Chromium	100	4.0 U	22.400 J	13.2	26.4
Copper	1,000*	5.4 U	19.200	12.3	24.6
Iron	300*	***1,660.000***	***4,050.000 J***	***2,855***	***5,710***
Lead	15	1.0 U	1.4 U	1.2	2.4
Magnesium		1,430.000	2,280.000	1,855	3,710
Manganese	50*	30.800	18.900	24.85	49.8
Mercury	2	0.1 U	0.1 U	0.1	0.2
Sodium	160,000	22,500.000	14,600.000	18,550	37,100
Zinc	5,000*	88.900	121.000	104.95	209.9

Key:

µg/L	=	Micrograms per liter
J	=	Parameter positively detected: however reported concentration is approximate.
U	=	Parameter not detected, vdue reported equals one-half the detection limit.
RC	=	Reference concentration, calculated as two times the mean concentration (MC).
FPDWS	=	Florida and/or USEPA Primary Drinking Water Standard (lower of the two) MCL
*	=	Florida Secondary Drinking Water Standard (FSDWS)
Bold kdia	=	The reported vdue exceeds the FPDWS/USEPA MCL or FSDWS MCL.

Table 7-10
Site 1
Summary Analytical Results for Deep Groundwater Samples
(All results in µg/L)

Parameter	FPDWS/RC	Sample Identification Number		
		01GGM43	01GGM44	01GGM45
Inorganics				
Aluminum	200*/436	***2,630.000 J***	***1.0*** 10.000	762.000
Arsenic	50/4.5	4.100 J	—	—
Barium	2,000/14	10.900	11.900	15.300
Calcium	—/1,150	**18.600.000**	**47.700.000**	10,300.000
Chromium	100126	11.300	—	—
Copper	1,000*/24	5.600	4.200	12.200
Iron	300*/5,710	6.720.000	***2,450.000***	***8,500.000***
Lead	15/2.4	2.800 J	—	—
Magnesium	—/3710	1,540.000	2,070.000	2,060.000
Manganese	50*/49	87.700	***65.400***	53.600
Mercury	2/0.2	0.240	—	—
Sodium	160,000/37,100	4,340.000	5,590.000	8,760.000
Zinc	5,000*/209	45.1 00	50.600	—

Notes:

µg/L	=	Micrograms per liter
—	=	Indicates parameter analyzed but not detected above method detection limit.
J	=	Parameter positively detected; however reported concentration is approximate.
FPDWS	=	Florida and/or USEPA Primary Drinking Water Standard (lower of the two) MCL
*	=	Florida Secondary Drinking Water Standard MCL
RC	=	Reference concentration calculated from reference data as two times the mean concentration.
Bold Underline	=	The reported value exceeds the RC calculated for this parameter.
Bold Italic	=	The reported value exceeds the USEPA/FPDWS or FSDWS.
Bold Underline and Italic	=	The reported value exceeds both the RC and the USEPA/FPDWS or FSDWS.

Inorganics

Elevated concentrations of metals (relative to drinking water standards) frequently were detected in Site 1 groundwater samples. **FPDWS** MCLs for arsenic, beryllium, chromium, lead, mercury, and nickel, and **FSDWS** MCLs for aluminum, iron, and manganese were exceeded in shallow, intermediate, and deep samples. However, comparable concentrations of these metals (also exceeding **MCLs)** were detected in shallow and intermediate reference samples.

Additionally, samples from the shallow and intermediate wells hydraulically upgradient (south) of the site proper generally exhibited metals concentrations comparable to or greater than concentrations detected in samples collected farther downgradient, at the site proper. Antimony and cadmium concentrations exceeding MCLs were detected in site samples, but not in reference samples. However, these metals each were detected in only two samples, one of which was upgradient of the site.

Few distinct trends in the distributions of 1993 metals concentrations axe evident. Comparable concentrations of metals were detected in both shallow and intermediate samples. In general, the areal distributions of these concentrations in shallow and intermediate samples are sporadic, varying by both parameter and well depth interval. Although groundwater across the site consistently has been determined to flow northward in the surficial zone, no commensurate concentration gradient in any of the metals concentrations is evident.

Concentrations of less water-soluble metals (beryllium, cadmium, chromium, lead, mercury, and nickel) generally were detected more frequently and/or at higher concentrations in samples from newly installed shallow wells compared to existing shallow wells. Additionally, some existing shallow wells were notably less turbid than newly installed wells, indicating these relatively higher concentrations may be the result of metals adsorbed to entrained finer-grained aquifer matrix material in the turbid samples. The reason for the difference in the turbidity observed between newly installed wells and existing wells is unknown. Both types of wells were

(re)developed and purged identically before sampling. Newly installed wells were constructed with the same type filter pack material (U.S. standard sieve size 20-30 silica sand) and well screen slot size (0.01 inch) as the existing wells (G&M 1986). However, existing wells were installed with only 2.5 feet of well screen versus the 10 feet of screen installed with the new wells, which may affect the amount of fine-grained material capable of entering the well. Alternatively, the less turbid existing wells may be installed in areas where relatively less fine-grained aquifer matrix is present.

Metals concentrations detected in samples from the site's deep wells, while below FPDWS MCLs, were elevated relative to those reported for reference deep supply wells. However, deep site wells monitor a different portion of the main producing zone than do the reference wells. Based on well logs, deep wells at the site are installed into the uppermost portion of the main producing zone (total depths ranging from 58 to 107 feet bls), just below the confining clay of the low permeability zone (G&M 1986). Deep supply wells used as reference at NAS Pensacola are installed into the main producing zone to a significantly greater depth than site wells (total depth approximately 175 feet bls for each, see Table 5-5 from Section 5.2.1 for specific well construction information). Additionally, supply wells are inherently less turbid than site monitoring wells, due to difference in well design and nature of operation, which likely results in lower metals concentrations in referemce samples.

Total (i.e., unfiltered) metals concentrations detected in samples collected from existing wells during the 1991 Phase I investigation (E&E 1991g) were comparable to those collected from the same wells during this investigation. No distinct temporal trends were evident from comparing the two data pups.

Due to the sporadic distribution of metals concentrations, the general lack of downgradient concentration trends, and the fact that upgradient and reference metals concentrations are generally comparable with those detected at the site, metals concentrations detected in 1993

Site 1 samples cannot be conclusively attributed to site activities based on these analytical results. Instead, frequently elevated (with respect to MCLs and RCs) metal concentrations appear to be in large part a function of sample turbidity commonly observed in most site and reference samples.

Organics

Analytical results confirm organic groundwater contamination is present in the landfii area. Available information regarding past landfill activities performed onsite indicates large volumes of heterogeneous industrial wastes were disposed of across the entire landfi area (see Section 4.2 for Contaminant Source Survey), resulting in a multitude of potential contaminant sources. The following conclusions drawn from the organics data further support the presence of numerous contaminant sources across the landfill.

Several volatile and semivolatile organics were detected in shallow and intermediate Site 1 groundwater samples. Pesticides also were detected in a limited number of shallow groundwater samples. Most detected concentrations of organic compounds were relatively low; however FPDWS MCLs for specific compounds were exceeded. The distribution of organic compounds in site groundwater extends toward Bayou Grande, west and north of the site, and beneath the adjacent golf course, east and northeast of the site. In general, relatively higher concentrations of organic compounds were detected in samples from the central portion of the site, along the western and eastern margins of the landfill. However, the locations of relatively higher or lower concentrations of individual organic contaminants often vary by compound as well as by depth interval (shallow versus intermediate samples). Furthermore, specific trends in the concentrations of detected organics indicating distinct plumes of individual contaminants are not readily discernible in the data.

Volatile Organic Compounds

Several aromatic and aliphatic hydrocarbon VOCs were detected in shallow and intermediate

groundwater samples. The distribution of VOCs detected in samples from both depth intervals extends toward Bayou Grande to the west and north, and beneath the golf course to the east and northeast. In general, the highest concentrations of VOCs were in samples from the central portion of the site, along the landfill's eastern and western boundaries, indicating the central, 1970s-era portion may be the primary source of these compounds. However, samples from the southcentral and southwestern portions also exhibited VOCs, indicating such sources may exist in the older, 1950s-era portion. VOCs were detected less frequently and at relatively lower concentrations in samples from the northern 1960s-era portion of the site, indicating either relatively low concentration sources are present here, or these compounds have been advectively transported downgradient from sources in the site's central portion.

Shallow and intermediate groundwater samples contained generally comparable concentrations of VOCs. However, this relationship does not hold true for all VOC groups (aromatics versus aliphatics), individual compounds, or site areas. Generally low concentrations (most less than 10 μg/L) of aliphatic VOCs were detected sitewide in both shallow and intermediate samples. Aromatic VOCs also were detected across the site; however, aromatics were detected more frequently and at generally higher concentrations than aliphatics. The aromatic benzene and the aliphatics tetrachloroethene, trichloroethane, vinyl chloride, and 1,2-dichloroethene were detected in site samples at concentrations exceeding FPDWS MCLs. Benzene, the most predominant VOC exceeding MCLs, was detected in samples across the site at concentrations ranging up to 74.0 μg/L. Tetrachloroethene, trichloroethene, and vinyl chloride were detected at maximum concentrations of 4.0 μg/L, 5.0 μg/L, and 23.0 μg/L, respectively. Additionally, 1,2-dichloroethene (170.0 μg/L) was detected in a single intermediate samples (01GI65). Aliphatic VOCs exceeding MCLs were detected in relatively few site samples (each with three or fewer detected concentrations per depth interval).

Overall, concentrations of VOCs detected in samples from existing shallow wells during the 1991 Phase I investigation were comparable to those samples from the same wells during this

investigation. However, concentrations of 1,2-dichloroethene, ethylbenzene, toluene, trichloroethane, vinyl chloride, and xylenes generally were detected less frequently and/or at lower concentrations during this investigation than in the 1991 study. Specifically, one or more of these VOCs was either not detected or detected at lower concentrations in samples from the center of the site (01GGM33 and 01GGM35), the western extent (01GGM41 and 01GGM42), and the northern extent (01GGM04 and 01GGM05) during this investigation. When compared to the results of the 1986 Characterization Study, concentrations of vinyl chloride in shallow samples from the central (01GGM34) and northern (01GGM05) portions of the site during this investigation are significantly lower than those detected during the previous investigation. Additionally, concentrations of vinyl chloride and benzene detected in samples from the site's eastern margin (01GGM39 and 01GGM38, respectively) during the 1986 study were not detected during this or the 1991 investigation. Benzene concentrations detected in shallow samples from the site's central portion (01GGM34 and 01GGM35) during this and the 1986 investigation are comparable. However, concentrations of chlorobenzene detected in samples from the site's central portion (01GGM33, 01GGM34, and 01GGM35) during this and the 1991 investigation were not detected or were detected at lower concentrations during the 1986 investigation. Importantly, concentrations of benzene detected in deep groundwater samples collected during the 1986 investigation were not detected during this investigation or the 1991 investigation.

Semivolatile Organic Compounds

Several chlorinated aromatic, PAH, and phenolic semivolatile compounds were detected in shallow and intermediate groundwater samples. The distribution of semivolatiles in site groundwater is generally consistent with the distribution of VOCs, indicating that the central, 1970s-era portion of the landfill may represent the primary source of these compounds.

Comparable concentrations of chlorinated aromatics were detected in shallow and intermediate samples. The distribution of these compounds primarily across the site's central portion was also similar in both sample groups. However, chlorinated aromatics generally were not detected

in samples from the landfill's west-central and southwestern boundaries. The highest concentrations of these compounds were detected in samples from the central portion of the site, adjacent to the landfill boundary.

PAHs and phenolic compounds were detected primarily across the site's central portion. Samples from the northern portion exhibited few detections of these compounds. Furthermore, PAHs and phenolic compounds generally were detected more frequently and at slightly higher concentrations in intermediate samples than in shallow samples. Samples from the central and east-central portions of the site contained the highest concentrations of these compounds. The only detected semivolatile approaching a regulatory concentration was pentachlorophenol. A single concentration of pentachlorophenol equal to the 1.0 μg/L MCL for this parameter was detected in an intermediate sample from the south-central portion of the site.

Concentrations of semivolatiles detected in samples collected from existing wells during the 1991 Phase I investigation (E&E 1991g) were comparable to those in samples collected from the same wells during this investigation. No distinct temporal trends were evident from comparing the two data groups.

Pesticides

Only limited amounts of pesticides were detected in site groundwater. Pesticides were detected in only two shallow groundwater samples (01GGM35 and 01GS58). A single relatively low concentration (0.004 μg/L) of alpha-Chlordane was detected in sample 01GGM35 from the center of the site. Slightly higher concentrations of 4,4'-DDE and 4,4'-DDT (0.064 μg/L and 0.014 μg/L, respectively) in sample 01GS58 from the site's southeastern margin are likely the result of pesticide application to the golf course. However, each of these concentrations was an extremely low, qualified detection which may be associated with the turbidity observed in shallow samples.

Pesticides were not detected in shallow or deep groundwater samples collected at Site 1 during the 1986 and 1991 investigations.

7.4 Physical Parameter and Radiation Analytical Results

Physical parameter and radiation analyses were conducted on selected soil and groundwater samples for use in the risk assessment and FS. The results are included as Appendix C of this report. Selected analytical results are summarized below.

Grain-size analyses of near-surface soil (collected 2 to 5 feet bls) comprising the surficial aquifer zone at Site 1 indicate fairly uniform conditions throughout the area. Generally greater than 90 percent of this analyzed soil was composed of fine- to medium-grained sand. The remaining percentage of the material consisted of clay and silt-sized particles. Total organic carbon in soil ranges from not detected to 3,000 mg/kg dry weight. Cation exchange capacity of soil ranges from 1.3 to 5.4 milligram equivalent per 100 grams (meq/100g).

Permeabilities of the near-surface soil range from 3.445×10^{-2} to 2.923×10^{-3} cm/sec. Permeabilities measured on clays of the low permeability zone were very low, 6.524×10^{-7} cm/sec for sample 01SI5940 from 38 to 40 feet bls, and 8.19×10^{-7} cm/sec for sample 01SI4840, from 38 to 40 feet bls.

Assuming near-surface soil is representative of the sands above the clay layer, permeabilities between the surficial zone and low permeability zone differ by four to five orders of magnitude. However, permeabilities in the near surface soil are likely higher than those of underlying aquifer sediments due to weight loading at depth. Within the clay, permeability varies at least one order of magnitude. The higher permeabilities in the clay likely correspond to horizons containing small lenses of sand and silt.

Analytical results indicate the landfill is not a significant source of radiation. Only low concentrations of apparently ambient radiation were detected in surface soil samples 01SS3901 and 01SI5901. Each individual gamma radionuclei detected was below 1.0 picocurie per *gram* (pCi/g). No concentrations of radiation above detection limits were reported for groundwater samples 01GGM33, 01GGM35, 01GGM44, 01GI28, and 01GI59.

8.0 ADDITIONAL *SAMPLJNG* ACTIVITIES — 1994

Sediment, surface water, and groundwater were sampled during June and July 1994 to provide additional data for completing the Site 1 RI/FS. Specifically, sediment and surface water in adjacent wetlands were sampled to preliminarily characterize these media and the potential effects from the site. Surface water and sediment data were intended to supplement data collected by USEPA's Environmental Services Division (ESD) during July 1992. Data from several sample locations selected by ESD did not meet the objectives of this RI and therefore were not used. ESD data meeting RI objectives were used to assess potential effects.

Because groundwater samples collected during the initial E/A&H 1993 sampling event were commonly characterized by high turbidities, numerous site monitoring wells were re-sampled using low-flow techniques to collect unbiased low-turbidity samples representative of actual groundwater conditions. Specifically, groundwater was resampled to fulfill the following objectives:

- Samples were collected in areas immediately downgradient of the landfill to confirm previously detected (relatively higher) concentrations of analyzed parameters;
- Samples were collected at reference locations to establish representative ambient inorganic concentrations for shallow groundwater at NAS Pensacola;
- Samples were collected at a new location downgradient of the landfill to determine the full extent of apparently site-impacted groundwater extending east-northeast from the site; and,
- Samples were collected from wells adjacent and upgradient of wetlands to provide water quality data for groundwater likely discharging to these features, concurrent with wetland surface water and sediment sampling. This infomation is not intended to delineate contamination in site wetlands, but to establish a preliminary link between the site and wetlands. This information will be used to focus the wetlands sampling to be determined during the Site 41 RI.

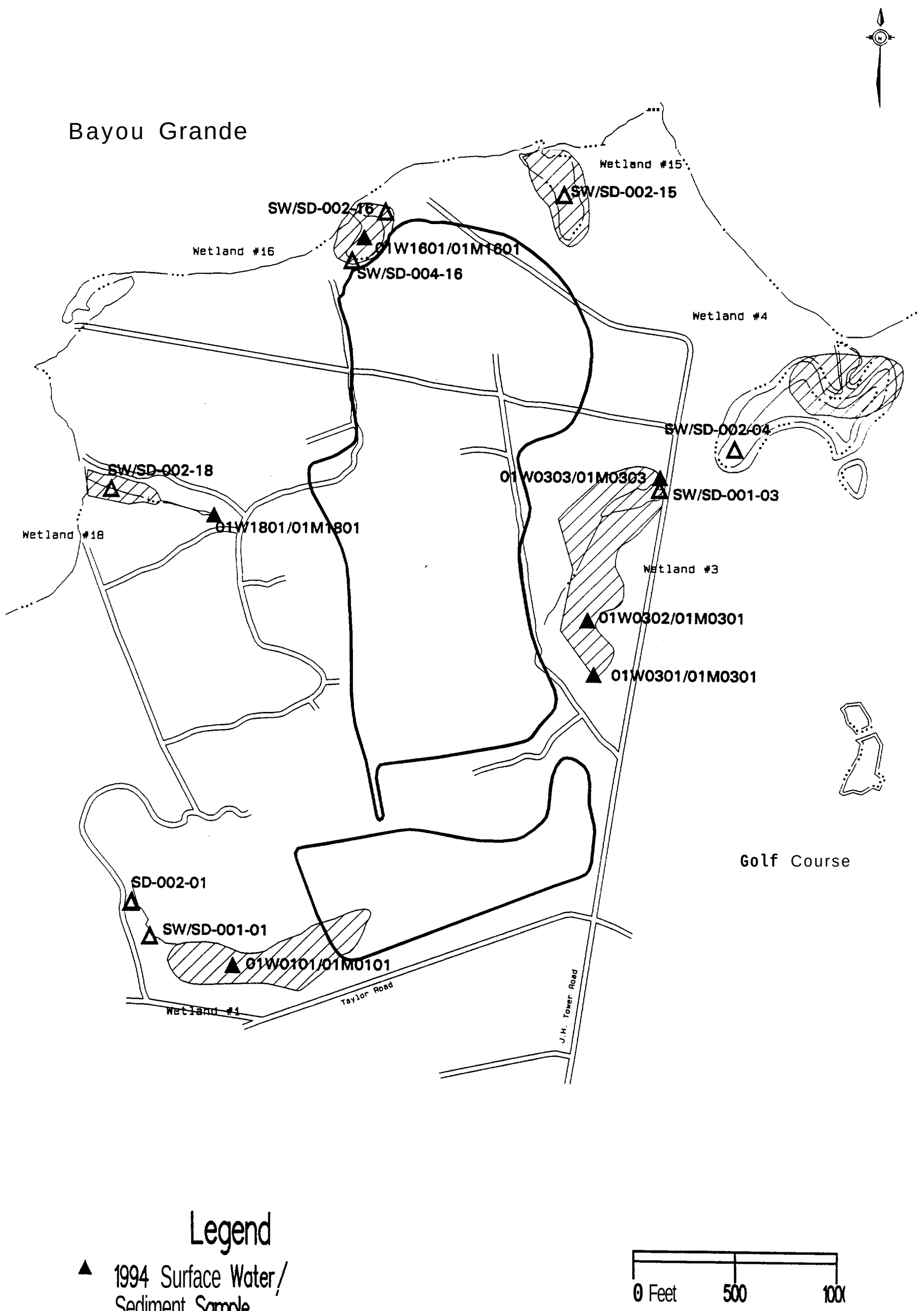
Due to the distinct time frame and purpose of the additional 1994 sampling activities, they are discussed here separately from the 1993 RI activities. The following subsections contain discussions of sampling methodologies (Section 8.1), groundwater elevations and flow direction (Section 8.2), and analytical results (Section 8.3). The initial 1993 fieldwork activities are contained in the other sections of this report (specifically, Chapter 5, Methodology, and Chapter 7, Nature and Extent of Contamination, 1993). However, a summary discussion of site groundwater quality is presented in Section 8.3.2, comparing the 1993 and 1994 sampling results.

8.1 Methodology

8.1.1 Surface Water and Sediment

Six surface water and six sediment samples were collected from Site 1 wetlands on June 28 and 29, 1994. Sample locations are shown on Figure 8-1A. Table 8-1 lists samples locations, sample identification numbers, and analytical parameters analyzed during the 1994 sampling event. Each sediment and surface water sample number (e.g., 01M0301) indicates the associated site number ("01" for Site 1), the media sampled ("M" for sediment, "W" for surface water), the wetland reference number (03 indicates wetland number 3), and the sample location (01 indicates sample station 1 of wetland 3).

Surface water and sediment samples were collected in and upstream of associated wetlands at locations selected to obtain samples most representative of groundwater discharge. At Wetland 16, salinity and conductivity were measured at the perimeter and bottom waters of the wetland to assess the potential for groundwater discharge. Bottom salinities were relatively lower than those of the top waters, indicating probable groundwater discharge through the sediment layer. The sampling location in this wetland was then selected based on this information.



Legend

▲ 1994 Surface Water/ Sediment Sample

△ 1992 ESD Sediment/Surface Water Sample

Remedial Investigation Report
Site 1
Pensacola, Florida

FIGURE 8-1A
Sediment and Surface Water Sample Locations - 1994 Sampling Activities

Date: November 22, 1994 | AML: site1

Surface water was sampled by immersing sample jars into the water and allowing them to fill. When surface water was very shallow, a depression was made to form a pool into which a jar was immersed to collect the sample. Sediment samples were collected using a stainless-steel spoon except at Wetland 16, where an Eckman dredge was employed. All procedures followed *CSAP* methodology.

Table 8-1
Sediment and Surface Water Samples and Analytical Parameters
Site 1
1994 Sampling Event

Media	Sample Location	Sample Number	Analytical Parameters
Sediment	Wetland 1 Location 1	01M0101	TAL/TCL, TOC, GS
	Wetland 3 Location 1	01M0301	TAL/TCL, TOC, GS
	Wetland 3 Location 2	01M0302	TAL/TCL, TOC, GS
	Wetland 3 Location 3	01M0303	TAL/TCL, TOC, GS
	Wetland 16 Location 1	01M1601	TAL/TCL, TOC, GS
	Wetland 18 Location 1	01M1801	TAL/TCL, TOC, GS
Surface Water	Wetland 1 Location 1	01W0101	TAL/TCL
	Wetland 3 Location 1	01W0301	TAL/TCL
	Wetland 3 Location 2	01W0302	TAL/TCL
	Wetland 3 Location 3	01W0303	TAL/TCL
	Wetland 16 Location 1	01W1601	TAL/TCL
	Wetland 18 Location 1	01W1801	TAL/TCL

Key:
TAL/TCL = Contract Laboratory Program Target Analyte List/Target Compound List
TOC = Total organic carbon
GS = Grain size

All sample locations were field marked with stakes and will be surveyed for reference during the upcoming wetland investigations (Site 41).

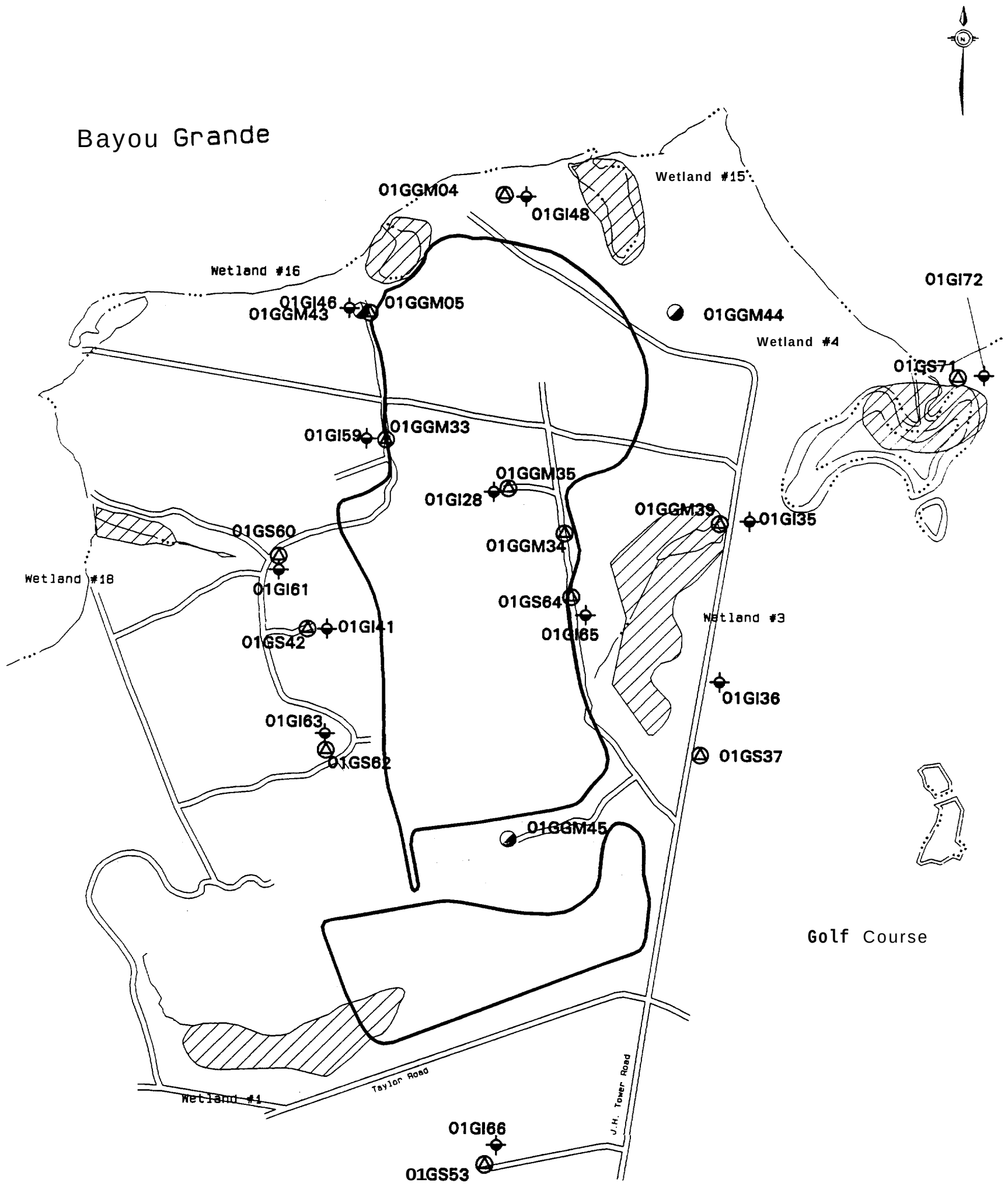
8.1.2 Groundwater

Groundwater was sampled from 32 wells from June 28 through July 6, 1994. This included resampling 26 previously installed wells (G&M 1984/1986 and E/A&H 1993) onsite and four reference wells offsite, and the initial sampling of two wells newly installed along the golf course downgradient of the site (01GS71 and 01GI72). Monitoring wells sampled in 1994 are shown on Figure 8-1B. Except for samples collected from three deep wells (GM-43, GM-44, and GM-45) and the four reference wells (01GS67, 01GI68, 01GS69, and 01GI70), samples were analyzed for the full TAUTCL parameter list. Due to the absence of organic parameters in 1993 samples, reference and deep well samples were analyzed for TAL inorganics only. Table 8-2 lists monitoring wells sampled, corresponding sample numbers, and parameters analyzed during the 1994 resampling. Samples were collected using low-flow, quiescent sampling techniques; all other sampling protocol and methodology were consistent with the initial 1993 sampling event.

Well Installation

Two additional monitoring wells (shallow well 01GS71 and one intermediate well 01GI72) were installed in June 1994 downgradient of the site, on the northeastern side of Golf Course Pond. Wells were installed here to determine the northeasternmost extent of apparent site-impacted groundwater extending from the landfill toward and beneath the adjacent golf course.

Construction information for the two wells installed in 1994 is included on Table 5-5. The monitoring wells were drilled and installed by Layne Environmental, Inc., of Pensacola, Florida, under the supervision of an E/A&H geologist, using the same procedures and methods employed during 1993 drilling activities (see Section 5.2.1). Soil boring lithologic logs and construction diagrams for the 1994 wells are contained in Appendices B and D, respectively. The 1994 wells were developed using the same surge-and-pump technique described in Section 5.2.2.



Legend

- Shallow Monitoring Well
- Deep Monitoring Well
- Intermediate Monitoring Well

0 Feet 500 1000

Remedial Investigation Report
Site 1
Pensacola, Florida

FIGURE 8-1B
Groundwater Sample Locations
- 1994 Sampling Activities

Date: November 22, 1994 | AML: site1

Table 8-2
Monitoring Wells, Groundwater Samples, and Analytical Parameters
Site 1
1994 Sampling Event

Level	Well Number	Sample Number	Analytical Parameters
Shallow	01GS37	01GS37	TALKCL
	01GS42	01GS42	TALKCL
	01GS53	01GS53	TALKCL
	01GS60	01GS60	TALKCL
	01GS62	01GS62	TALKCL
	01GS64	01GS64	TALKCL
	01GS67[a]	01GS67	TAL
	01GS69[b]	01GS69	TAL
	01GS71[c]	01GS71	TALKCL
	GM-04	01GGM04	TALKCL
	GM-05	01GGM05	TALKCL
	GM-33	01GGM33	TALKCL
	GM-34	01GGM34	TALKCL
	GM-35	01GGM35	TALKCL
	GM39	01GGM39	TALKCL
Intermediate	01GI28	01GI28	TALKCL
	01GI35	01GI35	TALKCL
	016136	01GI36	TAL/TCL
	01GI41	01GI41	TALKCL
	01GI46	01GI46	TALKCL
	01GI48	01GI48	TALJTCL
	01GI59	01GI59	TALKCL
	01GI61	01GI61	TALJTCL
	01GI63	01GI63	TALKCL
	01GI65	01GI65	TALKCL
	01GI66	01GI66	TALKCL
	01GI68[a]	01GI68	TAL
	01GI70[b]	01GI70	TAL
	01GI72[c]	01GI72	TALKCL

Table 8-2
Monitoring Wells, Groundwater Samples, and Analytical Parameters
Site 1
1994 Sampling Event

Level	Well Number	Sample Number	Analytical Parameters
Deep	GM-43	01GGM43	TAL
	GM-44	01GGM44	TAL
	GM-45	01GGM45	TAL

Key:

•	=	Reference well located near Building 696
•	=	Reference well located near Building 706
•	=	Newly installed (1994) shallow/intermediate well
TAL	=	Target Analyte List only
TAL/TCL	=	Contract Laboratory Program Target Analyte List/Target Compound List

Groundwater Sampling

Before collecting samples, wells were purged of at least three volumes using a peristaltic pump and decontaminated Teflon tubing. Purging was performed at a slow (approximately .25 gallons per minute [gpm] or less), controlled pumping rate while field parameters and turbidity levels were monitored. For all wells, field parameters stabilized and turbidity readings of 10 nephelometric turbidity units (NTUs) or less were obtained within four well volumes.

Unfiltered groundwater samples were collected immediately after well purging. Using the same peristaltic pump and Teflon tubing, groundwater for all analyses (except VOCs) was collected under low vacuum pressure via an inline collection/transfer bottle apparatus. This apparatus consisted of a two-aperture Teflon cap attached to a laboratory-certified, 300 series .5-gallon glass container. Teflon tubing from the well was attached to one aperture while the tubing from the peristaltic pump was attached to the second. The vacuum created by the pump was sufficient to lift groundwater from the well, filling the collection/transfer bottle at a low controlled flow rate (approximately 380 milliliters [ml] per minute). Using this technique, groundwater with minimal turbidity was collected and transferred to the appropriate sample containers (prepreserved, if required) for each analysis. Unagitated sample volumes for VOC analysis were

collected in prepreserved 40-ml VOA vials by removing the Teflon line from the well and the transfer bottle, and the allowing groundwater it retained to drain backward into the vials at a controlled rate.

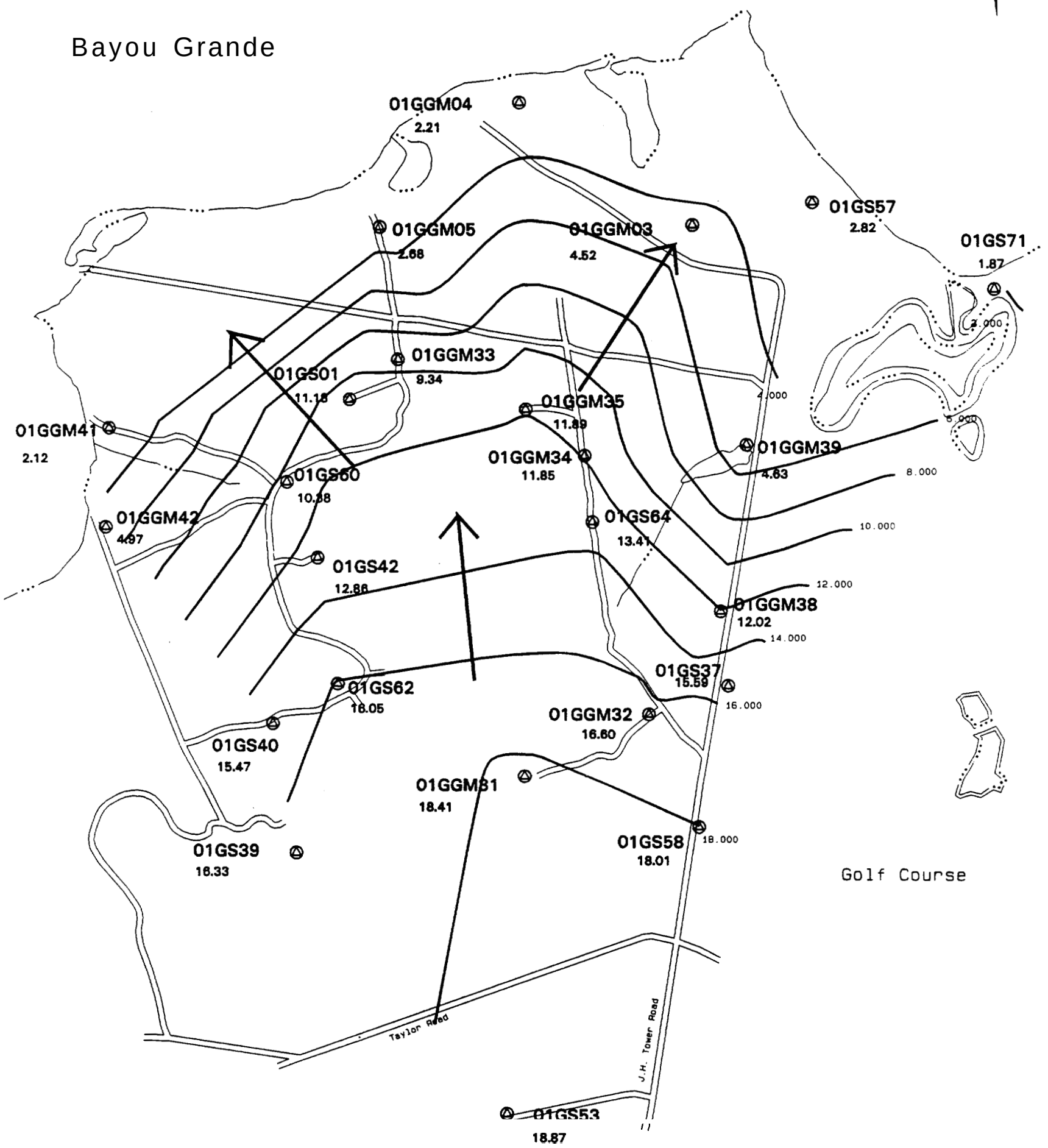
Hydrologic Assessment

Water levels were measured during high ti& on July 12, 1994. Measurements were taken at 44 site wells (24 shallow, 17 intermediate, and three deep) to determine groundwater elevation and direction of groundwater flow across the site during 1994 sampling activities. Water levels for shallow, intermediate, and deep monitoring wells were plotted to construct potentiometric surface maps for the three well depths on this date. These maps and a discussion of groundwater flow direction during the 1994 sampling activities are presented in Section 8.2.

Methods employed in 1994 to measure water levels, and calculate elevations, gradients, and flow velocities were consistent with those used during the 1993 assessment, as described in Section 5.4.1.

8.2 Hydrologic Assessment Results

Table 8-3 lists water level measurements and calculated water level elevations for July 12, 1994. Water levels measured during the approximate high tide were used to construct potentiometric surface diagrams across the site for this date. Figures 8-2 through 8-4 illustrate the potentiometric surface for shallow, intermediate, and deep well depths. Potential groundwater flow directions, approximately perpendicular to equipotential water level contour lines, are shown on each figure.



Legend

ROADS

SHORELINE

SHALLOW MONITORING WELL

2.88 Water Level Elevation In Feet Above MSL

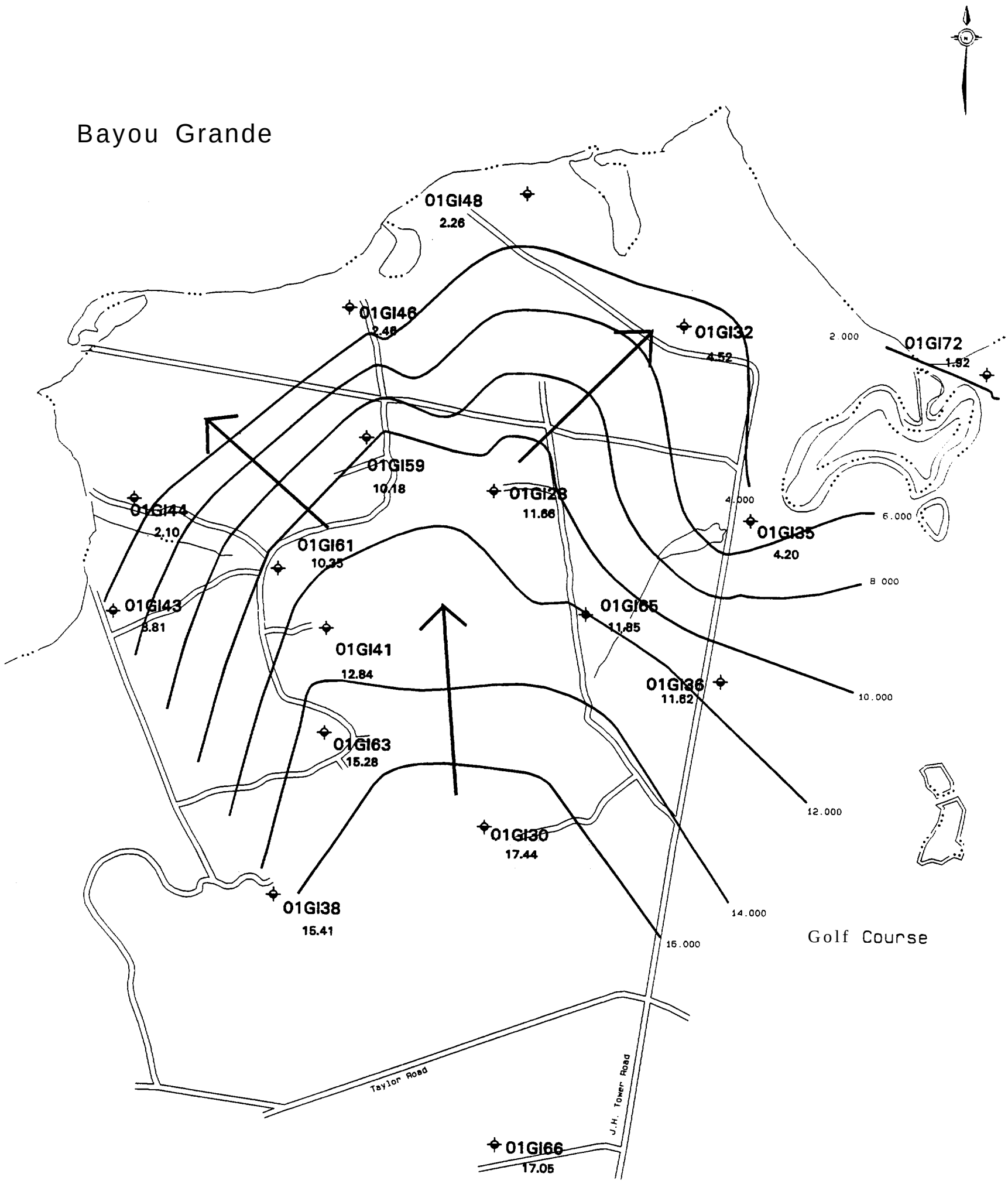
Potential Groundwater Flow Direction

0 Feet 500 1000

Remedial Investigation Report
Site 1 Resampling Event
Pensacola, Florida

FIGURE 8-2
POTENTIOMETRIC SURFACE 7/12/94
SHALLOW MONITORING WELLS - HIGH TDE

Date: November 22, 1994 AML: piezo01



Legend

ROADS

SHORELINE

INTERMEDIATE MONITORING WELL

2.00 Water Level Elevation In Feet Above MSL

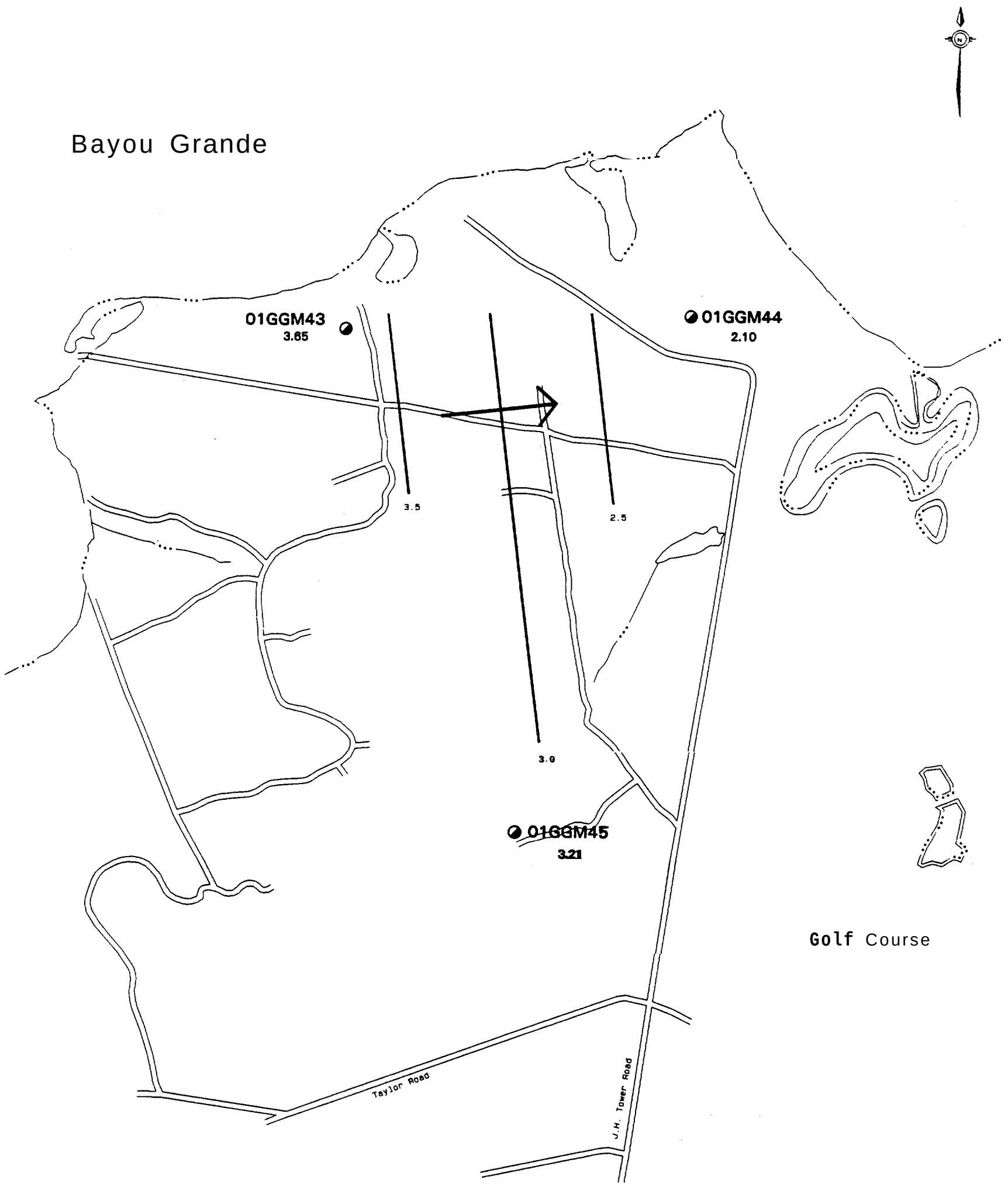
Potential Groundwater Flow Direction

0 Feet 500 1000

Remedial Investigation Report
Site 1 Resampling Event
Pensacola, Florida

FIGURE 8-3
POTENTIOMETRIC SURFACE 7/12/94
INTERMEDIATE MONITORING WELLS - HIGH TIDE

Date: November 22, 1994 AML: piezo01



Legend

ROADS

SHORELINE

DEEP MONITORING WELL

2.88 Water Level Elevation In Feet Above MSL

Potential Groundwater Flow Direction

0 Feet 500 1000

Remedial Investigation Report
Site 1 Resampling Event
Pensacola, Florida

FIGURE 8-4
POTENTIOMETRIC SURFACE 7/12/94
DEEP MONITORING WELLS - HIGH TIDE

Table 8-3
Water Level Elevation Data
Site 1
1994 Sampling Event

Well Number	Top of Casing Elevation[a]	High Tide[b]	
		Depth to Water (BTOC)	Water[a] Level Elevation
Shallow Wells			
01GS01	15.52	4.34	11.18
01GS37	17.18	1.59	15.59
01GS39	18.53	2.20	16.33
01GS40	20.91	5.44	15.47
01GS42	18.65	5.79	12.86
01GS53	31.53	12.66	18.87
01GS57	12.37	9.55	2.82
01GS58	25.71	7.70	18.01
01GS60	16.88	6.50	10.38
01GS62	20.51	4.46	16.05
01GS64	18.55	5.14	13.41
01GS71[c]	5.84	3.97	1.87
GM-03	19.78	15.26	4.52
GM-04	11.05	8.84	2.21
GM-05	8.03	5.35	2.68
GM-31	20.32	2.18	18.14
GM-32	19.20	2.60	16.60
GM-33	16.18	6.84	9.34
GM-34	16.14	4.29	11.85
GM-35	16.14	4.25	11.89
GM-38	20.34	8.32	12.02
GM-39	7.66	3.03	4.63

Table 8-3
Water Level Elevation Data
Site 1
1994 Sampling Event

Well Number	Top of Casing Elevation[a]	High Tide[b]	
		Depth to Water (BTOC)	Water[a] Level Elevation
GM-41	5.24	3.12	2.12
GM-42	14.83	9.86	4.97
Intermediate Depth Wells			
01GI28	16.96	5.30	11.66
01GI30	20.84	3.40	17.44
01GI32	20.49	15.97	4.52
01GI35	5.92	1.72	4.20
01GI36	17.83	6.21	11.62
01GI38	18.74	3.33	15.41
01GI41	18.42	5.58	12.84
01GI43	16.07	12.26	3.81
01GI44	5.89	3.79	2.10
01GI46	9.49	7.03	2.46
01GI48	11.50	9.24	2.26
01GI59	15.24	5.06	10.18
01GI61	17.04	6.69	10.35
01GI63	20.54	5.26	15.28
01GI65	18.50	6.65	11.85
01GI66	31.79	14.74	17.05
01GI72[c]	5.80	3.88	1.92

Table 8-3 Water Level Elevation Data Site 1 1994 Sampling Event			
		High Tide[b]	
Well Number	Top of Casing Elevation[a]	Depth to Water (BTOC)	Water[a] Level Elevation
Deep Wells			
GM-43	8.89	5.24	3.65
GM-44	20.56	18.46	2.10
GM-45	20.29	17.08	3.21

Key:
[a] = In feet above mean seal level (MSL)
[b] = Water level measured 7/12/94 during high tide et approximately 1400 hours
• Newly installed (6/27/94) downgradient well
BTOC = Below top of well casing

Groundwater Flow

As Figures 8-2 and 8-3 show, shallow and intermediate groundwater flow directions for the 1994 sampling period are essentially the same as those observed in 1993. Again, groundwater flow at each of these depth intervals is generally northward, toward Bayou Grande and adjacent surface water features, with components to the northwest and northeast. However, due to abnormally high rainfall in June and July 1994 (for the Pensacola municipal area, 30.91 total inches during this period in 1994 vs. 13.82 inches on average [pers.comm. NOAA 19941) water levels measured during and shortly after the resampling event were approximately 1.5 to 5 feet higher than those measured in 1993. The largest increases in water level elevation (typically greater than 3 feet) were observed at well locations in the site's central portion; water levels measured near the coastline were generally not more than 2 feet above 1993 levels.

Figure 8-4 illustrates the potentiometric surface and potential groundwater flow direction for deep site wells. Deep groundwater levels measured in 1994 were also elevated (approximately 1 to 4 feet) over those measured in 1993; the largest change was observed at inlandmost well location GM-45 (4.3 feet). The potential eastern groundwater flow direction measured for the deep zone in 1994 is distinctly different from the southward direction Observed in 1993. This is likely an effect of the anomalously high rainfall during this time frame, as recharge and leakage rates to the main producing zone would likely be affected under these abnormal conditions.

Hydraulic Gradient

Similar to the 1993 groundwater flow regime (as discussed in Section 6.2.2), the potentiometric surface diagrams for 1994 indicate overall shallow and intermediate depth well groundwater flow may be divided into three predominant components: a central (to the site) north-northwest flow, a northwest flow, and a northeast flow. Table 8-4 presents July 1994 horizontal hydraulic gradients for selected well pairs which approximately coincide with these predominant flow

Table 8-4 Horizontal Hydraulic Gradient Site 1 1994 Sampling Event			
Well Pair	Distance Between Wells (feet)	Difference Between Water Levels (feet)	Horizontal Gradient
		High Tide	High Tide
Shallow			
GM-31/GM33	1885	8.80	.0047
01GS60/GM-41	785	8.26	.0105
GM-35/GM-03	1090	7.37	.0068
Intermediate			
01GI30/01GI59	1885	7.26	.0039
01GI61/01GI44	790	8.25	.0104
01GI28/01GI32	1100	7.14	.0065

directions at Site 1. As Table 8-4 shows, the shallow and intermediate flow horizontal gradients are relatively similar in magnitude ranging from .0039 to .0105, again indicating the two depth intervals are part of the same flow system. The central flow direction has the lowest gradient of the three at both depth intervals. Gradients along the two remaining flow directions are slightly steeper than the central flow direction, likely a result of steeper topographic gradients along the site's margin as the coastline is approached. The highest gradient of the three is the northwestern gradient in both depth intervals, again likely reflecting the relatively steeper topographic gradient along the site's western margin. As compared to 1993, gradients observed during the 1994 sampling event are relatively steeper, probably as a result of inland groundwater mounding due to above-average rainfall and an increased volume of groundwater moving through the shallow aquifer zone toward discharge points along Bayou Grande.

Groundwater Flow Velocity

Table 8-5 presents July 1994 groundwater flow velocity estimates for the shallow and intermediate well intervals. Average velocity estimates were calculated using the geometric mean for hydraulic conductivity. As a result of steeper horizontal hydraulic gradients,

Table 8-5
Groundwater Velocity Results
1994 Sampling Event

Flow Direction	Hydraulic[a] Conductivity (feet/day)			Horizontal Hydraulic Gradient	Groundwater Velocity[b] (feet/day)		
					High Tide		
	Low Value	High Value	Average Value	High Tide	Low Value	High Value	Average Value
Shallow Wells							
North-Northwestern flow	14.67	162.73	47.93	.0047	0.27	3.06	0.90
Northwertern flow	14.57	162.73	47.93	.0105	0.61	6.83	2.01
Northeastern flow	14.67	162.73	47.93	.0068	0.40	4.43	1.30
Intermediate Wells							
North-Northwestern flow	4.77	109.83	24.19	.0039	0.07	1.71	0.38
Northwestern flow	4.77	109.83	24.19	.0104	0.20	4.67	1.01
Northeastern flow	4.77	109.83	24.19	.0065	0.12	2.86	0.63

groundwater flow velocities calculated for 1994 groundwater data are slightly higher than those calculated for 1993 water level data (see Section 6.2.3 for a detailed discussion of 1993 calculations). Using hydraulic conductivity data from 1993 specific capacity tests, groundwater velocity estimates range from 0.27 ft/day to 6.83 Wday in the shallow well depth interval, and 0.07 Wday to 4.57 Wday in the intermediate well depth interval (as compared to 1993: 0.17 Wday to 5.01 ft/per day in the shallow well depth interval, and 0.08 Wday to 3.38 ft/day in the intermediate well depth interval). Consistent with 1993 groundwater data, in July 1994 the northwestern flow direction along the site's western portion had the highest velocity estimates due to the relatively steeper horizontal gradients for this direction. Additionally, the north-northwestern flow direction calculated for the central portion had the lowest velocity estimates due to the relatively lower horizontal gradient.

8.3 Nature and Extent of Contamination

The nature and extent discussion for 1994 sampling activities will be organized by media. The sampling approach, methodology, and sample locations were discussed in Section 8.1 of this report.

8.3.1 Surface Water and Sediment

Tables 8-6 and 8-7 summarize analytical results for sediment and surface water samples, respectively, collected during the 1994 sampling event. Sample locations are shown on Figure 8-1A and 8-1B. The complete analytical report for these samples is contained in Appendix H.

Table 8-6
Summary Analytical Results for Sediment Samples
1994 Sampling Event

Parameter	USEPA Region IV Sediment Screening Value	Wetland 1 01M0101	Wetland 3 01M0301	Wetland 3 01M0302	Wetland 3 01M0303	Wetland 16 01M1601	Wetland 18 01M1801
Inorganics (ppm)							
Aluminum	—	4430 J	2540 J	809 J	1630 J	6120 J	8120
Arrenio	8	—	1.6 J	1.6 J	—	1.4 J	8.4 J
Barium	—	10.9	8.6	6.2	1.6	4.2	35.9
Cadmium	1	—	2.2	—	—	—	—
Calcium	—	327 J	1030 J	355 J	396 J	464 J	6840 J
Chromium	33	7.8	16.9	2.4	1.6	10.3	—
Copper	28	6.1	6.2	—	—	—	—
Iron	—	1490 J	13200 J	15800 J	1940 J	4680 J	15000 J
Lead	21	22 J	36.3 J	5.6 J	7.2 J	4.1 J	63.3 J
Magnesium	—	130	98	—	40.4	1190	961
Manganese	—	3.7	36.1	6.6	2.3	14.3	105
Sodium	—	204	—	—	—	1890	738
Vanadium	—	4.6	4.4	2.2	2.6	6.9	—
Zinc	68	10.4	15.8	6.0	4.0	12.2	17.1

Table 8-6
Summary Analytical Results for Sediment Samples
1994 Sampling Event

Parameter	USEPA Region IV Sediment Screening Value	Wetland 1 01M0101			Wetland 3 01M0301			Wetland 3 01M0302			Wetland 3 01M0303			Wetland 16 01M1601			Wetland 18 01M1801		
Organics (ppb)																			
Dieldrin	3.3	**3.7 J**			—			—			—			—			—		
4,4'-DDE	—	5.8 J			3.4 J			2.5 J			120 J			—			150		
Endrin	3.3	—			0.53 J			—			—			—			**13.0 J**		
4,4'-DDD	—	3.1 J			19.0			6.2			400 J			0.41 J			150		
4,4'-DDT	3.3	1.2 J			**9.9**			1.3 J			**220**			—			—		
alpha-Chlordane	1.7	—			0.56 J			0.51 J			**2.2 J**			—			**12.0 J**		
gamma-Chlordane	—	—			—			—			—			—			9.5 J		
TOC %	—	<.01			0.8			0.4			0.2			0.4			1.8		
Grain size %	—	1.3	79.0	20.7	0.1	90.1	9.8	0.1	97.5	2.4	0.6	93.7	5.7	0	90.7	9.3	4.4	77.4	18.2

Notes:
TOC % = Total organic carbon percentage
Grain Size % = Percentage of gravel, sand, fines
Bold underlined = Values exceed sediment screening value.

Table 8-7
Summary Analytical Results for Surface Water Samples
1994 Sampling Event

Parameter	IFSQS[c]	AWQC[a]	Wetland 1 01W0101	Wetland 3 01W0301	Wetland 3 01W0302	Wetland 3 01W0303	Wetland 16 01W1601[b]	Wetland 18 01W1801
Inorganics (ppb)								
Aluminum	—/1500	87/—	*[2120]*	[170]	[175]	[98.6]	198.91	[237]
Arsenic	50/50	190136	3.4	—	—	—	—	—
Barium	—/—	—/—	32.1	35.8	34.4	30.5	—	—
Calcium	—/—	—/—	11700	29100	29100	27600	145000	3060
Chromium, Total	—/-[d]	1210/—[d]	13.5	—	—	—	—	—
Chromium, Trivalent	—/673000[e]	117/103[e]	NA	NA	NA	NA	NA	NA
Chromium, Hexavalent	11/50[f]	11/50[f]	NA	NA	NA	NA	NA	NA
Copper	—/2.9	1212.9	*[7.5]*	—	—	—	—	—
Iron	1000/300	[1000/—]	*[3540]*	*[8080]*	*[8430]*	*[7810]*	*[414]*	*[848]*
Lead	*5015.6*	3.2/8.5	*[6.0 J]*	—	—	1.9 J	—	—
Magnesium	—/—	—/—	2140	2280	2320	2310	419000	1110
Manganese	—/—	—/—	143	127	136	146	56.6	47.6
Potassium	—/—	—/—	1040	1950	1840	1680	162000	901
Sodium	—/—	—/—	5510	7010	7220	7420	3820000	5340
Vanadium	—/—	—/—	10.2	4.7	—	—	—	—
Zinc	1000/86	110/86	39.7	—	—	—	—	—

[Bold items in brackets denote changes to the first draft of document.]

Table 8-7
Summary Analytical Results for Surface Water Samples
1994 Sampling Event

Parameter	[FSQS[c]	AWQC[a]	Wetland 1 01W0101	Wetland 3 01W0301	Wetland 3 01W0302	Wetland 3 01W0303	Wetland 16 01W1601[b]	Wetland 18 01W1801
Organics (ppb)								
1,4-Dichlorobenzene	—/—	11.2119.9	—	[2.0 J]	**12.0 J]**	—	—	—
Benzene	**71.28/71.28**	531109	—	2.0 J	1.0 J	—	—	—
Chlorobenzene	—/—	1951105	—	6.0 J	7.0 J	—	1.0 J	—
1,1-Dichloroethane	4 — . 1	—/—	—	—	—	. —	***2.0 J***	—

Key:
a = USEPA Ambient Water Quality Criteria; chronic values for freshwaterlsaltwater("—" means no value given)
b = Salinity greater than 3 parts per thousand
IC = Florida Surface Water Quality Standards far Class III waters. freshwater/saltwater
d = FSQSAWQC for Total Chromium
e = FSQSAWQC far Trivalent Chromium
f = FSQS-AWQC for Hexavalent Chromium
NA = Not analyzed
Bold italic = Value exceeds FSQS
Bdd underlined = Value exceeds ambient water quality criteria]
— = Not detected at or above the method detection limit

[Bold items in brackets denote changes to the first draft of document.]

In general, only lead and pesticide concentrations were of consequence in sediment samples collected near or within the selected wetlands. Several parameters (arsenic, cadmium, lead, dieldrin, endrin, DDT, and alpha-Chlordane) exceeded Region IV Sediment Screening Values (SSV. However, most exceedences were relatively small; most detected concentrations were of the same order of magnitude as respective SSVs. -For several wetlands, analytical results from this study did not agree with those from ESD;s study, which is not unexpected given the media's heterogeneity.

Analytical results of surface waters associated with wetlands near Site 1 did not reveal significant[ly high] concentrations of either organic or inorganic constituents. **[Several** metal **(aluminum, copper, iron, and lead) concentrations detected exceeded Florida and/or USEPA water quality standards.** Aluminum **and iron were detected in wetland samples at levels exceeding surface water standards, suggesting these metals may occur at elevated concentrations. Additionally,]** low concentrations **of** volatile and semivolatile compounds (7.0 ppb or less) were detected in surface water samples from Wetlands 3 and 16. Wetland sediment and surface water were evaluated with regard to shallow and intermediate groundwater quality (i.e., groundwater to surface water discharge scenario). Currently, site groundwater does not appear to be greatly affecting wetland sediment and surface water quality. However, generally low concentrations detected in wetland samples are partially attributable to past groundwater discharge to these features.

Wetland 1

Previous ESD **[sediment]** sampling from drainage ditches downstream of Wetland 1 **[(sample locations SD-0001-01 and SD-002-01)]** indicated low metal concentrations in addition to organics in sediments (*see* Appendix A, Table A-8). During the 1994 investigation, lead, barium, and pesticides were the only contaminants of consequence noted. Both lead and dieldrin

[detected in 1994 sediment samples] slightly exceeded SSV's; SSVs were unavailable for the other constituents detected.

[1994 surface water samples contained aluminum, copper, iron, and lead concentrations exceeding both USEPA and Florida Surface Water Standards. However, only the copper and lead exceedences appear anomalous given that aluminum and iron typically exceeded one or both of these standards at all wetland sampling locations. No organic parameters were detected in Wetland 1 surface water samples.]

No correlation was found between parameters detected in Wetland 1 and those detected at Test Trench 12. Although pesticides and lead were found at both locations, the ubiquitous nature of these compounds does not signify the trench as a sole source of these contaminants to the wetland. In addition, site conditions (highly permeable soil and relatively low topographic relief) and fate and transport mechanisms for organochlorine compounds and lead do not favor surficial movement of these parameters.

Wetland 3

[Aluminum and iron concentrations exceeding USEPA and/or Florida surface water criteria were detected in all Wetland 3 surface water samples. However, because comparable concentrations of these metals were detected in all wetlands, these likely represent ambient conditions.]

[Additionally,] barium was found at all three [wetland 3] surface water stations. [Barium] concentrations, near 30 ppm, were similar to those observed by ESD (SW-001-03). Relatively low benzene, chlorobenzene, and 1,4-dichlorobenzene concentrations (7 ppb or less) were

present at stations 01W0301 and 01W0302, but were not detected at 01W0303. **[The detected 1,4-dichlorobenzene concentrations exceeded USEPA ambient water quality criteria.]**

The highest inorganic sediment concentrations were observed upstream at station 01M0301. This trend likely reflects groundwater metal concentrations adsorbing to abundant suspended particulates available in the upstream portion of the wetland. Cadmium and lead were the only metals to exceed SSVs, and these only slightly. Detected organics consisted only of pesticides, with highest values observed at station **[01M0303]**, which is close to a road and the golf course. Most detected DDT concentrations exceeded the SSV. However, based on the distribution of detected pesticides and the apparent lack of significant pesticide contamination in site groundwater (see Section 8.3.2 for groundwater discussion), the source is not likely Site 1. Rather, these are residual concentrations from routine insect-control application along roadways and in areas of standing water. ESD observed several additional inorganic constituents in the wetland than occurred in the 1994 samples, but pesticide **[compounds]** found were similar in both studies.

Most likely, knowing the variety of disposed products, past practices at Site 1 have contributed to parameter concentrations detected in Wetland 3. Presently, benzene, chlorobenzene, and 1,4-dichlorobenzene detected in site groundwater appear to be impacting surface water quality at Wetland 3.

Wetland 15

Only ESD data were used to assess potential effects of Site 1 activities on Wetland 15. The ESD sample collected from directly within the wetland (SW/SD-002-15) was used in the assessment. ESD found low concentrations of barium and lead in surface water samples (see

Appendix A, Table A-9). Sediments contained barium, chromium, and lead. No other significant contaminants were detected.

At present, it does not appear that Site 1 is contributing to parameters detected in Wetland 15. Metal concentrations observed within the wetland were not consistent with those detected in 1994 groundwater samples from nearby upgradient wells. Volatiles and semivolatiles detected in nearby shallow and intermediate groundwater (samples 01GGM04 and 01GI48, were not found in surface water samples.

Wetland 4

The Wetland 4 assessment used ESD data (SW/SD-002-04) in conjunction with data collected at the farthest downstream location in Wetland 3. ESD data indicated nominal concentrations of lead and barium in surface water, with sediments containing several metals along with pesticides. The 1994 samples indicate surface waters at location 01W0303 contain few, if any, contaminants other than barium; sediments at this location have been impacted primarily by pesticides.

As in Wetland 3, Site 1 may have contributed to parameters (i.e., metals) previously detected in Wetland 4, although there are other input sources. Specifically, golf course surface water runoff, pesticide/herbicide application, and tidal action (bayou surface water quality) affect sediment and surface water quality of this wetland. At present, only metals and volatile organics detected in nearby shallow and intermediate groundwater (samples 01GGM39 and 01GI35), likely discharging to Wetland 4, appear to be of potential consequence to this wetland. However, no significant concentration (no detection of VOCs at all) of these parameters were detected in Wetland 3 or 4 samples, therefore; groundwaters' affect on this wetland appears to be undiscernible.

Wetland 16

Salinity was measured at surface, middle, and near bottom depths in Wetland 16. Salinity was consistently lower at the bottom depth, indicating potential groundwater discharge to this wetland is occurring through the substrate. Surface water sample 01W1601 was collected as close to the substrate as possible to capture the maximum effect groundwater discharge may have on this wetland. Sample results revealed only relatively low concentrations of **[metals, and the organics]** chlorobenzene and 1,1,dichloroethene. **[Of these detections, only iron exceeded Florida surface water saltwater criteria.]** Metals observed by ESD in Wetland 16 surface water (samples SW-004-16, SW-003-16, and SW-002-16) were not found in 1994.

Sediment at Wetland 16 contained some of the same metals found in the ESD study (SW-002-16, SD-003-16, SD-004-16) such as arsenic, barium, lead, and chromium, but at lower concentrations. Silver and volatiles found by ESD were not found in the sediment during this study.

Apparently Site 1 has impacted surface water and sediment within Wetland 16. **[Comparison of]** constituents and concentrations from the ESD study to this study suggests that time may be reducing sediment concentrations of metals and pesticides. Based on nearby shallow and intermediate groundwater quality results from this study (relatively low concentrations of organic and inorganic parameters detected in samples 01GGM05 and 01GI46), it appears that future contaminant input to Wetland 16 via groundwater discharge will be minimal.

Wetland 18

No significant.contaminants were found at Wetland 18 (01W1801) based on the results of 1994 surface water sampling. [Only **aluminum and iron surface water concentrations exceeded**

USEPA or Florida surface water criteria.] Because sampling locations differed greatly, the ESD samples, from areas of high tidal influence (SD-002-18), could not be compared to the 1994 samples from areas influenced by groundwater discharge.

Parameters detected at significant concentrations in Wetland 18 sediments included arsenic, barium, lead, DDD, DDE, alpha-Chlordane, and endrin. Lead and arsenic both exceeded SSVs, as did endrin and alpha-Chlordane. Although sediment sampling locations from this study were not directly comparable to ESD's, it is generally believed that reviewing the constituents observed during the two studies was of value. As in 1994 samples, ESD sediment samples collected within Wetland 18 proper contained lead and pesticides.

Groundwater discharge from Site 1 to Wetland 18 has likely impacted sediment quality both above and within the wetland. Arsenic, barium, and various volatile and semivolatile compounds were detected in nearby upgradient intermediate groundwater (sample 01GI61, see Table 8-12); however, these parameters have not been identified in associated surface water.

8.3.2 Groundwater

For consistency (with 1993 Sampling Nature and Extent, Section 7.3), groundwater quality will be discussed in the following sections by depth intervals corresponding to the shallow, intermediate, and deep well intervals monitored onsite. It should be noted no physical separation between the shallow and intermediate depth intervals is apparent, other than relative vertical position, and that these two intervals should be considered part of the same hydrologic system — the surficial zone. Following the analytical results sections will be a concluding discussion of groundwater quality (based on 1994 analyses) incorporating all monitored intervals. Additionally, the conclusion section will present any apparent temporal trends in the current groundwater analytical data as compared to the 1993 groundwater quality information for Site 1.

Analytical Results

Establishment of Reference

Summary analytical results for reference groundwater samples used to evaluate ambient groundwater quality (inorganic parameters only) at NAS Pensacola are presented in Tables 8-8 (shallow and intermediate zones) and Table 8-9 (deep zone). As discussed in Section 8.1.2, shallow and intermediate reference monitoring wells 01GS67, 01GI68, 01GS69, and 01GI70 were resampled in July 1994 using low-flow rate quiescent sampling techniques to obtain additional groundwater quality data for these respective zones. As discussed in Section 5.2, (potable water) deep supply wells 01DSW50 and 01DSW51 were sampled in July 1993 to obtain the remaining deep zone data. Because supply wells contained operable turbine pumps, these wells were sampled directly from a valve at the well head without using a bailer (resulting in visually determined low-turbidity samples). For comparison, reference sample results have been used in the following discussion to define a range of concentrations for each detected inorganic parameter representing ambient conditions. Further, an RC has been calculated for each inorganic parameter, equal to two times the parameter's mean concentration, to approximate the upper extent of the ambient concentration range for analyzed inorganic parameters. In instances where an analyzed parameter was not detected above the quantitation limit, a value of one-half the reported detection limit was used to calculate the mean concentration for the RC.

Inorganic parameters detected in 1994 site groundwater samples will be discussed in the following sections relative to RCs, FPDWS/USEPA or FSDWS MCLs, and FGGCs. As noted on Tables 8-8 and 8-9, concentrations of aluminum and iron detected in reference samples exceeded secondary drinking water standards for all well intervals, indicating these metals naturally occur at relatively high concentrations at NAS Pensacola. This is also consistent with regional reference data for Escambia County (FGS 1992).

Table 8-8
Summary Analytical Results for Shallow and Intermediate Reference Groundwater Samples
June 1994
(All results in µg/L)

Parameter	FPDWS	Sample Number					
		01GS67	01GI68	01GS69	01GI70	Mean Concentration	RC (2xMC)
Aluminum	200*	***4240.0***	146.5 U	***3270.0***	109.0 U	***1941.4***	***3882.8***
Antimony	6	15.1 U	15.1 U	15.1 U	15.1U	***15.1***	***30.2***
Arsenic	50	1.4 U	1.4 U	1.4 U	1.4 U	1.4	2.8
Barium	2000	5.5 U	6.75 U	9.45 U	4.75 U	6.6	13.2
Beryllium	4	.55 U	.55 U	.55 U	.55 U	.55	1.1
Cadmium	5	1.7 U	1.7 U	1.7 U	1.7 U	1.7	3.4
Calcium	—	17800.0	5670.0	6300.0	5350.0	8780.0	17560.0
Chromium	100	4.85 U	2.6 U	59.9	2.6 U	17.5	35.0
Cobelt	—	2.05 U	2.05 U	2.05 U	2.05 U	2.05	4.1
Copper	1000*	5.4 U	6.4 U	16.2	5.4 U	8.1	16.2
Iron	300*	*677.0*	***942.0***	*1770.0*	26.65	***853.9***	*1707.8*
Lead	15	.a U	.a U	.8 U	.8 U	.8	1.6
Maaneeium	—	795.0 U	665.0 U	1255.0 U	3030.0	1436.3	2872.6
Manganese	60*	6.7	8.9	26.7	1.55 U	11.0	22.0
Mercury	2	.1 U	.1 U	.1 U	.1 U	.1	.2
Nickel	100	19.96 U	19.95 U	19.96 U	19.95 U	19.95	39.9

Table 8-8
Summary Analytical Results for Shallow and Intermediate Reference Groundwater Samples
June 1994
(All results in µg/L)

Parameter	FPDWS	Sample Number					
		01GS67	01GI68	01GS69	01GI70	Mean Concentration	RC (2xMC)
Potassium	—	13,300.0	1,275.0U	6,560.0	3,200.0	6,083.8	12,167.6
Selenium	50	1.95U	1.95U	1.95U	1.95U	1.95	3.9
Silver	100	2.0U	2.0	2.0U	2.0	2.0	4.0
Sodium	160,000	10,700.0	8,350.0	7,830.0	9,810.0	9,172.5	18,345.0
Thallium	2	1.8U	1.8U	1.8U	1.8	1.8	**3.6**
Vanadium	**[49**]**	7.9	3.75U	3.75U	3.75	4.8	9.6
Zinc	5,000'	8.75U	3.9U	290	3.75	76.60	153.20

Key:
µg/L = Micrograms per liter
U = Parameter not detected, value reported equals one-half detection limit
RC = Reference concentration, calculated as two times the mean concentration (MC)
FPDWS = Florida and/or USEPA Primary Drinking Water Standard (lower of the two) MCL
* = Florida Secondary Drinking Water Standard (FSDWS)
[** = Florida Groundwater Guidance Concentration]
Bold italics = The reported value exceeds the FPDWSNSEPA or FSDWS MCL
— = No standard established

[Bold items in brackets denote changes to the first draft of document.]

Table 8-9
Summary Analytical Results for Deep Reference Groundwater Samples
Site 1
(All results in µg/L)

Parameter	FPDWS	Sample Identification Number		Mean Concentration	RC (2x MC)
		01GDSW50	01GDSW51		
Aluminum	200*	***345.000***	91.900	***218.45***	***436.9***
Barium	2000	6.65 U	7.6 U	7.07	14.16
Calcium	—	3260.000	8240.000	6760	11500
Chromium	100	4.0 U	22.400 J	13.2	26.4
Copper	1000.	6.4 U	19.200	12.3	24.6
Iron	300*	***1660.000***	***4050.000 J***	***2855***	***6710***
Magnerium	—	1430.000	2280.000	1866	3710
Manganese	50*	30.800	18.900	24.86	49.8
Sodium	160,000	22500.000	14600.000	18660	37100
Zinc	5000*	88.900	121.000	104.96	209.9

Key:

µg/L	=	Micrograms per liter
J	=	Parameter positively detected; however reported concentration is approximate
U	=	Parameter not detected, value reported equals one-half the detection limit
RC	=	Reference concentration, calculated as two times the mean concentration (MC)
FPDWS	=	Florida and/or USEPA Primary Drinking Water Standard (lower of the two) MCL
*	=	Florida Secondary Drinking Water Standard (FSDWS)
Bold Italics	=	The reported value exceeds the FPDWS/USEPA MCL or FSDWS MCL.
—	=	No standard established

Site Groundwater Quality

Final stabilization values for temperature, pH, and conductivity measured during well purging before sampling are presented in Table 8-10. In 1994, observed pH values ranged from 4.55 to 7.08 across the site, with the majority falling within 5.5 to 6.5 units. Conductivity values varied widely from less than .100 mS/cm to more than .500 mS/cm. Measured groundwater temperatures were approximately 22 to 24 °C.

Table 8-10
Groundwater Field Parameters
Site 1
1994 Sampling Event

Well ID	pH Units	Conductivity (mS/cm)	Temperature (°C)	Turbidity (NTUs)
Shallow Wells				
01GS37	5.56	.150	23.1	16
01GS42	4.55	.037	23.1	1
01GS53	6.60	.138	24.0	9
01GS60	4.76	.042	22.6	0
01GS62	5.42	.404	22.6	1
01GS64	6.16	.525	24.3	3
01GS67[a]	6.68	.326	24.1	15
01GS69[b]	5.76	.188	23.3	12
01GS71	5.44	.161	22.9	0
GM04	6.20	.387	21.8	1
GM05	5.04	.123	22.2	0
GM33	6.04	.568	20.9	0
GM34	6.26	.741	23.0	7
GM35	6.14	.753	23.2	0
GM39	6.01	.497	22.1	0
[illegible]				
01GI28	5.88	.632	22.3	0
01GI35	5.96	.263	22.6	1

Table 8-10
Groundwater Field Parameters
Site 1
1994 Sampling Event

Well ID	pH Units	Conductivity (mS/cm)	Temperature (°C)	Turbidity (NTUs)
01GI36	4.90	.108	22.0	3
01GI41	5.78	.449	21.7	6
01GI46	6.10	.529	21.1	1
01GI48	6.20	.389	22.0	2
01GI59	5.93	.526	21.4	0
01GI61	5.64	.409	21.0	2
01GI63	5.89	.373	22.1	10
01GI65	5.50	.567	21.9	0
01GI66	5.50	.083	24.8	1
01GI68[a]	6.77	.145	24.8	6
01GI70[b]	5.40	.203	21.9	6
01GI72	5.40	.152	22.2	1
Deep Wells				
GM43	6.31	.223	22.2	1
GM44	7.08	.271	21.8	1
GM45	5.61	.109	21.5	1

Summary analytical results tables for parameters detected in shallow, intermediate, and deep groundwater samples are presented in the following discussions. Bold underlined type indicates the reported value exceeded the RC calculated for that parameter; bold italic type indicates the reported value exceeds the FPDWS/USEPA or FSDWS MCL or FGGC. The complete analytical report for all groundwater samples collected in 1994 is contained in Appendix I.

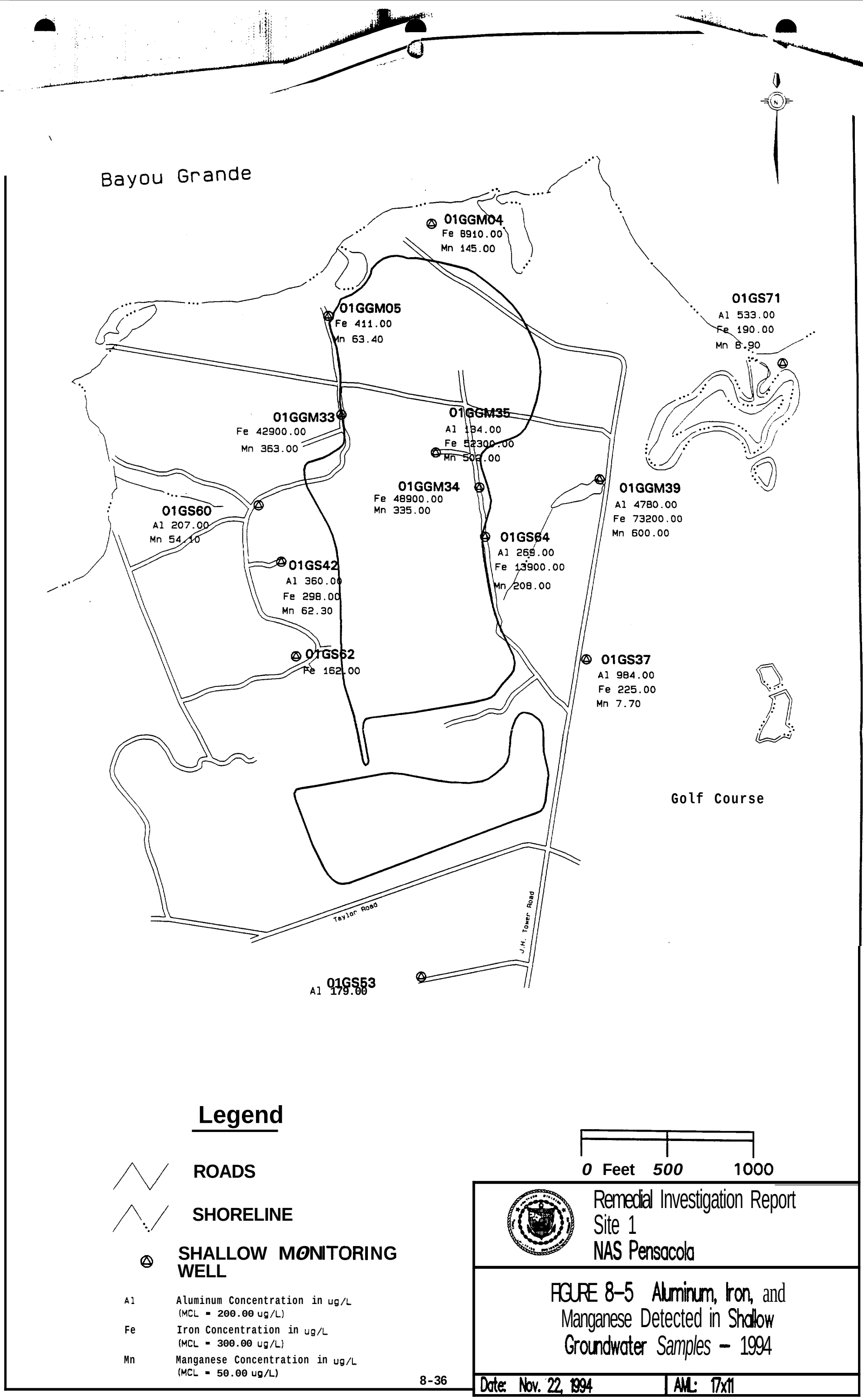
8.3.2.1 Shallow Groundwater

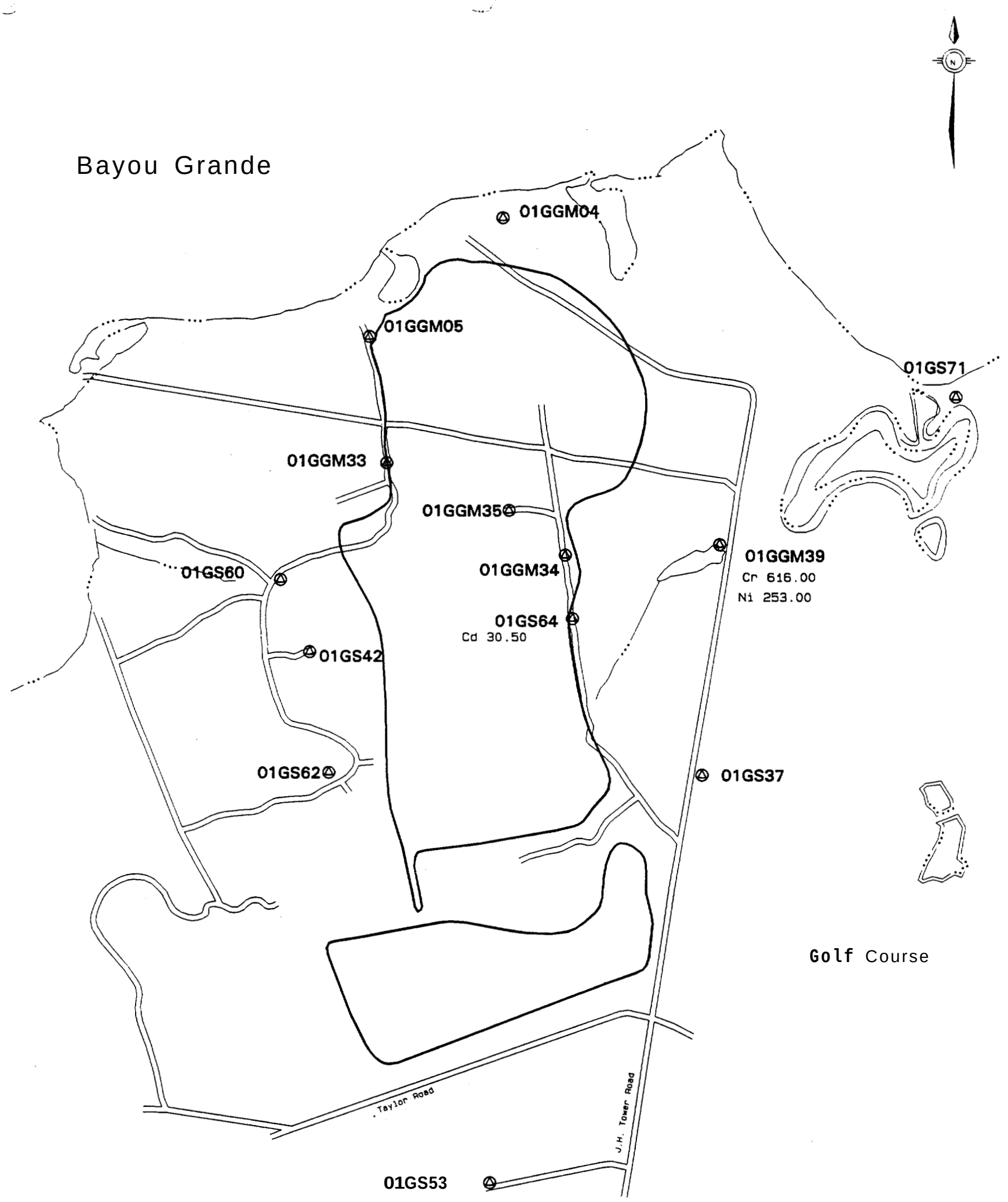
Thirteen shallow wells were sampled during July 1994 and samples were analyzed for the full TAL/TCL parameter list. Table 8-11, at the end of the Section, summarizes analytical results for these samples. Concentrations of inorgaaics, volatiles, semivolatiles, and pesticides were detected in shallow samples.

Inorganics

Numerous metals were detected in shallow groundwater samples collected from Site 1 during the 1994 resampling event. The following six metals were detected at concentrations exceeding FPDWS/USEPA or FSDWS MCLs and/or RCs: aluminum, cadmium, chromium, iron, manganese, and nickel. Additionally, the following five metals exceeded RCs only: calcium, cobalt, magnesium, vanadium, and zinc. Due to the numerous metals detected, this discussion will focus on those exceeding MCLs. Figures 8-5 and 8-6 illustrate the distribution of metals detected in 1994 shallow groundwater samples exceeding secondary and primary MCLs, respectively.

As Figure 8-5 shows, aluminum was detected in most shallow samples. Detected concentrations ranged from 134 µg/L to 4,780 µg/L. Six of these concentrations exceeded the 200 µg/L secondary MCL for this parameter. However, only the concentration detected in sample 01GGM39, 4,780 µg/L, exceeded the 3,883 µg/L RC for aluminum. This sample was from the site's eastern margin, along the edge of the golf course.


Bayou Grande
01GGM04
Fe 8910.00
Mn 145.00
01GGM05
Fe 411.00
Mn 63.40
01GS71
Al 533.00
Fe 190.00
Mn 8.90
01GGM33
Fe 42900.00
Mn 363.00
01GGM35
Al 134.00
Fe 52300.00
Mn 502.00
01GGM34
Fe 48900.00
Mn 335.00
01GGM39
Al 4780.00
Fe 73200.00
Mn 600.00
01GS60
Al 207.00
Mn 54.10
01GS64
Al 269.00
Fe 13900.00
Mn 208.00
01GS42
Al 360.00
Fe 298.00
Mn 62.30
01GS62
Fe 162.00
01GS37
Al 984.00
Fe 225.00
Mn 7.70
Golf Course
Taylor Road
J.H. Tower Road
01GS53
Al 179.00
Legend
ROADS
SHORELINE
SHALLOW MONITORING WELL
Al Aluminum Concentration in ug/L (MCL = 200.00 ug/L)
Fe Iron Concentration in ug/L (MCL = 300.00 ug/L)
Mn Manganese Concentration in ug/L (MCL = 50.00 ug/L)
0 Feet 500 1000
Remedial Investigation Report
Site 1
NAS Pensacola
FIGURE 8-5 Aluminum, Iron, and Manganese Detected in Shallow Groundwater Samples - 1994
Date: Nov. 22, 1994
AML: 17x11



Legend

ROADS

SHORELINE

SHALLOW MONITORING WELL

Cd — Cadmium Concentration in ug/L (MCL = 5.00 ug/L)

Cr — Chromium Concentration in ug/L (MCL = 100.00 ug/L)

Ni — Nickel Concentration in ug/L (MCL = 100.00 ug/L)

0 Feet 500 1000

Remedial Investigation Report
Site 1
NAS Pensacola

FIGURE 8-6 Cadmium, Chromium and Nickel Detected in Shallow Groundwater Samples - 1994

Date: Nov. 22, 1994 | AML: 17x11

Table 8-11
Summary Analytical Results for Shallow Groundwater Samples
Site 1
1994 Sampling Event
(All results in µg/L)

Parameter	FPDWS/RC	Sample Identification Number			
		01GS37	01GS42	01GS53	01GS60
Inorganics					
Aluminum	200*/3883	***984.000***	***360.000***	179.000	***207.000***
Arsenic	5012.8	—	—	—	—
Barium	2000113.2	8.900 J	—	2.400 J	11.100 J
Cadmium	5M.4	—	—	—	—
Calcium	—/17560	16300.000 J	—	**19600.000 J**	1070.000 J
Chromium (total)	100/35	—	—	—	—
Cobalt	—/4.1	—	—	—	—
Copper	1000*/16.2	—	—	—	—
Iron	300*/1708	225.000	298.000	—	—
Lead	15/1.6	—	—	—	—
Magnesium	—/2873	1340.000	—	333.000	657.000
Manganese	50*/22	7.700	***62.300***	—	***54.100***
Nickel	100/39.9	—	—	—	—
Potassium	—/12168	3010.000	—	—	—
Sodium	160000/18345	9820.000	4320.000	7810.000	4630.000
Vanadium	49**/9.6	—	—	—	—
Zinc	5000*/153	6.400	—	4.200	36.000

Table 8-11
Summary Analytical Results for Shallow Groundwater Samples
Site 1
1994 Sampling Event
(All results in µg/L)

Parameter	FPDWS/RC	Sample Identification Number		
		01GS62	01GS64	01GS71
Inorganics				
Aluminum	200*/3883	—	***269.000***	***533.000***
Arsenic	50/2.8	—	—	—
Barium	2000/13.2	3.700 J	**58.700 J**	—
Cadmium	5/3.4	—	***30.500***	—
Calcium	—/17560	199.000 J	**48900.000 J**	13100.000
Chromium (total)	100/35	—	—	—
Cobalt	—/4.1	—	—	—
Copper	1000*/16.2	—	—	—
Iron	300*/1708	162.000	***13900.000***	190.000
Lead	15/1.6	—	**5.300 J**	—
Magnesium	—/2873	897.000	2770.000	—
Manganese	50*/22	—	***208.000***	8.900
Nickel	100/39.9	—	—	—
Potassium	—/12168	**13800.000**	—	3610.000
Sodium	160000/18345	**31800.000**	3620.000	8580.000
Vanadium	49**/9.6	—	—	—
Zinc	5000*/153	7.000	**436.000**	—

Table 8-11
Summary Analytical Results for Shallow Groundwater Samples
Site 1
1994 Sampling Event
(All results in µg/L)

Parameter	FPDWS/RC	Sample Identification Number			
		01GGM04	01GGM05	01GGM33	01GGM34
Inorganics					
Aluminum	200*/3883	—	—	—	—
Arsenic	50/2.8	—	—	16.400	—
Barium	2000/13.2	62.800 J	9.400 J	—	336.000
Cadmium	513.4	—	—	—	—
Calcium	—117560	72700.000 J	1110.000 J	73900.000	60800.000
Chromium (total)	100135	—	—	—	—
Cobalt	—/4.1	—	—	5.500	4.700
Copper	1000*/16.2	—	—	—	—
Iron	300*/1708	8910.000	411.000	42900.000	48900.000
Lead	1511.6	—	—	—	—
Magnesium	—12873	2200.000	1350.000	4100.000	3280.000
Manganese	50'122	145.000	63.400	363.000	336.000
Nickel	100/39.9	—	—	—	—
Potassium	—/12168	—	2560.000	3030.000	—
Sodium	160000/18345	3820.000	6470.000	5890.000	6270.000
Vanadium	49**/9.6	—	—	—	—
Zinc	5000*/153	—	—	—	—

Table 8-11
Summary Analytical Results for Shallow Groundwater Samples
Site 1
1994 Sampling Event
(All results in µg/L)

Parameter	FPDWS/RC	Sample Identification Number	
		01GGM35	01GGM39
Inorganics			
Aluminum	200*/3883	134.000	***4780.000***
Arsenic	5012.8	**5.900**	**42.600**
Barium	2000/13.2	67.200 J	24.900
Cadmium	513.4	—	—
Calcium	—117560	**53200.000 J**	**57400.000**
Chromium (total)	100/35	—	***616.000***
Cobalt	—141	—	12.000
Copper	1000*/16.2	—	**147.000**
Iron	300*/1708	***52300.000***	***73200.000***
Lead	1511.6	—	—
Magnesium	—/2873	3680.000	**5330.000**
Manganese	50*122	***502.000***	600.000
Nickel	100/39.9	—	***253.000***
Potassium	—11 2168	4570.000	4470.000
Sodium	160000/18345	4950.000	10200.000
Vanadium	49**/9.6	—	10.800
Zinc	5000*/153	7.500	**3020.000**

Table 8-11
Summary Analytical Results for Shallow Groundwater Samples
Site 1
1994 Sampling Event
(All results in µg/L)

Parameter	FPDWS	Sample Identification Number			
		01GS37	01GS42	01GS53	01GS60
Volatiles					
1,l-Dichloroethans	700**	—	—	—	—
1,2-Dichloroethene	70	—	—	—	—
1,1,2-Trichloroethane	5	—	—	—	—
1,1,2,2-Tetrachloroethane	—	—	—	—	—
Benzene	1	—	—	—	—
Bromoform	4**	—	—	—	—
Chlorobenzene	100	—	—	—	1.000 J
Chloroethane	140**	—	—	—	—
Chloroform	6**	—	4.000 J	—	5.000 J
Ethylbenzene	700	—	—	—	—
4-Methyl-2-Pentanone (MIBK)	350**	—	—	—	—
Toluene	1000	—	—	—	—
Vinyl Chloride	1	—	—	—	—
Xylene (total)	10000	—	—	—	—
Semivolatiles					
1.2-Dichlorobenzene	600	—	—	—	—
1,4-Dichlorobenzene	75	—	—	—	—
2-Methylnaphthalene	—	—	—	—	—
2,4-Dimethylphenol	400**	—	—	—	—
Naphthalene	6.8**	—	—	—	—
Pesticides					
alpha-BHC	0.05**	—	—	—	—
Dieldrin	0.1**	—	—	—	—

Table 8-11
Summary Analytical Results for Shallow Groundwater Samples
Site 1
1994 Sampling Event
(All results in µg/L)

Parameter	FPDWS	Sample Identification Number		
		01GS62	01GS64	01GS71
Volatiles				
1,1-Dichloroethane	700**	2.000 J	—	—
1,2-Dichloroethene	70	—	—	—
1,1,2-Trichloroethane	6	—	—	—
1,1,2,2-Tetrachloroethane	—	—	—	—
Benzene	1	***12.000***	***3.000 J***	—
Bromoform	4**	—	—	—
Chlorobenzene	100	7.000 J	31.000	—
Chloroethane	140**	2.000 J	—	—
Chloroform	6**	—	—	—
Ethylbenzene	700	39.000	—	—
4-Methyl-2-Pentsnone (MIBK)	350**	—	—	—
Toluene	1000	2.000 J	—	—
Vinyl Chloride	1	—	—	—
Xylene (total)	10000	110.000	—	—
Semivolatiles				
1,2-Dichlorobenzene	600	—	—	—
1,4-Dichlorobenzene	76	8.000 J	3.000 J	—
2-Methylnaphthalene	—	—	—	—
2.4-Dimethylphenol	400**	3.000 J	—	—
Naphthalene	6.8**	—	2.000 J	—
Pesticides				
alpha-BHC	0.05**	—	—	—
Dieldrin	0.1**	—	—	0.0076 J

Table 8-11
Summary Analytical Results for Shallow Groundwater Samples
Site 1
1994 Sampling Event
(All results in µg/L)

Parameter	FPDWS	Sample Identification Number			
		01GGM04	01GGM05	01GGM33	01GGM34
Volatiles					
1,1-Dichloroethane	700**	—	—	—	—
1,2-Dichloroethene	70	—	—	—	—
1,1,2-Trichloroethane	5	2.000 J	—	—	—
1,1,2,2-Tetrachloroethane	—	6.000 J	—	—	—
Benzene	1	—	—	2.000 J	***12.000***
Bromoform	4**	***4.000 J***	—	—	—
Chlorobenzene	100	36.000	1.000 J	31.000	24.000
Chloroethane	140**	—	—	—	—
Chloroform	6**	—	—	—	—
Ethylbenzene	700	—	—	—	—
4-Methyl-2-Pentenone (MIBK)	350**	8.000 J	—	—	—
Toluene	1000	—	—	—	—
Vinyl Chloride	1	—	—	—	—
Xylene (total)	10000	—	—	—	—
Semivolatiles					
1.2-Dichlorobenzene	600	—	—	—	—
1,+Dichlorobenzene	75	4.000 J	—	7.000 J	5.000 J
2-Methylnaphthalene	—	—	—	—	3.000 J
2,4-Dimethylphenol	400**	—	—	—	—
Naphthalene	6.8**	—	—	—	***9.000 J***
Pesticides					
alpha-BHC	0.05**	—	—	—	0.0043 J
Dieldrin	0.1**	—	—	—	—

Table 8-11
Summary Analytical Results for Shallow Groundwater Samples
Site 1
1994 Sampling Event
(All results in µg/L)

Parameter	FPDWS	Sample Identification Number	
		01GGM35	01GGM39
Volatiles			
1,1-Dichloroethane	700**	—	1.000 J
1,2-Dichloroethene	70	—	1.000 J
1,1,2-Trichloroethane	5	1.000 J	—
1,1,2,2-Tetrachloroethane	—	2.000 J	—
Benzene	1	***6.000 J***	***5.000 J***
Bromoform	4**	2.000 J	—
Chlorobenzene	100	36.000	15.000
Chloroethane	140**	—	—
Chloroform	6**	—	—
Ethylbenzene	700	—	—
4-Methyl-2-Pentanone (MIBK)	350**	—	—
Toluene	1000	—	—
Wnyl Chloride	1	—	***3.000 J***
Xylene (total)	10000	—	—
Semivolatiles			
1,2-Dichlorobenzene	600	4.000 J	—
1,4-Dichlorobenzene	75	8.000 J	4.000 J
2-Methylnaphthalene	—	—	—
2,4-Dimethyephenol	400**	—	—
Naphthalene	6.8**	***8.000 J***	—

Table 8-11
Summary Analytical Results for Shallow Groundwater Samples
Site 1
1994 Sampling Event
(All results in µg/L)

		Sample Identification Number	
Parameter	**FPDWS**	**01GGM35**	**01GGM39**
Pesticides			
alpha-BHA	0.05**	—	—
Dieldrin	0.1**	—	—

Key:

µg/L	=	Micrograms per liter
—	=	Indicates parameter analyzed but not detected above the method detection limit
J	=	Parameter positively detected; however reported concentration is approximate
FPDWS	=	Florida and/or USEPA Primary Drinking Water Standard (lower of the two) MCL
*	=	Florida Secondary Drinking Water Standard (FSDWS)
**	=	Florida Groundwater Guidance Concentration (FGGC)
RC	=	Reference concentration calculated as two times the mean concentration of analyzed parameters detected in reference samples. A value of one-half the detection limit was used to calculate the mean concentration when parameter was not detected.
Bold Underline	=	The reported value exceeds the reference concentration calculated for this parameter.
Bold Italics	=	The reported value exceeds the FPDWS/USEPA or FSDWS MCL or FGGC.
Bold, Underline and Italic	=	The reported value exceeds both the RC and MCL.

As Figure 8-6 shows, cadmium was detected only in sample 01GS64, from the landfill's eastern border. This concentration, 30.5 μg/L, exceeded both the 5 μg/L primary MCL and 3.4 μg/L RC for this parameter.

As Figure 8-6 shows, chromium was detected only in sample 01GGM39, from the site's eastern margin. This concentration, 616 μg/L, exceeded both the 100 μg/L primary MCL and 35 μg/L RC for this parameter.

As Figure 8-5 shows, iron was detected in most shallow samples at concentrations ranging from 162 μg/L to 73,200 μg/L. Seven of these concentrations exceeded the 300 μg/L secondary MCL and six exceeded the 1,708 μg/L RC for this parameter. Concentrations exceeding these standards were detected in samples 01GGM04 and 01GGM05 from the site's northern extent; samples 01GGM33 and 01GGM35 from the central portion; samples 01GS64 and 01GGM34, from the landfill's eastern boundary; and sample 01GGM39 from the site's eastern margin.

As Figure 8-5 shows, manganese was detected in most shallow samples at concentrations ranging from 7.7 μg/L to 600 μg/L. Nine of these concentrations exceeded both the 50 μg/L secondary MCL and 22 μg/L RC for this parameter. Concentrations exceeding these standards were detected in samples 01GGM04 and 01GGM05 from the northern extent; samples 01GGM33, 01GGM35, and 01GS60 from the central portion; samples 01GS64 and 01GGM34, from the landfill's eastern boundary; sample 01GS42 from the western boundary; and sample 01GGM39 from the site's eastern margin.

As Figure 8-6 shows, nickel was detected only in sample 01GGM39, from the eastern margin. This concentration, 253 μg/L, exceeded both the 100 μg/L primary MCL and 39.9 μg/L RC for this parameter.

Calcium, cobalt, magnesium, vanadium, and zinc (not shown on figures) each were detected in shallow groundwater at concentrations exceeding their respective RCs as follows:

- Calcium was detected in Seven samples (01GS53, 01GS64, 01GGM04, 01GGM33, 01GGM34, 01GGM35, and 01GGM39) exceeding the 17,560 μg/L RC;
- Cobalt was detected in three samples **(01GGM33, 01GGM34,** and 01GGM39) exceeding the 4.1 μg/L RC;
- Magnesium was detected in four samples (01GGM34, 01GGM34, 01GGM35, and 01GGM39) exceeding the 2,873 μg/L RC;
- Vanadium was detected in one sample (01GGM39) exceeding the 9.6 μg/L RC; and
- Zinc was detected in two samples (01GS64 and 01GGM39) exceeding the 153 μg/L RC.

[1994 shallow groundwater sample results **for wells located within 300 feet of surface water bodies (01GGM04, 01GGM05, 01GGM34, 01GGM39, 01GS60, 01GS64, and 01GS71) were compared to USEPA Region IV freshwater surface water screening values.** Aluminum **and iron concentrations commonly exceeded their respective screening values in most samples. Cadmium and zinc exceeded screening values in sample 01GS64; arsenic, chromium (total), copper, nickel, and zinc exceed respective screening values in sample 01GGM39.]**

Volatiles

As Table 8-11 shows, 14 VOCs (five aromatic hydrocarbon and nine aliphatic hydrocarbon compounds) were detected in shallow groundwater samples during the 1994 resampling event. Most of these compounds were detected infrequently and at relatively low concentrations. Figures 8-7 and 8-8 illustrate the distribution of VOCs exceeding MCLs and total VOC groups (aromatic and aliphatic hydrocarbons) detected in shallow groundwater samples, respectively.

As Figure 8-7 show.,detected concentrations of the aromatic VOC benzene, and the aliphatic VOC vinyl chloride equaled or exceeded FPDWS MCLs of 1.0 μg/L for each compound, respectively. Benzene was the most frequently detected of the tow VOCs, occurring in six shallow samples across the site's central, eastern, and southwestern portions. The highest benzene concentrations, 12.0 μg/L, was detected in sample 01GGM34 collected from the landfill's eastern boundary, and sample 01GS62 fro-m the southwestern boundary. Vinyl chloride was detected only in sample 01GGM39 (3.0 μg/L) from the site's eastern margin.

[Bold items in brackets denote changes to the first draft of document.]

Bayou Grande

01GGM04

01GGM05

01GS71

01GGM33
BENZ 2.00

01GGM35
BENZ 6.00

01GGM34
BENZ 12.00

01GGM39
V CHLO 3.00
BENZ 5.00

01GS60

01GS64
BENZ 3.00

01GS42

01GS62
BENZ 12.00

01GS37

Golf Course

Taylor Road

J.H. Tower Road

01GS53

Legend

ROADS

SHORELINE

SHALLOW MONITORING WELL

V.CHLO Vinyl Chloride Concentration in ug/L (MCL = 1.00 ug/L)

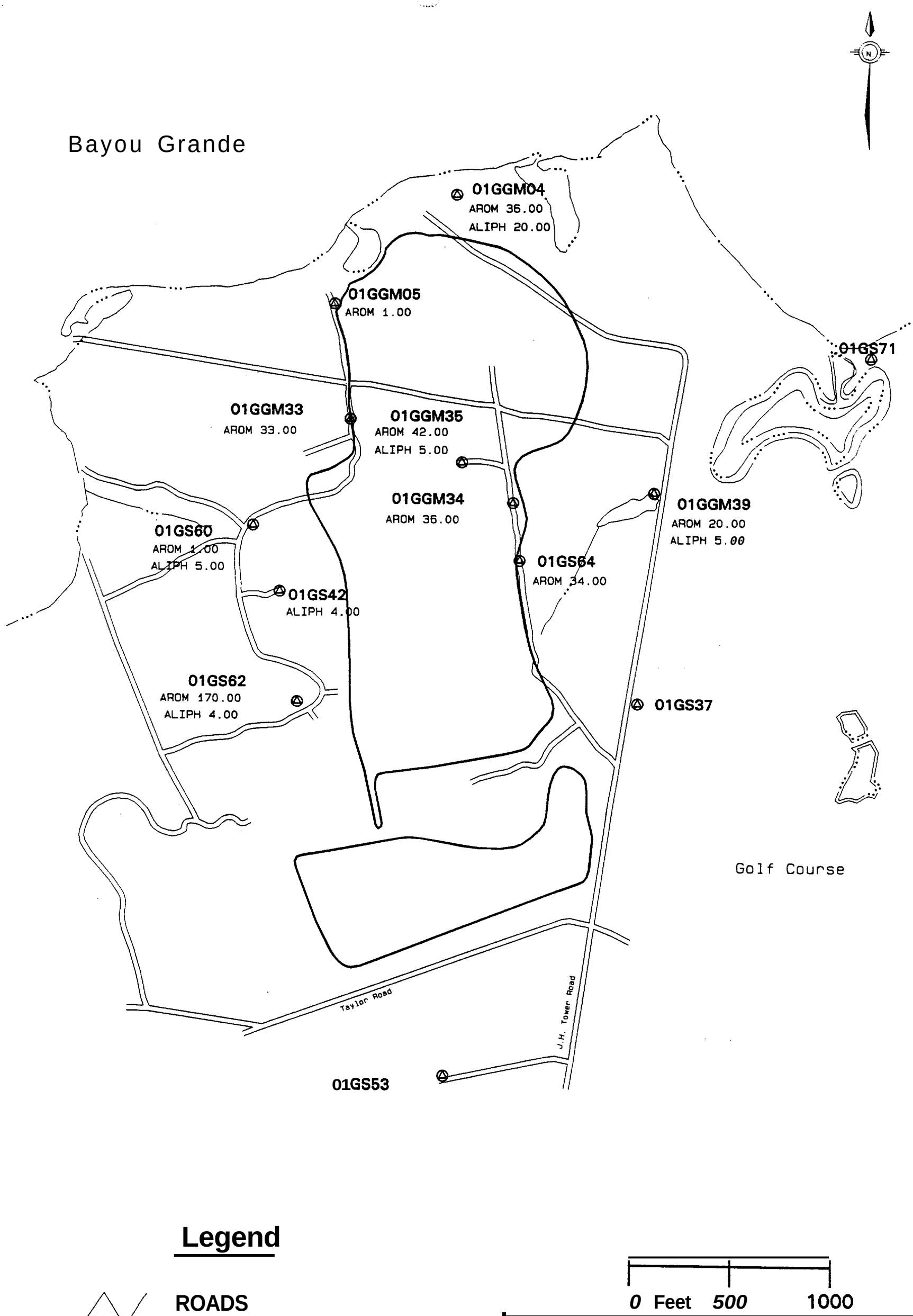
BENZ Benzene Concentration in ug/L (MCL = 1.00 ug/L)

0 Feet 500 1000

Remedial Investigation Report
Site 1
NAS Pensacola

FIGURE 8-7
VOCs Exceeding MCLs Detected
in Shalow Groundwater Samples - 1994

Date: Nov. 22, 1994 | AML: 17x11



Legend

ROADS

SHORELINE

SHALLOW MONITORING WELL

AROM Total Aromatic Concentration in ug/L

ALIPH Total Aliphatic Concentration in ug/L

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Site 1
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FIGURE 8-8 Total Aromatic and Total Aliphatic Hydrocarbon VOCs Detected in Shallow Groundwater Samples - 1994

Date: Nov. 22, 1994 | AML: 17x11

In addition to the previously discussed compounds, the most frequently detected VOC in shallow groundwater samples was the aromatic chlorobenzene, detected in nine of 13 samples. Other than benzene and ethylbenze, individual VOC's occurred infrequently, present in two or less samples (of 13total shallow samples). The aliphatics 1,1-dichloroethane, 1,1,2-trichloroethane, 1,1,2,2,-tetrachloroethane, bromofonn, and chloroform each were detected in two shallow samples at concentrations up to 2.0 μg/L, 2.0 μg/L, 6.0 μg/L, 4.0 μg/L, and 5.0 μg/L, respectively. The bromoform concentration detected in sample 01GGM04 from the site's northern extent equaled the 4.0 mg/L FGGC. Figure 8-8 illustrates concentmtions of total aromatic and total aliphatic hydrocarbon VOCs detected in shallow samples. Also included in these "total" concentrations are the VOCs exceeding MCLs.

Aromatic VOCs occurred at higher concentrations and more frequently than aliphatics in shallow groundwater. The highest concentrations of total aromatics were detected in samples 01GS62 (170 μg/L), from the landfill's southwestern boundary; 01GGMS35 (42 μg/L) from it's central portion; 01GGM34 (36 μg/L) from it's eastern boundary; and 01GGM04 (36 μg/L) from the site's northern extent. With one exception, concentrations of total aliphatic VOCs in shallow samples were below 10.0 μg/L. The highest concentmtion of total aliphatic VOCs (20.0 μg/L), was detected in sample 01GGM04. Overall, the highest total VOC concentrations (aromatics and aliphatics combined) were detected in samples 01GS62 (174 μg/L), 01GGM35 (47 μg/L), and 01GGM04 (56 μg/L). No VOCs were detected in sample 01GS71 from the newly installed farthest downgradient shallow well.

Semivolatiles

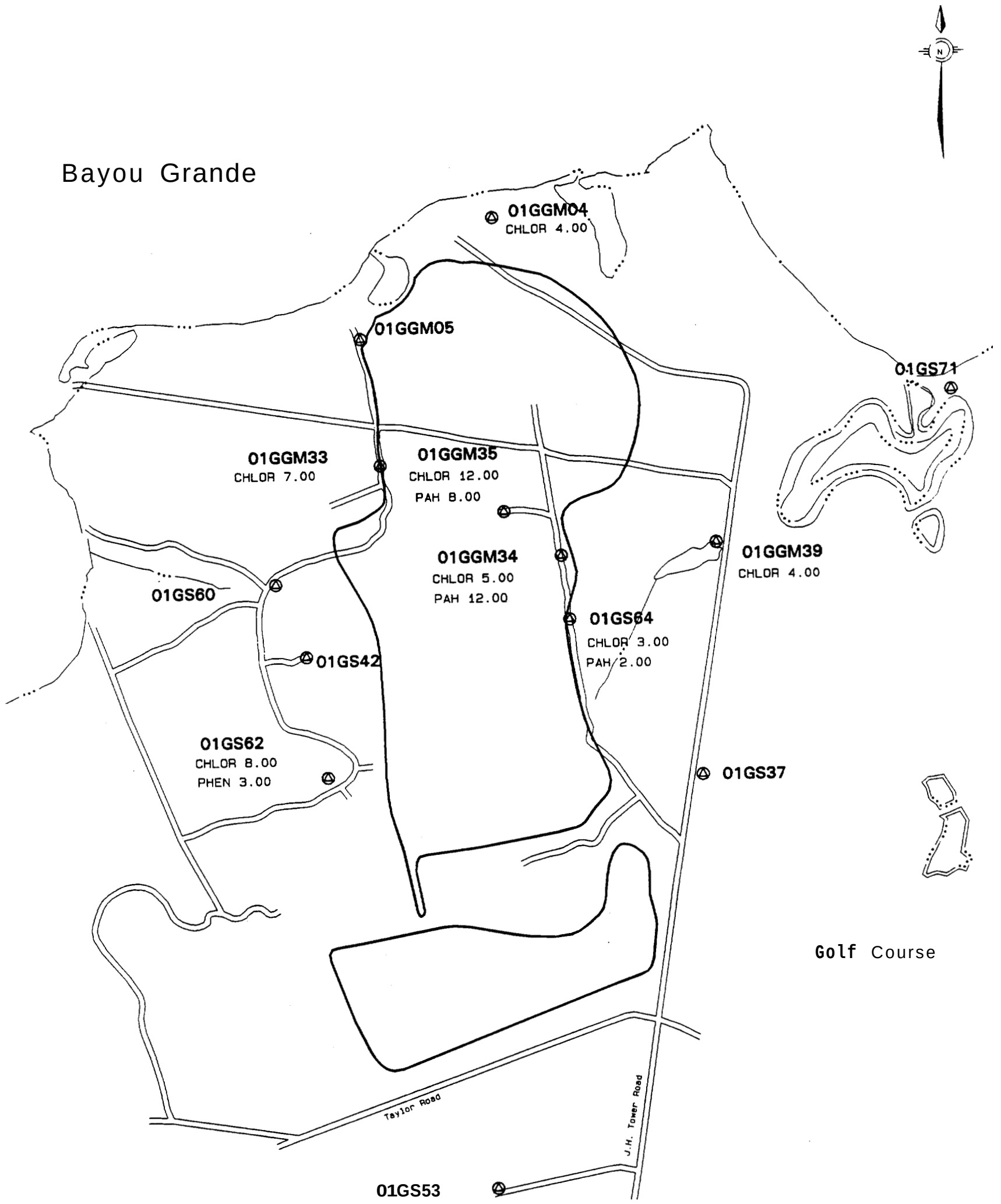
As Table 8-11 shows, five semivolatile compounds were detected in shallow groundwater samples during the 1994 resampling event. These included two chlorinated aromatics (o-dichlorobenzene and p-dichlorobenzene), two PAHs (2-methylnaphthalene and naphthalene), and one phenol (2,4-dimethylphenol). These compounds were detected primarily across the central and eastern portions of the site. Naphthalene was the only detected semivolatile which

exceeded an MCL or FGGC. Samples 01GGM34, from the landfill's eastern boundary, and 01GGM35, from it's central portion, each contained naphthalene concentrations (9.0 μg/L and 8.0 μg/L, respectively) exceeding the 6.8 μg/L FGGC. The highest concentrations of total semivolatiles included 20 μg/L detected in sample 01GGM35 from the central portion of the landfill, 17 μg/L in sample 01GGM34 from it's eastern boundary, and 11 μg/L in sample 01GS62 from it's southwestern boundary. However, individual compound concentrations detected in each sample were below 10 μg/L. Figure 8-9 illustrates the distribution of total chlorinated aromatics, PAHs, and phenols detected in shallow groundwater samples.

As Figure 8-9 shows, chlorinated aromatics were detected in seven samples across the central, northern, and southeastern portions of the site. The distribution of these detected concentrations is somewhat scattered; however the highest concentrations, up to 12.0 μg/L total chlorinated aromatics in sample 01GGM35, occur primarily in the central and east-central portions of the site, near the landfill boundary.

As Table 8-11 and Figure 8-9 show, PAHs and phenols were detected relatively infrequently (three or less detected concentrations for each group). Concentrations of PAHs were detected in three samples from the central and east-central portion of the site, along the landfill boundary. The highest total PAH concentration, 12.0 μg/L, was detected in sample 01GGM34. A single phenol concentration, 3.0 μg/L, was detected in sample 01GS62 from the southwestern landfill boundary.

No semivolatiles were detected in sample 01GS71 from the newly installed farthest downgradient shallow well.



Legend

ROADS

SHORELINE

SHALLOW MONITORING WELL

CHLOR Total Chlorinated Aromatic Concentration in ug/L

PAH Total PAH Concentration in ug/L

PHEN Total Phenol Semivolatile Concentration in ug/L

0 Feet 500 1000

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Site 1
NAS Pensacola

FIGURE 8-9 Total Chlorinated Aromatic, Total PAH, and Total Phenol Semivolatiles Detected in Shallow Groundwater Samples - 1994

Date: Nov. 22, 1994 | AML: 17x11

Pesticides

As Table 8-11 and Figure 8-10 show, two pesticides (alpha-BHC and dieldrin) were detected in shallow groundwater samples. Alpha-BHC (.0043 μg/L) and dieldrin (.0076 μg/L) were detected in one sample each, 01GGM34 and 01GS71, respectively, from the landfill's eastern boundary (01GGM34) and the newly installed farthest downgradient shallow well (01GS71). **[The dieldrin concentration slightly exceeded the USEPA Region IV freshwater surface water screening value. This is the only organic parameter detected in 1994 shallow groundwater samples, collected within 300 feet of site surface water bodies, which exceed these screening values.]**

8.3.2.2 Intermediate Depth Groundwater

Twelve intermediate wells were sampled in July 1994 and samples were analyzed for the full TAL/TCL parameter list. Table 8-12 summarized analytical results for these, samples. Concentrations of inorganics, volatiles, semivolatiles, and pesticides were detected in shallow samples.

Inorganics

Numerous metals were detected in intermediate groundwater samples from Site 1 during the 1994 resampling event. No metals were detected at concentrations exceeding FPDWS or USEPA primary drinking water standard MCLs; however, aluminum, iron and manganese concentrations exceeding FSDWS/USEPA secondary drinking water standard MCLs were frequently detected in intermediate samples. Additionally, the following nine metals exceeded RCs only; arsenic, barium, calcium, cobalt, iron, magnesium, manganese, potassium, and sodium. Due to the numerous metals detected, this discussion will focus on those exceeding MCLs. Figure 8-11 illustrates the distribution of metals detected in 1994 intermediate groundwater samples exceeding secondary MCLs.

As Figure 8-11 shows, aluminum was detected in most intermediate samples. Detected concentrations ranged from 139 μg/L to 205 μg/L. Only the highest concentration detected in sample 01GI66, collected upgradient of Site 1, exceeded the 200 μg/L secondary MCL for this parameter. No detected aluminum concentration exceeded the 3,883 μg/L RC for aluminum.

Bayou Grande

01GGM04

01GGM05

01GS71
DIEL 0.007

01GGM33

01GGM35

01GGM34
A-BHC 0.0043

01GGM39

01GS60

01GS64

01GS42

01GS62

01GS37

Golf Course

Taylor Road

J.H. Tower Road

01GS53

Legend

ROADS

SHORELINE

SHALLOW MONITORING WELL

A-BHC alpha-BHC Concentration in ug/L (FGGC = 0.05 ug/L)

DIEL Dieldrin concentration in un/L (FGGC = 0.1 ug/L)

0 Feet 500 1000

Remedial Investigation Report
Site 1
NAS Pensacola

FIGURE 8-10
Pesticides Detected in
Shallow Groundwater Samples - 1994

Date: Nov. 22, 1994 | AML: 17x11

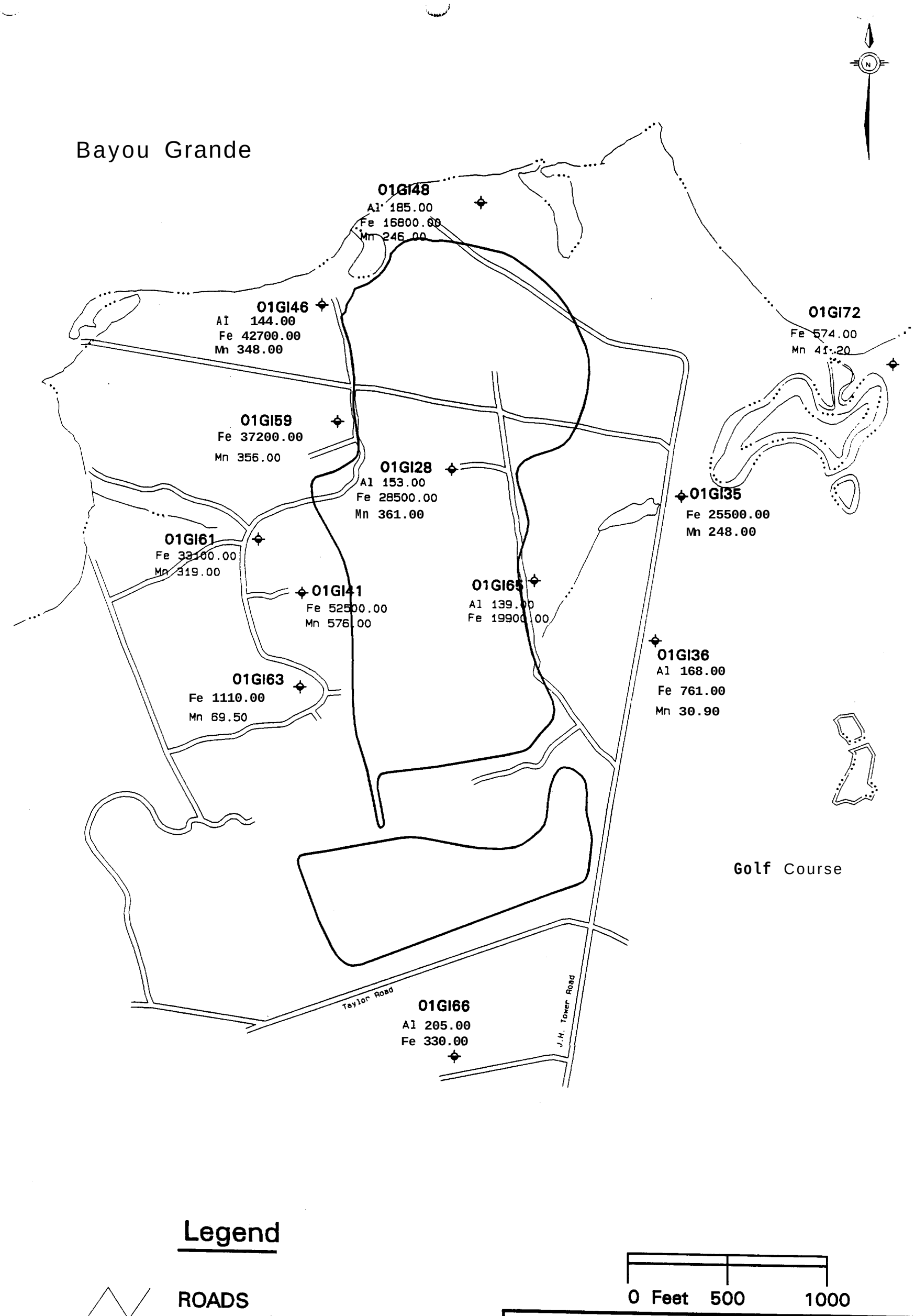

Bayou Grande
01GI48
Al 185.00
Fe 16800.00
Mn 246.00
01GI46
Al 144.00
Fe 42700.00
Mn 348.00
01GI72
Fe 574.00
Mn 41.20
01GI59
Fe 37200.00
Mn 356.00
01GI28
Al 153.00
Fe 28500.00
Mn 361.00
01GI35
Fe 25500.00
Mn 248.00
01GI61
Fe 33100.00
Mn 319.00
01GI41
Fe 52500.00
Mn 576.00
01GI65
Al 139.00
Fe 19900.00
01GI36
Al 168.00
Fe 761.00
Mn 30.90
01GI63
Fe 1110.00
Mn 69.50
Golf Course
Taylor Road
J.H. Tower Road
01GI66
Al 205.00
Fe 330.00
Legend
ROADS
SHORELINE
INTERMEDIATE MONITORING WELL
Al Aluminum Concentration in ug/L (MCL = 200.00 ug/L)
Fe Iron Concentration in ug/L (MCL = 300.00 ug/L)
Mn Manganese Concentration in ug/L (MCL = 50.00 ug/L)
0 Feet 500 1000
Remedial Investigation Report
Site 1
NAS Pensacola
FIGURE 8-11 Aluminum, Iron, and Manganese Detected in Intermediate Groundwater Samples - 1994
Date: Nov. 22, 1994
AML: 17x11

Table 8-12
Summary Analytical Results for Intermediate Groundwater Samples
Site 1
1994 Sampling Event
(All results in µg/L)

Parameter	FPDWS/RC	Sample Identification Number			
		01GI28	01GI35	01GI36	01GI41
Inorganics					
Aluminum	200*/3883	153.000	—	168.000	—
Arsenic	*5012.8*	—	**23.8**	—	—
Barium	2000/13.2	**14.200 J**	—	**13.400 J**	—
Calcium	—/17560	**27800.000 J**	**24100.000**	6760.000 J	**41700.000**
Cobalt	—/4.1	—	—	—	—
Iron	300*/1708	***28600.000***	***25500.000***	*761.000*	***52500.000***
Magnerium	—/2873	**6400.000**	—	2080.000	—
Manganese	50*/22	***361.000***	***248.000***	30.900	*676.000*
Potassium	—112168	12600.000	—	3070.000	4660.000
Sodium	160000/18345	9930.000	10000.000	7350.000	10400.000
Zinc	5000*/153	—	—	2.700	

Table 8-12
Summary Analytical Results for Intermediate Groundwater Samples
Site 1
1994 Sampling Event
(All results in µg/L)

Parameter	FPDWS/RC	Sample Identification Number			
		01GI46	01GI48	01GI59	01GI61
Inorganics					
Aluminum	200*/3883	144.000	185.000	—	—
Arsenic	50/2.8	24.000	9.800	7.500	20.500
Barium	2000/13.2	15.900 J	98.400 J	21.800	21.500 J
Calcium	—/17560	20100.000 J	57800.000 J	68800.000	26800.000
Cobalt	—/4.1	—	—	—	5.500
Iron	300*/1708	*42700.000*	*16800.000*	*37200.000*	*33100.000*
Magnesium	—/2873	4530.000	2830.000	6760.000	7380.000
Manganese	50*/22	*348.000*	*246.000*	*356.000*	*319.000*
Potassium	—/12168	5640.000	3420.000	5610.000	5980.000
Sodium	160000/18345	9430.000	6510.000	6290.000	16000.000
Zinc	5000*/153	4.300	—	—	—

Table 8-12
Summary Analytical Results for Intermediate Groundwater Samples
Site 1
1994 Sampling Event
(All results in µg/L)

Parameter	FPDWS/RC	Sample Identification Number			
		01GI63	01GI65	01GI66	01GI72
Inorganics					
Aluminum	200*/3883	—	139.000	***205.000***	—
Arsenic	5012.8	—	—	—	—
Barium	2000/13.2	23.100 J	20.000 J	8.800 J	—
Calcium	—117560	18600.000 J	17100.000 J	4660.000 J	10100.000
Cobalt	—14.1	—	—	—	—
Iron	300*/1708	***1110.000***	***19900.000***	***330.000***	***574.000***
Magnesium	—12873	3980.000	1350.000	506.000	3660.000
Manganese	50*/22	***69.500***	***128.000***	—	41.200
Potassium	—11 2168	5170.000	7730.000	2860.000	4090.000
Sodium	160000/18345	16000.000	29000.000	9500.000	10100.000
Zinc	5000*/153	4.100	44.300	36.800	—

Table 8-12
Summary Analytical Results for Intermediate Groundwater Samples
Site 1
1994 Sampling Event
(All results in µg/L)

Parameter	FPDWS	Sample Identification Number			
		01GI28	01GI35	01GI36	01GI41
Volatiles					
1,1-Dichloroethane	700**	—	—	—	2.000 J
1,2-Dichloroethene	70	2.000 J	2.000 J	3.000 J	2.000 J
Benzene	1	***9.000 J***	***7.000 J***	—	80.000
Chlorobenzene	100	29.000	3.000 J	—	***110.000***
Chloroethane	140**	—	—	—	—
Ethylbenzene	700	14.000	2.000 J	—	1.000 J
Toluene	1000	—	—	—	—
Trichloroethylene	3	—	—	2.000 J	—
Vinyl Chloride	1	—	2.000 J	—	***3.000 J***
Xylene (total)	10000	69.000	3.000 J	—	4.000 J
Semivolatiles					
2-Chlorophenol	35**	—	—	—	1.000 J
2-Methylnaphthalene	—	11.000	—	—	—
2,4-Dimethylphenol	400**	46.000	—	—	—
Bis(2-ethylhexhyl)phthalate (BEHP)	—	—	—	—	—
Isophorone	40**	—	—	—	—
Naphthalene	6.8**	***38.000***	—	—	***7.000 J***
2-Methylphenol	350**	—	—	—	—
1,2-Dichlorobenzene	600	5.000 J	—	—	5.000 J
1,4-Dichlorobenzene	76	7.000 J	—	—	14.000
Phenol	10**	—	—	—	—

Table 8-12
Summary Analytical Results for Intermediate Groundwater Samples
Site 1
1994 Sampling Event
(All results in µg/L)

Parameter	FPDWS	Sample Identification Number			
		01GI46	01GI48	01GI59	01GI61
Volatiles					
1,1-Dichloroethane	700**	3.000 J	—	—	5.000 J
1,2-Dichloroethene	70	3.000 J	—	—	2.000 J
Benzene	1	***3.000 J***	***1.000 J***	—	*33.000*
Chlorobenzene	100	18.000	20.000	19.000	***120.000***
Chloroethane	140**	1.000 J	—	—	—
Ethylbenzene	700	—	—	—	6.000 J
Toluene	1000	—	—	—	1.000 J
Trichloroethylene	3	—	—	—	—
Vinyl Chloride	1	***12.000***	—	—	***4.000 J***
Xylene	10000	—	—	—	43.000
Semivolatiles					
2-Chlorophenol	35**	—	—	—	—
2-Methylnaphthalene	—	—	—	—	—
2,4-Dimethylphenol	400**	—	—	—	—
Bis(2-ethylhexhyl)phthalate (BEHP)	—	11.000 J	—	—	—
Isophorone	40**	—	—	—	—
Naphthalene	6.8**	—	—	1.000 J	5.000 J
2-Methylphenol	350**	—	—	—	—
1,2-Dichlorobenzene	600	3.000 J	1.000 J	2.000 J	3.000 J
1,4-Dichlorobenzene	75	3.000 J	4.000 J	17.000	11.OW
Phenol	10**	—	—	—	1.000 J

Table 8-12
Summary Analytical Results for Intermediate Groundwater Samples
Site 1
1994 Sampling Event
(All results in µg/L)

		Sample Identification Number			
Parameter	**FPDWS**	**01GI63**	**01GI65**	**01GI66**	**01GI72**
Volatiles					
1,1-Dichloroethane	700**	—	8.000 J	—	—
1,2-Dichloroethane	70	—	65.000	—	—
Benzene	1	***6.000 J***	***10.000***	—	—
Chlorobenzene	100	—	23.000	—	—
Chloroethane	140**	—	—	—	—
Ethylbenzene	700	—	2.000 J	—	—
Toluene	1000	—	15.000	—	—
Trichloroethylene	3	—	—	1.000 J	—
Vinyl Chloride	1	—	***7.000 J***	—	—
Xylene	10000	5.000 J	5.000 J	—	—
Semivolatiles					
2-Chlorophenol	35**	—	—	—	—
2-Methylnaphthalene	—	—	—	—	—
2,4-Dimethylphenol	400**	—	4.000 J	—	—
Bis(2-ethylhexhyl)phthalate (BEHP)	—	—	—	—	—
Ieophorone	40**	—	1.000 J	—	—
Naphthalene	6.8**	1.000 J	5.000 J	—	—
2-Methylphenol	350**	—	3.000 J	—	—

Table 8-12
Summary Analytical Results for Intermediate Groundwater Samples
Site 1
1994 Sampling Event
(All results in µg/L)

		Sample Identification Number			
Parameter	**FPDWS**	**01G163**	**01G165**	**01G166**	**014172**
1,2-Dichlorobenzene	600	—	2.000 J	—	—
1,4-Dichlorobenzene	75	—	10.000	—	—
Phenol	10**	—	—	—	—

Key:

µg/L	=	Micrograms per liter
—	=	Indicates parameter analyzed but not detected above the method detection limit.
J	=	Parameter positively detected; however reported concentration is approximate.
FPDWS	=	Florida and/or USEPA Primary Drinking Water Standard (lower of the two) MCL
*	=	Florida Secondary Drinking Water Standard (FSDWS)
**	=	Florida Groundwater Guidance Concentrations (FGGC)
RC	=	Reference concentration calculated as two times the mean concentration of parameters detected in reference samples. A value of one-half the detection limit was used to calculate the mean concentration when parameter was not detected.
Bold Underline	=	The reported value exceeds the reference concentration calculated for this parameter.
Bold Italics	=	The reported value exceeds the FPDWS/USEPA or FSDWS MCL or FGGC.
Bold, Underline and Italic	=	The reported value exceeds both the RC and the MCL.

As Figure 8-11 shows, iron was detected in all intermediate samples, ranging from 330 µg/L to 52500 µg/L, exceeding the 300 µg/L secondary MCL. Eight of the 12 concentrations also exceeded the 1708 µg/L RC for this parameter. The highest iron concentrations were detected in samples 01GI41 (52500 µg/L) and 01GI61 (33100 µg/L) collected at the landfill's western boundary; samples 01GI28 (28500 µg/L) and 01GI59 (37200 µg/L) from the site's central portion; and sample 01GI46 (42700 µg/L), from the landfill's northwestern boundary.

As Figure 8-11 shows, manganese was detected in most intermediate samples at concentrations ranging from 30.9 µg/L to 576 µg/L. Eight of these concentrations exceeded the 50 µg/L secondary MCL; all 11 detected concentrations exceeded the 22 µg/L RC for this parameter. Concentrations exceeding the MCL were detected in samples 01GI48 and 01GI46 from the site's northern extent; samples 01GI59 and 01GI28, from the central portion; samples 01GI61, 01GI41, and 01GI63, from the landfill's western boundary; and sample 01GI35 from the site's eastern margin.

Arsenic, barium, calcium, cobalt, magnesium, potassium, and sodium (not shown on figure) each were detected in intermediate groundwater at concentrations exceeding their respective RCs as follows:

- Arsenic was detected in five samples (01GI35, 01GI46, 01GI48, 01GI59, and 01GI61) exceeding the 2.8 µg/L RC;
- Barium was detected in eight samples (01GI28, 01GI36, 01GI46, 01GI48, 01GI59, 01GI61, 01GI63, and 01GI65) exceeding the 13.2 µg/L RC;
- Calcium was detected in eight samples (01GI28, 01GI35, 01GI41, 01GI46, 01GI48, 01GI59, 01GI61, and 01GI63) exceeding the 17,560 µg/L RC;
- Cobalt was detected in one sample (01GI61) exceeding the 4.1 µg/L RC;
- Magnesium was detected in six samples (01GI28, 01GI46, 01GI59, 01GI61, 01GI63, and 01GI72) exceeding the 2,873 µg/L RC;

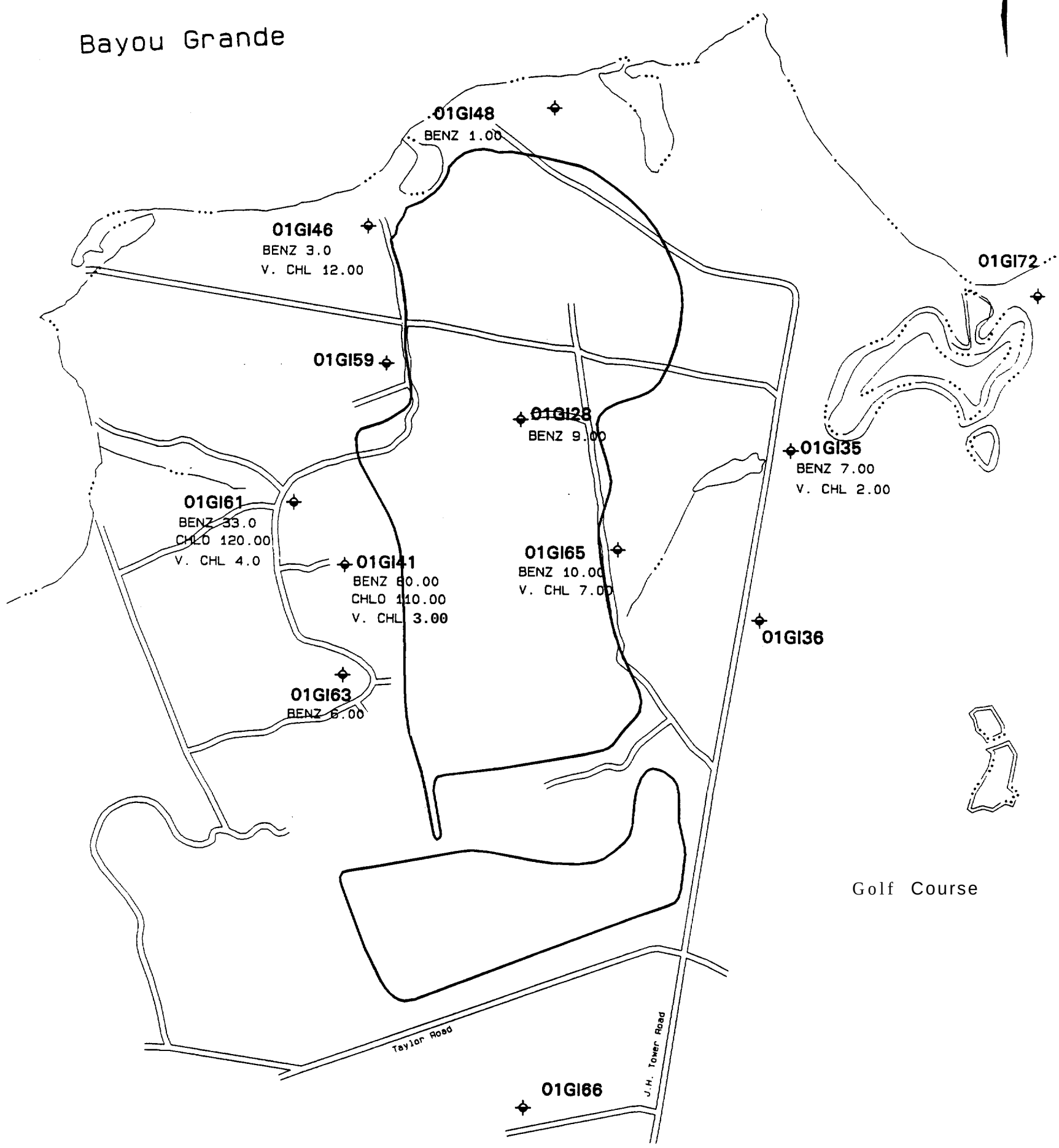
- Potassium was detected in one sample (01GI28) exceeding the 12,168 μg/L RC; and
- Sodium was detected in one sample (01GI65) exceeding the 18,345 μg/L RC.

Volatiles

As Table 8-12 shows, 10 VOCs (five aromatic hydrocarbon and five aliphatic hydrocarbon compounds) were detected in intermediate groundwater samples during the 1994 resampling event. Most of these compounds were detected at relatively low concentrations (below MCLs). Figures 8-12 and 8-13 illustrate the distribution of VOCs exceeding MCLs and total VOC groups (aromatic and aliphatic hydrocarbons) detected in intermediate groundwater samples, respectively.

As Figure 8-12 shows, detected concentrations of the aromatic VOCs benzene and chlorobenzene, and the aliphatic VOC vinyl chloride equaled or exceeded FPDWS MCLs of 1.0 μg/L, 100 μg/L, and 1.0 μg/L for each compound, respectively. Benzene and chlorobenzene were the most frequently detected VOCs in intermediate samples, each occurring in eight samples across the site's central, eastern, western, and northern portions. The highest benzene concentrations, 80 μg/L and 33 μg/L, were detected in samples 01GI41 and 01GI61, respectively, from along the landfill's western boundary. The highest chlorobenzene concentrations, 110 μg/L and 120 μg/L, which exceeded the MCL, were also detected in samples 01GI41 and 01GI61, respectively. Vinyl chloride was detected in five samples across the site's central western, eastern, and northwestern portions. The highest concentrations were detected in samples 01GI65 (7.0 μg/L) from the landfill's eastern boundary, and 01GI46 (12.0 μg/L) from its northwestern boundary.

In addition to the previously discussed compounds, the most frequently detected VOCs in intermediate groundwater samples were the aliphatic 1,2-dichloroethene, detected in seven of 12 samples, and the aromatics ethylebenzene and xylene(s), detected in five and six of 12 samples, respectively. The highest detected concentrations of these respective VOCs were 65



Legend

ROADS

SHORELINE

INTERMEDIATE MONITORING WELL

V.CHL Vinyl Chloride Concentration in ug/L (MCL = 1.00 ug/L)

BENZ Benzene Concentration in ug/L (MCL = 1.00 ug/L)

CHLO Chlorobenzene Concentration in ug/L (MCL = 100.00 ug/L)

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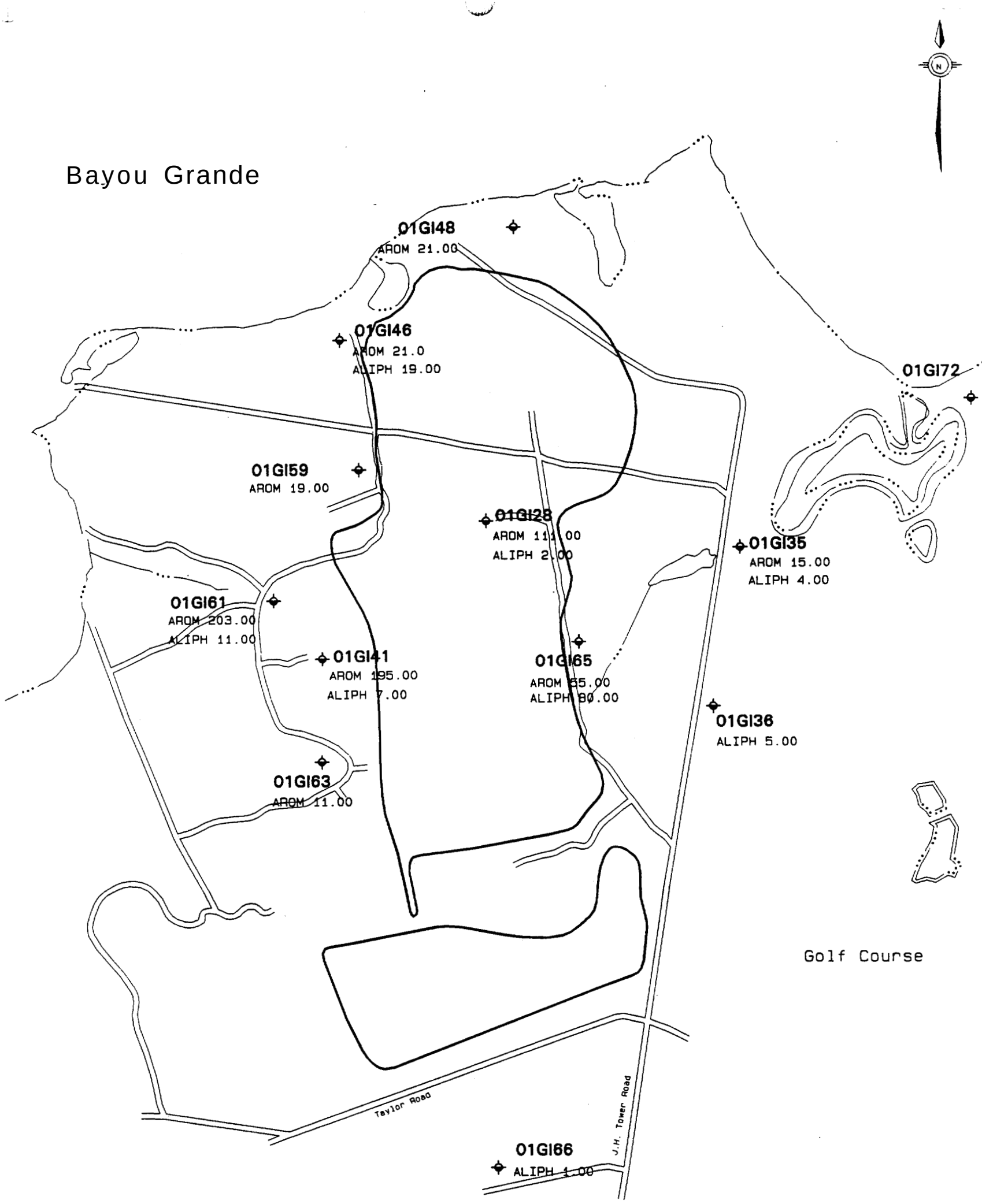
Site 1
NAS Pensacola

FIGURE 8-12
VOCs Exceeding MCLs Detected in Intermediate Groundwater Samples - 1994

Date: Nov. 22, 1994 | AML: 17x11



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ROADS

SHORELINE

INTERMEDIATE MONITORING WELL

AROM Total Aromatic Concentration in ug/L

ALIPH Total Aliphatic Concentration in ug/L

0 Feet 500 1000

Remedial Investigation Report
Site 1
NAS Pensacola

FIGURE 8-13 Total Aromatic and Total Aliphatic Hydrocarbon VOCs Detected in Intermediate Groundwater samples - 1994

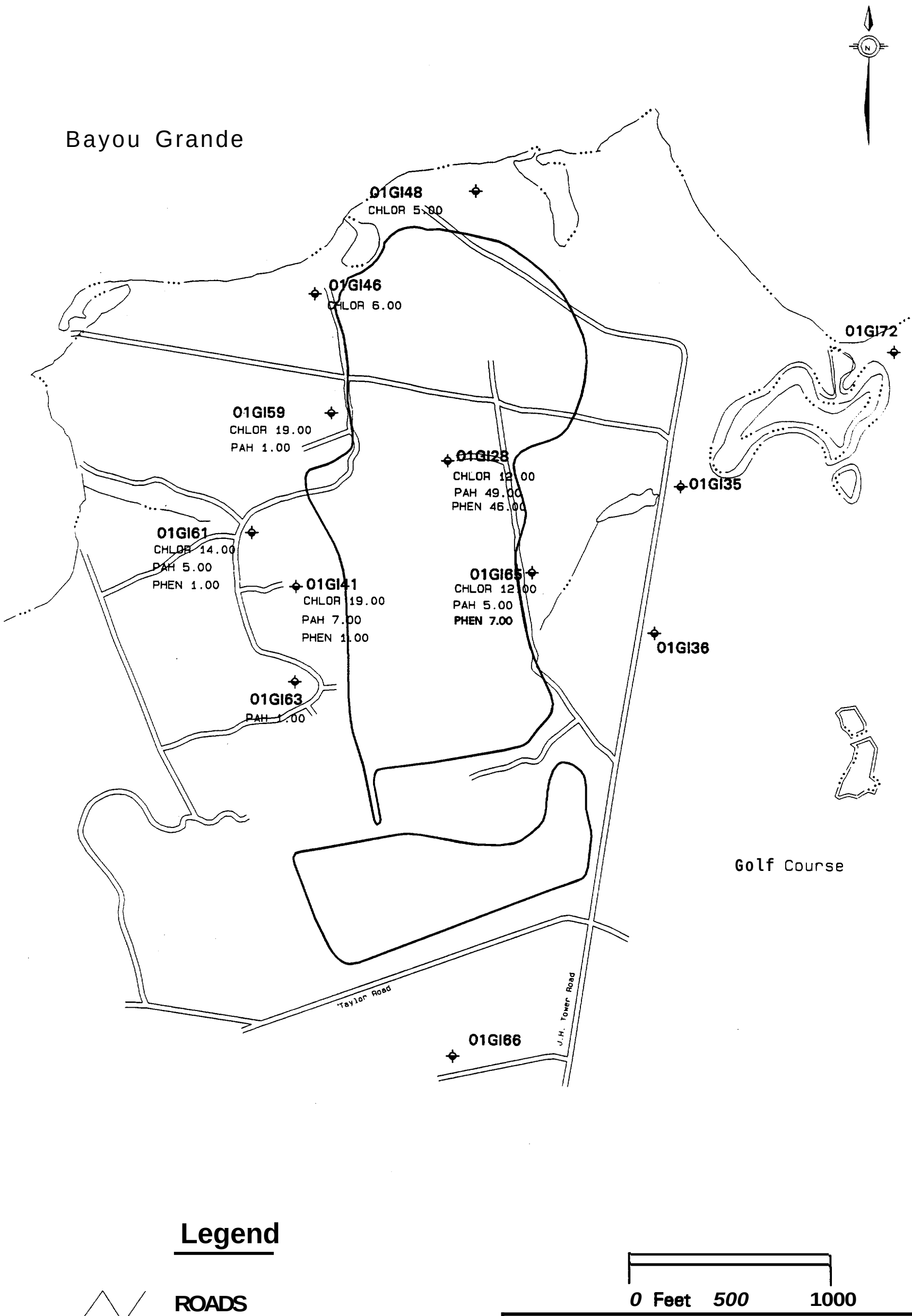
Date: Nov. 22, 1994 | AML: 17x11

μg/L (01GI65), 14μg/L (01GI28), and 59 μg/L (01GI28). Figure 8-13 illustrates concentrations of total aromatic and total aliphatic hydrocarbon VOCs detected in intermediate samples. Also included in these "total" concentrations are the VOCs that exceeded MCLs.

Aromatic VOCs occurred at higher concentrations, and slightly more frequently than aliphatics in intermediate groundwater. The highest concentrations of total aromatics were detected in samples 01GI61 (203 μg/L) and 01GI41 (195 μg/L), from the landfill's western and southwestern boundaries, respectively; and 01GI28 (111 μg/L) from the landfill's central portion. The highest concentrations of total aliphatic VOCs were detected in samples 01GI65 (80 μg/L) and 01GI46 (19 μg/L), from the landfill's eastern and northwestern boundaries, respectively. Overall, the highest total VOCs concentrations (aromatics and aliphatics combined) were detected in samples 01GI61 (214 μg/L) and 01GI41 (202 μg/L). No VOCs were detected in sample 01GI72 from the newly installed farthest downgradient intermediate well.

Semivolatile Organic Compounds

As Table 8-12 shows, 10 semivolatile compounds were detected in intermediate groundwater samples during the 1994 resampling event. These included two chlorinated aromatics (o-dichlorobenzene and p-dichlorobenzene), two PAHs (2-methylnaphthalene and naphthalene), and four phenols (2-chlorophenol, 2,4-dimethylphenol, o-cresol, and phenol), one pthalate (BEPH), and one ketone (isophorone). These compounds were detected primarily across the central, western, and eastern portions of the site. Naphthalene was the only detected semivolatile exceeding an MCL or FGGC. Samples 01GI28 and 01GI41 each contained naphthalene concentrations (38.0 μg/L and 7.0 μg/L, respectively) exceeding the 6.8 μg/L FGGC. The highest concentrations of total semivolatiles included 107 μg/L detected in sample 01GI28 from the central portion of the landfill, 25 μg/L in sample 01GI65 from the it's eastern boundary, and 20 μg/L in sample 01GI61 from the it's western boundary. However, with few exceptions, individual semivolatile compound concentrations detected in each sample were generally below 10 μg/L. Figure 8-14 illustrates the distribution of total chlorinated aromatics, PAHs, and phenols detected in intermediate groundwater samples.



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ROADS

SHORELINE

INTERMEDIATE MONITORING WELL

CHLOA Total Chlorinated Aromatic Concentration in ug/L

PAH Total PAH Concentration in ug/L

PHEN Total Phenol Semivoletile concentration in ug/L

0 Feet 500 1000

Remedial Investigation Report
Site 1
NAS Pensacola

FIGURE 8-14 Total Chlorinated Aromatic, Total PAH, and Total Phenol Semivolatiles Detected in Intermediate Groundwater Samples - 1994

Date: Nov. 22, 1994 | AML: 17x11

As Figure 8-14 shows, chlorinated aromatics were detected in seven samples across the central, northern, western, and eastern portions of the site. Detections of chlorinated aromatics are distributed rather consistently around the landfill's boundary at sampled locations. The magnitude of these concentrations is also generally comparable across the site, ranging from 5.0 µg/L to 19 µg/L, the highest of which was detected in samples from the central (01GI59) and western (01GI41) site areas. However, phenol concentrations varied more, ranging from 1.0 µg/L to 46 µg/L, the highest of which was detected in sample 01GI28 in the site's central portion. Like phenols, PAHs concentrations varied from 1.0 µg/L to 49 µg/L, with the highest also detected in sample 01GI28.

No semivolatiles were detected in sample 01GI72 collected from the newly installed farthest downgradient intermediate well.

8.3.2.3 Deep Groundwater

Summary analytical results for deep groundwater samples collected from reference locations in 1993 are presented in Table 8-9. No organic compounds were detected in reference samples. These results have been used to calculate the RC value for each detected parameter. Because no organic compounds were detected in deep groundwater samples from Site 1 in 1993, the three deep site wells were resampled during July 1994 and samples were analyzed for TAL inorganics only. Table 8-13 summarizes analytical results for these samples. Concentrations of several inorganics were detected in 1994 deep groundwater samples.

Table 8-13
Summary Analytical Results for Deep Groundwater Samples
Site 1
1994 Sampling Event
(All results in µg/L)

Parameter	FPDWS/RC	Sample Identification Number		
		01GGM43	01GGM44	01GGM45
Inorganics				
Aluminum	200*/437	142.000	—	*317.000*
Barium	2000/14.2	7.500 J	—	—
Calcium	—/11 1500	**21900.000 J**	**50300.000**	7080.000
Iron	300*/5710	***3100.000***	***1690.000***	*4130.000*
Magnesium	—/3710	1060.000	—	—
Manganese	60*/149.8	***90.100***	***69.300***	24.100
Sodium	160000/37100	4680.000	6540.000	9070.000
Zinc	5000*/210	—	6.600 B	—

Key:

µg/L	=	Micrograms per liter
—	=	Indicates parameter analyzed but not detected above the method detection limit.
J	=	Parameter positively detected; however reported concentration is approximate.
FPDWS	=	Florida and/or USEPA Primary Drinking Water Standard (lower of the two) MCL
*	=	Florida Secondary Drinking Water Standard (FSDWS)
RC	=	Reference concentration calculated as two times the mean concentration of parameters detected in reference samples. A value of one-half the detection limit was used to calculate the mean concentration when parameter was not detected.
Bold Underline	=	The reported value exceeds the reference concentration calculated for this parameter.
Bold Italics	=	The reported value exceeds the FPDWS/USEPA or FSDWS MCL.
Bold, Underline and Italic	=	The reported value exceeds both the RC and the MCL.

Inorganics

Numerous metals concentrations were detected in groundwater samples from the three deep wells — GM-43, GM-44, and GM-45 — installed during the 1986 Characterization Study (see Section2.2.2 for details of previous investigations). All metals concentrations in deep groundwater samples were below FPDWS MCLs. However, some deep samples exceeded FSDWS MCLs for aluminum (01GGM45), iron (01GGM43, 01GGM44, and 01GGM46), and manganese (01GGM43 and 01GGM44). Figure 8-15 illustrates the concentration of metals exceeding secondary drinking water standards.

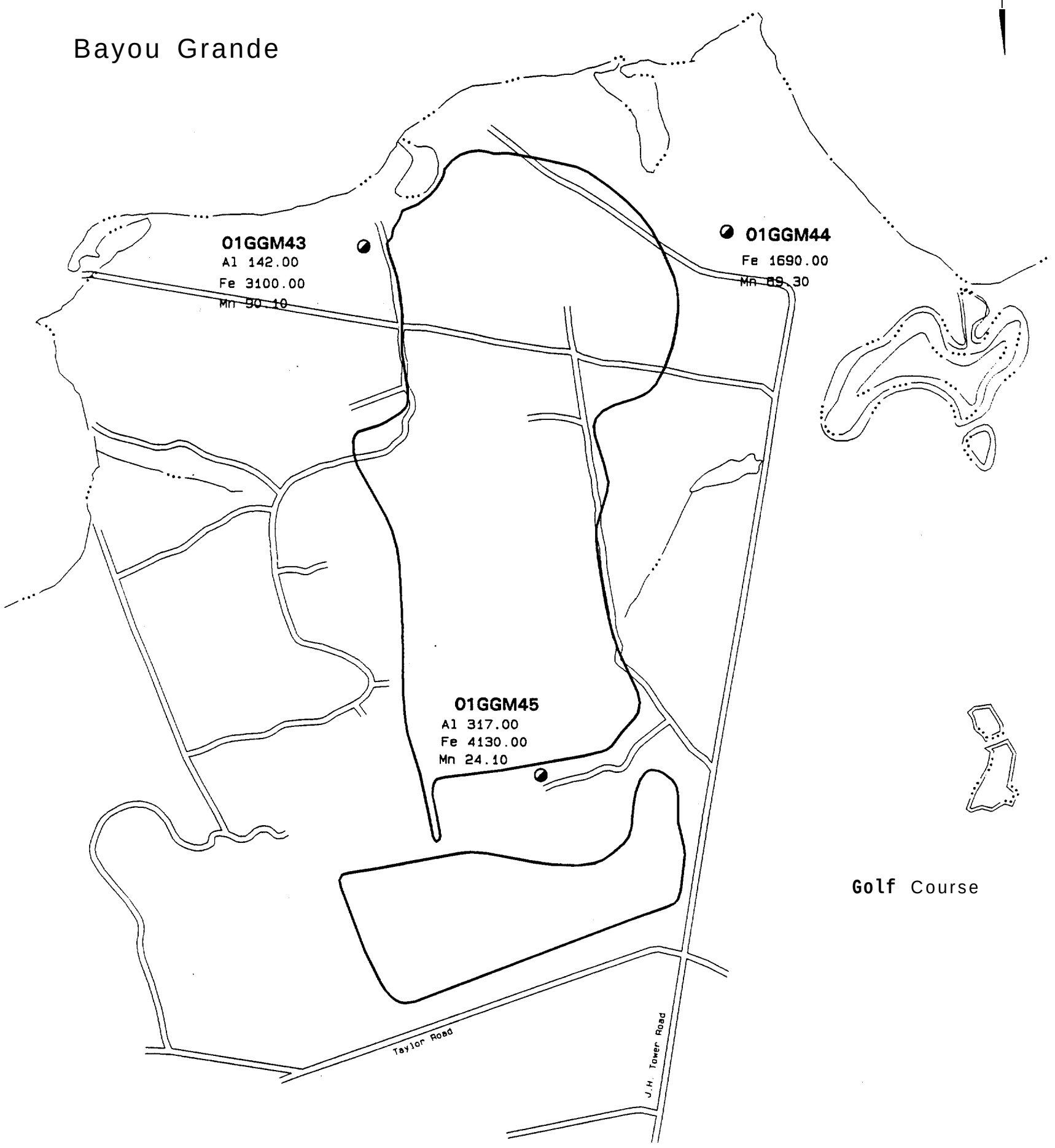
Deep groundwater sample metal concentrations collected from the site in 1994 were generally comparable to those in reference samples collected from the two deep supply wells in 1993. No 1994 samples exceeded RCs calculated from the 1993 reference data. Furthennore, concentrations of aluminum, iron, magnesium, sodium, and zinc detected in site samples were within the range of or lower than reference concentrations. However, a relatively low concentration of barium (01GGM43) was detected in site groundwater that was not detected in reference samples.

8.3.2.4 Summary and Conclusions

To organize the following discussion of Site 1 groundwater quality, this Section will evaluate the previously discussed 1994 analytical results by parameter group (inorganics vs. organics, etc.) for all monitored intervals combined. Additionally, 1993 groundwater sample results will be compared to the 1994 results to note any apparent temporal trends in site groundwater quality.

Inorganics

Metals were commonly detected in 1994 site groundwater samples. Metals concentrations (cadmium, chromium, and nickel) exceeding FPDWS/USEPA primary drinking water standard



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ROADS

SHORELINE

DEEP MONITORING WELL

Al	Aluminum Concentration in ug/L (MCL = 200.00 ug/L)
Fe	Iron Concentration in ug/L (MCL = 300.00 ug/L)
Mn	Manganese Concentration in ug/L (MCL = 50.00 ug/L)

0 Feet 500 1000

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Site 1
NAS Pensacola

FIGURE 8-15 Aluminum, Iron, and Manganese Detected in Deep Groundwater Samples - 1994

Date: Nov. 22, 1994

AML: 17x11

MCLs were detected only in a limited number of shallow samples (i.e., no other depth interval sample exceeded primary MCLs). Samples exceeding the primary MCL were collected from the landfill's eastern boundary (01GS64, 30.5 $\mu g/L$ of cadmium), and the site's eastern margin (01GGM39, 253 $\mu g/L$ of nickel and 616 $\mu g/L$ of chromium). Aluminum, iron, and manganese were frequently detected across the site in all depth interval samples at concentrations exceeding secondary drinking water MCLs. However, RCs calculated for aluminum and iron (from reference data) also exceeded MCLs. Concentrations of arsenic, barium, calcium, cobalt, iron, magnesium, manganese, potassium, sodium, vanadium, and zinc exceeding RCs were detected in either shallow and/or intermediate samples. Shallow and intermediate groundwater samples exceeding the greatest number of MCLs and/or RCs (six or more) were collected as follows: from the site's central portion (01GGM33, 01GGM35, 01GI59, 01GI28); the landfill's eastern boundary (01GG34 and 01GS64); the western boundary (01GI61), the northwestern boundary (01GI46); and the site's eastern margin (01GGM39). Based on 1994 analytical results, the greatest impact to site groundwater quality with respect to inorganics appears to be in these areas.

Inorganic concentrations detected in 1993 samples were greatly reduced, or detected less frequently (or not at all) in 1994 samples. Table 8-14 presents a statistical summary of 1993 and 1994 analytical results, comparing inorganic concentrations detected at Site 1 for samples common to both sampling events. In 1993, several metals (arsenic, beryllium, chromium, lead, mercury, and nickel) were frequently detected in shallow and intermediate samples at concentrations exceeding primary drinking water standard MCLs. However, 1994 samples exceeded only three primary MCLs (one each of cadmium, chromium, and nickel detected in shallow samples). Additionally, most inorganics were detected at lower concentrations and/or less frequently in 1994 samples. As Table 8-14 shows, inorganics occurring at reduced concentrations (lower mean or maximum concentrations) and/or frequency in 1994 samples included aluminum, antimony, arsenic, beryllium, chromium, cobalt, copper, lead, mercury, nickel, vanadium and zinc.

Table 8-14
Summary Statistics for Groundwater Analytical Results
Site 1
(All results in µg/L)

Parameter	1993 Samples				1994 Samples			
	Frequency of Detection	Min. Detected Concentration	Max Detected Concentration	Mean Detected Concentration	Frequency of Detection	Min. Detected Concentration	Max. Detected Concentration	Mean Detected Concentration
Shallow Samples								
Aluminum	12	519.000	320000.000	113466.583	7	134.000	4780.000	987.671
Antimony	1	36.600	36.600	36.600	0	—	—	—
Arsenic	6	6.300	41.700	18.860	3	5.900	42.600	21.300
Barium	12	16.800	391.000	183.125	10	2.400	335.000	66.410
Beryllium	5	1.700	6.200	3.64	0	—	—	—
Cadmium	1	5.000	5.000	6.000	1	30.500	30.500	30.600
Calcium	11	1610.000	61900.000	33943.636	11	199.000	73900.000	35926.364
Chromium (total)	8	12.000	429.000	201.450	1	616.000	616.000	616.000
Cobalt	6	9.600	39.700	25.783	3	4.700	12.000	7.400
Copper	10	4.800	177.000	103.060	1	147.000	147.000	147.000
Iron	12	3920.000	132000.000	62730.000	10	162.000	73200.000	24120.600
Lead	9	4.800	104.000	46.289	1	5.300	5,300	6.300
Magnesium	12	1440.000	11200.000	5605.000	11	333.000	6330.000	2357.909
Manganese	12	43.800	532.000	273.483	10	7.700	600.000	234.050
Mercury	5	1.700	2.300	2.000	0	—	—	—

Table 8-14
Summary Statistics for Groundwater Analytical Results
Site 1
(All results in µg/L)

Parameter	1993 Samples				1994 Samples			
	Frequency of Detection	Min. Detected Concentration	Max Detected Concentration	Mean Detected Concentration	Frequency of Detection	Min. Detected Concentration	Max. Detected Concentration	Mean Detected Concentration
Nickel	6	43.200	144.000	93.500	1	253.000	263.000	253.000
Potassium	9	2980.000	16500.000	6038.889	6	2660.000	13800.000	5240.000
Sodium	12	2580.000	28900.000	6836.833	12	3620.000	31800.000	8300.000
Vanadium	7	30.400	426.000	212.486	1	10.800	10.800	10.800
Zinc	12	23.900	627.000	160.968	7	4.200	3020.000	602.443
Intermediate Samples								
Aluminum	11	1610.000	70700.000	33930.909	7	139.000	205.000	166.671
Antimony	1	36.500	36.500	36.600	0	—	—	—
Arsenic	10	4.900	68.800	29.610	5	7.500	24.000	17.120
Barium	10	30.000	102.000	61.080	9	8.800	98.400	26.344
Beryllium	6	1.200	2.900	1.867	0	—	—	—
Calcium	11	6820.000	76600.000	26405.455	11	4600.000	68800.OW	28665.466
Chromium (total)	11	31.200	464.000	120.127	0	—		—
Cobalt	7	9.600	25.300	14.371	1	5.600	5.600	5.600
Copper	11	8.100	68.100	27.345	0	—	—	—

Table 8-14
Summary Statistics for Groundwater Analytical Results
Site 1
(All results in µg/L)

Parameter	1993 Samples				1994 Samples			
	Frequency of Detection	Min. Detected Concentration	Max Detected Concentration	Mean Detected Concentration	Frequency of Detection	Min. Detected Concentration	Max. Detected Concentration	Mean Detected Concentration
Iron	11	3530.000	78100.000	41684.545	11	330.000	52500.000	23491.000
Lead	7	2.300	41.800	19.571	0	—	—	—
Magnesium	11	1950.000	8490.000	5207.273	9	506.000	7380.000	3979.556
Manganese	11	69.700	542.000	247.073	10	30.900	576.000	268.240
Mercury	3	0.400	2.100	1.157	0	—	—	—
Niakel	7	19.200	219.000	61.314	0	—	—	—
Potassium	11	1820.000	37800.000	9810.000	11	2860.000	12600.000	5674.000
Selenium	1	8.800	8.800	8.800	0	—	—	—
Sodium	11	7420.000	32400.000	16699.091	11	6290.000	29000.000	11855.455
Vanadium	9	11.300	273.000	97.944	0	—	—	—
Zinc	11	24.000	221.000	83.555	6	2.700	44.300	16.667
Deep Samples								
Aluminum	3	762.000	2630.000	1467.333	2	142.000	317.000	229.500
Arsenic	1	4.100	4.100	4.100	0	—	—	—
Barium	3	10.900	15.300	12.700	1	7.500	7.500	7.500
Calcium	3	10300.000	47700.000	25533.333	3	7080.000	50300.000	26426.667

Table 8-14
Summary Statistics for Groundwater Analytical Results
Site 1
(All results in µg/L)

Parameter	1993 Samples				1994 Samples			
	Frequency of Detection	Min. Detected Concentration	Max Detected Concentration	Mean Detected Concentration	Frequency of Detection	Min. Detected Concentration	Max. Detected Concentration	Mean Detected Concentration
Chromium	1	11.300	11.300	11.300	0	—	—	—
Copper	3	4.200	12.200	7.333	0	—	—	—
Iron	3	2450.000	8500.000	5890.000	3	1690.000	4130.000	2973.333
Led	1	2.000	2.000	2.000	0	—	—	—
Magnesium	3	1540.000	2070.000	1890.000	1	1060.000	1060.000	1060.000
Manganese	3	63.600	01.100	66.700	3	24.100	90.100	61.167
Mercury	1	0.240	0.240	0.240	0	—	—	—
Sodium	3	4340.000	0760.000	6230.000	3	4600.000	9070.000	6763.333
Zinc	2	45.100	60.600	47.060	1	6.600	6.600	6.600

Key:
µg/L = Micrograms per liter
— = Indicates parameter analyzed but not detected above the method detection limit.

The significant reduction of inorganic concentrations in 1994 shallow and intermediate groundwater samples is apparently the result of the quiescent sampling technique (used in 1994) and the correspondingly low groundwater turbidity observed in 1994 samples.

Organics

Analytical results confirm site groundwater has been impacted by organic compounds. Several volatile and semivolatile organics were detected in shallow and intermediate Site 1 groundwater samples collected in 1994. Pesticides also were detected in a limited number of shallow groundwater samples. While most detected concentrations of organic compounds were relatively low, FPDWS MCLs for specific compounds were exceeded. The distribution of organic compounds in site groundwater extends toward Bayou Grande, west and north of the site, and beneath the adjacent golf course, east and northeast of the site. However, no organics were detected in the shallow and intermediate depth wells recently (June 1994) installed downgradient (northeast) of the site. In general, relatively higher concentrations of organic compounds were detected in samples from the central portion of the site, and along the western and eastern boundaries of the landfill. However, the locations of relatively higher or lower concentrations of individual organic contaminants often vary by compound as well as by depth interval (shallow vs. intermediate samples). Furthermore, specific trends in the concentrations of detected organics indicating distinct plumes of individual contaminants are not readily discernible in the data. Due to these spatial inconsistencies, the interpolation of parameter-specific areal trends (i.e., isocontouring of detected concentrations) was not possible. Instead, areas where organics were detected (especially where concentrations exceed ARARs) are discussed along with their proximity to the site (i.e., locations along the landfill's boundary).

Volatile Organic Compounds

Several aromatic and aliphatic hydrocarbon VOCs were detected in 1994 shallow and intermediate groundwater samples. The distribution of VOCs detected in samples from both depth intervals extends toward Bayou Grande to the west and north, and beneath the golf course

to the east and northeast. In general, the highest concentrations of VOCs again were detected in samples from the central portion of the site, and along the landfill's eastern and western boundaries, indicating the central, 1970s-era portion of the landfill may be the primary source of these compounds. However, samples from the southwestern portion of the site also exhibited VOCs, indicating such VOC sources may exist in the older, 1950s-era portion of the landfill. VOCs were detected less frequently and at relatively lower concentrations in samples from the northern 1960s-era portion, indicating either relatively low concentration sources are present in this area, or these compounds have been advectively transported (and subsequently reduced in concentration) downgradient from sources in the central portion of the site.

Intermediate groundwater samples generally contained higher concentrations of VOCs than shallow samples. Specifically, VOCs exceeding FPDWS MCLs were detected more frequently and at higher concentrations in intermediate samples. Additionally, total VOC concentrations were higher in intermediate samples. Benzene, the most predominant VOC exceeding MCLs, was detected in samples across the site at concentrations ranging up to 12 μg/L in shallow samples, and 80 μg/L in intermediate samples. Chlorobenzene and vinyl chloride were detected at their respective maximum concentrations of 120 μg/L and 12 μg/L in intermediate samples. These relatively higher concentrations were detected in samples from the site's central portion, or the landfill's eastern/western boundaries.

Generally low concentrations (most less than 10 μg/L) of aliphatic VOCs were detected sitewide in both shallow and intermediate samples. Aromatic VOCs also were detected across the site; however, aromatics were detected more frequently and at generally higher concentrations than aliphatics. The highest concentrations of each VOC group were also detected in intermediate samples in generally the same areas as VOCs exceeding MCLs. The relatively higher concentrations of VOCs in intermediate samples is likely the result of downgradient (lateral) and downward (vertical) transport having occurred between the shallow and intermediate depth zones given the age of the landfill (active from the 1950s to mid 1970s).

Overall, VOCs were detected at comparable concentrations in both 1993 and 1994 groundwater samples. Table 8-15 presents a statistical summary of 1993 and 1994 analytical results (for samples common to both events) comparing selected VOC concentrations detected at Site 1. For VOCs exceeding MCLs in shallow groundwater, benzene and chlorobenzene were detected with similar frequency in both years; however, vinyl chloride was detected less frequently in 1994 samples. The distribution of benzene and chlorobenzene detected in both years was comparable; however, 1994 samples contained lower maximum concentrations of all three VOCs (benzene, chlorobenzene, and vinyl chloride). For intermediate groundwater, benzene and chlorobenzene were detected at comparable concentrations and frequency during both years. However, vinyl chloride was detected more frequently, but at lower concentrations, in 1994 than 1993.

Semivolatile Organic Compounds

Several chlorinated aromatic, PAH, and phenolic semivolatile compounds were detected in shallow and intermediate groundwater samples. The distribution of semivolatiles in site groundwater again is generally consistent with the distribution of VOCs, indicating that the central, 1970s-era portion of the landfii may be the primary source of these compounds.

Slightly lower concentrations of chlorinated aromatics were detected in shallow than in intermediate samples; however, the distribution of these compounds primarily across the site's central portion was also similar in both sample groups. The highest concentrations of these compounds were detected in samples from the central portion of the site, and adjacent to the landfill's eastern/western boundaries.

PAHs and phenolic compounds were also detected only across the site's central portion. Samples from the northern portion exhibited no detections of these compounds. Furthermore, PAHs and phenolic compounds were detected more frequently and at slightly higher concentrations in intermediate samples than in shallow ones. Samples from the central and east-central portions of the site had the highest concentrations of these compounds.

Table 8-16
Summary Statistics for Groundwater Analytical Results
Site 1
(All results in µg/L)

Parameter	1993 Samples				1994 Samples			
	Frequency of Detection	Min. Detected Concentration	Max Detected Concentration	Mean Detected Concentration	Frequency of Detection	Min. Detected Concentration	Max. Detected Concentration	Mean Detected Concentration
Shallow Samples								
Benzene	7	3.000	55.000	14.714	6	2.000	12.000	6.667
Chlorobenzene	10	4.000	120.000	33.900	9	1.000	36.000	20.222
Vinyl Chloride	3	3.000	9.000	5.667	1	3.000	3.000	3.000
Total Chlorinated Aromatics	—	2.000	23.000	8.375	—	3.000	12.000	6.143
Total Phenols	—	2.000	20.000	7.250	—	3.000	3.000	3.000
Total PAHs	—	2.000	25.000	15.333	—	2.000	12.000	7.333
Intermediate Samples								
Benzene	9	2.000	74.000	14.333	8	1.000	80.000	18.626
Chlorobenzene	8	2.000	120.000	29.625	8	3.000	120.000	42.750
Vinyl Chloride	3	3.000	23.000	15.000	5	2.000	12.000	5.600
Total Chlorinated Aromatics	—	1.000	19.000	8.400	—	5.000	19.000	12.429
Total Phenols	—	1.000	63.000	14.100	—	1.000	46.000	13.750
Total PAHs	—	1.000	40.000	9.667	—	1.000	49.000	11.333

Key:
µg/L = Micrograms per liter
— = Detection frequency not given because reported concentrations represent parameter group "total concentrations" (i.e., multiple parameters detected).

Notable differences in detected semivolatile concentrations were observed between 1993 and 1994 groundwater samples. Table 8-15 presents a statistical summary of 1993 and 1994 analytical results (for samples common to both events) comparing total semivolatile group concentrations (chlorinated aromatics, phenols, and PAHs) detected at Site 1. For shallow groundwater, detected total chlorinated aromatics concentrations were comparable between years; however, both total phenolic and PAH compounds were generally detected at lower concentrations in 1994 samples. For intermediate groundwater, total chlorinated aromatics and PAHS were detected at generally comparable concentrations while phenols were detected less frequently and at lower concentrations in 1994 samples.

Pesticides

Only limited amounts of pesticides were detected in site groundwater. Pesticides were detected in only two shallow groundwater samples (01GGM34 and 01GS71). A single relatively low concentration (0.0043 μg/L) of alpha-BHC was detected in sample 01GGM34 from the center of the site, along the landfill's eastern boundary. Comparable concentrations of dieldrin (0.0076 μg/L) were detected in sample 01GS71 from the newly installed shallow well downgradient of the landfill area. Based on the location of detection and limited extent, the dieldrin detection is likely associated with routine pesticide application to the golf course. Likewise, the alpha-BHC detection may indicate a limited degree of impact from landfill wastes to the shallow groundwater.

Pesticide concentrations detected in 1993 and 1994 samples were very comparable. During each year, these low concentration detections were few in number and limited to the shallow depth interval. Specifically, alpha-Chlordane and alpha-BHC were detected in 1993 and 1994, respectively, at approximately the same magnitude (alpha-Chlordane concentration .0040 μg/L in 1993 and alpha-BHC concentration .0043 μg/L in 1994) 'inthe same general area of the site — the central to east central portion. The remaining concentrations (4,4'-DDE and 4,4'-DDT) detected along the golf course boundary in 1993 were not duplicated in 1994 and are likely remnants of previous golf course application.

9.0 DATA VALIDATION

All field and analytical data collected from the Site 1 investigation at NAS Pensacola have been validated. The initial analytical work performed from June 1993 to October 1993 was conducted by CompuChem Laboratories, Inc., of Research Triangle Park, North Carolina. Analytical work performed from June 1994 to July 1994, also was conducted by CompuChem Laboratories for data consistency and continuity. The analytical protocols adhered to the following guidance documents:

- USEPA Contract Laboratory Program (CLP), *Statement of Work (SOW) for Organic Analyses (CLP 3/90).*

- USEPA Contract Laboratory Program, *Statement of Work for Inorganic Analyses (CLP 3/90).*

- Determination of Hexavalent Chromium in Soil and Aqueous Samples based on *EPA Method 7196A*, contained in *Test Methods for Evaluating Solid Wastes (SW-846, 3rd Edition).*

- Determination of the mobility of both organic and inorganic analytes in liquid, solid, and multiphasic waste samples, using the Toxicity Characteristic Leaching Procedure (TCLP) for identifying hazardous waste based on the *TCLP EPA Method 1311* contained in *Test Methods for Evaluating Solid Wastes (SW-846, 3rd Edition).*

- NEESA Level D QA/QC guidelines as stated in the *Sampling and Chemical Analysis Quality Assurance Requirements for the Navy Installation and Restoration Program (NEESA 20.2-047B).*

Data useability was assessed using the following guidance documents:

- USEPA *CLP Functional Guidelines for Organic Data Review* (EPA 540/R-94/012), February 1994 (Functional Guidelines).

- USEPA *CLP Functional Guidelines for Inorganic Data Review* (EPA 540/R-94/013), February 1994 (Functional Guidelines).

9.1 Data Quality

The overall quality data received for NAS Pensacola's Site 1 for site remediation and risk assessment was evaluated and validated with the appropriate data qualifiers based on data usability and CLP contractual satisfaction. Initial sample collection and analysis for Site 1 at NAS Pensacola was perfomed under 17 organic and 17 inorganic CLP Sample Delivery Groups (SDGs). The more recent sampling resulted in collecting four organic and three inorganic SDGs.

9.2 Organic Analysis

Each SDG was received by the laboratory in good condition with the proper chain-of-custody documents and seals intact. All method and contractual holding times complied with QC requirements. All laboratory Verified Time of Sample Receipt (VTSR) dates were considered and noted in combination with sample collection dates and sample extraction and/or analysis dates. SDG 32's evaluation indicated that reference soil samples 01S6701, 01S6703, 01S6705, 0186707, 0186709, 01S6711, 0136713, 0186717, 01S6717D, 0186721, and 01S6721D all exceeded VTSR holding time requirements for extracting semivolatile samples. However, method holding times were within QC requirements, so no action was necessary.

Also, in Case 27314, SDG 603 samples 01SI2801, 01SI3001, 01SI3501, 01SI3601, 01SI4601, 01SI6001, and 01SS6401 each exceeded holding times for semivolatile extractions. The initial

analysis of semivolatile and pesticide/PCB samples 01SI3201, 01SI4301, 01SI4401, 01SI4801, 01SI5901, 01SI591C, 01SI5933, 01SS0101, 01SS3901, 01SS391C, 01SS4201, and 01SS6201 in Case 27314 SDG 637 exceeded contractual holding times. In Case 27314 SDG 865, pesticide/PCB samples 01GI68 and 01GS67 were re-extracted beyond holding time requirements while SDG 1508 semivolatile sample 01GGM41 also was re-extracted and re-analyzed beyond holding time. All associated data were qualified as estimated.

Because all of the samples in SDGs 32, 603, and 637 exceeded holding times for semivolatile and/or pesticide/PCB extractions by 11 to 13 days, professional judgment was used to assess data quality and usability. Therefore, it was determined that all associated positive sample results should be deemed usable with some qualification of sample results as estimated based on holding times, spiking criteria and blank contamination.

The pesticide/PCB samples 01GI68 and 01GS67 in SDG 865 were re-extracted due to low surrogate recovery for decachlorobiphenyl. The second extract and analysis also exhibited low recovery for decachlorobiphenyl on both the quantitation and confirmation columns. Because there were no positive results for the first or second extracts, no data qualification was deemed necessary. In SDG 1508, the initial semivolatile analysis of sample 01GGM41 showed both the peak splitting of surrogate 2-fluorophenol and the elution of large contamination peaks. These large contamination peaks also were detected in the associated method blank. Therefore, the sample was re-extracted 14 days beyond the VTSR. Although the reanalysis exhibited no peak splitting or large contamination peaks from the out-of-holding-time condition of the second extract, all positive sample results were qualified with a J flag as estimated.

9.2.1 Blanks

Blanks assist in determining the existence and magnitude of any contamination resulting from the labomtory or field. All associated data were evaluated to determine whether the data are inherently variable, or if the problem is an isolated occurrence that does not affect the data. In

the blank data provided for the Site 1 investigation, various concentrations of toluene, methylene chloride, acetone for volatiles, and several phthalate esters for semivolatiles were detected. These compounds are considered common laboratory artifacts and were evaluated and qualified based on Functional Guidelines action levels found for each SDG.

Action levels are based on the highest positive sample concentration of any laboratory artifact found in each method blank(s) or QC sample above the Contract Required Quantitation Limit (CRQL). In other words, no positive sample result for a common laboratory artifact is reported unless the concentration of that particular artifact exceeds the action level of 10 times (10X) the amount found in any blank(s). For compounds not considered to be common laboratory artifacts, the action level is five times (5X) the amount found in any blank or QC sample.

Two types of blanks were created in the laboratory while preparing and analyzing samples: method blanks and instrument blanks. Each sample designation will be followed by a number corresponding to that blank. For example, the third volatile method blank would be designated "VBLK03."

Method Blank

VBLK	—	Volatile Method Blank
SBLK	—	Semivolatile Method Blank
PBLK	—	Pesticide/PCB Method Blank

These blanks are used by the laboratory to determine the concentrations of contamination associated with sample processing and analysis. Method blanks are identified by the laboratory using the first letter of the analysis fraction performed followed by the abbreviation BLK for "Blank."

Instrument Blank

PIBLK — Pesticide/PCB Instrument **Blank**

An instrument blank is used by the laboratory to determine if any contamination is present before, during, or after pesticide/PCB sample analysis that *can* be attributed to the gas chromatography instrumentation.

Volatiles: While validating the data of **Case** 27314, **SDGs** 17, 32, 120, 142, ***504,*** 603, 637, 658, 865, 1085, 1287, 1392, 1508, 2030, 2076, 2270, and 2369, and the more recent SDGs 00001, **00006, 00011,** and 00018, the common volatile **laboratory** artifacts methylene chloride, acetone, and 2-butanone were identified above the CRQL in the associated method blanks, trip blanks and field **blanks. (Note:** Field blanks were designated **as** DI system blanks and potable water blanks). Also, the volatile target analytes toluene, chloroform, bromodichloromethane, and dibromochloromethane were detected in the trip blanks and/or equipment rinsate blanks for SDGs 17, 658, and 865.

In addition, the trip blanks, potable water blanks, equipment rinsate blanks, and equipment rinsate/trip blanks for SDGs 142, 865, and 1085 **also contained** several volatile target compounds, including toluene, bromodichloromethane, dibromochloromethane, bromoform, 2-butanone and carbon disulfide. **(Note:** Equipment rinsate/trip blanks **are** actually trip blanks accompanying equipment **rinsate** blanks to the laboratory as **QA** samples. **These** samples have the same basic designation as sample 01GET01.) Also, volatile potable water blanks contained bromodichloromethane, dibromochloromethane, bromoform, and chloroform at various concentrations. SDGs 2030, 2076, 2270, and 2369 each **indicated** only low to medium concentrations of toluene, acetone, and methylene chloride for volatile analysis. Although some of these compounds **are** not considered common laboratory artifacts, action levels were calculated for each compound and **all** associated sample results were qualified accordingly.

Semivolatiles: In the case of semivolatile analysis, the common laboratory artifacts bis(2-ethylhexyl)phthalate, butylbenzylphthalate, diethylphthalate, and di-n-butylphthalate were present at low concentrations in the method blanks, potable water blanks, equipment rinsate blanks, and equipment rinsate/trip blanks for SDGs 17, 120, 142, 504, 658, 856, 1085, 1287, 1392, 1508, 2030, 2076, 2270, 2369 and the more recent SDGs 00001, 00006, 00011, and 00018. Phenol, which is not considered a laboratory artifact, was found in the equipment blanks 01SE01 and 01SE02 in SDG 17, method blanks SBLK26, SBLK62 and SBLK82 for SDG 658, and in method blanks SBLK55 and SBLK62 for SDG 865. In SDG 1287, phenol also was indicated in the method blanks SBLK17 and SBLK99 and the equipment blank 01GE02. Phenol again was reported in method blank SBLK99 for SDG 1392 and method blank SBLK39 for SDG 1508. Pentachlorophenol, which is not considered a common laboratory artifact, was reported in method blanks SBLK35 and SBLK62 for SDGs 658, 865 and 2369. Although some of these compounds are not considered common laboratory artifacts, action levels were calculated for each compound and all associated sample results were flagged accordingly.

Pesticides/PCBs: During pesticide/PCB analysis, the laboratory reported low concentrations of various pesticides/PCBs in the method blanks, instrument blanks, and potable water blanks of several organic SDGs. For instance, the method blank PBLK23 in SDG 32 contained a low concentration of the target analyte 4,4'-DDD while method blanks PBLK53, PBLK57, and pesticide instrument blank PIBLKL2 indicated small amounts of heptachlor, dieldrin, 4,4'-DDE, endosulfan sulfate, 4,4'-DDT, methoxychlor, a-chlordane, and g-chlordane contamination. For SDGs 865 and 2030, the pesticide g-chlordane was reported in method blank PBLK86 and PBLK69 respectively. Also, method blank PBLK28 in SDG 865 and method blank PBLK69 in SDG 2030 indicated low concentrations of heptachlor, 4,4'-DDE, and methoxychlor contamination.

In SDG 2076, the method blank PBLK16 contained a low concentration of the pesticide heptachlor while method blank PBLK80 reported a low concentration of aldrin. In SDG 2270,

the method blank PBLK14 exhibited small concentrations of endosulfan sulfate, methoxychlor, and heptachlor while d-BHC was present at a low concentration in the pesticide instrument blank PIBLKVK. For SDG 2369 the method blank PBLK29 showed a small concentration of heptachlor.

Also, the instrument blank PIBLKEG indicated a small amount of 4,4'-DDE in SDG 1085 and in SDG 1287, the method blanks PBLK75 and PBLK77 reported low concentrations for pesticides heptachlor, dieldrin, endrin, aldrin, and g-BHC (lindane). In addition, the equipment blank 01GE02 and the DI system blank 59FI-0719 contained low concentrations of dieldrin, heptachlor, and aldrin. In SDG 1392, the method blank PBLK78 indicated small amounts of heptachlor, aldrin, dieldrin, and endrin contamination.

During the laboratory's day-to-day activities and operations, samples from several different NAS Pensacola sites were analyzed together within several SDGs. As a result, equipment rinsate blanks, equipment rinsate/trip blanks, potable water blanks and trip blanks from these other sites also were used in evaluating pesticide/PCB sample results for Site 1. Since none of the target pesticide/PCB analytes is considered a common laboratory artifact, E/A&H believes the laboratory introduced the associated QA/QC blank sample contamination was while preparing, diluting, or analyzing the samples. Therefore, as in the case of volatiles, semivolatiles, and pesticides/PCBs, action levels were calculated based on the analyte concentrations indicated in each SDG and all associated sample results were qualified accordingly.

Tentatively Identified Compounds (TICs): Non-target compounds identified by analysis are labeled as TICs and in CLP analyses these compounds are reported for volatiles and semivolatiles. Many of the TICs reported by the laboratory for volatile sample analysis of SDG 17 were identified as chlorinated benzenes and laboratory artifacts while the TICs in SDG 32 could be characterized as laboratory artifacts and/or an alcohols. No TICs were reported in any of the volatile samples for SDG 120 and 142. TICs found in SDG 504 in

several samples were identified as laboratory artifacts and were not considered sample constituents.

The four TICs detected in SDG 603 could be characterized as substituted benzenes, hydrocarbons, and unknowns while the TICs in SDG 637 were identified as unknowns, unknown hydrocarbons, and benzenes. The four TICs found in SDG 658 were characterized as laboratory artifacts while the TICs in SDG 865 were characterized as unknowns and substituted benzenes. Only six of the volatile samples in SDG 1085 contained TICs identified by the labomtory as artifacts while the TICs in the volatile sample 01GGM04 were characterized as tetramethylbutane and hydrocarbons. Also, the TICs in four volatile samples for SDG 1287 and samples 01GI28D, 01GI32, and 01GI41 were characterized as substituted benzenes, hydrocarbons, and unknowns. The TICs found in four volatile samples for SDG 1508 were identified as substituted benzenes, Freon, hydrocarbons, laboratory artifacts, and unknowns.

In SDG 2030, the analyte toluene was identified above the CRQL in 01S7501, 01S8201, and 01S8210. The TICs found in 01S7501 and 01S8201 could be characterized as hydrocarbons and unknowns, whereas the TICs in the remaining samples were assessed as labomtory artifacts. In SDG 2076, volatile samples 01G79 and 01SE14 each contained TICs that could be characterized as substituted benzenes.

Also, in SDG 2270, TICs were found in 19 samples. Although several of these TICs could be characterized as laboratory artifacts, most of them were unknowns. None was considered a sample constituent. The TICs found in the volatile analysis of SDG 2369 all were characterized as laboratory artifacts and were not considered sample constituents.

TICs found in semivolatile samples for SDG 17 were characterized as blank contaminants, laboratory artifacts, aldol condensation products, chlorinated hydrocarbons, and unknowns while the TICs identified in SDG 32 also could be characterized as hydrocarbons, carboxylic acids,

tetrachloroethane, acid esters, and unknowns. The TICs found in SDG 120 were identified as hydrocarbons, substituted hydrocarbons, and unknowns and were not considered sample constituents. TICs found in 11 the samples for SDG 142 were identified as laboratory artifacts and blank contaminants, hydrocarbons, and unknowns and were not considered sample constituents.

Also, in SDG 504, the TICs in sample 01P05 were identified as blank contaminants and laboratory artifacts while the TICs in the method blanks and remaining samples could be characterized as alkenes, substituted ethanols, carboxylic acids, and unknowns. The TICs in SDG 603 all could be identified mainly as unknowns of siloxanes and carboxylic acids. The TICs in SDG 637 could be characterized as unknowns, aldol condensation products, blank contaminants, and laboratory artifacts. All the TICs assessed as laboratory artifacts, blank contaminants, and aldol condensation reaction products were not considered sample constituents. Few TICs were found in any of the method blanks and semivolatile samples for SDGs 658 and 865, however, all compounds detected were characterized as laboratory artifacts and the TCL analyte phenol.

For SDG 1085, the semivolatile TIC in sample 01GS37 was identified as a laboratory artifact and the TICs found in the method blanks and remaining samples were identified as carboxylic acids, hydrocarbons, substituted phenols, phthalates, unknowns, and cyclohexenone. Two volatile TCL analytes also were detected as TICs in the semivolatile analysis of sample 01GI35. These compounds also were detected in the TCL volatile analysis of this sample.

TICs identified in the method blanks and all the samples for SDG 1287 were characterized as unknowns, hydrocarbons, substituted benzenes, and substituted phenols while the TICs detected in the method blanks and semivolatile samples for SDG 1392 were identified as substituted benzenes, substituted phenols, unknowns, laboratory artifacts, blank contaminants, and aldol

condensation products. All the TICs assessed as laboratory artifacts, blank contaminants, and aldol condensation reaction products were not considered sample constituents.

The TICs found in the method blanks and all of the samples for SDG 1508 were characterized as unknowns, hydrocarbons, and substituted hydrocarbons and the TICs in the samples for SDG 2030 could be characterized as hydrocarbons, substituted phenols, PAHs, polynucleic aromatics, carboxylic acids, dichloroisocyanatobenzene, PCBs, cyclohexenone, pesticide compounds (such as 4,4'-DDE and chlordane), and unknowns. Few TICs were found in most of the samples for SDG 2076, however, numerous TICs were detected in samples 01G79 and 01SE20. In sample 01G79 the TICs could be characterized as polycyclic aromatic hydrocarbons, substituted benzenes, and unknowns. In sample 01SE20, the TICs could be characterized as unknowns and halogenated unknowns.

In SDG 2270, TICs were found in all the samples. Although some of the TICs in these samples were characterized as hydrocarbons and unknowns, most were assessed as laboratory artifacts, blank contaminants, and aldol condensation reaction products. Finally, the TICs found in the samples for SDG 2369 were characterized as hydrocarbons, phthalates, trismethylphenylphosphoric acids, and unknowns.

In evaluating the data provided by these QC samples, all frequencies and compliance requirements were satisfactory. E/A&H believes these common laboratory artifacts and other blank contaminants are partially, if not all, a result of laboratory conditions when samples were analyzed. Therefore, no conclusions or recommendations for Site 1 at NAS Pensacola are based on laboratory artifacts.

9.2.2 Calibration

Requirements for instrument calibration were established to ensure the data provided are acceptable qualitatively and quantitatively. The initial calibration measures the instrument's

stability, indicating its sensitivity and capabilities before the analytical run. Continuing calibration indicates the instrument's performance throughout and at the end of each subsequent analytical run. Historical performance data indicate poor response and/or erratic behavior by those compounds known as common laboratory artifacts. Since no contractual criteria for these compounds exist, for review and data validation purposes, all compounds including the common laboratory artifacts were considered for qualification when the following criteria were not met.

- Initial/continuing calibration standard relative response factors (RRFs) for all target compounds and surrogates must be equal to or greater than 0.05.

- Percent relative standard deviation (%RSD) must not exceed ± 30 percent in the initial calibration.

- Percent difference (%D) not exceeding ± 25 percent in the continuing calibration.

Volatiles: Several volatile compounds — including methylene chloride, acetone, 2-butanone, 2-hexanone, and chloromethane —consistently failed %RSD criteria during the initial calibration analysis for almost every organic SDG. Also, acetone, 2-butanone, 2-hexanone, and chloromethane each failed %D criteria during the continuing calibration analysis for several SDGs. However, the RRFs for each of these compounds were within CLP QC criteria.

Semivolatiles: Compounds 2,2'-oxybis(1-chloropropane), 2-nitroanailine, di-n-octylphthalate, bis(2-ethylhexyl)phthalate, hexachlorobutadiene, n-nitroso-di-n-propylamine, butylbenzylphthalate, and the surrogate 2,4,6-tribromophenol failed %D criteria due to poor response andor frequent intervals of erratic behavior. Although this was a systematic occurrence, these poor responders represent the large majority of compounds failing both %D and/or %RSD for nearly each SDG. If the %RSD was greater than 30 percent and eliminating either the high point or the low point on the initial calibration curve and recalculating did not

restore the %RSD result to a value less than or equal to 30 percent, then all associated positive sample results outside the linear portion of the initial calibration curve were qualified with a J flag. However, if this action restored the %RSD result to a value below 30 percent, no action is deemed necessary under CLP QC protocols.

Pesticide/PCBs: All calibration criteria were met for all samples.

9.2.3 Precision

In each analytical method used to analyze environmental samples, variations in the reported results may be due to the random differences in the matrix's handling and analysis. These variations are referred to as the ***precision*** or the ***reproducibility of*** results. To demonstrate reproducibility, the CLP SOW specifies adding known quantities of several compounds to two separate aliquots of each sample matrix type. The "spiked" aliquots are referred to as the MS and the MSD. These samples then *can* be analyzed by applying the same preparation techniques and analytical methods used for all the samples of similar matrix types. This enables the MS and MSD to be used to detect matrix effects caused by contamination during analysis that also could interfere and/or cover up target compounds present within the sample.

MS/MSD semivolatile results for SDG 17 were within QC criteria; however, the laboratory indicated that due to the low volume of raw sample, duplicate blank spikes were analyzed instead of duplicate sample spikes. The duplicate blank spikes met all accuracy and precision criteria, except for 4-chloro-3-methylphenol, 4-nitrophenol, and pentachlorophenol in the MSD. These compounds were qualified due to their high recoveries which were attributed to the more efficient recoveries generally obtained using pure DI water instead of actual samples.

For SDG 32, phenol exhibited an MSD high percent recovery during semivolatile analysis. In the pesticide/PCB analysis, failure of either the percent recovery or %RPD in the MSD was reported for compounds g-BHC, heptachlor, aldrin, dieldrin, endrin, and 4,4'-DDT. *Also,* in

SDG 120, the compounds 4,4'-DDT, g-BHC, heptachlor, dieldrin, and endrin failed percent recovery criteria for MS and/or MSD analysis.

Semivolatile analysis for SDG 142, indicated high percent recoveries for compounds 4-chloro-3-methylphenol and 4-nitrophenol during MS/MSD analysis while pyrene exhibited a low percent recovery within the same MSD. In SDG 504, 1,1-dichloroethene indicated a high %RPD during volatile analysis and benzene exhibited a high percent recovery within the MSD. *Also,* semivolatile analysis of the MS showed a high recovery for pentachlorophenol and semivolatile analysis for SDG 603 indicated high %RPDs for 1,2,4-trichlorobenzene and acenaphthene. *Also,* in SDG 637 benzene failed percent recovery for volatile analysis in the MSD and phenol failed percent recovery for semivolatile analysis in the MS.

All MS/MSD sample results for SDG 658 were within QC criteria except for the pesticide compound dieldrin. Dieldrin failed %RPD criteria during the analysis of the MSD and the semivolatile compounds 4-nitrophenol, 4-chloro-3-methylphenol, 4-Ntrophenol, and pentachlorophenol failed percent recovery criteria for the MS and MSD. In SDG 1085 the pesticides aldrin and endrin failed percent recovery during MS analysis and g-BHC failed the percent recovery for both MS and MSD analysis. Semivolatile analysis for SDG 1287 indicated that compound 4-nitrophenol failed percent recovery for the MS and the pesticide g-BHC failed percent recovery for both the MS and the MSD.

Semivolatile analysis for SDG 1392 indicated a high percent recovery for 4-nitrophenol. *Also,* pesticide/PCB analysis showed dieldrin, endrin, and 4,4'-DDT with low percent recoveries for the MSD and the compound g-BHC exhibited a high percent recovery in both the MS and MSD. Semivolatile analysis for SDG 1508 indicated a high recovery for the analyte 4-nitrophenol in the MSD and 4-chloro-3-methylphenol exhibited a high recovery within both the MS and MSD. Pesticide/PCB analysis in SDG 1508 showed a low percent recovery for the pesticide g-BHC

in both the MS/MSD and the pesticides heptachlor, dieldrin, and endrin exhibited a low percent recovery for the MS only.

Finally, semivolatile analysis of SDG 00006 indicated failure of %RPD for the analytes 1,4-dichlorobenzene, n-nitroso-di-n-propylene, 1,2,4-trichlorobenzene, and pyrene for sample 01GI48. All values were biased high. Semivolatile analysis of SDG 00011 indicated that compounds 4-chloro-3-methylphenol, nitmphenol, 2,4-dinitrotoluene, and pentachlorophenol failed percent recovery QC criteria for the MSNSD.

E/A&H believes the MSNSD results indicate the effect of sample matrix on the associated sample data, including the MSNSD samples themselves. This *can* be determined by consistent high percent recoveries when deionized water is analyzed and the inconsistent percent recoveries and %RPDs reported when soil samples were analyzed. As a general rule, no action is taken on MSNSD data alone. However, the MS and MSD results are used in conjunction with other QC criteria, such as surrogate recoveries, internal standard area QC requirements, and the comparison of %RSD results of non-spiked compounds with the original sample results to determine the need to qualify some of the associated positive sample results as estimated or unusable.

9.2.4 Accuracy

Accuracy is the degree to which a given result agrees with the *true* value. To check the accuracy in a volatile, semivolatile, pesticide, and/or PCB analysis, the CLP SOW requires adding known amounts of *surrogate compounds* or compounds unlikely to be found in the actual samples. If upon analysis of the sample, the percent recovered for the surrogate compounds are accurate, (i.e., close to the known concentrations as defined within the limits set by the CLP) then the reported target compound concentrations are assumed to be accurate.

Also, the accuracy of the overall measurement system indicates any bias that may exist in the environmental laboratory and/or in the field sampling/analysis plan. Possible sources of error may include the sampling process, field and/or laboratory contamination, preservation, handling, or the sample matrix itself. Other methods used to determine field inaccuracies include trip blanks and the preparation and analysis of field blanks, potable water blanks, and equipment rinsate blanks.

Volatiles: All volatile surrogate recoveries were met for all samples.

Semivolatiles: Semivolatile surrogate spike analysis for SDG 17 indicated a low surrogate recovery for nitrobenzene-d5 in sample 01SE02 and in SDG 32, the method blank SBLK09 and sample 01S6713 exhibited a high surrogate recovery for 2-fluorophenol. Only four samples from Site 1 were included in SDGs 120 and 142 and all semivolatile surrogates were within CLP QC requirements. Semivolatile analysis for SDG *504* indicated low recoveries for surrogate 2-fluorobiphenyl in samples 01P06 and 01SE04. Only two semivolatile samples were in SDG 603 and both were within QC requirements. All semivolatile samples in SDG 637 were within QC criteria and in SDG 658, the method blank SBLK26 failed surrogate recovery for 2-fluorobiphenyl.

Furthermore, in SDG 865, semivolatile sample 01GS69 failed recovery criteria for 2-fluorobiphenyl and in SDG 1085, samples 01GGM39 and 01GS37 failed surrogate recovery for 2-fluorobiphenyl and semivolatile sample 01GI66 also failed recovery criteria for terphenyl-d14. Semivolatile samples 01GGM33D and 01GI30 and method blanks SBLK91 and SBLK99 each failed surrogate recovery for 2-fluorobiphenyl while semivolatile sample 01GS62 failed surrogate recovery for terphenyl-d14 in SDG 1287.

All semivolatile samples for SDG 1392 were within QC criteria, however method blank SBLK99 failed surrogate recovery for 2-fluorobiphenyl and in SDG 1508, method blanks SBLK39 and

SBLK35 failed sumgate recovery for 2-fluorobiphenyl and 2-fluorophenol, respectively. Semivolatile analytical data within each SDG are not believed to have been affected by surrogate recoveries because CLP data validation guidelines suggest no action be taken unless two or more semivolatile surrogates within the same fraction (i.e., base neutral or acid fraction) are outside compliance criteria.

Pesticide/PCBs: In SDG 17, pesticide/PCB surrogate recovery criteria for decachlorobiphenyl (DCB) were not met for sample 01P01 and method blank PBLK82 on both the quantitation and confirmation columns. *Also,* in SDG 32, method blank PBLK15 failed surrogate recovery for tetrachloro-m-xylene (TCX) on the quantitation column and sample 0126717DMSD failed surrogate recoveries for both DCB and TCX on both quantitation and confirmation columns. In SDG 120, sample 0136723 and 01S6723MSD failed surrogate recovery for DCB on both the quantitation and confirmation columns and sample 0186719 failed surrogate recovery for TCX on the quantitation column only. Because CLP QC limits are advisory, no action is provided for samples with failing surrogate recoveries. Therefore, the pesticide/PCB analytical data within these SDGs are believed to be reliable and usable with the appropriate data qualifiers.

Only two pesticide/PCB samples for Site 1 were in SDG 142, and both exhibited surrogate recoveries within QC criteria. However, in SDG *504,* samples **01SE03, 01SE04, 01SE03MSD,** and the DI system blank 59FI-0610 all failed surrogate recovery for DCB on both the quantitation and the confirmation columns. Also, samples 01SE03MS and 01P04 failed surrogate recovery for DCB on the quantitation column and method blank PBLK14 failed surrogate recovery for TCX on the confirmation column. DI system blank 59FI-0614 failed surrogate recovery for both DCB and TCX on both the quantitation and confinnation column.

Pesticide/PCB sample 01P06 also exhibited a low surrogate recovery for TCX on the confirmation column and sample 01P05 failed surrogate recovery for TCX on both the quantitation and confiiation columns. All associated sample results were qualified accordingly

using informed professional judgment because CLP QC limits for pesticide/PCB surrogates are advisory only.

In SDG 603, method blank PBLK05 and samples 01SI3501 and 01SI4601 failed surrogate recovery for TCX on the confirmation column. For SDG 637, sample 01SI4401 failed surrogate recovery for DCB on both the quantitation and confirmation columns and TCX on the quantitation column only. Sample 01SI4801 failed surrogate recovery for TCX on the confirmation column and sample 01SI5901 also failed surrogate recovery for TCX on both the quantitation and confirmation columns.

In SDG 658, sample 01SE11 and the DI system blank 59FI-0621 failed surrogate recovery on the quantitation and confirmation columns and samples 01SE12, 01SE12MS, and 01SE12MSD each failed surrogate recovery for DCB on the quantitation column. Also, samples 01SE12MS and 01SE12MSD exhibited low surrogate recoveries for TCX on the confirmation column and the method blank PBLK54 failed surrogate recovery on the confiiation column.

For SDG 865, samples 01GI68, 01GE01, 01GS67, 01GS69, and 01GDSW51 and DI system blanks 59FI-0701, 59FI-0709, and 59FIMI all failed surrogate recovery for DCB on the quantitation and confirmation columns. Method blank PBLK35 also failed surrogate recovery for DCB on both the quantitation and confirmation columns. In addition, sample 01GS67 failed surrogate recovery for TCX on both the quantitation and confirmation columns while sample 01GI68 failed TCX recovery on the confirmation column and DI system blank 59FIMI failed surrogate recovery on the quantitation column.

In SDG 1085, the samples 01GI35, 01GI35MS, 01GI35MSD, 01GI36, 01GS37, 01GI53, 01GS57, 01GS58, 01GS66, 01GI70, 01GGM04, 01GGM32, 01GGM38, and 01GGM39 all failed surrogate recovery for DCB on both the quantitation and confirmation columns. Also, sample 01GGM03 failed surrogate recovery criteria for DCB on the confirmation column and

method blank PBLK56 and samples 01GI35, 01GI35MS, 01GI35MSD, and 01GGM38 each failed surrogate recovery for TCX on the confirmation column. Samples 01GGM03, 01GGM39, 01GI66, and DI system blank 59FI-0714 each failed surrogate recovery for TCX on both the quantitation and confirmation columns. Finally, sample 01GGM04 failed surrogate recovery for TCX on the quantitation column only.

Also in SDG 1287, pesticide/PCB samples 01GE02, 01GI28, 01GI30, 01GI38, 01GS39, 01GS40, 01GI59, 01GI59D, 01GS62, 01GS62MS, 01GI63, 01GGM31, 01GGM33D, 01GGM35D, method blank PBLK75, and DI system blank 59FI-0719 each failed surrogate recovery criteria for DCB on both the quantitation and confirmation columns. Method blank PBLK77 failed surrogate recovery for DCB on the confirmation column while samples 01GI59, 01GI59D, 01GS62MS, 01GS62MSD, 01GGM33D, and 01GGM35D each failed TCX on the confirmation column. Also, sample 01GS62 failed surrogate recovery for TCX on both the quantitation and the confirmation columns.

For SDG 1392, pesticide/PCB samples 01GS01, 01GI28D, 01GI32, 01GI32MS, 01GI41, 01GS42, 01GI43, 01GS64, 01GI65, 01GGM33, 01GGM35, 01GGM42, 01GGM44, and 01GGM44D each failed surrogate recovery for DCB on both the quantitation and confirmation columns. Samples 01GI32MSD failed surrogate recovery for DCB on the quantitation column only. Also, samples 01GS64, 01GI65, 01GI41, 01GI32MS, and 01GGM42 all failed surrogate recovery for TCX on both the quantitation and confinnation columns. Samples 01GI32, 01GGM33, and 01GGM35 also failed surrogate recovery for TCX on the confirmation column.

Furthermore, in SDG 1508, samples 01GI44, 01GI46, 01GI46MS, 01GI46MSD, 01GI48, 01GDSW50, 01GS60, 01GI61, 01GGM05, 01GGM41, 01GGM43, and 01GGM45 each failed surrogate recovery for DCB on the quantitation and confirmation columns. Also, samples 01GI61 and 01GI46MS each failed surrogate recovery for TCX on both the quantitation and

confirmation columns and samples 01GI48 and 01GGM41 failed surrogate recovery for TCX on the quantitation column only.

In SDG 00001, samples 01W0303MS, 01W0303MSD, 01ME01, 01W0301, 01W0302, 01W0303, 01W0303D, 01W0101, 01ME01RE, and method blanks PBLK15 and PBLK99 each failed surrogate recovery QC criteria for TCX and/or DCB on both the primary and confirmation columns. In SDG 00006, samples 01GI46, 01GI66, 01GI48MS, 01GI48MSD, 01GS37, 01GI36, 01GI28, 01GI48, 01GGM35, 01GGM04D, 01GS62, 01GS64, 01GS64D, 01GI63, and method blanks PBLK11 and PBLK30 each failed surrogate recovery QC criteria for TCX and/or DCB on both the primary and confirmation columns. In SDG 00011, samples 01M0302, 01M0101, 01M1601, and 01M1801 failed surrogate recovery for TCX on both the primary and confirmation columns. In SDG 00018, samples 01GGM34MS, 01GGM34MSD, 01GGM34, 01GS61, 01GGM33, 01GS71, 01GI72, 01GE02, 01FB02, 01GGM39, 01GI35, 01GI41, and method blanks PBLK14, PBLK26, PBLK40, and PBLK50 failed surrogate recovery criteria for TCX and DCB on both the primary and/or confirmation columns.

However, as indicated earlier, the pesticide/PCB analytical data within each SDG are determined reliable and usable with the appropriate data qualifiers based on the evaluation of all associated QC, such as the initial and continuing calibrations, retention time criteria, and %D and %RSD criteria because CLP QC limits are advisory and no action is provided for samples with failing surrogate recoveries.

9.2.5 Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represent the characteristic of a population, parameter variations at a sampling point, or an environmental condition. The duplicate samples help indicate the overall field and laboratory precision. A greater variance should be expected for the soil sample duplicates than for water sample duplicates due to the differences in matrix. In all cases, the duplicate results were found in close

agreement with the original results since most variations are due mainly to common laboratory artifacts.

9.2.6 Completeness

Completeness is the percentage of measurements made that are judged valid. One hundred and eighty-four samples were analyzed for full CLP TCL investigation of Site 1. All positive organic sample results were determined to be valid with some qualification. Therefore, the data meet the 90 percent completeness level.

9.2.7 Comparability

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another. All samples for Site 1 were collected using the USEPA Region IV standard operating procedures and analyzed according to CLP SOW protocol.

9.3 Inorganic Analysis

The analytical methods were performed in accordance with the USEPA CLP SOW for Inorganics Analyses (3/90) guidelines. However, for hexavalent chromium analysis the laboratory employed Method 7196A and for the determination of characterized contaminants in hazardous waste leachate, TCLP Method 1311. Each method is listed in the USEPA's Test *Methods for Evaluating Solid Wastes, SW-846,* 3rd *Edition.* Results were reported according to CLP format outlined including but not limited to, forms listed under NEESA Level D guidelines.

9.3.1 Holding Times

All inorganic samples were received by the laboratory in good condition with the proper custody documents and seals intact. From the date of collection to the date of sample digestion or preparation, all sample holding times were within contractual requirements.

93.2 Calibration

The purpose of initial and continuing calibration is to ensure the instrument is capable of acceptable and quantitative performance at the beginning and throughout each analytical run. Initial and continuing calibrations were performed for the inorganics analysis within the criteria established by the USEPA CLP Inorganics SOW.

933 Blanks

Blank results are used to determine the presence and magnitude of any contamination problems. In review of the data, the continuing calibration blanks in SDG 141210 contained low concentrations of beryllium, mercury, manganese, and the preparation blank contained a significant amount of calcium. In SDG 141379, beryllium, manganese, and calcium were present within the continuing calibration blanks and manganese also was present in the preparation blanks. Also, the continuing calibration blanks in SDG 141509 contained low concentrations of beryllium, barium, cobalt, copper, vanadium, arsenic, and manganese. However, significant amounts of magnesium and calcium were in the continuing calibration blank. The preparation blank in SDG 314135 indicated low concentrations of aluminum and sodium while SDG 314217 also contained low concentrations of aluminum, calcium, and zinc.

In SDG 314605, the continuing calibration blank contained low concentrations of manganese and beryllium while the prepamtion blank contained a low concentration of manganese. Also, in SDG 314647, the preparation blanks contained low concentrations of aluminum, iron, and sodium. The continuing calibration blanks contained low concentrations of manganese. The preparation blanks in SDG 314703 indicated low concentrations of aluminum, calcium, iron, and sodium while the preparation blanks in SDG 314936 contained low concentrations of arsenic, barium, calcium, lead, magnesium, and sodium and the continuing calibration blanks contained low concentrations of cadmium.

In SDG 731418, the preparation blanks contained low concentrations of manganese, lead, aluminum, calcium, and zinc while the preparation blanks in SDG 731446 indicated low concentrations of aluminum, sodium, and zinc. In SDG 893811, the calibration blanks contained low concentrations of beryllium and manganese at 1.4 $\mu g/L$ and 5.5 $\mu g/L$ respectively. SDG 893612 indicated only beryllium at 1.1 $\mu g/L$ in the calibration blank and calcium and magnesium in the preparation blank. In SDG 289362, the analytes beryllium, calcium, copper, barium, and zinc were present in low concentrations in the preparation blank, and the initial and continuing calibration blanks. As required under CLP QC guidelines, all associated sample results were qualified based on the calculated action levels determined from the concentration of blank contaminants found in each SDG. Action levels for metals are calculated based on five times (5X) the highest positive sample concentration of any analyte found within an initial or continuing calibration blank and/or preparation blank.

9.3.4 ICP Interference Check Sample Analyses

The inductive coupled plasma (ICP) interference check sample analysis (ICS) is performed to check the laboratory's instrument and the background correction factors. The ICSA samples indicated no interferences. The ICS samples also satisfactorily met the contractual compliance requirements as stated under CLP.

9.3.5 Laboratory Control Sample Analyses

The Laboratory Control Sample Analysis (LCSA) is designed to monitor the efficiency of the overall performance in all steps of analysis, including the digestion procedures. All LCSA results were within contractual compliance requirements, except for nickel in SDG 141210. The LCSA sample in SDG 141210 exhibited less than 80 percent recovery for nickel. Therefore, all associated positive sample results for this analyte were qualified as estimated with a J flag and all non-detected results also were qualified as estimated with a UJ flag.

9.3.6 Duplicate/Spike

Duplicate samples are used to determine the precision of analytical methods for each parameter. In SDG 142051, the duplicate precision for analytes aluminum, cadmium, calcium, copper, lead, and manganese each failed %RPDs during analysis, however, SDG 141210 indicated no associated field duplicate sample analysis. For SDG 142274, lead failed CLP control limits for duplicate analysis between samples 0187313 and 01S7313D. SDGs 142291 and 142375 indicated no associated field duplicate sample analysis. In SDG 141379, zinc failed duplicate CLP control limits during the analysis of samples 01GI59 and 01GI59D, however the analysis of samples 01GI28 and 01GI28D indicated all analytes were within QC criteria.

SDG 141509 indicated no associated field duplicate analysis, however, in SDG 141743, aluminum failed duplicate precision criteria. In SDG 314135, antimony failed percent recovery criteria for metals, therefore all associated positive sample results were qualified as unusable. Also, the analytes barium, calcium, lead, manganese, and zinc each exhibited high %RPD for field duplicate precision. All field duplicate precision results for SDG 314217 were within CLP QC criteria, however in SDGs 314376 and 314605, several analytes exhibited high %RPD for field duplicate precision analysis. Finally, in SDGs 314647, 314703, 314936, 731418, and 731446, no field duplicate sample analysis was associated with these SDGs.

Spiked samples are designed to provide information about the effects of the sample matrix on the digestion and measurement methodology. For instance, the MS recovery for lead in SDG 142051 was greater than 200 percent, therefore all positive results greater than the IDL were qualified as estimated. In SDG 141210, the percent recovery for arsenic, lead, selenium, and thallium all were below 50 percent while the percent recovery for mercury was 145 percent. Therefore, according to CLP protocols, all associated non-detected sample results for arsenic, lead, selenium, and thallium were qualified as estimated at the reported quantitation limits, as the UJ flag indicates. Also, all positive sample results for these compounds were qualified with a J flag as estimated.

In SDG 141379, the analytes aluminum, arsenic, lead, selenium, and thallium exhibited recoveries below 75 percent and all associated sample results were qualified accordingly. The analytes in SDG 141509 were all within QC criteria, however, in SDG 142274 the MS recoveries for antimony and cadmium were less than 75 percent. As a result and according to CLP guidelines, all associated non-detected sample results were qualified as estimated at the reported quantitation limit and all associated positive sample results were qualified as estimated values.

In SDG 142291 for MS analysis, the laboratory indicated the analyte thallium exhibited a percent recovery of zero and the-analyte selenium showed a recovery of less than 75 percent. All associated positive sample results for thallium were qualified as unusable and those for selenium were flagged as estimated. Again in SDG 142375, antimony and cadmium exhibited recoveries of less than 75 percent, with the recovery of selenium at less than 30 percent. Also, in SDG 141743, lead and thallium indicated MS recoveries at below 75 percent and aluminum at less than 30 percent. All associated sample results were qualified according to CLP protocols.

In SDG 142388, the analytes aluminum, arsenic, and selenium exhibited recoveries for the MS of less than 30 percent. Sample analysis of 01GI68R, 01GI70R, 01GS67R, and 01GS69R showed high concentrations of aluminum but no positive results for selenium. Therefore, all positive sample results for aluminum were qualified as estimated and all positive results and non-detects for arsenic and selenium were qualified as unusable. Also, the analytes antimony, cadmium, thallium, and zinc all exhibited percent recoveries of less than 75 percent. Positive sample results for these analytes were qualified as estimated and all nondetect results were qualified as estimated at the reported quantitation limits.

In SDG 314135, the analyte antimony exhibited a less than 30 percent recovery in the matrix spike and in SDG 314217, the metals antimony and selenium each exhibited recoveries of less than 30 percent. Also, thallium reported a recovery of less than 75 percent and lead a recovery

of greater than 140 percent. All positive and non-detected sample results for antimony in both SDGs and selenium in SDG 314135 were qualified as unusable. All associated sample results for lead and thallium were qualified as estimated (J flag).

In SDG 314605, all analytes were within CLP QC criteria for MS analysis. In SDG 314647, antimony and cadmium exhibited recoveries below 75 percent while the recovery for mercury was again reported above the upper limit at 140 percent. Positive sample results for all three analytes were qualified as estimated and all non-detect results for antimony and cadmium were qualified as estimated at the reported quantitation limits. The analytes lead and thallium were reported at less than 75 percent in SDG 314703. In SDG 314936, the analytes chromium, iron, and nickel each exhibited an MS recovery of greater than 130 percent. Therefore, all associated positive sample results were qualified as estimated according to CLP protocols.

In SDG 731418, the MS recovery for thallium indicated a recovery below 50 percent. The recovery for cyanide was reported at less than 30 percent. *Also,* in SDG 731446, the analyte arsenic indicated a recovery of less than 75 percent. As a result and according to CLP guidelines, all associated non-detected sample results for thallium and arsenic were qualified as estimated at the reported quantitation limits, as the UJ flag indicates. All positive sample results for thallium and arsenic were qualified as estimated while all positive and non-detected results for cyanide in SDG 731418 were qualified as unusable.

Evaluation of SDGs 893811, 893612, and 289362 from the recent sampling event indicated that the *spike* recovery for thallium in SDG 893811 was at 62.3 percent. Therefore all positive results and nondetects were qualified as estimated with J and UJ flags, respectively. *Also,* matrix interferences were indicated for the *analytes* barium, calcium, and thallium in 893811, which resulted in all positive values being qualified as estimated. All spiked analytes were within QC criteria in SDG 893612 except for lead. The spike recovery for lead was 132.8 percent, which resulted in qualifying all positive results as estimated. A matrix

interference was present for arsenic in samples 01M0301, 01M0302, 01M0303, 01M1601, and 01M1801 and selenium in sample 01M1801. All associated positive sample results were qualified as estimated for these analytes in SDG 893612.

In SDG 289362, the analytes lead and thallium showed spike recoveries of 72.4 and 57.5 percent, respectively. All associated positive sample results and non-detects were qualified as estimated. Matrix interferences were reported for arsenic in samples 01ME01, 01W0303, and 01W0303D; lead in samples 01ME01, 01W0101, 01W0303, 01W0303D, 01W1601, and 01W1801; selenium in samples 01ME01, 01W0302, 01W0303, and 01W0303D; and thallium in samples 01ME01, 01W0101, 01W0301, 01W0302, 01W0303, 01W0303D, 01W1601, and 01W1801. All associated positive sample results were qualified as estimated for each analyte in the affected samples.

The section **9.3.7** Quantitation Limits has been extensively revised. For readability this section has not been bolded or bracketed.

9.3.7 Quantitation Limits

All soil samples and sediment samples exhibit elevated quantitation limits due to the percent moisture content of each soil and/or sediment sample. The moisture content is inherent in the soil and sediment sample and must be considered and calculated before the sample is analyzed and applied to the final results after sample analysis. A calculation is also done for any diluted samples, for example:

If a 1:10 dilution of an extract is necessary, the reported limit is 100 U. However, for a soil sample, the value must also be adjusted for percent moisture. For example, if the sample had a 24% moisture content and a 1:10 dilution factor for low level soil analysis was also performed, then the sample quantitation limit for phenol (330 U) would be corrected to:

$$\frac{(330\ U) \times df}{D} \quad \text{where} \quad D = \frac{100 - \%\ \text{moisture}}{100}$$

df = dilution factor

At 24% moisture, $D = \frac{100 - 24}{100} = 0.76$

Therefore:

$$\frac{(330\ U)}{0.76} \times 10 = 4300\ U$$ Rounded to the appropriate number of significant figures

The actual percent moisture in each soil sample varies with physical and chemical characteristics, such as clay content, surface area @article size) of the soil and/or bulk density, location of a particular soil boring in proximity to a water source, and the soil's permeability and porosity. Permeability and porosity are the two most important physical characteristics in determining the percent moisture content in soil. Permeability refers to the ease with which liquids and/or water penetrate or pass through the bulk soil. The greater the permeability, the less resistant the soil becomes to infiltration by liquids and the dissolved chemicals they contain. As particle size decreases, which indicates a high clay content, permeability tends to decrease because of the proximity of the soil particles. This proximity physically retards contaminant movement. Porosity refers to the amount of soil sample contamination between soil particles, and is interrelated with permeability. As porosity increases, permeability increases. The amount of liquids that *can* be held in the soil or sediment also increases. Therefore, the vertical and lateral movement of the liquid may be retarded, which saturates the soil. This soil saturation water and various concentrations of chemical contaminants leads to a combination of different percent moisture contents and matrix interferences. This combination of moisture content and matrix interferences mainly contribute to the elevation of soil and sediment quantitation limits. This problem is magnified even more due to dilutions and/or medium level soil analyses. The primary purpose of the medium level soil analyses quantitation limits in the 3/90 Organic CLP

SOW are to provide reference contract-required quantitation limits for soils that show high percent moisture content and/or severe matrix interferences. Table 9-1 is the sample summary of elevated quantitation limits. .

9.4 Validation Worksheets

In every E/A&H data validation project, worksheets are used to detail the evaluation of the analytical data. On certain sheets, the validation procedures will be equivalent to the standard operating procedures provided by the ***USEPA CLP National Functional Guidelines for Organic and Inorganic Data Review.*** Other sections will cover areas that are more subjective due to the complexities of the analytical methods, and will only provide documentation on the actions taken by the data evaluator. The worksheets will be provided upon request or and will be included in the NAS Pensacola Site *1 — Final Report file.*

9.5 Data Assessment

The method blanks, trip blanks, potable water blanks, DI system blanks, equipment rinsate blanks, and the equipment rinsate trip blanks contained several volatile target compounds reported by the laboratory as contamination introduced while preparing, handling, and/or analyzing samples. These compounds include toluene, acetone, methylene chloride, chloroform, bromoform, bromodichloromethane, dibromochloromethane, 2-butanone, and carbon disulfide for volatiles.

The semivolatile analysis of the method blanks, equipment rinsate blanks, and potable water blanks indicated low-to-medium levels of bis(2-ethylhexyl)phthalate, butylbenzylphthalate, diethylphthalate, di-n-butylphthalate, phenol, and pentachlorophenol contamination in several SDGs. Also, the pesticide/PCB method blanks, instrument blanks, equipment blanks, and potable water blanks indicated low concentrations of several pesticide/PCB target compounds, such as aldrin, dieldrin, methoxychlor, heptachlor, endrin ketone, d-BHC, a-chlordane,

Table 9-1
Explanation of Elevated Sample Quantitation Limits
NAS Pensacola Site 1

Sample Summary			
01M0101 **	01SS6201 **	01S8118 **	01SI3601 **
01M0301 **	01SS6401 **	01S8120 **	01SI4301 **
01M0302 **	01S6701 **	01S6721D **	01SI4401 **
01M0303 **	01S6703 **	01S6723 **	01SI4601 **
01M0303 **	0186705 **	01S6901 **	01SI4801 **
01M0303D **	01S6707 **	01GS69 **	01SI5901 **
01M0303D **	0156709 **	01S6903 **	01SI591C **
01M1801 **	01S6711 **	01S6905 **	01SI5933 **
01M11801 **	0186713 **	01S6907 **	01M0303DL ***
01S7402 **	01S6717 **	01S6911 **	01M0303DDL ***
01S7710 **	01S6717D **	0156913 **	01S8001DL ***
01SS0101 **	01S6719 **	01S7101 **	01M1601 ****
0187313 **	01S6721 **	01S7108 **	01S7402 ****
01S7313D **	01S7701 **	01S7112 **	01S7402D ****
01S7404 **	01SI6001 **	01S7201 **	01S7610 ****
01S7404D **	01S7715 **	0157209 **	01S8201 ****
01S7501 **	01S7801 **	01S7211 **	01S8210 ****
01S7518 **	0157806 **	01S7301 **	01S7310DL *****
01S7601 **	01S7809 **	0188214 **	01S7310RE *****
01SS3901 **	01S7901 **	01SI3001 **	01S7402DDL *****
01SS391C **	01S8001 **	01SI3201 **	01S8210DL *****
01SS4201 **	01S8101D **	01SI3501 **	

Notes:

*	–	Samples indicated high quantitation limits due to dilution only.
**	–	Samples indicated high quantitation limits due to percent moisture only.
***	–	Samples indicated high quantitation limits due to dilution and percent moisture only.
****	=	Samples indicated high quantitation limits due to percent moisture and matrix interferences.
*****	=	Samples indicated high quantitation limits due to dilution, percent moisture and matrix interferences.

g-chlordane, 4,4'-DDE, 4,4'-DDD, 4,4'-DDT, and endosulfan sulfate. All associated positive results were qualified according to calculated action levels and CLP protocols. Results below the CLP action level are not considered site-related.

The laboratory used a leachate blank identification scheme for TCLP organic and inorganic fractions specific to the type of analysis being done. All leachate blanks with the ZHEBLK206, ZHEBLK210, ZHEBLK221, and ZHEBLK designations were used to identify TCLP volatile analysis blanks and those designated as B, B1, 01B1, and/or 01BLANK were used to identify TCLP semivolatile, pesticide, herbicides, and inorganic leachate blanks. However, the blanks 01HBLK57 and 01HBLK64 were used to identify the method blanks that were associated with herbicide analysis as designated by the letter "H" listed in the sample identification number. (Note: The leachate blank is the equivalent to a method blank because the leachate blank uses the same TCLP extraction fluid used to extract the samples themselves.)

As indicated earlier, the extraction of the reference soil samples designated 01S6701, 0186703, 0156705, 01S6707, 01S6709, 01S6709, 01S6709, 01S6711, 01S6713, 0186717, 01S6717D, 01S6721, and 01S6721D for semivolatile analysis exceeded the holding time requirements by two days. All associated data were qualified accordingly.

Samples designated with an L, N, or O were identified as material blanks collected from the filter pack sand, portland cement, and bentonite material (chips and/or pellets) used to construct the newly installed monitoring wells at Site 1. Wells were installed at both Site 1 and Site 39 during the same time period. Because the Same well construction materials were used at both sites, a single set of material blank samples were collected for QA/QC purposes. Most of these samples were identified with "39" as the first two digits (e.g., 39SNOl-bentonite chips, 39SN02-bentonite pellets, 39SO01-portland cement, and 39SL01-filter pack sand). An additional sample, 01N01, was collected from the bentonite slurry used at Site 1. Target compounds including a VOC (toluene), a semivolatile(phenol), a PCB (aroclor 1260), and several pesticides

(aldrin, dieldrin, endosulfan I, heptachlorepoxide, alpha-chlordane, and gamma-chlordane) were detected at generally low concentrations (most at parts per billion concentrations) in these samples. The absence of these compounds (except for infrequent detections of toluene and phenol) in samples collected from newly installed wells indicates their presence in construction materials are not at significant concentrations to leach appreciable amounts and adversely affect groundwater. These blanks were used in conjunction with all other blanks and QA/QC samples in evaluating all site analytical data, according to CLP protocols.

Further discussion with the project geologist involved evaluating samples associated with test trenching performed across previously filled and older covered landfill trenches. Test trenching was performed to document and determine how the older landfill trenches were constructed and to characterize their wastes. Soil samples were collected from the native soil underlying the waste interval, the surface soil above the waste interval, and the waste interval itself. Test trenching samples were designated as 01S7101 through 0138214 with sample 01G79 indicated as the only groundwater trenching sample collected and analyzed.

Evaluation of the sample data for hexavalent chromium and TCLP volatiles, TCLP semivolatiles, TCLP pesticides, TCLP herbicides, and TCLP inorganic analyses indicated no significant concentrations of hazardous waste contaminants. Also, SDG 142388 consisted of samples 01GE4, 01GI68R, 01GI70R, 01GS67R, and 01GS69R. Four of these samples are designated with an "R" because they were re-sampled due to inconsistencies noticed in the initial sampling procedures and within the samples themselves.

Several metals failed duplicate and/or spike recoveries during inorganic analysis. However, the most significant were antimony, cadmium, selenium, and thallium. The low spike recoveries for antimony, Selenium, and thallium were noted in SDGs 141210, 142241, 314135, and 314217. Selenium and antimony were qualified as unusable in SDG 314135. Thallium was qualified as unusable in SDG 142291 and cadmium showed consistent spike recoveries at less

than 75 percent. It should be noted the poor recoveries exhibited by several of these analytes may be attributed to interference caused by the high sodium content found in many of the samples.

In SDG 893811, a matrix interference was encountered during the analysis of barium, calcium, and thallium. All associated positive sample results were qualified as estimated (J flag).

In conclusion, the overall data quality of the analytical work done for Site 1 at NAS Pensacola, except sample results qualified as unusable, was considered satisfactory and usable for site remediation and risk assessment.

Data Qualifier Definitions

The following definitions provide a brief explanation of the data qualifiers used in the validation process.

U — The compound was analyzed for, but was not detected above the reported sample quantitation limit.

J — The compound was positively detected, however the reported concentration is considered to approximate the concentration within the sample.

UJ — The compound was not detected above the reported sample quantitation limit. However, the reported quantitation limit is an approximate and may not represent the actual limit of quantitation necessary to accurately and precisely measure the compound in the sample.

R — The sample results are rejected due to serious deficiencies in the laboratory's ability to analyze the sample and meet QC criteria. The presence of the compound cannot be verified.

10.0 BASELINE RISK ASSESSMENT

This **section has been extensively revised. For readability this section has not been bolded or bracketed.**

Introduction

A baseline risk assessment (BRA) is the analysis of the potential adverse effects on actual or hypothetical human or ecological receptors that could arise from exposures to hazardous substance releases from a site if no remedial actions are taken to reduce the extent of present environmental pollution. The baseline risk at Site 1 at the NAS Pensacola is the risk to human or ecological receptors (real or hypothetical) is that which may result under various scenarios if no remedial actions are taken to reduce the extent of existing environmental contamination. The following baseline risk assessment was prepared in accordance with the guidelines set forth in:

- *Risk Assessment Guidance for Superfund, Volume I-Human Health Evaluation Manual, Part A*, USEPA/OERR, USEPA/540/1-89/002, December 1989 (Interim). (RAGS Part A).

- *Risk Assessment Guidance for Superfund, Volume I-Human Health Evaluation Manual,(Part B, Development of Risk-Based Preliminary Remediation Goals)*, USEPA/OERR, USEPA/540/R92/003, December 1991 (Interim). (RAGS Part B).

- *Risk Assessment Guidance for Superfund, Volume I-Human Health Evaluation Manual, Supplemental Guidance-Standard Default Exposure Factors-Interim Final*, USEPA/OERR, OSWER Directive: 9285.6-03, March 25, 1991. (RAGS Supplement).

- *Dermal Exposure Assessment: Principles and Applications. Interim Report* USEPA/ORD, USEPA/6008-91/011B, January 1992. (Dermal Guidance).

- ***Risk Assessment Guidance for Superfund, Volume I-Human Health Evaluation Manual, Supplemental Guidance-Dermal Risk Assessment-Interim Guidance***, USEPA/OERR, August 18, 1992. (Supplemental Dermal Guidance).

- Supplemental Guidance to RAGS: Region IV Bulletin Default Oral Absorption Values for Dermal Reference Dose Adjustment. (Dermal Adjustment Supplement).

- Supplemental Guidance to RAGS: Region IV Bulletin, Development of Health-Based Preliminary Remediation Goals, Remedial Goal Options and Remediation Levels (Supplemental RGO Guidance).

- Supplemental Guidance to RAGS: Region IV Bulletin, Exposure to VOCs during Domestic Water Use: Contributions from Ingestion, Showering and Other Uses (Supplemental Groundwater VOC Guidance).

- USEPA Region III Contaminant of Concern Screening Table, March 18, 1994 and USEPA Region III Risk-Based Concentration Table, January 1995, (Roy L. Smith); (RBC Screening Tables).

- USEPA OSWER RAGS Supplement: ***Draft Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities,*** May, 27, 1994 (OSWER Lead Guidance).

- USEPA ORD RAGS Supplement: ***Guidance on Estimating Exposure to VOCs During Showering,*** July 10, 1991 (ORD VOC Guidance).

- FDEP Soil Cleanup Goals For Florida, September 29, 1995 (CGs).

Objectives

The objectives of the BRA are to:

- Characterize the source media and determine the chemicals of potential concern (COPCs) for Site 1 at NAS Pensacola.
- Identify potential receptors and quantify potential exposures under current and future conditions.
- Qualitatively and quantitatively evaluate the adverse effects associated with the site-specific COPCs.
- Characterize the potential baseline risks associated with Site 1 at NAS Pensacola under current and future conditions.
- Evaluate the uncertainties related to exposure predictions, toxicological data, and resultant carcinogenic risk and noncarcinogenic hazard predictions.

The value of the risk assessment as a basis for making remedial decisions depends on an adequate characterization of chemical contamination. Variables considered in characterizing the study area and its associated risk are the amount, type, and location of sources, the potential pathways of exposure (media type and migration routes), and the type, sensitivities, exposure duration, and dynamics of the potentially exposed populations (receptors). The RI presented in previous chapters provided the site characterization data used in this assessment.

The focus of the investigation at Site 1 was the assessment of the effects of past landfill disposal practices on environmental media on and near Site 1 at NAS Pensacola. Grab soil samples from the surface and various depths were collected and analyzed for the TCL and TAL using CLP

March 1990 Statement of Work (3/90 SOW) methods. In addition, groundwater samples collected from 25 shallow/intermediate monitoring wells and three deep monitoring wells were analyzed for the same list of parameters as soil samples. The sediment/surface water data from the Site 1 investigation were collected to determine if a pathway for contaminant migration exists from Site 1 to the surrounding wetlands. Using the data presently available, screening comparisons were made for chemicals reported in surface water and sediment. However, the wetlands have not been characterized, and the investigation is currently ongoing. Human health risk estimates will be included in the BRA for Site 41, Wetlands Investigation. Section 10.1 presents the Human Health Assessment for Site 1, and Section 10.2 presents the Ecological Risk Assessment for Site 1.

10.1 Human Health Assessment

10.1.1 Site Background

NAS Pensacola is 5 miles southwest of Pensacola, on a peninsula in southern Escambia County. Site 1 refers to an area historically used as a landfill. The southernmost portion was first used as a landfill in the 1950s, the northern portion in the 1960s, and the central portion was used from the mid-1960s to the mid-1970s, when the fill operations ceased at Site 1. The first investigation of Site 1 began in approximately 1982. Site 1's history is detailed in Section 2.

10.1.2 Organization

A human health risk assessment, as defined by RAGS Part A, includes the following steps:

- Site characterization: Data regarding site geography, geology, hydrogeology, climate, and demographics of populations in the area are evaluated.

- Data collection: Samples of environmental media, including reference samples, are analyzed.

- Data evaluation: The analytical data are analyzed statistically to identify the nature and extent of contamination and establish a preliminary list of COPCs that will subsequently be refined to identify chemicals of concern (COCs).

- Exposure assessment: Potential receptors are identified under current and future conditions, potential exposure pathways are identified and exposure point concentrations (EPCs) and chemical intakes are quantified.

- Toxicity assessment: The adverse effects of the COPCs are qualitatively evaluated, and quantitative estimates of the relationship between exposure and severity or probability of effect are made.

- Risk characterization: The outputs of the exposure assessment and the toxicity assessment are combined to quantify the total noncancer and cancer risk to the hypothetical receptors.

- Uncertainty: The areas of recognized uncertainty in human health risk assessments, in addition to medium and exposure pathway-specific influences, are discussed and evaluated.

- Risk/Hazard Summary: The results of the quantification of exposure (risk and hazard) for the potential receptors and their exposure pathways identified under the current and future conditions are presented and discussed.

- Remedial Goal Options: Exposure concentrations within the USEPA target risk range of 10^{-6} to 10 for carcinogenic COCs and 0.1, 1, and 10 for noncarcinogenic COCs are quantified.

10.1.2.1 Identification of Chemicals of Potential Concern

When performing a BRA, data for environmental media are compiled to determine potential site-related chemicals and exposures for each medium as outlined in RAGS Part A.

10.1.2.2 Data Sources

Data for NAS Pensacola, specifically Site 1, have been gathered during multiple investigative phases. During the initial E/A&H investigation, soil borings were completed at Site 1 to assess the distribution of soil contamination above the water table. Soil was sampled in 1993. During the second-phase investigation, no additional soil borings were completed at Site 1 for contamination assessment.

The groundwater investigation was conducted in 1993 during the Phase I investigation, and in June 1994 for the Phase II investigation. Phase I groundwater sampling was performed using traditional bailer techniques, and Phase II sampling was performed using the quiescent sampling technique E/A&H recently adopted. The quiescent sampling effort targeted the most heavily impacted wells and those that would be best used to assess a contaminant migration pathway from Site 1 to the surrounding wetlands (for the ecological assessment). Combining the two datasets was considered inappropriate because the two sampling techniques have been shown to produce vastly different turbidity. Approximately 80% of the original wells were re-sampled in June 1994 using the quiescent technique, and two additional wells were installed (well locations GS71 and GI72). Thirteen shallow, 12 intermediate, and three deep monitoring wells were resampled using the quiescent technique, and data from these wells were used as the basis for groundwater exposure characterization. Shallow and intermediate groundwater data from Phase II sampling were combined to compute EPCs for the shallow groundwater pathway. Groundwater and soil samples used in the BRA are listed in Tables 10-1 through 10-3. Surface water and sediment samples used in the BRA are listed in Table 10-4.

Table 10-1
Sample Identification Numbers For Groundwater Samples
NAS Pensacola, Site 1
Pensacola, Florida

Sample Identification Number	Screened Interval
01GGM34	Shallow
01GS64	Shallow
01GI65	Intermediate
01GGM39	Shallow
01GI35	Intermediate
01GGM04	Shallow
01GI48	Intermediate
01GGM05	Shallow
01GI46	Intermediate
01GS60	Shallow
01GI61	Intermediate
01GS53	Shallow
01GI66	Intermediate
01GS42	Shallow
01GI41	Intermediate
01GGM33 h	Shallow
01GI59 h	Intermediate
01GGM35 h	Shallow
01GI28 h	Intermediate

Sample Identification Numbers For Groundwater Samples
NAS Pensacola, Site 1
Pensacola, Florida

Sample Identification Number	Screened Interval
01GS62	Shallow
01GI63	Intermediate
01GS37	Shallow
01GI36	Intermediate
01GS71	Shallow
01GI72	Intermediate
01GGM43	Deep
01GGM44 h	Deep
01GGM45	Deep

Shallow and intermediate well results were combined to evaluate shallow groundwater exposure. Deep monitoring wells were addressed separately, and screened below the aquitard (See Section 7 of the RI report).

E/A&H June 1994 RI groundwater sampling results were exclusively used to derive exposure point concentrations to quantitate exposures.

Table 10-2
Sample Identification Numbers For Surface Soil Samples
NAS Pensacola, Site 1
Pensacola, Florida

Sample Identification Number	Sample Location	Corresponding Well Location ID
01SS0101	Perimeter	01GS01
01S12801	Perimeter	01GI28
01SI3001	Perimeter	01GI30
01SI3201	Perimeter	01GI32
01SI3501	Perimeter	01GI35
01SI3601	Perimeter	01GI36
01SS3901 h	Perimeter	01GS39
01SS4201	Perimeter	01GS42
01SI4301	Perimeter	01GI43
01SI4401	Perimeter	01GI44
01SS4601	Perimeter	01GI46
01SI4801	Perimeter	01GI48
01SI5901 h	Perimeter	01GI59
01SI6001	Perimeter	01GS60
01SS6201	Perimeter	01GS62
01SS6401	Perimeter	01GS64
01S7101 h	Test Trench 1	NA
01S7201 h	Test Trench 2	NA

Table 10-2
Sample Identification Numbers For Surface Soil Samples
NAS Pensacola, Site 1
Pensacola, Florida

Sample Identification Number	Sample Location	Corresponding Well Location ID
01S7301 h	Test Trench 3	NA
01S7501 h	Test Trench 5	NA
01S7601 h	Test Trench 6A	NA
01S7701 h	Test Trench 7	NA
01S7801 h	Test Trench 8	NA
01S7901	Test Trench 9	NA
01S8001	Test Trench 10A	NA
01S8101 h	Test Trench 11	NA
01S8201	Test Trench 12	NA

Notes:
h = Analyzed for hexavalent chromium in addition to full TAL/TCL; no hexavalent chromium was detected in surface soil samples.

All samples were analyzed separately from the corresponding well location; surface soil was sampled at times other than during groundwater monitoring well installation.

Perimeter refers to samples collected at the perimeter of the landfill area.

Test Trench refers to samples collected during the trenching activities within the bounds of the landfill; these surface soil samples are not associated with a monitoring well location; refer to Section 5 (Field Investigation and Methodology) for trench location descriptions, basis for sampling, and applicable figures.

Table 10-3
Sample Identification Numbers for All Soil Depths
NAS Pensacola, Site 1
Pensacola, Florida

Sample Identification Number	Sample Location	Corresponding Well Location ID
01S7101	Test Trench 1	NA
01S7108	Test Trench 1	NA
01S7112	Test Trench 1	NA
01S7201	Test Trench 2	NA
01S7209	Test Trench 2	NA
01S7211	Test Trench 2	NA
01S7301	Test Trench 3	NA
01S7310	Test Trench 3	NA
01S7313	Test Trench 3	NA
01S7402	Test Trench 4	NA
01S7404	Test Trench 4	NA
01S7501	Test Trench 5	NA
01S7508	Test Trench 5	NA
01S7518	Test Trench 5	NA
01S7601	Test Trench 6A	NA
01S7610	Test Trench 6A	NA
01S7701	Test Trench 7	NA
01S7710	Test Trench 7	NA

Table 10-3
Sample Identification Numbers for All Soil Depths
NAS Pensacola, Site 1
Pensacola, Florida

Sample Identification Number	Sample Location	Corresponding Well Location ID
01S7715	Test Trench 7	NA
01S7801	Test Trench 8	NA
01S7806	Test Trench 8	NA
01S7809	Test Trench 8	NA
01S7901	Test Trench 9	NA
01S7914	Test Trench 9	NA
01S8001	Test Trench 10	NA
01S8101	Test Trench 11	NA
01S8118	Test Trench 11	NA
01S8120	Test Trench 11	NA
01S8201	Test Trench 12	NA
01S8210	Test Trench 12	NA
01S8214	Test Trench 12	NA
01SI2801	Perimeter	01GI28
01SI3001	Perimeter	01GI30
01SI3501	Perimeter	01GI35
01SI3601	Perimeter	01GI36
01SI4301	Perimeter	01GI43

Table 10-3
Sample Identification Numbers for All Soil Depths
NAS Pensacola, Site 1
Pensacola, Florida

Sample Identification Number	Sample Location	Corresponding Well Location ID
01SI4601	Perimeter	01GI46
01SI4801	Perimeter	01GI48
01SI5901	Perimeter	01GI59
01SI6001	Perimeter	01GI60
01SS0101	Perimeter	01GS01
01SS3901	Perimeter	01GS39
01SS4201	Perimeter	01GS42
01SS6201	Perimeter	01GS62
01SS6401	Perimeter	01GS64

Notes:
.All samples were analyzed separately from the corresponding well location; surface and subsurface soil was sampled at times other than during Qroundwater monitoring well installation.

Perimeter refers to samples collected at the perimeter of the landfill area.

Test Trench refers to samples during the trenching activities within the bounds of the landfill; these surface soil samples are not associated with a monitoring well location; refer to Section 5 (Field Investigation and Methodology) for trench location descriptions, basis for sampling, and applicable figures.

Table 10-4
Sample Identification Numbers For Surface Water and Sediment Samples
NAS Pensacola, Site 1
Pensacola, Florida

Sample Identification Number	Corresponding Sediment Sample Identification Number
01W0101	01M0101
01W0301	01M0301
01W0302	01M0302
01W0303	01M0303
01W0303D	01M0303D
01W1601	01M1601
01W1801	01M1801

Note:
Refer to Sections 7, 8, and 11 for discussions of the nature and extent of contamination and potential fate and transport of contaminants.

All samples were analyzed for the TAL/TCL at DQO Level IV, in accordance with the *Analytical Support Branch Laboratory Operations and Quality Control Manual*, September 1990. All sampling, sample handling, chain of custody protocol and field QA/QC was performed in accordance with the Environmental Compliance Branch Standard Operating Procedures and Quality Assurance Manual, (ECBSOP/QAM), February 1, 1991.

All surface water and sediment data collected during Phase I were used to determine potential migration pathways from Site 1 to nearby wetlands. Additional sampling will be performed during the wetlands investigation (Site 41), and these media (sediment and surface water) will be included in the BRA for Site 41. A preliminary assessment of sediment and surface water was included in this BRA, but the data set is not complete however, risk management conclusions should be based on the complete data set, which will be included in the Site 41 BRA. Surface water and sediment data are presented and discussed in both Section 8 (Nature and Extent of Contamination) and Section 10.2 (Ecological Risk Assessment).

10.1.2.3 Data Validation

Data validation is an after-the-fact, independent, systematic process of evaluating data and comparing them to pre-established criteria to confirm that they are of the technical quality necessary to support the decisions made in the remedial investigation/feasibility study (RI/FS) process. Specific parameters associated with the data are reviewed to determine whether they meet the stipulated DQOs. The quality objectives address five principal parameters: precision, accuracy, completeness, comparability, and representativeness. To verify that these objectives are met, field measurements, sampling and handling procedures, laboratory analysis and reporting, and nonconformances and discrepancies in the data are examined to determine compliance with appropriate and applicable procedures. The procedures and criteria for validation are defined in the RI/FS Data Validation Program Guidelines, which are based on the USEPA National Functional Guidelines for Data Review (USEPA 1988a; USEPA 1988b). For further discussion of data validation, refer to Section 9 of the RI.

10.1.2.4 Site-Related Data

All environmental sampling data were evaluated for suitability for use in the quantitative BRA. Data obtained via the following analytical methods were not considered appropriate for the quantitative BRA:

- Analytical methods that are not specific for a particular chemical, such as total organic carbon or total organic halogen.

- Field screening instruments including total organic vapor monitoring units (MicroTip) and organic vapor analyzers.

Once the data set was complete, statistical methods were used to evaluate the RI analytical results to (1) identify COPCs and (2) establish EPCs of potential receptor locations. The statistical methods used in data evaluation are discussed below. The rationale used to develop this methodology and the statistical techniques are based on the following sources:

- **RAGS Part A**
- ***Statistical Methods for Environmental Pollution Monitoring*** (Gilbert, 1987)

Quattro Pro 5.0 was used to perform most of the statistical calculations. For each set of data used to describe the concentration of chemicals in a contaminated area, the following information was tabulated: frequency of detection, range of detected values, mean concentrations, and upper confidence limit (UCL) on the mean of the concentration (assuming a lognormal distribution, as requested by USEPA Region IV).

10.1.2.5 Selection of Chemicals of Potential Concern

The objective of this section of the BRA is to screen information that is available on the substances detected at Site 1 (chemicals present in site samples or CPSSs) in order to develop

a list or group of chemicals referred to as COPCs. The information, to be discussed within this section, consists of both federal and State of Florida cleanup criteria and standards for soil and groundwater. COPCs are those chemicals selected in consideration of their comparison to screening concentrations (risk-based and NAS Pensacola-specific reference concentrations), intrinsic toxicological properties, persistence, fate and transport characteristics, and cross-media transport potential. Any COPC that is carried through the risk assessment process and found to contribute to a pathway that exceeds a 10^{-6} risk or hazard index (HI) greater than 1 for any of the exposure scenarios evaluated in this risk assessment and has an incremental lifetime cancer risk (ILCR) greater than 10'' or HQ greater than 0.1 is referred to as a COC.

Before Site 1 risks could be evaluated, it was first necessary to determine the nature and extent of the contamination at the sites. This was accomplished by noting the chemicals detected in each medium.. These chemicals represent the CPSSs for Site 1. The nature and extent of CPSSs was discussed in detail in Sections 7 and 8 of the RI. In order to reduce the list of CPSSs and to produce a more focused BRA, the following tasks were performed.

Comparison of Site-Related Data to Screening Concentrations

Two groups of soil data were used in this assessment: 0-1 foot and all depths to the water table. Potential future land use was assessed using the surface soil data set for residential, trespass, and worker scenarios. Maximum concentrations of CPSSs detected in surface soil at Site 1 were compared to medium-specific USEPA Region III risk-based residential screening concentrations (RBCs) dated March 7, 1995 (noncarcinogen RBCs were adjusted to reflect a target hazard quotient of 0.1) and FDEP Soil CGs as established in a FDEP memorandum dated September 29, 1995. All depths soil data were compared to screening values which include the volatilization from soil-to-air pathway and to soil concentrations that would be protective of groundwater.

In accordance with RAGS Part A, essential elements that are potentially toxic only at extremely high concentrations may be eliminated from further consideration as COPCs in a risk assessment. Specifically, an essential nutrient may be screened out of a risk assessment if it is shown to be present at Concentrations that are not associated with adverse health effects. Based on RAGS, the lack of risk-related data, and USEPA's recommendations, the following essential nutrients were eliminated from the human health risk assessment: calcium, iron, magnesium, potassium, and sodium.

A future site resident who theoretically places an unfiltered well in his/her backyard would not be expected to differentiate between the shallow and intermediate aquifer (i.e., there is no defined aquitard). Therefore, shallow and intermediate depth groundwater were assessed as one exposure medium. Deep zone groundwater was assessed separately. The maximum concentrations of CPSSs detected in groundwater were compared to RBCs for tap water as listed in the RBC screening table, maximum contaminant levels (MCLs), secondary maximum contaminant levels (SMCLs), and Florida Drinking Water Standards (FDWS). The maximum concentrations detected in shallow and intermediate (combined depth) groundwater were compared to the lowest of the four groundwater screening criteria, as were the deep groundwater data. CPSSs with maximum detected concentrations that exceed their corresponding risk-based concentrations, goals, levels, and/or standards were retained for NAS Pensacola-specific reference concentration screening, elimination based on essential nutrient status, and possible further evaluation in the risk assessment.

For CPSSs reported in both soil and groundwater, Florida CGs (FDEP's *September 29, 1995 Cleanup Goals for Florida*) and SSLs (USEPA's January 31, 1995 *Region III Risk-Based Concentration Table)* calculated for protection of groundwater were used as screening values. Screening values used for organic CPSSs were Florida CGs, and screening values used for inorganic CPSSs were SSLs (or background concentrations, where available). All soil intervals were included in this screening effort.

Screening for the indirect soil-to-air exposure pathway was performed using maximum concentrations of VOCs detected in soil and comparing the maximum reported concentration to USEPA Region III screening values for the soil-to-air exposure pathway (USEPA's January 31, 1995 *Region 111 Risk-Based Concentration Table).* All soil depths were compared so the maximum calculated air concentrations reflect the maximum soil concentrations detected at any Site 1 location.

Surface water was sampled to determine if contaminants migrate from Site 1 to the surrounding wetlands. The wetland sediment and surface water human health risk will be completed as part of the wetlands investigation, Site 41. To address human health exposure, a conservative screening method was first used to focus the BRA on surface water CPSSs potentially posing higher risk and/or hazard relative to other surface water CPSSs. Tap water screening values were used as a relative comparison, which should not be interpreted as an indication of risk and/or hazard for the surface water pathway. CPSSs having higher concentrations than the corresponding screening values were formally addressed in this BRA.

Sediment was sampled to determine if contaminants migrate from Site 1 to the surrounding wetlands. Sediment data were compared to soil screening values to focus the BRA onto CPSSs potentially posing higher risk relative to USEPA and FDEP risk and hazard thresholds. The comparison of sediment data to soil screening values was a relative comparison only, and should not be interpreted as an indication of risk and/or hazard for the sediment pathway. CPSSs having higher concentrations than the corresponding screening values were formally addressed in this BRA.

This screening process was used to focus the risk assessment and thereby reduce the number of CPSSs in soil in terms of formal assessment. Those CPSSs whose maximum detected concentrations in soil exceeded corresponding screening values were evaluated further in the screening process with respect to NAS Pensacola-specific reference concentrations (where

applicable). Risk management decisions should consider the data set for surface water and sediment which will be used to perform the Site 41 RI/FS, as the surface water and sediment data addressed in this BRA are a preliminary assessment only.

Comparison of Site-Related Data to NAS Pensacola-Specific Reference Concentrations

Reference data for Site 1 consist of soil and groundwater results for inorganic chemicals. Table 10-5 lists reference concentrations for inorganic chemicals detected in NAS Pensacola surface soil samples. As these sample locations are background or reference areas, all soil depths were included in the reference concentration determination. Tables 10-6 and 10-7 list reference concentrations for shallow and intermediate groundwater (combined) and deep groundwater, respectively. These data were previously presented in Sections 7 and 8 (Nature and Extent of Contamination).

Soil and groundwater CPSSs that exceeded screening concentrations, goals, levels, and/or standards were compared to NAS Pensacola-specific reference concentrations established for Site 1. The procedure for comparing the concentrations of inorganic chemicals onsite with those in reference samples is referred to as the 2X reference rule or the "twice reference criterion." Inorganic CPSSs from Site 1 whose maximum detected concentrations exceeded corresponding reference concentrations were retained for further consideration as COPCs in the BRA. Those chemicals with maximum concentrations less than 2X reference concentrations are not considered further in this risk assessment unless deemed appropriate based on chemical-specific characteristics. This comparison assists in accounting for naturally occurring chemicals that are ubiquitous in nature (aluminum, silicon, and chloride, etc.). It was assumed that organic chemicals are not present in reference samples.

Table 10-5
Reference Concentrations - Surface Soil (0 to 1 foot depth)
NAS-Pensacola Site 1
Pensacola, Ronda

Parameter	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)	Mean Rafarance Concentration (mg/kg)	Reference (2X Mean) Concentration (mg/kg)
Aluminum	92.5	12400	1916.9	3833.8
Antimony	4.65	4.1	4.7	9.5
Arsenic	1.7	2.4	0.78	1.6
Barium	1.2	10.1	2.3	4.6
Beryllium	NC	NC	NC	Not Applicable
Cadmium	NC	NC	NC	Not Applicable
Calcium	35.7	6740	456.2	912.4
Chromium	2.4	11.8	3.1	6.2
Cobalt	NC	NC	NC	Not Applicable
Copper	5.1	5.1	2.9	5.7
Cyanide	NC	NC	NC	Not Applicable
Iron	206	918C	1372.E	2745.0
Lead	0.44	21	3.7	7.3
Magnesium	366	365	66.7	133.4
Manganesa	1.7	63.7	10.7	21.4
Mercury	NO	NC	NC	Not Applicable
Nickel	NO	NO	NC	Not Applicable
Potassium	NO	NO	NC	Not Applicable
Selenium	NO	NO	NC	Not Applicable
Silwr	NC	NO	NC	Not Applicable
Sodium	97.2	97.2	53.9	107.9
Thallium	NO	NO	NO	Not Applicable
Vanadium	1.6	20.5	2.9	5.8
Zinc	3.3	29	8.4	16.9

NOTES:

- All units expressed in milligrams/kilogram (mg/kg) unless otherwise noted.
- One half the detection limit was applied as the default value for nondetects to compute the mean concentration.

Not Applicable Indicates that no referenca concentration was established because the chemical was not detected in reference location samples.

ND Indicates the chemical was not detected in any well.

Tabla 10-6

Reference Concentrations - Shallow/Intermediate Groundwater
NAS-Penracola Site 1
Pensacola, Florida

Parameter	FPDWS (ug/L)	Sample Number 01GS67	01GS68	01GS69	01GS70	Mean Concentration	Reference Concentration
Aluminum	200*	4240	146.5 U	3270	109 U	1909.4	3818.9
Antimony	6	15.1 U	15.1 U	15.1 U	15.1 U	ND	Not Applicable
Arsenic	50	1.4 U	1.4 U	1.4 U	1.4 U	ND	Not Applicable
Barium	2000	5.5 U	6.75 U	9.45 U	4.75 U	ND	Not Applicable
Beryllium	4	0.55 U	0.55 U	0.55 U	0.55 U	ND	Not Applicable
Cadmium	5	1.7 U	1.7 U	1.7 U	1.7 U	ND	Not Applicable
Calcium	NA	17800	5670	6300	5350	8780.0	17560.0
Chromium	100	4.85 U	2.6 U	59.9	2.6 U	16.2	32.5
Cobalt	NA	2.05 U	2.05 U	2.05 U	2.05 U	ND	Not Applicable
Copper	1000*	5.4 U	5.4 U	16.2	5.4 U	6.1	12.2
Iron	300*	677	942	1770	26.65	853.9	1707.8
Lead	15	0.8 U	0.8 U	0.8 U	0.8 U	ND	Not Applicable
Magnesium	NA	795 U	665 U	1255 U	3030	1096.9	2193.8
Manganese	50*	6.7	8.9	26.7	1.55 U	10.8	21.5
Mercury	2	0.1 U	0.1 U	0.1 U	0.1 U	ND	Not Applicable
Nickel	100	19.95 U	19.95 U	19.95 U	19.95 U	ND	Not Applicable
Potassium	NA	13300	1275 U	6560	3200	5924.4	11848.8
Selenium	50	1.95 U	1.95 U	1.95 U	1.95 U	ND	Not Applicable
Silver	100	2 U	2 u	2 u	2 U	ND	Not Applicable
Sodium	160000	10700	8350	7830	9810	9172.5	18345.0
Thallium	2	1.8 U	1.8 U	1.8 U	1.8	ND	Not Applicable
Vanadium	49	7.9	3.75 U	3.75 U	3.75 U	3.4	6.8
Zinc	5000*	8.75 U	3.9 U	290	3.75 U	74.6	149.1

NOTES:

NA No applicable standard has been established.
ND Indicates the chemical was not detected in any well.
FPDWS Florida (or USEPA) Primary Drinking Water Standard (lower of the two).
Not Applicable Indicates that no reference concentration was established because the chemical was not detected in reference wells.
U Indicates parameter not reported at the detection limit.
* Indicates that it is e secondary Drinking Water Standard (FSDWS).
- All units expressed in micrograms/liter (ug/L) unless otherwise noted.
- One half the detection limit was applied as the default value for nondetects to compute the mean concentration.
- Reference well samples were collected using quiescent sampling methods in June 1994.

Table 10-7

Reference Concentrations - Deep Groundwater
NAS-Pensacola Site 1
Pensacola, Florida

Parameter	FPDWS (ug/L)	Reference Concentration (ug/L)
Aluminum	200*	436.9
Antimony	6	Not Applicable
Arsenic	50	Not Applicable
Barium	2000	14.2
Beryllium	4	Not Applicable
Cadmium	5	Not Applicable
Calcium	NA	11500.0
Chromium	100	26.4
Cobalt	NA	Not Applicable
Copper	1000*	24.6
Iron	300*	5710.0
Lead	15	Not Applicable
Magnesium	NA	3710.0
Manganese	50*	49.8
Mercury	2	Not Applicable
Nickel	100	Not Applicable
Potassium	NA	Not Applicable
Selenium	50	Not Applicable
Silver	100	Not Applicable
Sodium	160000	37100.0
Thallium	2	Not Applicable
Vanadium	49	Not Applicable
Zinc	5000*	209.9

NOTES:

NA No applicable standard has been established.
ND Indicates the chemical was not detected in any well.
FPDWS Florida (or USEPA) Primary Drinking Water Standard (lower of the two).
Not Applicable Indicates that no reference concentration was established because the chemical was not detected in reference wells.
U Indicates parameter not reported at the detection limit.
* Indicates that it is a secondary Drinking Water Standard (FSDWS).
- All units expressed in micrograms/liter (ug/L) unless otherwise noted.
- One half the detection limit was applied as the default value for nondetects to compute the mean concentration.
- Reference well samples were collected using quiescent sampling methods in June 1994.

In accordance with RAGS Part A, essential elements that are potentially toxic only at extremely high concentrations may be eliminated from further consideration as COPCs in a risk assessment. Specifically, an essential nutrient may be screened out of a risk assessment if it is shown to be present at concentrations that are not associated with adverse health effects. Based on RAGS, the lack of risk-related data, and USEPA's recommendations, the following essential nutrients were eliminated from the human health risk assessment: calcium, iron, magnesium, potassium, and sodium.

Calculation of Risk and Hazard

Those CPSSs with chemical-specific exceedances of RBCs, CGs, MCLs, SMCLs, FDWS, and reference concentrations are considered to be COPCs. The final step in identifying COCs from the refined list of CPSSs involves calculating chemical-specific cancer risks and HQs for COPCs, and evaluating frequency and consistency of detection and relative chemical toxicity.

An individual cancer risk threshold of 10^{-6}, based on USEPA standard limits, was used in the COC selection process if the corresponding exposure pathway resulted in a total cancer risk of 10'' or greater. Any COPC meeting the criteria has been retained as a COC. COPCs that contribute to hazard index of 1 or greater for an exposure pathway and have a calculated hazard quotient of 0.1 or greater have also been retained as COCs. Section 10.1.4, Toxicity Assessment, provides a more detailed discussion of cancer risk thresholds and noncancer toxicity.

10.1.2.6 COPCs in Soil

Tables 10-8 and 10-9 list the ranges of detected concentrations of CPSSs in Site 1 soil (surface soil and all depth interval data, respectively), with corresponding chemical-specific soil screening values assuming residential land use, and twice the corresponding reference criterion (reference

Table 10-8
Chemicals Detected in Site 1 Surface Soil
NAS Pansacola, Site 1
Pensacola, Florida

	Chemical	Frequency of Detection	Default Concentration (mg/kg)	Range of Detected Concentrations (mg/kg)	Mean of Hits (mg/kg)	Screening Value (mg/kg)	Source	Reference Concentration (mg/kg)	Notes		
e	Aluminum	26 I 2 7		483 - 13600	2163	7800	RBCr	3834	1	2	
	Arsenic	2 / 27		0.9 - 1.1	1	0.43	RBCr	1.66	1		
	Barium	19 / 27		1.4 - 20.4	4.91	660	RBCr	4.63		2	
e	Beryllium	1 / 27	0.21	0.61 - 0.61	0.61	0.16	RBCr		1	2	3
•	Cadmium	3 / 27	0.6	6.2 - 99	36.87	3.9	RBCr		1	2	3
	Calcium	22 / 27		33.1 - 2910	618.4	100000	+	912		2	
	Chromium (trivalent)	12 / 27	1.0	2.2 - 117	24.2	7800	RBCr	6.2		2	
	Cobalt	2 / 27		2.1 - 2.8	2.46	470	RBCr			2	
	Copper	9 / 27		3.1 - 54.9	16.19	290	RBCr	6.74		2	
	Iron	27 / 27	23.2	46.4 - 42300	3012.8	100000	+	2746		2	
•	Lead	23 / 27	0.216	0.9 - 441	32	400	OSWER	7.32	1	2	
	Magnesium	9 / 27		79.7 - 246	131.6	100000	+	133.4		2	
•	Manganese	19 / 27		2.3 - 191	20.31	39	RBCr	21.4	1	2	
	Mercury	3 / 27		0.18 - 0.81	0.61	2.3	RBCr			2	
	Nickel	3 / 27		14.1 - 26.6	19.9	160	RBCr			2	
	Silver	2 / 27		6.2 - 6.3	6.26	39	RBCr			2	
	Sodium	13 / 27		29 - 77.9	41.6	100000	+	107.9			
	Vanadium	16 / 27		2.1 - 23	4.34	66	RBCr	6.83		2	
	Zinc	26 / 27		1.6 - 219	21.8	2300	RBCr	16.87		2	
	4.4'-DDD	9 / 27		0.000078 - 0.016	0.0027	2.7	RBCr			2	
	4,4'-DDT	12 / 27		0.00034 - 0.099	0.0204	1.9	RBCr			2	
	Aldrin	3 / 27		0.00012 - 0.0014	0.00057	0.038	RBCr			2	
•	Aroclor 1248	1 / 27	0.0166	0.19 - 0.19	0.19	0.083	RBCr		1	2	3
•	Aroclor 1264	1 / 27	0.0166	0.31 - 0.31	0.31	0.083	RBCr		1	2	3
•	Aroclor 1260	3 / 27	0.00235	0.0047 - 0.13	0.048	0.083	RBCr		1	2	
	Dieldrin	6 / 27		0.00019 - 0.02	0.0049	0.04	RBCr			2	
	Endosulfan I	1 1 2 7		0.000061 - 0.000061	6.1E-06	47	RBCr			2	
	Endosulfan II	2 / 27		0.00034 - 0.0037	0.000355	47	RBCr			2	
	Endosulfan sulfate	6 / 27		0.00012 - 0.001	0.00044	47	RBCr			2	

Table 10-8
Chemicals Detected in Site 1 Surface Soil
NAS Pensacola, Site 1
Pensacola, Florida

Chemical	Frequency of Detection	Default Concentration (mg/kg)	Range of Detected Concentrations (mg/kg)	Mean of Hits (mg/kg)	Screening Value (mg/kg)	Source	Reference Concentration (mg/kg)	Notes
Endrin	6 127		0.000099 - 0.00058	0.00026	2.3	RBCr		2
Endrin aldehyde	4 I 2 7		0.00017 - 0.0029	0.00104	2.3	RBCr		2
Endrin keytone	2 127		0.00027 - 0.0016	0.000935	2.3	RBCr		2
Heptachlor epoxide	6 127		0.000081 - 0.0014	0.000538	0.07	RBCr		2
alpha-BHC	1127		0.00013 - 0.00013	0.00013	0.1	RBCr		2
alpha-Chlordane	6 127		0.000064 - 0.13	0.0244	0.49	RBCr		2
beta-BHC	1 127		0.0002 - 0.0002	0.0002	0.36	RBCr		2
delta-BHC	6 127		0.000061 - 0.0016	0.000401	0.1	RBCr		2
gamma-BHC (Lindane)	1127		0.00021 - 0.00021	0.00021	0.49	RBCr		2
gamma-Chlordane	6 127		0.00016 - 0.1 1	0.0188	0.49	RBCr		2
2.4-Dimethylphenol	1 127		3.6 - 3.6	3.6	160	RBCr		2
4-Methylphenol	1127		1.2 - 1.2	1.2	39	RBCr		2
Benzo(a)anthracene	1 127		0.066 - 0.066	0.066	0.88	RBCr		2
Benzo(a)pyrene	1127		0.06 - 0.06	0.06	0.088	RBCr		2
Benzo(blfluoranthene	3 127		0.066 - 0.13	0.082	0.88	RBCr		2
Benzo(g,h,i)perylene	1 127		0.048 - 0.048	0.048	14	CG		2
Benzo(k)fluoranthene	3 127		0.066 - 0.13	0.082	8.8	RBCr		2
Butylbenzylphthalate	1127		0.07 1 - 0.07 1	0.07 1	1600	RBCr		2
Chrysene	1 127		0.067 - 0.067	0.067	88	RBCr		2
Fluoranthene	1127		0.1 1 - 0.1 1	0.1 1	310	RBCr		2
Indeno(1,2,3-cd)pyrene	1127		0.047 - 0.047	0.047	0.88	RBCr		2
Phenanthrene	1 127		0.038 - 0.038	0.038	230	RBCr (pyrene)		2
bis(2-chloroethyl)ether	1 127		0.23 - 0.23	0.23	0.6	CG		2
1,1,1-Trichloroethane	1127		0.001 - 0.001	0.001	610	CG		2
Acetone	2 127		0.084 - 0.28	0.182	260	CG		2
Chloroform	1127		0.002 - 0.002	0.002	0.6	CG		2
Tetrachloroethene	1127		0.006 - 0.006	0.006	12	CG		2
Toluene	3 127		0.001 - 0.016	0.0103	620	CG		2

Table 10-8
Chemicals Detected in Site 1 Surface Soil
NAS Pensacola, Site 1
Pensacola, Florida

Chemical	Frequency of Detection	Default Concentration (mg/kg)	Range of Detected Concentrations (mg/kg)	Mean of Hits (mg/kg)	Screening Value (mg/kg)	Source	Reference Concentration (mg/kg)	Notes

NOTES:

- • Retained as a COPC based on comparison to the most conservative screening value.
- 1 Does not exceed lower of the USEPA Region III screening value or Florida CG.
- 2 Does not exceed reference concentration.
- 3 Mean of hits exceeds both the risk-based screening value and the reference concentration.
- CG and/or RBC Residential screening value from FDEP or USEPA Region III Screening Concentration Table (March 1994).
- RBCr USEPA Region III residential Risk Based Screening Value, March 1996 Table hazard quotient = 0.1 and target risk = 1E-6.
- CG FDEP residential soil scraening value (April 1996).
- ND Indicates not determined.
- CG are based on noncarcinogenic or carcinogenic effects; screening values for aggregate residents were used for carcinogen based CG, and child exposure (more conservative) was used for noncarcinogen-based CG.
- The screening value for alpha-BHC was used as a surrogate for delta-BHC due to structural similarity; this RfD is the most conservative screening value of the BHC isomers.
- The screening value for endrin was used as e surrogate for endrin aldehyde based on structural similarity.
- The screening value for endosulfan was used as a surrogate for endosulfan sulfate due to structural similarity.
- The lesser of one-half the quantitation limit or one-half lowast reported hit for each COPC was used as the default concentration (listed above) for all nondetects.
- The maximum benzo(a)pyrene equivalent concentration computed was 0.07 mg/kg.

Table 10-9
Chemicals Detected in All Soil Depths
Soil-to-Groundwater Protection Screening
NAS Pensacola, Site 1
Penracola, Florida

	Chemical	Frequency of Detection	Default Concentration (mg/kg)	Range of Detected Concentrations (mg/kg)	Mean of Hits (mg/kg)	Leaching Eased Screening (mg/kg)	Source	GW Std Exceeded (Y or N)	Reference Concentration (mg/kg)	Notes
	Ethylbenzene	3 1 46		0.01 - 16	6.36	0.2	CG leaching	N		1 2
	2,4-Dimethylphenol	3 1 46		1.7 - 610	206.1	1.8	CG leaching	N		1 2
*	1,4-Dichlorobenzene	4 / 46	0.005	0.01 - 4.3	2.673	0.9	CG leaching	Y		1 2
	Toluene	9 / 46		0.001 - 2300	263.672	0.2	CG leaching	N		1 2
	Chlorobenzene	3 1 46		0.006 - 0.16	0.061	0.8	CG leaching	Y		2
	Phenol	1 / 46		5 - 6	6	0.02	CG leaching	N		1 2
o	Xylene (total)	3 1 46	0.005	0.022 - 49	16.384	0.1	CG leaching (OL)	Y		1 2
	alpha-BHC	2 / 46		0.00013 - 0.00044	0.000285	0.0004	SSL	N		1 2
	1,2-Dichloroethene (total)	1 / 46		0.003 - 0.003	0.003	0.2	CG teaching	Y		2
	4-Chloro-3-methylphenol	1 / 46	0.166	1.4 - 1.4	1.4	42	CG leaching	N		2
o	Dieldrin	12 ▮ 46		0.00019 - 0.072	0.00889	0.001	SSL	Y		1 2
	Chloroform	1 / 46		0.002 - 0.002	0.002	0.02	CG leaching	Y		2
	1,1,1-Trichloroethane	2 1 46		0.001 - 0.001	0.001	0.9	CG leaching	N		2
	Trichloroethene	1 / 46		0.002 - 0.002	0.002	0.01	CG leaching	Y		2
o	Naphthalene	4 1 46	0.16	0.32 - 16	6.406	0.1	CG leaching (OL)	Y		1 2
*	2-Methylnaphthalene	4 / 46	0.1 1	0.22 - 6.8	3.08	0.1	CG leaching (OL)	Y		1 2
	2-Methylphenol	1 / 46		19 - 19	19	1.1	CG leaching	N		1 2
	1.2-Dichlorobenzene	3 1 46		0.81 - 62	26.27	6.8	CG leaching	N		2
o	Aluminum	44 / 46	32.2	141 - 13600	2298	NA	CG leaching	Y	3834	2
	Arsenic	13 ▮ 46		0.86 - 2.6	1.253	16	SSL	Y	1.66	2
*	Barium	37 ▮ 46	0.21	0.69 - 1060	43.981	32	SSL	Y	4.63	2
*	Cadmium	8 1 46	0.6	1.5 - 214	46.1126	6	SSL	Y		2
	Cobalt	2 1 46		2.1 - 2.8	2.46	NA		N		2
	Chromium	26 ▮ 46		2.2 - 916	66.096	3800	SSL	N	6.2	2
o	Copper	14 ▮ 46	1.6	3.1 - 212	42.621	NA		Y	6.74	2
o	Manganese	36 ▮ 46	0.43	1.9 - 191	17.88	NA		Y	21.4	2
o	Nickel	6 1 46	3.2	11.1 - 66.7	24.167	. 21	SSL	Y		2
	Lead	36 ▮ 46	0.216	0.78 - 441	36.971	NA		N	7.32	2
	Vanadium	27 ▮ 46		2.1 - 23	4.604	NA		N	6.83	2
	Zinc	42 ▮ 46		1.6 - 6930	186.362	42000	SSL	Y	16.87	2

Table 10-9
Chemicals Detected in All Soil Depths
Soil-to-Groundwater Protection Screening
NAS Pensacola, Site 1
Pensacola, Florida

Chemical	Frequency of Detection	Default Concentration (mg/kg)	Range of Detected Concentrations (mg/kg) .	Mean of Hits (mg/kg)	Leaching Based Screening (mg/kg)	Source	GW Std Exceeded (Y or N)	Reference Concentration (mg/kg)	Notes

NOTES:

* Rateined as a chemical of potential concern based on comparison to the corresponding screening value for leachability, reference concentration, and groundwater results.

1 Maximum concentration exceeds leaching based CG (organics) or soil screening guidance level (SSL) for groundwater protection (USEPA, EPA/540/R-94/101, December 1994) with a DAF of 10.

2 Maximum concentration exceeds the soil reference concentration (background levels).

Frequency of detection is the number detected over number analyzed; an additional sample was analyzed for VOCs.

The lesser of one-half the quantitation limit and one-half lowest reported hit for each COPC was used as the default concentration (listed above) for all non-detects.

CG leaching Florida cleanup goal for soil based on groundwater protection.

SSL USEPA Soil Screening Guidance Level for groundwater protection.

(OL) Indicates the groundwater standard is based on an organoleptic response.

GW Std Exceeded Indicates whether the applicable groundwater risk-besed concentration or ARAR was exceeded in shallowlintermediate wells.

NA Not available.

concentrations). Table 10-8 shows the screening comparison for hypothetical site residents' direct exposure to surface soil (i.e., RBCs and CGs), and Table 10-9 shows a comparison to screening values which are protective of groundwater (i.e., CGs and SSLs protective of groundwater). COPCs identified in Site 1 soil, CPSSs that exceed the lowest of soil RBCs and CGs, and reference concentrations, are denoted in the tables by the symbol "*" next to the chemical name. Those CPSSs eliminated from further consideration in this risk assessment due to maximum detected concentrations falling below soil RBCs/CGs and/or reference concentrations are denoted in the tables by the numerical symbols of "1" and "2", respectively.

10.1.2.7 COPCs in Air (Via Volatilization from Soils)

Due to the presence of volatiles in site soil, the maximum reported soil VOC concentrations were compared to soil-to-ambient air protective screening values. As shown in Table 10-10, two compounds were detected in soil in excess of the corresponding screening values. Maximum concentrations reported for toluene and tetrachloroethene exceeded the corresponding soil-to-air screening values. The two exceedances mentioned above were reported in sample 01S082 at a depth of 10 feet, and the reported concentrations were within the same order of magnitude as the corresponding soil-to-air screening values. Surface soil is generally the only continuous source of volatile air pathway contaminants, and soil-to-air screening values are based on this assumption. At a depth of 10 feet, volatiles would have to migrate through the overlying soil, and dilution and attenuation effects would generally mitigate concentrations subsequently emanating from surface soil. No VOC concentrations reported in surface soil exceed the soil-to-air screening values. Therefore, no COPCs were identified for the soil-to-air exposure pathway. All-soil-depth results do suggest, however, that unacceptable VOC concentrations could exist in some areas of the landfill under confined space conditions during intrusive activities.

Table 10-10
Volatilization from Soil to Air Screening, Site 1 Soils (All Depths)
NAS Pensacola, Site 1
Pensacola, Florida

Chemical	Frequency of Detection	Range of Detected Concentrations (mg/kg)	Mean of Hits (mg/kg)	Soil-to Air RBC (mg/kg)	Screening Concentrations Ambient Air (ug/m3)		Notes
Ethylbenzene	3 140	0.01 - 16	6.36	200	100	n	
1,2-Dichlorobenzene	3 146	0.81 - 62	26.3	300	21	n	
Chlorobenzene	3 140	0.006 - 0.16	0.061	04	2.1	n	
Chloroform	1 146	0.002 -0.002	0.002	0.2	0.078	c	
1,2-Dichloroethene (total)	1 /46	0.003 -0.003	0.003	1500	3.3	n	
1.4-Dichlorobenzene	3 146	0.42 - 4.3	2.67	7700	0.26	c	
1,1,1-Trichloroethane	2 140	0.001 -0.001	0.001	980	100	n	
1,2,4-Trichlorobenzene	2 146	0.043 - 0.48	0.262	240	0.84	n	
• Tetrachloroethene	4 140	0.000 - 28	7.1	11	3.1	c	1
• Toluene	9 146	0.001 - 2300	263.6	620	42	n	1
Trichloroethene	1 140	0.002 - 0.002	0.002	3	1	c	
Xylene (total)	3 140	0.022 - 48	16.4	320	730	n	

NOTES:

1 Maximum detected soil concentration exceeds soil-to-air RBC.
2 Mean of detected concentretions exceeds soil-to-air RBC.
- Trans isomer assumed for 1,2-Dichloroethane (most conservative with respect to volatilization).
Ambient Air RBC ug/m3 from USEPA Region III March 1996 Risk-Based Concentration Tables.
Max Hit mglkg Maximum soil concentration detected.
Soil-to-Air RBC Screening Values were excerpted from USEPA Region III's March 1996 Risk-Based Concentration Tables.

10.1.2.8 COPCs in Groundwater

Tables 10-11 and 10-12 list the ranges of detected concentrations of CPSSs in the groundwater data sets (combined shallow and intermediate groundwater, and deep groundwater, respectively), with their corresponding chemical-specific levels/standards for groundwater and twice background criterion (reference concentrations). COPCs were identified assuming site groundwater will be used as a potable source.

10.1.2.9 COPCs in Surface Water

As previously discussed, surface water was sampled to determine if contaminants migrate from Site 1 to the surrounding wetlands. The wetland sediment and surface water human health risk will be completed as part of the wetlands investigation, Site 41. Please refer to Sections 7 and 8 (Nature and Extent of Contamination) and Section 10.2 (Ecological Risk Assessment) for data presentation and discussions pertaining to potential contaminant migration. CPSSs having higher concentrations than the corresponding screening values were formally addressed in this BRA, as Table 10-13 shows. However, risk management decisions should consider the data set that will be generated during the Site 41 RI/FS.

10.1.2.10 COPCs in Sediment

Please refer to Sections 7 and 8 (Nature and Extent of Contamination) and Section 10.2 (Ecological Risk Assessment) for data presentation and discussions pertaining to potential contaminant migration. CPSSs having higher concentrations than the corresponding screening values were formally addressed in this BRA, as Table 10-14 shows. As mentioned above, risk management decisions should consider the data set that will be generated during the Site 41 RI/FS.

Table 10-11
Chemicals Detected in Shallow and Intermediate Groundwater
Comparison to Screening Concentrations
NAS Pensacola, Site 1
Pensacola, Florida

Chemical	Frequency of Detection	Default Concentration (mg/L)	Range of Detected Concentrations (mg/L)	Mean of Hits (mg/L)	Screening Value (mg/L)	Source	Reference Concentration (mg/L)	Notes
* **1,1,2,2-Tetrachloroethane**	2 125	0.001	0.002 - 0.006	0.004	0.000052	RBC	NA	1 2 3
* 1,1,2-Trichloroethane	2 / 25	0.0005	0.001 - 0.002	0.001 5	0.00019	RBC	NA	1 2 3
1.1-Dichloroethane	6 / 25	0.0005	0.001 - 0.008	0.0035	0.081	RBC	NA	2
1,2-Dichlorobenzene	8 125	0.0005	0.001 - 0.005	0.0031 3	0.037	RBC	NA	2
* **1,2-Dichloroethene**	8 125	0.0005	0.001 - 0.065	0.01	0.0055	RBC	NA	1 2 3
* **1,4-Dichlorobenzene**	14 125	0.001 5	0.003 - 0.01 7	0.00757	0.00044	RBC	NA	1 2 3
2,4-Dimethylphenol	3 / 25	0.001 5	0.003 - 0.046	0.01 77	0.073	RBC	NA	2
2-Chlorophenol	1 / 2 5	0.0005	0.001 - 0.001	0.001	0.018	RBC	NA	2
* **2-Methylnaphthalene**	2 / 25	0.001 5	0.003 - 0.01 1	0.007	0.0068	FSDWS (OL)	NA	1 2 3
2-Methylphenol	1 125	0.001 5	0.003 - 0.003	0.003	0.18	RBC	NA	2
4-Methyl-2-Pentanone(MIBK)	1 125	0.004	0.008 - 0.008	0.008	0.18	RBC	NA	2
* Aluminum	14 125	0.0625	0.134 - 4.78	0.603	0.2	FSDWS	3.82	1 2
* Arsenic	8 125	0.001 4	0.0059 - 0.0426	0.01869	0.000044	RBC	ND	1 2 3
* Barium	18 / 25	0.001 2	0.0024 - 0.335	0.0441	0.26	RBC	ND	1 2
* Benzene	14 125	0.0005	0.001 - 0.08	0.01 43	0.00036	RBC	NA	1 2 3
* Bromoform	2 125	0.001	0.002 - 0.004	0.003	0.0024	RBC	NA	1 2 3
* Cadmium	1 / 25	0.001 7	0.0305 - 0.0305	0.0305	0.0018	RBC	ND	1 2 3
* Chlorobenzene	17 125	0.0005	0.001 - 0.1 2	0.035	0.0039	RBC	NA	1 2 3
Chloroethane	2 125	0.0005	0.001 - 0.002	0.001 5	0.14	FPDWS	NA	2
* Chloroform	2 125	0.002	0.004 - 0.005	0.0045	0.00015	RBC	NA	1 2 3
* Chromium (as +III)	1 / 2 5	0.0026	0.616 - 0.616	0.61 6	0.1	FPDWS	0.0325	1 2 3
Cobalt	4 / 25	0.00205	0.0047 - 0.01 2	0.0069	0.22	RBC	ND	2
* Copper	1 1 2 5	0.0054	0.147 - 0.1 47	0.1 47	0.14	RBC	0.0122	1 2 3
* Dieldrin	1 1 2 5	0.0000038	0.0000076 - 0.0000076	7.6E-06	0.0000042	RBC	NA	1 2 3
Ethylbenzene	6 125	0.0005	0.001 - 0.039	0.01067	0.13	RBC	NA	2
Isophorone	1 1 2 5	0.0005	0.001 - 0.001	0.00 1	0.071	RBC	NA	2
Lead	1 1 2 5	0.0008	0.0053 - 0.0053	0.0053	0.015	TT	ND	2
* Manganese	22 125	0,00155	0.0077 - 0.6	0.2356	0.018	RBC	0.0215	1 2 3
* Naphthalene	9 125	0.0005	0.001 - 0.038	0.00844	0.0088	FSDWS (OL)	NA	1 2 3
* Nickel	1 125	0.01 995	0.253 - 0.253	0.253	0.073	RBC	ND	1 2 3
Phenol	1 1 2 5	0.0005	0.001 - 0.001	0.001	2.2	RBC	NA	2
Toluene	3 / 25	0.0005	0.001 - 0.01 5	0.006	0.04	FSDWS (OL)	NA	2
* Trichloroethylene	2 / 25	0.0005	0.001 - 0.002	0.001 5	0.0016	RBC	NA	1 2
Vanadium	1 1 2 5	0.00375	0.0108 - 0.01 08	0.01 08	0.026	RBC	0.0068	2

Table 10-11
Chemicals Detected in Shallow and Intermediate Groundwater
Comparison to Screening Concentrations
NAS Penracola, Site 1
Penracola, Florida

Chemical	'Frequency of Detection	Default Concentration (mg/L)	Range of Detected Concentrations (mg/L)	Mean of Hits (mg/L)	Screening Value (mg/L)	Source	Reference Concentration (mg/L)	Notes
Vinyl chloride	6 / 25	0.001	0.002 - 0.012	***0.0052***	0.000019	RBC	NA	1 2 **3**
Xylene (total)	7 / 25	0.001 5	0.003 - 0.11	0.0327	0.02	FSDWS (OL)	NA	1 2 **3**
Zinc	12 / 25	0.0013	0.0027 - 3.02	0,336	1.1	RBC	0.149	1 2
alpha-BHC	1 / 25	2.1 5E-06	4.3E-06 - 4.3E-06	4.3E-06	0.000011	RBC	NA	2
bis(2-Ethylhexyl)phthalate	1 / 25	***0.0005***	0.011 - 0.01 1	0.01 1	. 0.0048	RBC	NA	1 2 **3**

NOTES:

1 The maximum concentration detected exceeds the risk-bared screening value.
2 The maximum concentration detected exceeds the reference concentration.
3 The mean of hits exceeds both the risk-based end reference concentrations.
* Based on the comparison to screening and reference concentrations, this chemical ir a COPC and will be addressed in the risk assessment.
ND Not detected m background shallow/intermediate wells.
NA Not applicable.
TT The treatment technology-based action level was used as a screening value for lead.
FPDWS Florida primary drinking water standard.
FSDWS Florida secondary drinking water standard; (OL) indicates that FSDWS is bared on organoleptic endpoints.
RBC USEPA Region III Risk-based screening concentration for tap water.
- All reference concentrations were taken from Table 8-8, Section 8 Nature and Extent of Contamination.

Table 10-12
Chemicals Detected in Deep Groundwater
Comparison to Screening Concentrations
NAS Pensacola, Site 1
Pensacola, Florida

Chemical	Frequency of Detection	Default Concentration (mg/L)	Range of Detected Concentrations (mg/L)	Mean of Hits (mg/L)	Screening Value (mg/L)	Source	Reference Concentration (mg/L)	Notes
Aluminum	2 / 3	0.125	0.142 - 0.317	0.23	0.2	FSDWS	0.437	1
• Manganese	3 / 3	0.012	0.0241 - 0.0901	0.0612	0.018	RBC	0.050	1 2
Barium	1 1 3	0.0038	0.0075 - 0.0075	0.0075	0.26	RBC	0.014	
Zinc	1 1 3	0.0026	0.0066 - 0.0066	0.0066	1.1	RBC	0.210	

NOTES:

1 The maximum concentration detected exceeds the risk-based screening value.
2 The maximum concentration detected does not exceed the reference concentration; no maximum concentration is less than the corresponding background concentration (if applicable).
• Based on the comparison to screening and reference concentrations, this chemical is a COPC and will be addressed in the risk assessment.
NA Not available.
TT The treatment technology-based action level was used as a screening value for lead.
FPDWS Florida primary drinking water standard.
FSDWS Florida secondary drinking water standard; (OL) indicates that FSDWS is based on organoleptic endpoints.
RBC USEPA Region III Risk-based screening concentration for tap water.
- All reference concentrations were taken from Table 8-9, Section 8 Nature and Extent of Contamination.

Table 10-13
Chemicals Detected in Site 1 Surface Water
NAS Pensacola Site 1
Pensacola, Florida

Parameter	Frequency of Detection	Default Concentration (ug/L)	Range of Detected Concentrations (ug/L)	Mean of Hits (ug/L)	Screening Value (ug/L)	Source	Reference Concentration (ug/L)	Notes	
Aluminum	6 /6	49.3	98.6 - 2120	483.3	3700	RBCr	NA		2
• Arsenic	1 /6	1.7	3.4 - 3.4	3.4	0.038	RBCr	NA	1	2
Barium	4 /6	16.05	32.1 - 35.8	33.95	260	RBCr	NA		2
Chromium	1 16	6.75	13.5 - 13.5	13.5	3700	RBCr	NA		2
Copper	1 16	3.75	7.5 - 7.5	7.5	140	RBCr	NA		2
Lead	2 /6	0.95	1.9 - 6	3.95	15	TTAL	NA		2
• Manganese	6 /6	23.8	47.6 - 149	109.9	18	RBCr	NA	1	2
Vanadium	2 /6	2.35	4.7 - 10.2	7.5	26	RBCr	NA		2
Zinc	1 /6	19.85	39.7 - 39.7	39.7	1.100	RBCr	NA		2
• 1,4-Dichlorobenzene	2 /6	1	2 - 2	2	0.44	RBCr	NA	1	2
1,1-Dichloroethane	1 /6	1	2 - 2	2	81	RBCr	NA		2
• Benzene	2 /6	0.5	1 - 2	1.5	0.36	RBCr	NA	1	2
• Chlorobenzene	3 /6	0.5	1 - 7	4.7	3.9	RBCr	NA	1	2

NOTES:

- • Retained as a COPC based on comparison to the most conservative screening value.
- 1 Maximum detected exceeds the residential risk-based screening value.
- 2 Maximum detected exceeds reference concentration.
- RBC Residential screening value from USEPA Region III Screening Concentration Table (March 1994) or latest Risk-Based Concentration Table values provided by USEPA Region III (TR = 1E-6, HQ adjusted to 0.1).
- RBCr USEPA Region III residential Risk-Based Screening Value, March 1994 Table.
- TTAL Treatment Technique-based Action Level for lead.
- NA Indicates not available; reference wetland surface water has been identified, but sampling activities have not been initiated.

Table 10-14
Chemicals Detected in Site 1 Sediment (0-1' bgs)
NAS Pensacola Site 1
Pensacola, Florida

Parameter	Frequency of Detection	Default Concentration (mg/kg)	Range of Detected Concentrations (mg/kg)	Mean of Hits (mg/kg)	Screening Value (mg/kg)	Source	Reference Concentration (mg/kg)	Notes	
• Aluminum	6 /6	404.5	809 - 8120	3763.2	7800	RBCr	NA	1	2
• Arsenic	4 /6	0.7	1.4 - 8.4	3.3	0.37	RBCr	NA	1	2
Barium	6 /6	0.95	1.9 - 35.9	11.1	550	RBCr	NA		2
Cadmium	1 /6	1.1	2.2 - 2.2	2.2	3.9	RBCr	NA		2
Chromium	5 /6	0.85	1.7 - 16.9	7.8	7800	RBCr	NA		2
Copper	2 /6	3.05	6.1 - 6.2	6.2	290	RBCr	NA		2
Lead	6 16	2.05	4.1 - 63.3	23.3	400	OSWER	NA		2
• Manganese	6 /6	1.85	3.7 - 105	28.2	39	RBCr	NA	1	2
Vanadium	5 /6	1.1	2.2 - 6.9	4.2	55	RBCr	NA		2
Zinc	6 /6	2.35	4.7 - 17.1	11.0	2300	RBCr	NA		2
Endosulfan I	1 /6	0.00415	0.0083 - 0.0083	0.0083	47	RBCr	NA		2
Dieldrin	1 /6	0.00185	0.0037 - 0.0037	0.0037	0.04	RBCr	NA		2
4,4'-DDE	5 16	0.00125	0.0025 - 0.15	0.058	1.9	RBCr	NA		2
Endrin	2 16	0.000265	0.00053 - 0.013	0.0068	2.3	RBCr	NA		2
4,4'-DDD	6 16	0.000205	0.00041 - 0.53	0.12	2.7	RBCr	NA		2
4,4'-DDT	4 /6	0.0006	0.0012 - 0.23	0.06	1.9	RBCr	NA		2
alpha-Chlordane	4 /6	0.000255	0.00051 - 0.012	0.0038	0.49	RBCr	NA		2
gamma-Chlordane	2 16	0.001	0.002 - 0.0095	0.0058	0.49	RBCr	NA		2
Phenol	1 16	0.0275	0.055 - 0.055	0.055	4700	RBCr	NA		2

NOTES:

- • Retained as a COPC based on comparison to the most conservative screening value.
- 1 Maximum detected exceeds the residential risk-based screening value.
- 2 Maximum detected exceeds reference concentration.
- RBC Residential screening value from USEPA Region III Screening Concentration Table (March 1994) or latest Risk-Based Concentration Table values provided by USEPA Region III (TR = 1E-6, HQ adjusted to 0.1).
- RBCr USEPA Region III residential Risk-Based Screening Value, March 1994 Table.
- OSWER USEPA OSWER guidance cleanup level of residential soil.
- NA Indicates not available; reference wetlands sediments have been identified, but sampling activities have not been initiated.

10.1.2.11 COPCs in All Media Sampled

Table **10-15** summarizes the results of the screening procedure and comparison to reference concentrations used to identify COPCs. The table also lists the ranges of concentrations for COPCs detected in soil and groundwater (combined shallow/intermediate and deep water bearing zones) as well as surface water and sediment.

10.1.3 Exposure Assessment

The purpose of this section of the BRA is to determine the magnitude of contact that a potential receptor may have with site-related **COPCs.** Exposure assessment involves four stages:

- Characterization of the physical setting and land use of the site;
- Identification of COPC release and migration pathways;
- Identification of the potential receptors, under various land use or site condition scenarios, and the pathways by which they might be exposed; and
- Quantification of intakes, or contact rates, of COPCs.

10.1.3.1 Characterization of Exposure Setting

Physical Setting

NAS Pensacola is a 5,800-acre facility on the western edge of the Florida panhandle, on a peninsula bounded by Pensacola Bay to the east and south and Bayou Grande to the north. Site 1 consists of an inactive landfill which was used from the early *1950s* until 1976 for disposal of nearly all solid waste generated at NAS Pensacola, as well as waste from outlying Navy installations.

The site occupies approximately 80 acres and is approximately 250 feet south of Bayou Grande, *500* feet north of Taylor Road, and **0.35** miles west of the golf course. The northernmost portion of Site 1 has been used in the past as a camping area, primarily by Boy Scout troops.

Table 10-15
Summary of COPCs (All Media)
NAS-Pensacola, Site #1
Pensacola, Florida

	Surface Soil (mg/kg)	All Depth Soil (mg/kg)	Shallow and Intermediate (mg/L)	Deep (mg/L)	Surfece Water (mg/L)	Sediment (mg/kg)
1,1,2,2-Tetrachloroethane			0.002-0.006			
1,1,2-Trichloroethane			0.001-0.002			
1,2-Dichloroethene (total)			0.001-0.065			
1,4-Dichlorobenzene			0.003-0.01 7		0.002	
4-Chloro-3-methylphenol		0.42-4.3 GWP				
Aluminum	483-13600	141-13600 GWP	0.134-4.78			809-8 120
Aroclor-1248	0.19					
Aroclor-1254	0.31					
Aroclor-1260	0.0047-0.13					
Arsenic			0.0059-0.0426		0.0034	1.4-8.4
Barium		0.69-1050 GWP	0.0024-0.335			
Benzene			0.001-0.08		0.001-0.002	
Beryllium	0.61					
bis(2-Ethylhexyl)phthalate			0.01 1			
Bromoform			0.002-0.004			
Cadmium	5.2-99	1.5-214 GWP	0.0305			
Chlorobenzene			0.001-0.12		0.001-0.007	
Chloroform			0.004-0.005			
Chromium			0.616			
Copper		3.1-212 GWP	0.147			
Dieldrin		0.00019-0.072 GWP	7.6E-06			
Lead	0.9-441					
Manganese	2.3-191	1.9-191 GWP	0.0077-0.6	0.0241-0.0901	0.0476-0.149	3.7-105
2-Methylnaphthelene		0.22-6.8 GWP	0.003-0.01 1			
Naphthalene		0.32-16 GWP	0.001-0.038			
Nickel		11.l-55.7 GWP	0.253			
Tetrachloroethene		0.006-26 AIR				
Toluene		0.001-2300 AIR				
Trichloroethene			0.001-0.002			
Vinyl chloride			0.002-0.01 2			
Xylene		0.22-49 GWP	0.003-0.1 1			
Zinc			0.0027-3.02			

NOTES:

GWP Indicates chemical was retained as a COPC based on groundwater protection.
AIR Indicates chemical wes retained as a COPC based on potential volatilizetion and inhalation exposure.

Site 1's northern portion is not fenced, and trespassing could occur here. The central and southern portions of the site are fenced; however, these portions are accessible to potential trespassers via paths from the northern portion of the property.

Climate — NAS Pensacola has a mild, subtropical climate, with average annual temperature ranges from 55°F in the winter to 81°F in the summer. Temperature extremes can range from less than 7°F in the winter to more than 102°F in the summer. November is the driest month of the year, with an average rainfall of 3.2 inches based on climatological data from 1962 to 1991. Annual rainfall averages approximately 60 inches, with the highest amounts in July and August. During the spring and fall, rainfall is the lowest (an average of 4 inches per month).

Winds originate from the north during the winter and the south during the summer. Hurricanes and tornadoes can substantially damage the nearshore environment. According to recorded history, nine hurricanes have passed within 50 miles of Pensacola.

Hydrogeology — Three main regional hydrogeologic units have been identified/defined within the stratigraphy beneath the Florida Panhandle. In descending order, the units are the Surficial/Sand-and-Gravel Aquifer, the Intermediate System, and the Floridan Aquifer System. The surficial aquifer is composed of unconsolidated clastic deposits approximately 300 feet thick at NAS Pensacola. It is referred to as the Sand-and-Gravel Aquifer and is used as a major source of drinking water in locations other than NAS Pensacola (SEGS 1986). Due to the Sand-and-Gravel Aquifer being the uppermost unit contiguous with land surface and receiving recharge through direct infiltration, it is susceptible to contamination from surface activities. Neither the Sand-and-Gravel Aquifer nor the deep water-bearing zone is used within Site 1 as a potable water source. The deep aquifer is used to derive industrial process water at NAS Pensacola locations other than Site 1. Other than three deep zone monitoring wells, investigations at Site 1 have been limited to the Surficial/Sand-and-Gravel Aquifer. The groundwater zones defined at Site 1 are the shallow and intermediate (combined) and deep

groundwater zones. These zones refer to three general depths at which monitoring wells have been completed at Site 1.

The two monitoring well depths present within the Sand-and-Gravel Aquifer, with shallow and intermediate depth monitoring wells completed, are within the surficial zone. The shallow wells monitor conditions near the water table, whereas the intermediate wells monitor conditions at the base of the surficial zone immediately above the underlying clays and silts of the low-permeability zone. Deep wells monitor conditions below the underlying clays and silts (i.e., the Floridan Aquifer).

Groundwater flow studies at the site have involved potentiometric mapping of the two well completion depths. Available studies from the past 12 years show shallow groundwater under natural conditions radiating to the north, east, and west from the southern central portion of the site.

Discharge and groundwater flow are north, east, and west flowing toward wetlands shown in Section 8 Figures 8-2 through 8-4 (Nature and Extent of Contamination — 1994). Deep groundwater flow data are limited by the small number of wells completed at this depth.

Comparison of water levels between the studied depths shows a consistently downward hydraulic gradient from shallow to intermediate, implying shallow groundwater migrates downward toward the intermediate depth. At the southern portion of Site 1, a downward hydraulic gradient that appears to be unaffected by tidal influences is indicated by the studies performed onsite. However, under certain tidal conditions, the hydraulic gradient appears to be upward from deep to intermediate depth groundwater in the northern portion of the site (closest to Pensacola Bay). See Section 6 (Geologic and Hydrologic Results) for a more detailed discussion of the water-bearing zones at Site 1.

10.1.3.2 Potentially Exposed Populations

Under current land use conditions at Site 1, access to the areas of concern is restricted to authorized personnel only, but the area is not fenced. Access onto NAS Pensacola is restricted, but the potential for trespass at Site 1 exists if an individual gains access to or lives on the base. Uniform exposure has been assumed for surface soils to address a potential (current use) trespasser/camper walking throughout Site 1. It will also be assumed that the trespasser is between 7 and 16 to increase the conservative nature of this assessment and to address the potential exposure of Boy Scout campers. This additional scenario is intended to address camping in the northernmost portion (campsites historically used by Boy Scout troops) and walking through all areas of Site 1.

Currently, there are no plans for development at Site 1; however, exposure has been addressed under the future land use scenario. Hypothetical future residential and worker exposure scenarios were developed to account for any potential site use. As requested by USEPA Region IV, the hypothetical future residential scenario includes groundwater assessment assuming potable use. At this time, there are no reported plans to decommission the facility (NAS Pensacola) or substantially alter current Site 1 operations. As a result, current exposure conditions are expected to continue unaltered for the foreseeable future.

10.1.3.3 Identification of Exposure Pathways

The potential pathways of exposure to soil and groundwater chemicals which were evaluated during the BRA are listed in Table 10-16. Details regarding the rationale for exposure pathway selection/rejection for the respective media are also provided in Table 10-16 and are detailed in the following paragraphs. These approaches were consistent with the requests of USEPA Region IV and FDEP to evaluate reasonable maximal exposure (RME) conditions.

Table 10-16
Exposure Pathway: Summary
NAS Pensacola Site 1
Pensacola, Florida

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation	Reason for Selection or Exclusion
Future Land Use Site Worker	Air — Inhalation of gaseous contaminants emanating from soil	No (Qualified)	The gaseous air pathway is considered due to the results of the previously presented screening comparison, Table 10-10.
	Air — Inhalation of chemicals entrained in fugitive dust	**No**	Surface soil is vegetated, preventing fugitive dust generetion.
	Groundwater — Ingestion of contaminants during potable or general use	**No**	Groundwater is not currently used as a source of potable or industrial water at Site 1, nor would future workers be expected to use it.
	Groundwater — Inhalation of volatilized groundwater contaminants	**No**	Groundwater is not currently used as a source of potable or industrial water at Site 1.
	Soil — Incidental ingestion, all soil depth intervals	**Yes**	Soil contamination has been identified, and people may have to work in these areas in the future.
	Soil — Dermal contact, all soil depth intervals	**Yes**	Soil Contamination has been identified, and people may heve work in these areas in the future.
	Sediment — Incidental ingestion	**No**	Sediment remains submerged throughout the year, and site workers would not be expected to be exposed to this medium. Samples were collected during the Site 1 investigation to determine if a pathway for Contamination exists from Site 1 to the surrounding wetlands. The wetlands will be characterized and addressed in the Site 41 BRA.

Table 10-16
Exposure Pathways Summary
NAS Pensacola Site 1
Pensacola, Florida

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation	Reason for Selection or Exclusion
Future Land Use Site Worker (continued)	Sediment — Dermal contact	No	Sediment remains submerged throughout the year, and site workers would not be expected to be exposed to this medium. Samples were collected during the Site 1 investigation to determine if a pathway for contamination exists from Site 1 to the surrounding wetlands. The wetlands will be characterized and addressed in the Site 47 BRA.
	Surface Water — Incidental ingestion	No	The tasks of site workers would not be expected to include working in and around surface water. Samples were collected during the Site 1 investigation to determine if a pathway for contamination exists from Site 1 to the surrounding wetlands. The wetlands will be characterized and addressed in the Site 41 BRA.
Potential Current Land Use - Infrequent Adolescent Child Trespasser (age 7-16)	Air — Inhalation of gaseous contaminants emanating from soil	No	No COPCs were identified for the residential exposure scenario, which would be protective of this exposure pathway.
	Air — Inhalation of chemicals entrained in fugitive dust	No	The surface soil areas of concern are vegetated and/or covered with detritus, preventing fugitive dust generation.
	Soil — Incidental ingestion	Yes	The possibility exists that older children (age 7 to 16) could gain access to the contaminated study areas.
	Soil — Dermal contact	Yes	The possibility exists that older child trespassers (age 7 to 16) could gain access to the contaminated study areas.

Table 10-16
Exposure Pathways Summary
NAS Pensacola Site 1
Pensacola, Florida

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation	Reason for Selection or Exclusion
Current Land Use Infrequent Adolescent Child Trespasser (age 7-16) (continued)	Sediment — Incidental ingestion	Yes	The possibility exists that older children (age 7 to 16) could gain access to the impacted study areas. Samples were collected during the Site 1 investigation to determine if a pathway for contamination exists from Site 1 to the surrounding wetlands. The wetlands will be characterized and addressed in the Site 41 BRA.
	Sediment — Dermal contact	Yes	Sediment remains submerged throughout the year. Although this pathway would not be expected to be significant,' this pathway was addressed. Samples were collected during the Site 1 investigation to determine if a pathway for contamination exists from Site 1 to the surrounding wetlands. The wetlands will be characterized and addressed in the Site 41 BRA.
	Surface Water — Incidental ingestion	Yes	The possibility exists that older children (age 7 to 16) could gain access to Site 1 surface water bodies and swim in the area. Samples were collected during the Site 1 investigation to determine if a pathway for migration exists from Site 1 to the surrounding wetlands. The wetlands will be characterized and addressed in the Site 41 BRA.
Future Land Use Site Residents (Child and Adult)	Air — Inhalation of gaseous contaminants emanating from soil	No	No COPCs were identified for this exposure pathway.
	Air — Inhalation of chemicals entrained in fugitive dust	No	The surface soil areas of concern are vegetated, preventing fugitive dust generation.

Table 10-16
Exposure Pathways Summary
NAS Pensacola Site 1
Pensacola, Florida

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation	Reason for Selection or Exclusion
Future Land Use Site Residents (Child and Adult) (continued)	Groundwater — Ingestion of contaminants during potable or general use	Yes	The combined shallow/intermediate and the deep water-bearing zone could hypothetically be used as a residential water source.
	Groundwater — Inhalation of volatilized contaminants during domestic use	Yes	Significant volatile organic compound concentrations were reported in the shallow/intermediate water-bearing zone wells only.
	Soil — Incidental ingestion	Yes	Surface soil contamination has been identified, and residents would have significant opportunity for exposure.
	Soil — Dermal contact	Yes	Surface soil contamination has been identified, and residents would have significant opportunity for exposure.
	Surface Water — Incidental ingestion during recreational activities	No (Qualified)	Surface water contamination has been identified, and residents would have significant'opportunity for exposure during recreational activities. The trespasser scenario was used as a preliminary assessment of Site 1 surface water. Samples were collected during the Site 1 investigation to determine if a pathway for contamination exists from Site 1 to the surrounding wetlands. The wetlands will be characterized and addressed in the Site 41 BRA.

Table 10-16
Exposure Pathways Summary
NAS Pensacola Site 1
Pensacola, Florida

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation	Reason for Selection or Exclusion
Future Land Use Site Residents (Child and Adult) **(continued)**	Sediment — Incidental ingestion	No (Qualified)	Surface water contamination has been identified, and residents would have significant opportunity for exposure during recreational activities. Samples were collected during the Site 1 investigation to determine if a pathway for contamination exists from Site 1 to the surrounding wetlands. The trespasser scenario was used as a preliminary assessment of Site 1 sediment. The wetlands will be characterized and addressed in the Site 41 BRA.
	Sediment — Dermal contact	No (Qualified)	Sediment remains submerged throughout the year, and site residents would not be expected to be exposed to this medium, except during recreational activities. Samples were collected during the Site 1 investigation to determine if a pathway for contamination exists from Site 1 to the surrounding wetlands. The wetlands will be characterized and addressed in the Site 41 BRA. Although this pathway would not be expected to be significant, it was addressed. The trespasser scenario was used as a preliminary assessment of Site 1 sediment.
	Fish and shellfish — Ingestion of species obtained from contaminated surface water	No	To date, no edible aquatic species have been identified at Site 1. This exposure pathway will be addressed in the Site 41 BRA.
	Wild game or domestic animals — Ingestion of tissue impacted by media contamination	No	Hunting/taking of game and/or raising livestock is prohibited at Site 1.

Table 10-16
Exposure Pathways Summary
NAS Pensacola Site 1
Pensacola, Florida

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation	Reason for Selection or Exclusion
Potential Future Land Use — Site Residents (Child and Adult) (continued)	Fruits and vegetables. Ingestion of plant tissues grown in contaminated media	No	The potential for significant exposure via this indirect pathway is low relative to the direct exposure pathways addressed in this BRA.

Note:
Based on the recommendations of USEPA, Region IV, dermal contact exposure pathways were not considered viable for aqueous media.

10.1.3.3.1 Soil

For current scenarios, incidental ingestion and dermal contact soil pathways were evaluated for a trespassing child (age 7 to 16). This assumption increases the likelihood of obtaining a conservative estimate of risk. Uniform exposure has been assumed for surface soil to address a potential (current use) trespasser/camper walking throughout Site 1. Exposure assumptions are approximately analogous to the Boy Scouts use of the site. Due to the exclusively biased sampling effort employed Site 1, EPCs represent conservative estimates of average media quality.

As presented in Sections 2, 7, and 8 of this report, the primary AOC at Site 1 is the area defined by refuse material (see Section 2, Figure 2-2 of this report for a graphical representation). Therefore, it is likely that only a fraction of a receptor's soil contact would occur in the AOC. However, the assumption of uniform exposure exclusively within the AOC lends additional conservatism to the risk assessment.

With respect to residential and worker exposure conditions, no complete exposure pathways currently exist at Site 1. However, complete exposure pathways could exist when based on an estimate of the reasonable maximum exposure under potential future conditions. It is assumed that Site 1 may be developed in the future as a residential or commercial/industrial area. If so, future residents or workers could be exposed to soil via the incidental ingestion and dermal contact routes of exposure associated with living in the area. Potential exposure to volatilized soil contaminants is addressed in Section 10.1.3.3.5.

10.1.3.3.2 Groundwater

Shallow and intermediate monitoring well data were combined to assess the potential future residential well scenario which could include both water-bearing zones. Because the intermediate and deep water-bearing zones are separated by a distinct aquitard, the deep monitoring well data were addressed separately. This approach assumes that each water-bearing zone studied has the same potential viability as a potable water source. Although none of the aquifers studied currently serve as a source of potable water at Site 1, this approach is consistent with the National Contingency Plan (NCP) which calls for protection of groundwater to allow for its maximum beneficial use. There are no current plans to use onsite groundwater for potable or industrial purposes. The future resident was assumed to make potable use of the combined shallow/intermediate or deep aquifers onsite. These approaches were consistent with the requests of USEPA Region IV and FDEP to evaluate RME conditions.

10.1.3.3.3 Surface Water

As previously discussed, surface water was sampled only to determine if contaminants migrate from Site 1 to the surrounding wetlands. As stated in Section 8.3.1 of this RI, surface water at Wetlands 3 and 4 appears to have been impacted by Site 1. Benzene, chlorobenzene, and 1,4-dichlorobenzene were reported in Wetland 3 surface water. VOCs and metals detected in nearby groundwater monitoring wells are likely discharging into Wetland 4. However, inorganic concentrations reported in Wetland 4 sediment and surface water are not significantly elevated

(i.e., above screening values), and no VOCs were detected in surface water. The golf course is another likely source of inorganic and pesticide CPSSs reported in Wetlands 3 and 4. As discussed in Sections 7, 8, and 11, contaminants are potentially migrating from groundwater to Wetlands 3 and 16.

A preliminary assessment of human exposure to wetland surface water was performed assuming a child (age 7 to 16) trespassing/swimming scenario. Additional data will be collected as part of the wetlands investigation, Site 41, which will include a BRA based on the final data set for the wetlands at NAS Pensacola. Please refer to Sections 7 and 8 (Nature and Extent of Contamination), Section 11 (Fate and Transport of Contamination), and Section 10.2 (Ecological Risk Assessment) for additional data presentation and discussions pertaining to potential contaminant migration. The absence of data from reference wetlands precludes full, accurate assessment of surface water-related risk. The surface water/sediment surrounding Site 1 will be further addressed in the Wetlands Investigation RI (Site 41).

10.1.3.3.4 Sediment

As previously discussed, sediment was sampled only to determine if contaminants have the potential to migrate from Site 1 to the surrounding wetlands. As discussed in Sections 7, 8, and 11, surface water might have been impacted by past uses of Site 1. Wetlands 3, 4, and 16 were identified as potentially impacted based on a comparison of surrounding groundwater monitoring well data to wetland sediment and surface water data.

A preliminary assessment of human exposure to wetland sediment was performed assuming a child (age 7 to 16) trespassing/swimming scenario. Additional data will be collected as part of the wetlands investigation, Site 41, which will include a BRA based on the final data set for the wetlands at NAS Pensacola. Please refer to Sections 7 and 8 (Nature and Extent of Contamination), Section 11 (Fate and Transport of Contamination), and Section 10.2 (Ecological Risk Assessment) for additional data presentation and discussions pertaining to potential

contaminant migration. The absence of data from reference wetlands precludes full, accurate assessment of sediment-related risk. The surface water/sediment surrounding Site 1 will be further addressed in the Wetlands Investigation RI (Site 41).

10.1.3.3.5 Air

Fugitive dust exposure was not evaluated as a potential indirect soil exposure pathway because of dense understory growth. This vegetative soil cover reduces ground-level wind velocities and minimizes dust generation from these areas. No significant VOC contamination was identified in site media which could lead to gaseous contaminant inhalation becoming a viable exposure pathway, assuming soil exposure is to surface soil only. The concentrations reported for tetrachloroethene and toluene, which were detected in one sample (01S8210), exceeded the soil screening values based on volatilization from soil to air. These concentrations were detected at a depth of 10 feet, and therefore, the soil-to-air exposure pathway would not be expected to be a significant contributor to overall risk and hazard. For all exposure pathways where risk projections included groundwater ingestion, inhalation exposure was addressed using the methods requested by USEPA Region IV for all VOC COPCs.

10.1.3.3.6 Protection of Groundwater

A comparison of maximum soil concentrations reported in all soil depths was made to screening concentrations based on the protection of groundwater (assuming residential potable use). This comparison revealed exceedances at only nine of 29 sample locations, and locations of concern are within the landfill boundaries. Most exceedances were reported at depth rather than in surface soil samples. Table 10-17 indicates which COPC(s) exceeded the corresponding screening values on a location-specific basis.

Table 10-17
Location-Specific Comparison to Screening Values
Protective of Groundwater
NAS Pensacola, Site 1
Pensacola, Florida

Parameter	01S72	01S73	01SI28	01S76	01S77	01S78	01S80	01S81	01S82
Aluminum			x		x		s		
Barium		x							
Cadmium	s	x			x		s	x	
Copper	x,s	x					s	x	s
Manganese	x					x		x	x,s
Nickel	s							x	
Dieldrin	s	x							
1,4-dichlorobenzene		x						x	
2-methylnaphthalene		x		x	x				x
Naphthalene		x		x	x				x
Xylene		x		x					

Notes:
x = Exceedance at depth
s = Exceedance in surface soil

10.1.3.4 Exposure Point Concentrations

The EPC is the concentration of a contaminant in an environmental medium that will be contacted by an actual or hypothetical receptor. Determination of EPC depends on factors such as:

- Availability of data
- Amount of data available to perform statistical analysis
- Reference concentrations not attributed to site impacts
- Location of the potential receptor

USEPA Region IV guidance assumes lognormal distributions for environmental data and the calculation of 95% UCL of the mean to quantify exposure. Because of the uncertainty associated with characterizing potentially nonhomogeneous areas, both the mean (natural log transformed) and the UCL on the mean for a lognormal distribution are reported for each COPC identified in Site 1 media. In general, outliers have been included in the calculation of the UCL because high values seldom appear as outliers for a lognormal distribution. Inclusion of outliers increases the overall uncertainty of the calculated risks and conservatively increases the estimate of the risk.

The UCL was calculated for a lognormal distribution as follows:

$$UCL = e^{\{\bar{a}+(0.5s_y^2)+[(H_{0.95}) * (s_y)/(n-1)^{0.5}]\}}$$

where:

$\bar{a}$ = $(\Sigma a)/n$ = sample arithmetic mean of the log-transformed data, a = ln(x)

s_y	=	sample standard deviation of the log-transformed data
n	=	number of samples in the data set
$H_{0.95}$	=	value for computing the one-sided upper 95% confidence limit on a lognormal mean from standard statistical tables (Gilbert, 1987)

The calculated values for upper 95% confidence limit are presented in Tables 10-18, 10-19, and 10-20 for COPCs identified in surface soil, combined shallow and intermediate zone groundwater, and deep zone groundwater, respectively. The tables also provide a statistical summary of COPCs identified at Site 1, which includes for each COPC the frequency of detection, mean and standard deviation of the natural log-transformed data, the H-statistic, the maximum of detected concentrations, default concentrations (discussed below), and the reference criterion, where applicable. For each medium, the lowest of either the maximum of positive detections or the 95% UCL mean concentration of each COPC identified in soil or groundwater was used to compute the corresponding risk/hazard. The value to be applied in subsequent exposure assessments as the EPC is also designated for reference.

Analytical results are presented as "nondetects" whenever chemical concentrations in samples do not exceed the detection or quantitation limits for the analytical procedures. Generally, the detection limit is the lowest concentration of a chemical that can be quantified above the normal, random noise of an analytical instrument or method. To apply the above-mentioned statistical procedures to a data set with reported "nondetects," it was assumed that the chemical was present at a default concentration. One-half of the lowest sample quantitation limit and one-half the lowest reported hit for the specific medium were compared, and the lesser of the two values was used as the default concentration. This default concentration was inserted for all reported "nondetects," and statistical calculation of the UCL was performed on this dataset. Depending on standard deviation and the number of samples, the UCL concentration is sometimes greater than the maximum concentration detected onsite. The lesser of the maximum or 95% UCL

Tabla **10-18**
Statistical Analysis of COPCs
Surface Soils **(0-1')**
NAS Pensacola, Site **1**
Pensacola, Florida

Chemical	n	Natural Log-Transformed mean	SD	H stat	UCL (mg/kg)	Max Hit (mg/kg)		Reference Concentration (mg/kg)	EPC (mg/kg)
Aluminum	27	7.386	0.966	2.426	4006	13600	UCL used	3833.8	4006
Beryllium**	27	-1.621	0.206	1.766	0.239	0.61	UCL used	0.41	0.239.
Cadmium	27	-0.316	1.179	2.717	2.738	99	UCL used	1	2.738
Lead	27	1.366	1.914	3.808	102.222	441	UCLused	7.32	102.222
Manganese	27	1.464	1.673	3.281	40.6678	191	UCL used	21.36	40.6678
Aroclor 1248**	27	2.894	0.470	1.929	0.024	0.19	UCL used	NA	0.024
Aroclor 1264' *	27	2.912	0.664	2.008	0.0269	0.31	UCL used	NA	0.0269
Aroclor 1260	27	1.079	0.810	2.266	0.00584	0.13	UCL used	NA	0.00584

NOTES:

n Total number of samples.
mean The average of the natural log-transformed data.
SD Standard deviation for a sample of a population of data.
H stat As taken from Gilbert, **1987;** cuboidal interpolation was used to determine the H statistic in accordance with Supplemental Guidance for RAGS, Calculating the Concentration Term.
EPC Exposure point Concentration used for risk assessment.
UCL **96%** Upper Confidence Level Mean calculated using the H stat.
- Max used and UCL used indicate the concentration used as EPC in the risk assessment.
- The reference concentrations were used as agreed by the Tier I Partnering Team.
- Indicates the Exposure Point Concentration (EPC) is less than or equal to the corresponding reference concentration.
** Beryllium, Aroclor **1248,** and Aroclor **1264** were reported in only one of **27** samples; therefore, exposure to these COPCs would **be** at only one location rather than sitewide.
NA Not available.

Table 10-19
Statistical Analysis of **COPCs**
Shallow and Intermediate Water-Bearing Zones
NAS Pensacola, Site 1
Pensacola, Florida

Chemical	n	Natural Log Transformed mean	SD	H stat	UCL (mg/L)	Max Hit (mg/L)		Reference Concentration (mg/L)	EPC (mg/L)
Vinyl chloride	25	2	0.69954	2.155	0.002462	0.012	UCL used	NA	0.002462
1,1,2,2-Tetrachloroethan	25	1.24	0.37881	1.871	0.001371	0.006	UCL used	NA	0.001371
1,2-Dichloroethene	25	3.54	1.1115	2.659	0.003035	0.065	UCL used	NA	0.003035
Benzene	25	8.22	1.61381	3.395	0.026387	0.08	UCLused	NA	0.026387
Toluene	25	1.16	0.72941	2.187	0.001129	0.015	UCL used	NA	0.001129
Chlorobenzene	25	24.28	2.06463	4.117	0.272237	0.12	Max used	NA	0.12
Ethylbenzene	25	2.94	1.17512	2.746	0.003317	0.039	UCL used	NA	0.003317
Xylene	25	10.24	1.25899	2.862	0.012807	0.11	UCL used	NA	0.012807
1,4-Dichlorobenzene	25	4.9	0.84839	2.322	0.007386	0.017	UCL used	NA	0.007386
1,1,2-Trichloroethane	25	0.58	0.30477	1.82	0.000637	0.002	UCL used	NA	0.000637
2-Methylnaphthalene	25	1.94	0.41642	1.898	0.00214	0.011	UCL used	NA	0.00214
Naphthalene	25	3.36	1.27853	2.891	0.00536	0.038	UCL used	NA	0.00536
Aluminum	25	365.1	1.05988	2.589	0.449	4.78	UCLused	3.8189	0.449
Arsenic	25	6.932	1.20059	2.781	0.012283	0.0426	UCL used	ND	0.012283
Barium	25	32.1	1.6426	3.439	0.11293	0.335	UCL used	ND	0.11293
Bromoform	25	1.16	0.30477	1.82	0.001275	0.004	UCL used	NA	0.001275
Zinc	25	162.192	2.20423	4.35	0.4614	3.02	UCL used	0.0746	0.4614
Manganese	25	207.586	1.91345	3.87	0.042009	0.6	UCLused	0.0215	0.042009
Cadmium	25	2.852	0.57742	2.035	0.002865	0.0305	UCL used	ND	0.002865
Chloroform	25	2.2	0.22513	1.774	0.002373	0.005	UCL used	NA	0.002373
Chromium (trivalent)	25	27.136	1.09355	2.635	0.010594	0.616	UCL used	0.0325	0.010594
Copper	25	11.064	0.66081	2.116	0.0102	0.147	UCL used	0.0122	0.0102
Dieldrin	25	0.003952	0.13863	1.731	4.1E-06	7.6E-06	UCL used	NA	4.1E-06
Nickel	25	29.272	0.50803	1.972	0.030824	0.253	UCL used	ND	0.030824

Table 10-19
Statistical Analysis of COPCs
Shallow and Intermediate Water-Bearing Zones
NAS Pensacola, Site 1
Pensacola, Florida

Chemical	n	Natural Log Transformed mean	SD	Hstat	UCL (mg/L)	Max Hit (mg/L)		Reference Concentration (mg/L)	EPC (mg/L)
Trichloroethene	25	0.58	0.30477	1.82	0.000637	0.002	UCL used	NA	0.000637
bis(2-Ethylhexyl)phthalate	25	0.92	0.61821	2.073	0.000889	0.011	UCL used	NA	0.000889
Chloroethane	25	0.58	0.30477	1.82	0.000637	0.002	UCL used	NA	0.000637
1,1-Dichloroethane	25	1.22	0.82293	2.292	0.001559	0.008	UCL used	NA	0.001559
1,2-Dichlorobenzene	25	1.34	0.8691	2.347	0.001916	0.005	UCL used	NA	0.001916

NOTES:

n Number of samples.
mean Mean of detected values including defaults for log-transformed data set.
SD Standard deviation for a sample of a population of data.
H stat "H" statistic, from Gilbert, 1987; cuboidal linear interpolation was used to determine this value in accordance with USEPA Guidance, Calculating the Concentration Term.
NA Not Applicable.
ND Indicates the chemical was not detected.
EPC Exposure point concentration used for risk assessment.
UCL 95% Upper Confidence Level Mean calculated using the H stat.
• Max used and UCL used indicate the concentration used as EPC in the risk assessment.

Table 10-20
Statistical Analysis of COPCs
Deep Water Bearing Zone
NAS Pensacola, Site 1
Pensacola, Florida

Chemical	n	Natural Log Transformed mean	SD	H stat	UCL (mg/L)	Max Hit (mg/L)		Reference Concentration (mg/L)	EPC (mg/L)
Manganese	3	3.9739	0.698	9.094	6.037	0.0901	Max used	0.0498	0.0901

NOTES:

- n Number of samples.
- mean Mean of detected values including defaults for log-transformed data set.
- SD Standard deviation for a sample of a population of data.
- H stat "H" statistic, from Gilbert, 1987; cuboidal linear interpolation was used to determine this value in accordance with USEPA Guidance, Calculating the Concentration Term.
- NA Not Applicable.
- EPC Exposure point concentration used for risk assessment.
- UCL 95% Upper Confidence Level Mean calculated using the H stat.
- Max used and UCL used indicate the concentration used as EPC in the risk assessment.

concentrations was used as the EPC in the risk assessment. Use of this algorithm as suggested in RAGS Part A is a reasonable compromise between use of zero and use of the sample quantitation limit to reduce the bias (positive or negative) in the calculated UCL.

10.1.3.5 Toxicity Equivalency Factors

Toxicity Equivalency Factors (TEFs) are chemical-specific values used to relate the carcinogenic potential of various polyaromatic hydrocarbons (PAHs) to that of benzo(a)pyrene [B(a)P]. As USEPA Region IV guidance suggests, the EPCs associated with the family of compounds that comprise PAHs are multiplied by a chemical-specific TEF. The following TEFs are used to convert the PAH concentrations to an equivalent concentration based on B(a)P:

Compound	TEF
Benzo(a)pyrene	1.0
Benzo(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Benzo(k)fluoranthene	0.01
Chrysene	0.001
Dibenzo(a,h)anthracene	1.0
Indeno(1,2,3-c,d)pyrene	0.1

10.1.3.6 Quantification of Exposure

This section describes the models, equations, and input parameter values used to quantify doses or intakes of the COPCs through the exposure pathways discussed in Section 10.1.3.3. The models are designed to estimate route- and medium-specific factors, which are multiplied by the EPC to estimate chronic daily dose. The intake model variables generally reflect 50th or 95th percentile values, which when applied to the EPCs ensure that the estimated intakes represent the RME. Formulae were derived from RAGS, Part A unless otherwise indicated. Table 10-21

Table 10-21
Parameters Used To Estimate Potential Exposures
For Current and Future Land Use Receptors

Pathway Parameters	CURRENT LAND USE Trespassing Child Age 7-16	FUTURE LAND USE Onsite Worker	Units
Incidental Ingestion of Soil			
Ingestion Rate	200[f]	50[b]	mg/day
Exposure Frequency	52[e]	250[b]	days/year
Exposure Duration	10[e]	25[b]	years
Body Weight	45[d]	70[b]	kg
AT-Noncancer	3,650[f]	9,125[f]	days
AT-Cancer	25,550[f]	25,550[f]	days
Dermal Contact with Soil			
Skin Surface Area	3,950[g]	4,100[g]	cm^2
Adherence Factor	1[h]	1[h]	mg/cm^2
Absorption Factor	CSV	CSV	unitless
Exposure Frequency	52[e]	250[b]	days/year
Exposure Duration	10[e]	25[b]	years
Body Weight	45[d]	70[b]	kg
Averaging Time-Noncancer	3,650[f]	9,125[f]	days
Averaging Time-Cancer	25,550[f]	25,550[f]	days
Incidental Surface Water Ingestion (while swimming)			
Ingestion Rate	0.13[f]	NA	liters/day
Exposure Frequency	52[b]	NA	days/year
Exposure Duration	10[e]	NA	years
Body Weight	45[d]	NA	kg
Averaging Time-Noncancer	3,650[d]	NA	days
Averaging Time-Cancer	25,550[e]	NA	days
Inhalation of Volatilized Surface Water Constituents (ORD VOC Guidance)			
$CDI_{inhalation} \cong CDI_{ingestion}$			

Note:
Trespasser assumptions for soil exposure were used to estimate incidental ingestion of and dermal contact with sediment while swimming (i.e., 16 waking hours per day were adjusted to reflect 2.6 hours swimming exposure per day swimming).

Table 10-21 Continued)
Parameters Used to Estimate Potential Exposures
for Future Land Use Receptors

	FUTURE LAND USE		
Pathway Parameters	Resident Adult	Resident Child (1-6 yrs)	Units
Incidental Ingestion of Soil			
Ingestion Rate	100'	200'	mg/day
Exposure Frequency	350[b]	350[b]	dayslyear
Exposure Duration	24"	6[a]	years
Exposure $Duration_{LWA}$	24"	6'	years
Body Weight	70'	15	kg
AT-Noncancer	8,760[d]	2,190[d]	days
AT-Cancer	25,550'	25,550[e]	days
Dermal Contact with Soil			
Skin Surface Area	4,100'	2,000'	cm^2
Adherence Factor	1[g]	1[g]	mg/cm^2
Absorption Factor	CSV	CSV	unitless
Exposure Frequency	350[b]	350[b]	dayslyear
Exposure Duration	24"	6'	years
Exposure $Duration_{LWA}$	24"	6[a]	years
Body Weight	70'	15'	kg
Averaging Time-Noncancer	8,760[d]	2,190[d]	days
Averaging Time-Cancer	25,550'	25,550'	days
Drinking Water Ingestion (Equivalent to Inhalation)			
Ingestion Rate	2	1	litersIday
Exposure Frequency	350[b]	350[b]	dayslyear
Exposure Duration	24"	6'	years
Exposure $Duration_{LWA}$	24'	6'	years
Body Weight	70'	15'	kg
Averaging Time-Noncancer	8,760[d]	2,190[d]	days
Averaging Time-Cancer	25,550'	25,550'	days
Inhalation of Volatilized Groundwater Constituents (ORD VOC Guidance)			
$CDI_{inhalation} \cong CDI_{ingestion}$			

Notes:

a	=	USEPA (1989a) "Risk Assessment Guidance for Superfund Vol. I, Human Health Evaluation Manual (Part A)."
b	=	Assumes a residential exposure frequency of 365 days per year with one two-week vacation.
c	=	USEPA (1991a, Risk Assessment Guidance for Superfund: Vol. I — Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals)," (OSWER Lead Guidance).
d	=	Calculated as the product of ED (years) x 365 days/year.
e	=	Calculated as the product of 70 years (assumed lifetime) x 365 days per year.
f	=	Skin surface area (i.e., adult resident - head, forearms and hands; child resident - head, arms, hands, and legs) provided by USEPA Region IV.
g	=	Specific guidance from USEPA Region IV (February 11, 1992 New Interim Region IV Guidance).
NA	=	Not applicable
CSV	=	Chemical-specific value

lists input parameters used to compute chronic daily intakes (CDI) for the potential current land use and future land use receptors. Figures 10-1 and 10-2 show the calculations used to estimate exposure for soil/sediment and water exposure pathways, respectively.

Age-adjusted ingestion and contact factors were derived for the future residential receptors (resident adult and resident child combined) for carcinogenic endpoints. These factors account for the difference in daily ingestion rates for soil and groundwater, surface areas, body weights, and exposure durations for children 1 to 6 years old and others 7 to 31 years old. The exposure frequency is assumed to be identical for the two exposure groups.

10.1.3.6.1 Incidental Ingestion of COPCs in Soil

Quantification of carcinogenic risk and hazard for COPCs identified in surface soils within Site 1 for the incidental ingestion pathway is estimated from the general equation:

$$CDI_s = (C_s)(IR)(FI)(EF)(ED)(CF)/(BW)(AT)$$

where:

CI_s	=	ingested dose of COPC (mg/kg-day)
C_s	=	concentration of COPC in soil (mg/kg)
IR	=	ingestion rate of soil (mg/d)
FI	=	fraction of daily intake from contaminated source (unitless)
EF	=	exposure frequency (d/yr)
ED	=	exposure duration (yr)
CF	=	conversion factor (10^{-6} kg/mg)
BW	=	body weight (kg)
AT	=	averaging time (d)

Figure 10-1

Formulae for Calculating CDI for Soil and/or Sediment

SOIL AND/OR SEDIMENT INGESTION PATHWAY

Residential Scenario:

Noncarcinogens - Child - Residential Scenario:

$$CDI_{NC\text{-}C} = \frac{C_s \times IR_{soil/sed/child} \times EF_{res} \times F \times FI \times ED_{child}}{AT_{NC\text{-}C} \times BW_{child}}$$

Noncarcinogens - Adult - Residential Scenario:

$$CDI_{NC\text{-}A} = \frac{C_s \times IR_{soil/sed/adult} \times EF_{res} \times F \times FI \times ED_{adult}}{AT_{NC\text{-}A} \times BW_{adult}}$$

Carcinogens (based on a lifetime weighted average):

$$CDI_C = \frac{C_s}{AT_C} \left[\frac{IR_{soil/sed/child} \times EF_{res} \times F \times FI \times ED_{child}}{BW_{child}} + \frac{IR_{soil/sed/adult} \times EF_{res} \times F \times FI \times ED_{adult}}{BW_{adult}} \right]$$

Figure 10-1 continues on the following page.

Figure 10-1 (continued)

Formulae for Calculating CDI for Surface Soil and/or Sediment

SOIL AND/OR SEDIMENT DERMAL CONTACT PATHWAY

Residential Scenario:

Noncarcinogens - Child - Residential Scenario:

$$CDI_{NC\text{-}C} = \frac{C_s \times CF_{soil/sed/child} \times EF_{res} \times F \times FC \times AF \times ABS \times ED_{child}}{AT_{NC\text{-}C} \times BW_{child}}$$

Noncarcinogens - Adult - Residential Scenario:

$$CDI_{NC\text{-}A} = \frac{C_s \times CF_{soil/sed/adult} \times EF_{res} \times F \times FC \times AF \times ABS \times ED_{adult}}{AT_{NC\text{-}A} \times BW_{adult}}$$

Carcinogens (based on a lifetime weighted average):

$CDI_c =$

$$\frac{C_s}{AT_C} \times \left[\frac{CF_{soil/sed/child} \times EF_{res} \times F \times FC \times AF \times ABS \times ED_{child}}{BW_{child}} + \frac{CF_{soil/sed/adult} \times EF_{res} \times F \times FC \times AF \times ABS \times ED_{adult}}{BW_{adult}} \right]$$

Figure 10-1 continues on the following page.

Figure 10-1 (continued)

Formulae for Calculating CDI for Surface Soil and/or Sediment

Variable	Description
BW_{child}	average child body weight (ages 1-6) (kg)
BW_{adult}	average adult body weight (kg)
BW_{trasp}	average trespasser body weight (ages 7-16) (kg)
ABS	absorbance factor (unitless value specific to organic versus inorganic compounds)
AF	adherence factor (1 mg/cm^2)
ED_{child}	child exposure duration (ages 1-6) (yr)
ED_{adult}	adult exposure duration (ages 7-31) (yr)
ED_{trasp}	trespasser exposure duration (ages 7-16) (yr)
$ED_{adult-w}$	adult worker exposure duration (yr)
EF_{res}	residential exposure frequency (ages 1-6) (days/year)
EF_{trasp}	trespasser exposure frequency (ages 7-16) (days/year)
EF_{w}	worker exposure frequency (days/year)
$IR_{soil/sed/child}$	child soil and/or sediment intake rate (mg/day)
$IR_{soil/sed/trasp}$	trespasser soil and/or sediment intake rate (mg/day)
$IR_{soil/sed/adult}$	adult soil and/or sediment intake rate (mg/day)
FC	fraction contacted from contaminated source (unitless = 1)
$CF_{soil/sed/child}$	child soil and/or sediment dermal contact factor (mg/day)
$CF_{soil/sed/trasp}$	trespasser soil and/or sediment dermal contact factor (mg/day)
$CF_{soil/sed/adult}$	adult soil and/or sediment dermal contact factor (mg/day)
AT_{C}	averaging time (carcinogen)
AT_{NC-A}	averaging time (noncarcinogen adult)
AT_{NC-C}	averaging time (noncarcinogen child)
C_{s}	chemical concentration in surface soil and/or sediment (mg/kg)
FI	fraction ingested from contaminated source (unitless = 1)
F	conversion factor (1 E-6 kg/mg)

Notes:
CDI indicates Chronic Daily Intake

The trespasser and/or worker scenario risk and hazard were calculated by substituting scenario-specific assumptions into the adult portions of the formulae and then deleting the child portions of the formulae.

Figure 10-2

Formulae for Calculating CDI for Water

WATER INGESTION PATHWAY

Residential Scenario:

Noncarcinogens - Child - Residential Scenario:

$$CDI_{NC\text{-}C} = \frac{C_w \times IR_{water/child} \times EF_{res} \times ED_{child} \times FI}{AT_{NC\text{-}C} \times BW_{child}}$$

Noncarcinogens - Adult - Residential Scenario:

$$CDI_{NC\text{-}A} = \frac{C_w \times IR_{water/adult} \times EF_{res} \times ED_{adult} \times FI}{AT_{NC\text{-}A} \times BW_{adult}}$$

Carcinogens (based on a lifetime weighted average):

$$CDI_C = \frac{C_w}{AT_C} \left[\frac{IR_{water/child} \times EF_{res} \times ED_{child} \times FI}{BW_{child}} + \frac{IR_{water/adult} \times EF_{res} \times ED_{adult} \times FI}{BW_{adult}} \right]$$

Figure 10-2 continues on the following page.

Figure 10-2 (continued1

Formulae for Calculating CDI for Water

PATHWAY: GROUNDWATER INHALATION WHILE SHOWERING

Residential Scenario:

In accordance with USEPA ORD RAGS Supplement: ***Guidance on Estimating Exposure to VOCs During Showering,*** July, 10, 1991 (ORD VOC Guidance).

$$CDI_{ingestion} = CDI_{inhalation}$$

Variable	Description
BW_{child}	average child body weight (ages 1-6) (kg)
BW_{trasp}	average trespasser body weight (ages 7-16) (kg)
BW_{adult}	average adult body weight (kg)
ED_{child}	child exposure duration during (ages 1-6) (yr)
ED_{trasp}	trespasser exposure duration during (ages 7-16) (yr)
ED_{adult}	adult exposure duration during (ages 7-31) (yr)
$ED_{adult-w}$	adult worker exposure duration during (yr)
EF_{res}	residential exposure frequency (days/year)
EF_{trasp}	trespasser exposure frequency (days/year)
EF_{w}	worker exposure frequency (days/year)
$IR_{water/child}$	child water intake rate (mg/day)
$IR_{water/adult}$	adult water intake rate (mg/day)
FI	fraction ingested from contaminated source (unitless = 11
AT_{C}	averaging time (carcinogen)
AT_{NC-A}	averaging time (noncarcinogen adult)
AT_{NC-C}	averaging time (noncarcinogen child)
C_{w}	chemical concentration in water (mg/l)

Note:
CDI indicates Chronic Daily Intake

Figure 10-1 provides the formulae used to calculate the CDI for soil pathways, which includes calculation of the soil ingestion contributions from the future residential receptors, current child trespassers, and the future site worker receptor. Soil ingestion exposure parameters for each .receptor, reflective of the RME, are listed beneath the formulae in the figure. Incidental surface soil ingestion CDIs are presented in Table 10-22, including all pertinent receptor groups and toxicological endpoints.

10.1.3.6.2 Dermal Contact with COPCs in Soil

Unlike the methods for estimating inhaled or ingested dose of COPCs, which quantify the dose presented to the barrier membrane (the pulmonary or gastrointestinal mucosa, respectively), dermal dose is estimated as the dose that crosses the skin and is systemically absorbed. For this reason, dermal toxicity values are also based on absorbed dose (see Section 10.1.4). The absorbed dose of COPC from soil is estimated from the equation:

$$A_s = (C_s)(SA)(AF)(ABS)(EF)(ED)(CF)/(BW)(AT)$$

where:

A_s	=	dermally absorbed dose of COPC (mg/kg)
C_s	=	concentration of COPC in soil (mg/kg)
SA	=	surface area of the skin available for contact with soil (cm^2/event)
AF	=	soil-to-skin adherence factor (mg/cm^2)
ABS	=	absorption factor (unitless, chemical-specific value)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
CF	=	conversion factor (10^{-6} kg/mg)
BW	=	body weight (kg)
AT	=	averaging time (days)

Table 10-22
Chronic Daily Intakes (CDI)
Incidental Ingestion of Surface Soil (0-1')
NAS Pensacola, Site 1
Pensacola, Florida

Chemical	Exposure Point Concentratbn (mg/kg)	TEF (unitless)	Fraction from Contaminated Source	Resident Adult H-CDI (mg/kg-day)	Resident Child H-CDI (mg/kg-day)	Resident lwa C-CDI (mg/kg-day)	Trespassing Child (age 7-18) H-CDI (mg/kg-day)	Trespassing Child (age 7-18) C-CDI (mg/kg-day)	Future Ske Worker H-CDI (mg/kg-day)	Future Site Worker C-CDI (mg/kg-day)
Aluminum	4006	NA	1	6.49E-03	5.12E-02	8.27E-03	1.27E-03	1.81E-04	1.98E-03	7.00E-04
Beryllium	0.239	NA	1	3.27E-07	3.06E-06	3.74E-07	7.67E-08	1.08E-08	1.17E-07	4.18E-08
Cadmium (food)	2.74	NA	1	3.75E-08	3.50E-05	4.29E-08	8.87E-07	1.24E-07	1.34E-06	4.79E-07
Lead	102.2	NA	1	1.40E-04	1.31E-03	1.80E-04	3.24E-06	4.82E-08	5.00E-05	1.79E-05
Manganese	40.67	NA	1	6.58E-06	5.19E-04	8.35E-06	1.28E-05	1.83E-08	1.98E-05	7.09E-06
Aroclor-1248	0.0241	NA	1	3.30E-08	3.08E-07	3.77E-08	7.83E-09	1.09E-09	1.18E-08	4.21E-09
Aroclor-1254	0.0269	NA	1	3.68E-08	3.44E-07	4.21E-08	8.62E-09	1.22E-09	1.32E-08	4.70E-09
Aroclor-1260	0.00584	NA	1	8.00E-09	7.47E-08	9.14E-09	1.85E-09	2.64E-10	2.88E-09	1.02E-09

NOTES:

lwa Lifetime weighted average; used to calculate carcinogenic CDI, RAGS Parts A and B.
CDI Chronic Daily Intake in mg/kg-day.
H-CDI CDI for hazard quotient.
C-CDI CDI for excess cancer risk.
NA No information available.
TEF Toxicity equivalency factor used to modify the concentration of polynuclear aromatic hydrocarbons relative to benzo(a)pyrene.

As the equation for dermal absorbed dose is written, the absorbed dose is expressed in terms of mg/kg-day. This assumes that the exposed skin surface area is constant for each exposure, and that one exposure occurs per day. A, must be expressed as mg/kg-day in order to be compatible with the expression of dermal toxicity values as mg/kg-day for noncancer effects and as reciprocal mg/kg-day for carcinogenicity.

Figure 10-1 provides the formulae for calculating the CDI for soil, which includes calculation of the dermal contact with soil contributions for the current worker and trespasser and 'futuresite residents. Dermal contact with soil contaminants reflective of RME for each receptor are listed beneath the formulae in the figure. Dermal reference doses and cancer slope factors are derived from the corresponding oral values. The methods regarding the derivation of these factors are discussed in Section 10.1.4. Dermal contact soil exposure CDIs are presented in Table 10-23 for dermal contact with surface soil.

10.1.3.6.3 Ingestion of COPCs in Groundwater

The following equation is used to estimate the ingestion of COPCs in groundwater:

$$CDI_w = (C_w)(IR)(EF)(ED)/(BW)(AT)$$

where:

CDI_w	=	ingested dose (mg/kg-day)
C_w	=	concentration of contaminant in groundwater (mg/L)
IR	=	ingestion rate (L/day)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
BW	=	body weight (kg)
AT	=	averaging time (days)

Table 10-23
Chronic Daily Intakes
Dermal Contact with Surface Soil (1)
NAS Pensacola, Site 1
Pensacola, Florida

Chemical	Dermal Absorption Factor (unitless)	Exposure Point Concentration (mg/kg)	TEF (unitless)	Fraction from Contaminated Source	Resident adult H-CDI (mg/kg-day)	Resident child H-CDI (mg/kg-day)	Resident lwa C-CDI (mg/kg-day)	Trespassing child (age 7-16) H-CDI (mg/kg-day)	Trespassing child (age 7-16) C-CDI (mg/kg-day)	Future Site Worker H-CDI (mg/kg-day)	Future Site Worker C-CDI (mg/kg-day)
Aluminum	0.001	4006	NA	1	2.25E-04	5.12E-04	1.21E-04	5.01E-05	7.16E-06	1.61E-04	5.74E-05
Beryllium	0.001	0.239	NA	1	1.34E-08	3.06E-08	7.22E-09	2.99E-09	4.27E-10	9.59E-09	3.42E-09
Cadmium (food)	0.001	2.74	NA	1	1.54E-07	3.50E-07	8.28E-08	3.43E-08	4.89E-09	1.10E-07	3.93E-08
Lead	0.001	102.2	NA	1	5.74E-06	1.31E-05	3.09E-06	1.28E-06	1.83E-07	4.10E-06	1.46E-06
Manganese	0.001	40.57	NA	1	2.28E-06	5.19E-06	1.23E-06	5.07E-07	7.25E-08	1.63E-06	5.81E-07
Aroclor-1248	0.010	0.0241	NA	1	1.35E-08	3.08E-08	7.28E-09	3.01E-09	4.31E-10	9.67E-09	3.45E-09
Aroclor-1254	0.010	0.0269	NA	1	1.51E-08	3.44E-08	8.13E-09	3.36E-09	4.81E-10	1.08E-08	3.85E-09
Aroclor-1260	0.010	0.00584	NA	1	3.28E-09	7.47E-09	1.76E-09	7.30E-10	1.04E-10	2.34E-09	8.37E-10

NOTES:

lwa Lifetime weighted average; used to calculate carcinogenic CDI RAGS Parts A and B.
CDI Chronic Daily Intake in mg/kg-day.
H-CDI CDI for hazard quotient.
C-CDI CDI for excess cancer risk.
NA No information available.
TEF Toxicity equivalency factor used to modify the concentration of polynuclear aromatic hydrocarbons relative to benzo(a)pyrene.
- The dermal absorption factor was applied to the EPC to reflect the different transdermal migration of inorganic versus organic chemicals.

Figure 10-2 provides the formulae for calculating the CDI for groundwater, which includes the calculation of the ingestion of groundwater by residential receptors. Groundwater ingestion exposure parameters reflective of RME exposure for the residential receptor are listed beneath the formulae in the figure. Tables 10-24 and 10-25 present groundwater ingestion CDIs for future site residents for the combined shallow/intermediate and deep water-bearing zones, respectively. The CDI for inhalation (Table 10-23) is equivalent to the ingestion CDI according to the most recent Supplemental Guidance to RAGS.

10.1.3.6.4 Inhalation of Volatilized COPCs During Domestic Water Use

The following equation is used to estimate VOC doses resulting from inhalation of VOCs during domestic groundwater use:

$$CDI, = CDI_w$$

where:

CDI, = VOC inhalation dose (mg/kg-day)

CDI_w = ingested dose (mg/kg-day)

The ORD VOC Guidance considers inhalation exposures during showering and other domestic activities equivalent to that from ingestion of 2 Uday of contaminated tap water. As a result, the inhalation CDIs have been set equal to the ingestion CDIs for each volatile groundwater contaminant. Calculation of risk/hazard associated with the inhalation pathway necessitates the use of chemical-specific inhalation slope factors and/or references doses. Where available, inhalation-based toxicological values have been applied in Section 10.1.5. No VOCs were detected in deep zone groundwater; therefore, this exposure pathway is not addressed.

Table 10-24
Chronic Daily Intakes for Future Residents
ingestion and Inhalation of Shallow and Intermediate Groundwater
NAS Pensacole, Site 1
Pensacole, Florida

Chemical	Exposure Point Concentration (mg/L)	Future use		
		Resident Adult H-CDI (mg/kg/day)	Resident Child H-CDI (mg/kg/day)	Resident lwa C-CDI (mg/kg/day) (a)
1,1-Dichloroethane	0.008	2.19E-04	5.1 1E-04	11 9E-04
1.2-Dichlorobenzene	0.005	1.37E-04	3.20E-04	7.44E-05
1,2-Dichloroethene (total)	0.00303	8.30E-05	1.94E-04	4.51 E-05
1,1,2,2-Tetrachloroethane	0.001	3.76E-05	8.76E-05	2.04E-05
1,4-Dichlorobenzene	0.007	2.02E-04	4.72E-04	1.10E-04
1,1,2-Trichloroethane	0.0006374	1.75E-05	4.07E-05	9.48E-06
2-Methylnaphthalene	0.002143	5.87E-05	1.37E-04	3.19E-05
Aluminum	0.45	1.23E-02	2.87E-02	6.68 E-03
Arsenic	0.01 23	3.37E-04	7.8 5E-04	1.83E-04
Barium	0.1 1293	3.09E-03	7.22E-03	1.68E-03
Benzene	0.0264	7.23E-04	1.69E-03	3.9 2E-04
Bis(2-ethylhexyl)phthalate	0.000889	2.44E-05	5.68 E-05	1.32E-05
Bromoform	0.0012749	3.49E-05	8.15E-05	1.90E-05
Cadmium	0.002865	7.85E-05	1.83E-04	4.26E-05
Chlorobenzene	0.1 2	3.29E-03	7.67E-03	1.78E-03
Chloroethane	0.002	5.48E-05	1.28E-04	2.97E-05
Chloroform	0.002373	6.50E-05	1.52E-04	3.53E-05
Chromium	0.0105936	2.90E-04	6.77E-04	1.58E-04
Copper	0.0101996	2.79E-04	6.52E-04	1.52E-04
Dieldrin	0.000004	1.13E-07	2.65E-07	6.1 6E-08
Manganese	0.042009	1.15E-03	2.69E-03	6.25E-04
Naphthalene	0.005399	1.48E-04	3.45E-04	8.03E-05
Nickel	0.030824	8.44E-04	1.97E-03	4.58E-04
Trichloroethene	0.000637	1.75E-05	4.07E-05	9.47E-06
Vinyl Chloride	0.002462	6.75E-05	1.57E-04	3.66E-05
Xylenes (total)	0.01 2807	3.51 E-04	8.19E-04	1.90E-04
Zinc	0.4614	1.26E-02	2.95E-02	6.86E-03

NOTES:

e Carcinogenic chronic daily intake is based on the lifetime weighted average (lwa) of an adult age 7-31 and a child age 1-6.
CDI Chronic daily intake in units of mg/kg/day.
H-CDI CDI for hazard quotient.
C-CDI CDI for excess cancer risk.

Table 10-25
Chronic Daily intakes for Future Residents
Ingestion and Inhalation of Deep Groundwater
NAS Pansacola, Site 1
Pensacola, Florida

Chemical	Exposure Point Concentration (mg/L)	Future Use		
		Resident Adult H-CDI (mg/kg/day)	Resident Child H-CDI (mg/kg/day)	Resident Iwa C-CDI (mg/kg/day) (a)
Manganese	0.0901	2.47E-03	5.76E-03	1.34E-03

NOTES:

a Carcinogenic chronic daily intake is based on the lifetime weighted average (Iwa) of an adult age 7-31 and a child age 1-6.
CDI Chronic daily intake in units of mg/kg/day.
H-CDI CDI for hazard quotient.
C-CDI CDI for excess cancer risk.

10.1.3.6.5 Ingestion/Inhalation of Surface Water, Ingestion of Sediment, and Dermal Contact With Sediment

CDIs for ingestion/inhalation of surface water, ingestion of sediment, and dermal contact with sediment were calculated using the formulae shown in Figures **10-1** and **10-2.** CDIs for ingestion/inhalation of surface water, ingestion of sediment, and dermal contact with sediment are shown in Tables **10-26, 10-27,** and **10-28,** respectively.

10.1.4 Toxicity Assessment

10.1.4.1 Carcinogenicity and Noncancer Effects

USEPA has established a classification system for rating the potential carcinogenicity of environmental contaminants based on the weight of scientific evidence. The cancer classes are described below. Cancer weight-of-evidence class "**A**" (human carcinogens) means that human toxicological data have shown a proven correlation between exposure and the onset of cancer (in varying forms). The **"B1"** classification indicates some human exposure studies have implicated the compound as a probable carcinogen. Weight-of-evidence class **"B2"** indicates a possible human carcinogen, a description based on positive laboratory animal data (for carcinogenicity) in the absence of human data. Weight-of-evidence class "C" identifies possible human carcinogens, and class "D" indicates a compound not classifiable with respect to its carcinogenic potential. **USEPA** has established slope factors (SF) for carcinogenic compounds. The SF is defined as a "plausible upper-bound estimate of the probability of a response (cancer) per unit intake of a chemical over a lifetime."

In addition to potential carcinogenic effects, most substances *can* **also** produce systemic toxic responses at doses greater than experimentally derived thresholds. **USEPA** has derived Reference Dose (RfD) values for these substances. **A** chronic RfD is defined as "an estimate (with uncertainty spanning perhaps an order of magnitude or greater) of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an

Table 10-26
Chronic Daily Intakes for Future Residents
Ingestion and Inhalation of Surface Water
NAS Pensacola, Site 1
Pensacola, Florida

Chemical	Exposure Point Concentration (mg/L)	Future Use: Trespassing Child (age 7-16)* H-CDI (mg/kg/day)	Future Use: Trespassing Child (age 7-16)* C-CDI (mg/kg/day)
1,4-Dichlorobenzene	0.002	2.47E-06	3.53E-07
Arsenic	0.0034	4.20E-06	6.00E-07
Benzene	0.002	2.47E-06	3.53E-07
Chlorobenzene	0.007	8.64E-06	1.23E-06
Manganese	0.149	1.84E-04	2.63E-05

NOTES:

CDI Chronic daily intake in units of mg/kg/day.
H-CDI CDI for hazard quotient.
C-CDI CDI for excess cancer risk.
* CDI was adjusted to represent 2.6 hours swimming par 16 waking hours.

Table 10-27
Chronic Daily Intakes (CDI)
Incidental Ingestion of Sediment
NAS Pensacola, Site 1
Pensacola, Florida

Chemical	Exposure Point Concentration (mg/kg)	Fraction from Contaminated Source	Trespassing child (age 7-16) H-CDI (mg/kg-day)	Trespassing child (age 7-16) C-CDI (mg/kg-day)
Aluminum	8120	1	4.18E-04	5.97E-05
Arsenic	8.4	1	4.32E-07	6.17E-08
Manganese	105	1	5.40E-06	7.72E-07

NOTES:

Iwa Lifetime weighted average; used to calculate carcinogenic CDI, RAGS Parts A and B.
CDI Chronic Daily Intake in mg/kg-day.
H-CDI CDI for hazard quotient.
C-CDI CDI for excess cancer risk.
- CDI was adjusted to represent 2.6 hours swimming per 16 waking hours.

Table 10-28
Chronic Daily Intakes (CDI)
Dermal *Contact* wkh Sediment
NAS Pensacola, *Site* 1
Pensacola, Florida

Chemical	Dermal Absorption Factor (unitless)	Exposure Point Concentration (mg/kg)	Fraction from Contaminated Source	Trespassing child (age 7-16) H-CDI (mg/kg-day)	Trespassing child (age 7-16) C-CDI (mg/kg-day)
Aluminum	0.001	8120	1	1.65E-05	2.36E-06
Arsenic	0.001	8.4	1	1.71E-08	2.44E-09
Manganese	0.001	105	1	2.13E-07	3.05E-08

NOTES:

Iwa Lifetime weighted average; used to calculate carcinogenic CDI, RAGS Parts A and B.
CDI Chronic Daily Intake m mg/kg-day.
KCDI CDI for hazard quotient.
C-CDI CDI for excess cancer risk.
- The dermal absorption factor was applied to the EPC to reflect the different transdermal migration of Inorganic versus organic chemicals.
- CDI was adjusted to represent 2.6hours swimming per 16 waking hours.

appreciable risk of deleterious effects during a lifetime." These toxicological values are used in risk formulae to assess the upper-bound level of cancer risk and noncancer hazard associated with exposure to a given concentration of contamination.

For carcinogens, the potential risk posed by a chemical is computed by multiplying the CDI (as mg/kg-day) by the SF (in reciprocal mg/kg-day). The hazard quotient (for noncarcinogens) is computed by dividing the CDI by the RfD. USEPA has set standard limits (or points of departure) for carcinogens and noncarcinogens to evaluate whether significant risk is posed by a chemical (or combination of chemicals). For carcinogens, the point-of-departure range is 1E-6 with a generally accepted range of 1E-4 to 1E-6. These risk values correlate with 1 in 10,000 and 1 in 1,000,000 excess cancer incidents resulting from exposure to xenobiotics.

For noncarcinogens, other toxic effects are generally considered possible if the hazard quotient (or sum of hazard quotients for a pathway — hazard index) exceeds unity (a value of 1). Although both cancer risk and noncancer hazard are generally additive (within each group) only if the target organ is common to multiple chemicals, a most conservative estimate of each may be obtained by summing the individual risks or hazards regardless of target organ. This BRA has taken the universal summation approach for each class of toxicant. Additional details regarding the risk formulae applied to Site 1 media are provided in Section 10.1.5.

Table 10-29 summarizes toxicological data in the form of RfDs and SFs obtained for each COPC identified in Site 1 media. Critical studies used in the establishment of toxicity classifications by USEPA are shown in the Integrated Risk Information System (IRIS) database (primary source) and/or Health Effects Assessment Summary Tables (HEAST) Fiscal Year 1994 (secondary source). Where applicable, these values were also included in the database for this BRA. Drinking water standards in the form of federal and State of Florida MCLs and guidance levels have been established for a number of chemicals detected in groundwater in the study

Table 10-29
Toxicological Database Information for
Chemicals of Potential Concern
NAS Pensacola, Site 1

Noncarcinogenic Toxicity Data

Chemical	Oral Reference Dose (mg/kg/day)		Confidence Level	Critical Effect	Uncertainty Factor Oral	Inhalation Reference Dose (mg/kg/day)		Confidence Level	Critical Effect	Uncertainty Factor Inhalation
1,2-Dichloroethene (total)	0.009	b	L	increased serum phosphatase	1000	ND				NO
1,4-Dichlorobenzene	ND				ND	0.229	a	M	increased liver weight	NUI
Aluminum	L	o			NO	ND				NO
Arsenic	0.0003	g	M	hyperpigmentation	E	NO				NO
Benzene	NO				NO	0.00171	e	NA		NO
Barium	0.07	a	M	increased blood pressure	NO	0.000143	b	NA		NO
Bromoform	0.02	a	M	hepatic lesions	ND	NO				NO
Chloroform	0.01	a	M	fatty cyst in liver	ND	ND				NO
Zinc	0.3	a	M	decreased enzyme levels	E	NO				NO
Beryllium	0.005	a	L	microscopic organ changes	100	ND				NO
bis(2-Chloroethyl)ether	ND				NO	NO				NO
bis(2-Ethylhexyl)phthalate	0.02	a	M	increased liver weight	1000	ND				NO
Cadmium (food)	0.001	a	H	proteinuria	10	NO				NO
Cadmium (water)	0.0005	a	H	proteinuria	10	ND				NO
Chlorobenzene	0.02	a	M	liver changes	1000	0.00571	c			10000
Chromium	L	a	L	NA	100/10	NO				NO
Copper	0.0371	b	NA	NA	NO	NO				NO
Dieldrin	5E-05	a	M	liver lesions	100	NO				NO
Lead	NO				NO	ND				NO
Manganese (water)	0.005	a	NA	neurological effects	1	1.43E-05	a	M	neurological effects	1000
Manganese (food)	0.14	g	NA	neurological effects	1	NO				NO
PCB Aroclor-1248	NO				ND	NO				NO
PCB Aroclor-1254	2E-05	a	NA		ND	NO				NO
PCB Aroclor-1260	NO				NO	ND				ND
Tetrachloroethene	0.01	a	M	hepatotoxicity	1000	ND				NO
Trichloroethene	0.006	e	NA		3000	NO				NO
Vinyl chloride	ND				ND	NO				NO
1,1,2-Trichloroethane	0.004	a	M	clinical serum chemistry	ND	ND				NO
1,1,2,2-Tetrachloroethane	ND				ND	ND				NO
Naphthalene	NO				ND	NO				NO
Nickel	0.02	a	M	decreased body and organ weight	300	NO				NO
4-Chloro-3-methylphenol	NO				ND	ND				NO
Toluene	0.2	a	M	increased liver weight	1000	ND			neurological effects	300
Xylene	2	a	M	decreased body weight, hyperactivi	100	ND				NO

Table 10-29 is continued on the following page.

Tabb 10-29
Toxicological Database Information fo
Chemicals of Potential Concern
NAS Pensacola, Site 1

Carcinogenic Toxkky Data

Chemical	Oral Slope Factor [(mg/kg/day)]-1		Inhalation Slope Factor [(mg/kg/day)]-1		Weight of Evidence	Tumor Type
1,2-Dichloroethene (total)	ND		ND		D	
1,4-Dichlorobenzene	0.024	b	ND		82	NA
Aluminum	ND		ND		ND	
Arsenic	1.6	a	16.1	a	A	various
Benzene	0.02s	a	0.029	a	A	leukemia
Barium	ND		ND		D	
Bromoform	0.0079	a	0.00385	a	B2	varbur
Chloroform	0.0061	a	0.0805	a	82	various
Zinc	NO		ND		D	
Beryllium	4.3	a	8.4	a	82	osteosarcoma
bis(2-Chloroethyl)ether	1.1	a	1.16	a	ND	hepatoma
bis(2-Ethylhexyl)phthalate	0.014	a	ND		82	hepatoma
Cadmium (food)	ND		6.3	a	81	lung
Cadmium (water)	ND		6.3	a	B1	lung
Chlorobenzene	ND		ND		D	
Chromium	ND		42	a	D	
Copper	ND		ND		D	
Dieldrin	16	a	16.1	a	82	hepatoma
Lead	ND		ND		82	varbur
Manganese (water)	ND		ND		D	
Manganese (food)	ND		ND		D	
PCB Aroclor-1248	7.7		ND		82	hepatocellular carcinoma
PCB Aroclor-1254	7.7		ND		82	hepatocellular carcinoma
PCB Aroclor-1260	7.7		ND		82	hepatocellular carcinoma
Tetrachloroethene	0.052	e	0.00203	e	ND	
Trichloroethene	0.01 1	f	0.006	a	82	NA
Vinyl chloride	1.9	b	0.3	b	A	hepatocellular, carcinoma
1,1,2-Trichloroethane	0.057	a	0.056	a	C	hepatocellular carcinoma
1,1,2,2-Tetrachloroethane	0.2	a	0.203	a	ND	
Naphthalene	ND		ND		D	
Nickel	ND		ND		D	
4-Chloro-3-methylphenol	ND		ND		D	
Toluene	ND		ND		D	
Xylene	ND		ND		D	

Tabb 10-29 is continued on the following page.

Table 10-29
Toxicological Database Information for
Chemicals of Potential Concern
NAS Pensacola, Site 1

Noncarcinogenic Toxkky Data

Chemical	Oral Reference Dose (mg/kg/day)	Confidence Level	Critical Effect	Uncertainty Factor Oral	Inhalation Reference Dora (mg/kg/day)	Confidence Level	Critical Effect	Uncertainty Factor Inhalation

NOTES

a Integrated Risk Information System (IRIS).
b Health Effects Assessment Summary Tables (HEAST).
c HEAST alternative method.
d USEPA Region III Screening Tables.
a EPA Environmental Criteria and Assessment Office - Cincinnati (provisional).
f Withdrawn from IRIS or HEAST.
NA Not applicable or not available.
ND Not determined d w to lack of information.
- Toxicological data for naphthalene were used as surrogates for 2-methylnaphthalene.

area. These chemicals include hazardous substances identified as toxicants (carcinogens and/or noncarcinogens) in published research studies. These standards are considered ARARs for groundwater potentially used as a source of potable water. The available drinking water standards for compounds detected in groundwater are included in the groundwater risk characterization and risk uncertainty discussions for reference.

10.1.4.2 Evaluating Dermal Toxicity

Dermal RfD values and SFs are derived from the corresponding oral values. In the derivation of a dermal RfD, the oral RfD is multiplied by an oral absorption factor (ABF), expressed as a decimal fraction. The resulting dermal RfD is based on the absorbed dose, which is the appropriate value with which to compare a dermal dose, because they are expressed as absorbed rather than administered (intake) doses. For the same reasons, a dermal SF is derived by dividing the oral SF by the ABF. The oral SF is divided rather than multiplied because SFs are expressed as reciprocal doses.

Appendix A of RAGS, Part A states that in the absence of specific data, an assumption of 5% oral absorption efficiency would be relatively conservative. Supplemental Guidance to RAGS: Region IV Bulletin indicates that in the absence of specific data, USEPA Region IV suggests an oral-to-dermal absorption factor of 80% for VOCs, 50% for SVOCs, and 20% for inorganic chemicals. These percentages (or associated fractions) were used in the BRA and are reflected in the applicable CDI results.

10.1.4.3 Toxicity Profiles for COPCs at Site 1

As required for BRAs by USEPA Region IV, summary toxicological profiles are included for all COPCs. Most information for the brief profiles below was gleaned from IRIS as a primary source, and HEAST. Another source of information was Smith, R.L., USEPA *Region III Risk-Based Screening Concenrrations Table,* March 1994. Any additional references are noted specifically in the briefs below (in parentheses). The profiles summarize adverse effects of

COPCs and the amount of the COPC associated with adverse effects. This means the inhalation reference dose (RfDi), oral reference dose (RfDo), inhalation slope factor (SFi), and oral slope factor (SFo) are included in the discussion where applicable.

1,2-Dichloroethene is a halogenated hydrocarbon associated with toxicity to the mucous membrane, skin, lung, cornea (irritation), and liver. This compound is less toxic than its alkane counterparts, and is neither mutagenic nor carcinogenic. There is no USEPA carcinogenicity listing for this compound. However, the RfDo has been set to 0.009 mg/kg-day by USEPA (Dreisbach, et al., 1987).

1,1,2-Trichloroethane depresses the central nervous system and also targets the liver and kidneys. Irritation of mucous membranes, skin, and eyes are also effects of exposure to this compound. This compound is not carcinogenic, but the resultant liver toxicity can be increased where exposure to 1,1,2-trichloroethane also includes exposure to alcohols and/or ketones. This compound is classified as a class C carcinogen by USEPA, which set the SFo and SFi to 0.057 and 0.056 $(mg/kg\text{-}day)^{-1}$, respectively. The RfDo has been set to 0.004 mg/kg-day (Dreisbach, et al., 1987).

1,1,2,2-Tetrachloroethane is a VOC used in industry and is also found as a contaminant in many other solvents. The target organs of this solvent are the central nervous system, the liver, and the kidneys. Chronic exposure causes congestion of the target organs, intoxication, tremor, and the alteration of nerve function. The effect on the liver *can* lead to jaundice. Acute exposure to this compound causes long-lasting narcosis with delayed onset. Additional effects are irritation of the mucous membranes, nausea, and headache which *can* progress to coma. Simultaneous exposure to alcohols or ketones *can* exacerbate the toxic effects of this compound. The exposure limit for inhalation is 1 ppm. In addition to the noncarcinogenic effects of tetrachloroethane, it is classified as a class A-B carcinogen by USEPA. The USEPA set the SFo and SFi to 0.2 and 0.203 $(mg/kg\text{-}day)^{-1}$, respectively (Dreisbach, et al., 1987).

Bromoform is a halogenated volatile organic, similar to chloroform. This compound targets the liver, kidney and central nervous system. Bromoform is classified as a B2 carcinogen by USEPA. The SFo and SFi are 0.0079 and 0.00385 $(mg/kg\text{-}day)^{-1}$, respectively. The RfDo is 0.02 mg/kg-day (Dreisbach, et al., 1987).

Chloroform, a halogenated hydrocarbon, has been used as a fumigant and an additive used to suppress the fire hazard of carbon disulfide, as well as having a low capacity for insect control. Volatile and gaseous anesthetics such as chloroform are sometimes used to produce general anesthesia. This contaminant is the primary chlorinated hydrocarbon produced during chlorination of drinking water, and is commonly present at low concentrations in most drinking water supplies. This compound depresses all function of the central nervous system in descending order from the cortex to the medulla. Additional target organs include the liver, heart, and kidney. Chloroform exposure to the heart sensitizes the muscle to arrhythmias, as do many halogenated hydrocarbons. This action could interfere with digitalis glycosides or a pacemaker in the form of premature or uncontrolled beats. Chloroform is a class B2 carcinogen, and USEPA set the SFo and SFi to 0.0061 and 0.0805 $(mg/kg\text{-}day)^{-1}$, respectively. The RfDo is 0.01 mg/kg-day (Dreisbach, et al., 1987).

2-Methylphenoland most compounds related to phenol are cellular toxicants. These compounds can cause bladder tumors, and might be carcinogens and/or sensitizers. USEPA has determined the RfDo to be 0.05 mg/kg-day (Dreisbach, et al., 1987).

Naphthalene, as well as ***2-methylnapthalene***, is obtained from coal tar, is used as a moth repellant and synthetic intermediate. The primary effect of naphthalene is on the kidneys due to its effect on the blood. Naphthalene was determined *to* be a USEPA class D carcinogen (i.e., not classified due to insufficient data), and USEPA determined the RfDo to be 0.04 mg/kg-day, which was withdrawn from IRIS/HEAST (Dreisbach, et al., 1987).

Tetrachloroethene **(PCE)** has been **used** as a solvent in industry and occurs as a volatile contaminant in other chlorinated hydrocarbons. Tetrachloroethene exposure can result in long-lasting narcosis with delayed onset and damage to the liver and kidneys. The principal manifestations of over-exposure to this halogenated hydrocarbon *are* coma, jaundice, and oliguria, and irritation of the eyes and nose followed by headache and nausea. Cyanosis and central nervous system depression progressing to coma appear up to four hours after the short-term exposure. Liver and kidney damage after apparent recovery or after repeated exposures causes acute symptoms such as nausea, vomiting, abdominal pain, jaundice, oliguria, and uremia. **PCE** exposure via the inhalation and/or skin absorption exposure pathways could result in headache, tremor, dizziness, peripheral paresthesia, hypesthesia, or anesthesia. **PCE** is a carcinogen, but is currently under review by **USEPA;** it is currently classified as a **B2-C** carcinogen. The RfDo has been set to 0.01 mg/kg-day, and the SF_o and SF_i have been set to 0.052 and 0.00203 **(mg/kg-day)$^{-1}$, respectively,** by **USEPA** (Dreisbach, et al., 1987).

Trichloroethene (TCE) is a mobile, volatile liquid with the characteristic odor of chloroform. Inhalation, intravenous and subcutaneous routes are all viable exposure pathways for this compound. TCE is a strong skin and eye irritant that is relatively less toxic if ingested. Inhalation of high concentrations causes narcosis and anesthesia. This compound targets the liver and other organs. TCE is a B2 carcinogen, and the SFo and SFi have been set by **USEPA** to 0.011 and 0.006 (mg/kg-day)$^{-1}$, respectively. **USEPA** also set the RfDo to 0.006 mg/kg-day (Dreisbach, et al., **1987).**

Aluminum is one of the most abundant metals in the earth's crust (7% aluminum), and it is ubiquitous in air and water, as well as soil. **This** metal is water-soluble, silvery, and ductile, which suggests its usefulness in **many** processes. Ingesting aluminum ***can*** affect the absorption of other elements within the gastrointestinal tract and *can* alter intestinal function. Aluminum ***can*** potentially interfere with the absorption of essential nutrients and cholesterol. Another effect on the gastrointestinal system is the inhibition of acetylcholine-induced contractions. These

contractions are part of the neuro-muscular system controlling bowel muscles. The effect could explain why aluminum-containing antacids often produce constipation. Aluminum dust is moderately flammable and explosive in heat. Inhaling this dust can cause fibrosis (aluminosis). No data are available on an applicable SF or the USEPA cancer group. The USEPA Region IV Office of Health Assessment suggested using the provisional oral RfD of 1.0 mg/kg-day. The aesthetic-based SMCL for drinking water is 50 to 200 μg/L (Klaassen, et al., 1986) (Dreisbach, et al., 1987).

Arsenic exposure via the ingestion route causes darkening and hardening of the skin in chronically exposed humans. Inhalation exposure to arsenic causes neurological deficits, anemia, and cardiovascular effects. USEPA set 0.3 μg/kg-day as the RfD for arsenic based on a NOAEL of 0.8 μg/kg-day in a human exposure study. Arsenic's effect on the nervous and cardiovascular systems is primarily associated with acute exposure to higher concentrations. Exposure to arsenic containing materials has been shown to cause cancer in humans. Inhaling these materials can lead to increased lung cancer risk, and ingestion of these materials is associated with increased skin cancer rates. Arsenic has been classified as a group A carcinogen by USEPA, which set the 1.5 $(mg/kg\text{-}day)^{-1}$ SF for arsenic. Human milk contains about 3 μg/L arsenic. The RBC for arsenic in tap water is 0.038 μg/L (Klaassen, et al., 1986).

Barium is used in various alloys, paints, soap, and manufacture processes. Barium sulfate is used to aid X-ray diagnosis. This element is relatively abundant in nature and is found in plant and animal tissue. Brazil nuts contain 3 to 4 mg per gram of nuts. The fatal absorbed dose of barium is approximately 1000 mg (for humans). Assuming an absorption efficiency of 5% for barium, 20,000 mg of ingested barium could be fatal (approximately 333 Brazil nuts, assuming 15 g/nut). Major toxic effects of this element are muscle stimulation, central nervous system effects, and effects on the heart. USEPA determined the RfDo and RfDi to be 0.07 and 1.43E-4 mg/kg-day, respectively (Dreisbach, et al., 1987) (Klaassen, et al., 1986).

Beryllium exposure via the inhalation route *can* cause inflammation of the lungs, a condition known as acute beryllium disease, as a result of short-term exposure to high concentrations. Removal from exposure reverses the symptoms. Chronic exposure to much lower concentrations of beryllium or beryllium oxide by inhalation has been reported to cause chronic beryllium disease, with symptoms including shortness of breath, scarring of the lungs, and berylliosis, which is noncancerous growths in human lungs. Both forms of beryllium disease can be fatal, depending on the severity of the exposure. Additionally, a skin allergy may develop when soluble beryllium compounds come into contact with the skin of sensitized individuals. *An* oral RfD of 0.0054 mg/kg-day has been set for beryllium based on a chronic oral bioassay (rats were the study species) which determined no adverse effect occurs at 0.54 mg/kg-day. Beryllium has been classified by USEPA as a group B2 carcinogen based on animal studies. It has been shown to induce lung cancer via inhalation in rats and monkeys, and to induce osteosarcomas in rabbits via intravenous or intramedullary injection. Human epidemiology studies of beryllium are considered inadequate. *An* SFi of 8.4 $(mg/kg\text{-}day)^{-1}$ and an SFo of 4.3 $(mg/kg\text{-}day)^{-1}$ have been set by USEPA (Gradient, 1991).

Cadmium can upset the stomach, leading to vomiting and diarrhea in acute exposure; acute inhalation of cadmium-containing dust can irritate the lungs. Chronic exposure to cadmium, either via inhalation or ingestion, has been shown to cause kidney damage (including kidney stones), emphysema, and high blood pressure. Other tissues reportedly injured by cadmium exposure in animals and humans include the lungs, testes, liver, immune system, blood, and the nervous system. An oral RfD of 0.001 (mg/kg-day) has been determined by USEPA, based on human studies (food) involving chronic exposure in which significant increased protein was found in the urine. A separate oral RfD for water has been determined by USEPA to be 0.0005 mg/kg-day. For inhalation exposure, cadmium has been classified by USEPA as a group B1, or probable human carcinogen, based on limited evidence from epidemiological studies in which an excess risk of lung cancer was observed in cadmium smelter workers. There is sufficient evidence of increased risk of lung cancer in rats and mice exposed to cadmium via

inhalation. Seven studies in which cadmium was administered orally to rats and mice have shown no evidence of carcinogenic response following exposure via this route. (Klaassen, et al., 1986).

Chromium exists in two stable, natural forms: trivalent (CrIII), and hexavalent (CrVI). Acute exposure to chromium can result in kidney damage following oral exposure, or damage to the nasal mucosa and septum following inhalation exposure. Chronic inhalation exposure to hexavalent chromium has resulted in kidney and respiratory tract damage, as well as excess lung cancer in both animals and humans following occupational exposure. Only hexavalent chromium is believed to be carcinogenic by inhalation. Oral RfD values for both forms of chromium are 1.0 and 5E-3 (mg/kg-day), respectively. For trivalent chromium, the RfD is based on liver toxicity in the rat. For the hexavalent form, the RfD is based on unspecified pathological changes observed in rat studies. In addition, hexavalent chromium is considered as a group A carcinogen for inhalation exposures, and a SFo of 42 $(mg/kg\text{-}day)^{-1}$ has been established for the hexavalent form. Vitamin supplements contain approximately 0.025 mg of chromium (Gradient, 1991).

Manganese is an essential nutrient. Chronic exposure to manganese, 0.8 mg/kg-day, causes mental disturbances. Studies have shown that manganese uptake from water is greater than manganese uptake from food, and the elderly appear to be more sensitive than children. Because of the different uptake rates in water and food, USEPA set two oral RfDs — one for water (10.005) and one for food (0.14 mg/kg-day). Inhalation of manganese dust causes neurological effects and increased incidence of pneumonia. An inhalation RfD was set at 0.0000143 mg/kg-day. According to USEPA, manganese cannot be classified as to its carcinogenicity; therefore, the cancer class for manganese is group D. The typical vitamin supplement dose of manganese is 2.5 mg/day (Klaassen, et al., 1986) (Dreisbach, et al., 1987).

Nickel is also an essential nutrient; a 5 μg dose is typical of supplemental vitamins. **USEPA** set the RfDo to 0.02 mg/kg-day. Chronic exposure of rats to nickel caused decreased body and organ weights. For a chronically exposed individual, nickel salts would affect the gastro-intestinal system, and would also target the liver and kidney. This element has been shown to be a sensitizer, an element that *can* produce allergic reactions. Sensitization of skin to nickel dust has been shown to occur in industry (Dreisbach, et al., 1987).

PCB Aroclors are a group of chlorinated hydrocarbons (such as ***Aroclors 1248,1254,*** and ***1260)*** that accumulate in fat tissue. Occupational exposure (both inhalation and dermal) to PCBs causes eye and lung irritation, loss of appetite, liver enlargement, increased serum liver enzyme concentrations, rashes and chloracne, and decreased birth weight of infants in heavily exposed worker/mothers. Of the effects listed above, the liver is the primary target organ. **USEPA** classified PCB aroclors as group B2 carcinogens, primarily based on animal data. Oral ingestion of PCBs causes liver and stomach tumors in rat studies. **USEPA** set 7.7 $(mg/kg\text{-}day)^{-1}$ as the SFo for **PCB** aroclors, and the RfD was set to 0.00007 mg/kg-day (Klaassen, et al., 1986) (Dreisbach, et al., **1987).**

Dieldrin is a polycyclic chlorinated pesticide. Short-term exposure to high doses of dieldrin causes tremors and convulsions. Chronic exposure can cause emotional and neuromuscular disturbances. Exposed individuals revert to normal approximately one week after the dieldrin source is removed. Dieldrin is classified as a B2 carcinogen by **USEPA;** the SFo, **SFi,** and RfDo were set to **16** $(mg/kg\text{-}day)^{-1}$, **16.1** $(mg/kg\text{-}day)^{-1}$, and 0.00005 mg/kg-day, respectively (Dreisbach, et al., 1987).

Benzene is a volatile organic which has been associated with leukemia. This chemical has been used as a solvent in coal tar naphtha, rubber, and plastic cement. **USEPA** lists benzene as a group **A** carcinogen. In large doses, benzene depresses the central nervous system, and chronic exposure depresses bone marrow. The oral SF for benzene was set by **USEPA** as

2.9E-2 $(mg/kg\text{-}day)^{-1}$, and an oral RfD has not been set. Occupational inhalation exposure to benzene is acceptable by OSHA at levels of 3.25 mg/m^3 or 1 ppm in air (Dreisbach, et al., 1987) (NIOSH, 1990).

Copper is a nutritionally essential element, necessary for many of the body's enzymes. In the past, lead pipes and solder were used for residential water pipes, and resulting lead concentrations in drinking water exceeded the guidelines set by the USEPA. Copper has been used to replace water pipes in residences due to its lower toxicity to man. Short-term exposure to copper can result in anemia (the lack of iron), the breakdown of red blood cells, and liver and kidney lesions. The target organs for copper are the liver, kidney, and red blood cell. Vitamin C reduces copper uptake from the gut, and other substances can also influence copper uptake. Copper fumes can cause metal fume fever. The RfD (0.0371 mg/kg-day) was derived from the treatment technique action level of 1.3 mg/L, which was set by the USEPA (equivalent to 2.6 mg/day for the average adult weighing 70 kg). In typical vitamin supplements, 2 mg/day is the approximate dose (NRC, 1989) (Klaassen, et al., 1986).

Lead has been classified as a group B2 carcinogen by USEPA based on animal data. No RfD or SF has been set by USEPA. However, a residential-based screening level has been proposed for lead in soil in the OSWER Lead Guidance, 400 mg/kg. An RfD and SF have not been set because of the confounding nature of lead toxicity. Lead accumulates in fat tissue and affects the brain, blood, and mental development of children. RfDs are based on the assumption that a threshold must be exceeded to result in toxic effects (other than carcinogenicity). Once lead accumulates in the body, other influences cause the actual levels in the blood to fluctuate — sometimes the lead is attached to binding sites, and sometimes lead is free flowing. If an exposed individual has previously been exposed to lead, this individual could lose weight, freeing the fat-bound lead. This fluctuation and lack of previous lead exposure'data are two of the reasons lead effects are difficult to predict (Klaassen, et al., 1986).

Zinc is an essential, ubiquitous element present in food, water, and soil. The average American daily intake is approximately 12 to 15 mg, and the recommended daily allowance (RDA) is 15 mg. Excessive exposure to zinc is relatively uncommon and requires exposure to high concentrations. This element does not accumulate under chronic exposure conditions, and body content is self-regulated by zinc liver concentrations and absorption mechanisms. Inhalation of zinc dust can cause metal fume fever, and the primary effect of zinc ingestion (at toxic concentrations) is gastrointestinal disturbance and irritation. Other effects on the blood, liver, and kidney are possible at higher concentrations. Twelve grams of elemental zinc per day were not shown to elicit effects other than gastrointestinal disturbances over two days. Experimental animals have been given 100 times the dietary requirements without discernible effects. USEPA determined that the RfDo is 0.3 mg/kg-day (Klaassen, et al., 1986).

Vinyl chloride is a volatile organic that can cause Raynaud's Phenomenon or white finger disease. It has been shown to cause angiosarcoma, a cancer. It has been also been associated with reproductive dysfunction in men and women. The primary target organs for non-carcinogenic effects are the liver, kidney, and nervous system. This compound inhibits one of the main metabolic pathways of the body (a group of enzymes), and can influence the toxicity of other compounds because of this effect. Due to the carcinogenicity of this compound, USEPA classified vinyl chloride as a class A carcinogen and set the SFi and SFo to 0.3 and 1.9 $(mg/kg\text{-}day)^{-1}$, respectively (Klaassen, et al., 1986) (Dreisbach, et al., 1987).

1,4-Dichlorobenzene is a CLP semivolatile organic compound; however, it was evaluated for the inhalation.pathway as a volatile due *to* its Henry's Law Constant. This compound affects the central nervous system, causes liver and kidney damage, and irritates the mucous membranes, skin, and eyes. This compound is classified by USEPA as a B2 carcinogen, with a SFo of 0.024 $(mg/kg\text{-}day)^{-1}$. The RfDi was set to 0.229 mg/kg-day (Dreisbach, et al., 1987).

Chlorobenzene is a volatile organic that affects the central nervous system, causes liver and kidney damage, and irritation of the mucous membranes, skin and eyes, USEPA set the RfDo and RfDi to 0.02 and 0.00571 mg/kg-day, respectively (Dreisbach, et al., 1987).

bis(2-Ethylhexyl)phthalate, otherwise known as DEHP or BEHP, is a plasticizer used in virtually every major product category. Phthalate esters are ubiquitously distributed in the environment. Although the toxicity of this compound is relatively low, it is a carcinogen. Reproductive effects are also possible (indicated in animal studies) due to chronic exposure to DEHP (Klaassen, et al., 1986). This compound is classified as a B2 carcinogen, and USEPA set the RfDo and SFo to 0.02 mg/kg-day and 0.014 $(mg/kg\text{-}day)^{-1}$, respectively.

4-Chloro-3-methylphenol is also known as 4-chloro-m-cresol, which is both an irritant and an allergen. Like most phenolic compounds, 4-chloro-m-cresol targets several organs including the liver, kidney, and central nervous system (Sax, 1989). No toxicological data are presently available through IRIS or HEAST.

Toluene is a gasoline additive and is used as a solvent in glues, inks, adhesives, and is as a detergent in the manufacture of dyes, lacquers, perfumes, pharmaceuticals, and saccharin. In humans, toluene is a known respiratory irritant with central nervous system effects. Toluene has not been determined to be a carcinogen, having a USEPA classification of D. The critical effect of this volatile organic chemical is changes in liver and kidney weights in study organisms. USEPA determined the inhalation RfD and oral RfD to be 0.4 mg/m^3 and 0.01 mg/kg-day, respectively (Harte, et al., 1991) (IRIS, 1995).

Xylene is widely used in industry and consumer products. This VOC is used as a building block for other solvents, plastics, and pharmaceuticals. Xylene is also used as a base for various pesticides, and is commonly found in paint, paint remover, nail polish, air fresheners,

degreasing cleaners, lacquers, glues, and pens. Xylene targets the respiratory tract and the central nervous system, and the effects can be enhanced by the ingestion of ethyl alcohol. Xylene has not been determined to be a carcinogen, having a USEPA classification of D. The critical effect of xylene in study organisms is hyperactivity, decreased body weight, and increased mortality. USEPA determined the oral RfD to be 2 mg/kg-day (Harte, et al., 1991) (IRIS, 1995).

10.1.5 Risk Characterization

Risk characterization combines the results of the exposure assessment and toxicity assessment to yield qualitative and quantitative expressions of risk for the exposed receptors. The quantitative component expresses the probability of developing cancer, or a non-probabalistic comparison of estimated dose with a reference dose for noncancer effects. These quantitative estimates are developed for individual chemicals, exposure pathways, transfer media and source media, and for each receptor for all media to which one may be exposed. The qualitative component usually involves comparison of COC concentrations in media with established criteria or standards for chemicals for which there are no suitable toxicity values. The risk characterization is used to guide risk management decisions.

Generally, the risk characterization follows the methods prescribed by RAGS Part A, as modified by more recent information and supplemental guidance cited in the earlier sections of this document. The USEPA methods are, appropriately, designed to be health-protective, and tend to overestimate risk. The risk results, however, are generally overly conservative, because risk characterization multiplies the conservatisms built into the exposure and toxicity assessments.

This section characterizes the potential health risks associated with the intake of Site 1 chemicals and methods used to estimate the types and magnitudes of health effects associated with exposure to these chemicals.

10.1.5.1 Risk Characterization Methodology

Potential risks to humans following exposure to COPCs are estimated using USEPA methods when available. These methods are health-protective and are likely to overestimate risk. Risks from hazardous chemicals are calculated for either carcinogenic or noncarcinogenic effects. Some carcinogenic chemicals may also pose a noncarcinogenic hazard. The potential human health effects associated with chemicals which may produce systemic toxic and carcinogenic influences are characterized for both types of health effects.

10.1.5.2 Carcinogenic Effects of Chemicals

The risk attributed to exposure to carcinogens is estimated as the probability of an individual developing cancer over a lifetime as a result of exposure to a potential carcinogen. In the low-dose range, which would be expected for most environmental exposures, cancer risk is estimated from the following linear equation (USEPA, 1989a):

$$ILCR = (CDI)(SF)$$

where

ILCR	=	incremental lifetime cancer risk, a unitless expression of the probability of developing cancer, adjusted for reference incidence
CDI	=	chronic daily intake, averaged over 70 years (mg/kg-day)
SF	=	cancer slope factor $(mg/kg\text{-}day)^{-1}$

For a given pathway with simultaneous exposure of a receptor to several carcinogens, the following equation is used to sum cancer risks:

where

$$Risk_i = ILCR(chem_1) + ILCR(chem_2) + \ldots ILCR(chem_i)$$

where

$Risk_p$	=	total pathway risk of cancer incidence
$ILCR(chem_i)$	=	individual chemical cancer risk

Cancer risk for a given receptor across pathways and across media is summed in the same manner.

10.1.5.3 Noncarcinogenic Effects of Chemicals

The risks associated with the noncarcinogenic effects of chemicals are evaluated by comparing an exposure level or intake with a reference dose. The hazard quotient (HQ), defined as the ratio of intake to RfD is defined as (RAGS, Part A):

$$HQ = CDI/RfD$$

where

HQ	=	hazard quotient (unitless)
CDI	=	intake of chemical (mg/kg-day)
RfD	=	reference dose (mg/kg-day)

Chemical noncarcinogenic effects are evaluated on a chronic basis, using chronic RFD values. *An* HQ of unity or 1 indicates that the estimated intake equals the RfD. If the HQ is greater than unity, there may be a concern for potential adverse health effects.

In the case of simultaneous exposure of a receptor to several chemicals, an HI will be calculated as the sum of the HQs by:

$$HI = CDI_1/RfD_1 + CDI_2/RfD_2 + \ldots CDI_i/RfD_i$$

where

HI	=	hazard Index (unitless)
CDI_i	=	intake for the ith toxicant
RfD_i	=	reference dose for the ith toxicant

10.1.5.4 Soil Pathways

Exposure to onsite soil was evaluated under three scenarios: current/future child trespasser, future site worker, and future site resident. Incidental ingestion and dermal contact were the two exposure routes considered after screening for volatilization from soils. For noncarcinogenic contaminants evaluated relative to future site residents, hazard was computed separately to address child and adult exposure. Tables 10-30 and 10-31 present the calculated risk and hazard for the incidental ingestion and dermal contact soil exposure pathways. As shown in the tables below, no soil exposure pathways of concern have been identified using the conservative assumptions in this assessment.

Future Site Worker Pathways

Data collected from surface soil (0-1 foot) were used to quantify the risk and hazard for this hypothetical future land use exposure pathway. The total carcinogenic risks for the potential future site worker for the ingestion and dermal contact pathways are 3E-7 and 2E-7, respectively. Hazard indices for the ingestion and dermal contact pathways were estimated at 0.01 and 0.002, respectively. Therefore, no COCs were identified for the future site worker pathways.

Current/Future Child Trespasser Pathways

Surface soils data (0-1 foot) were used to quantify the risk and hazard for this exposure pathway. The total carcinogenic risks for the current child trespasser for the ingestion and 'dermal contact

Table 10-30
Huard Quotients and IncrementalLifetime Cancer Risks
Incidental Surface Soil Ingestion
NAS Pensacola, Site 1
Pensacola, Florida

Chemical	Oral RfD Used (mg/kg-day)	Oral SF Used (mg/kg-day)-1	Potential Future Resident Adult Hazard Quotknt	Potential Future Resident Child Hazard Quotient	Potential Future Resident Iwa ILCR	Trespassing Child (age 7-16) Hazard Quotknt	Trespassing Child (age 7-16) ILCR	Future Site Workr Hazard Quotient	Future Site Worker ILCR
Aluminum	1	ND	0.005	0.05	NA	0.00127	NA	0.0020	NA
	ND	4.3	NA	NA	1.6E-06	NA	4.6E-08	NA	1.8E-07
Cadmium (food)	0.001	ND	0.004	0.035	NA	0.00087	NA	0.001	NA
Lead	ND	ND	NA	NA	NA	NA	NA	NA	NA
Manganese	0.14	ND	0.0004	0.0037	NA	0.00009	NA	0.00014	NA
Arocbr-1248	ND	7.7	NA	NA	2.9E-07	NA	8.4E-09	NA	3.2E-08
Arocbr-1254	2E-05	7.7	0.0018	0.02	3.2E-07	0.00043	9.4E-09	0.00066	3.6E-08
Arocbr-1260	ND	7.7	NA	NA	7.0E-08	NA	2.0E-09	NA	7.9E-09
Huard Indices			0.01	0.1		0.003		0.004	
Total Risk					2E-06		7E-08		3E-07

NOTES:

ND Not Determined due to lack of available information.
Iwa Lifetime weighted average; used to calculate excess carcinogenic risk, RAGS Parts A and B.
ILCR IncrementalLifetime Excess Cancer Risk.
NA Not applicable due to the lack of appropriate toxicological values.

Tabb 10-31
Hazard Quotients and Incremental Lifetime Cancer Risks
Dermal Contact wIth Surface Soll
NAS Pensacola, Site 1
Pensacola, Florida

Chemical	Oral to Dermal Adjustment	Oral RfD Used (mg/kg-day)	Oral SF Used (mg/kg-day)-1	Potential Future Resident Adult Hazard Quotient	Potential Future Resident Child Hazard Quotbnt	Potential Future Resident lwa ILCR	Trespassing Child (age 7-16) Hazard Quotient	Trespassing Chilc (age 7-16) ILCR	Future Site Worker Hazard Quotbnt	Future Site Worker ILCR
Aluminum	0.2	1	ND	0.0011	0.0026	NA	0.00025	NA	**0.0008**	NA
Beryllium	0.2	**ND**	4.3	NA	NA	1.6E-07	NA	**9.2E-09**	NA	7.4E-08
Cadmium (food)	0.2	0.001	ND	0.00077	0.0018	NA	0.00017	NP	**0.0005**	NA
Lead	0.2	ND	ND	NA	NA	NA	NA	NA	NA	NA
Manganese	0.2	0.14	ND	**0.00008**	0.0002	NA	0.000018	NA	**0.00006**	NA
Aroclor-1248	**0.5**	ND	7.7	NA	NA	1.1E-07	NA	**6.6E-09**	NA	**6.3E-08**
Aroclor-1254	**0.5**	2E-05	7.7	0.002	0.0034	1.3E-07	0.00034	7.4E-09	0.0011	**5.9E-08**
Aroclor-1260	0.6	ND	7.7	NA	NA	2.7E-08	NA	1.6E-09	NA	**1.3E.08**
Hazard Indices				**0.003**	**0.008**		0.0008		0.002	
Total Risks						**4E-07**		2E-08		**2E-07**

NOTES:

ND Not determined due to lack of available information.
lwa Lifetime weighted average; used to calculate excess carcinogenic risk, RAGS Parts A and B.
ILCR Incremental Lifetime excess Cancer Risk.
NA Not applicable due to the lack of appropriate toxicological values.
- Dermal to absorbed dose adjustment factor is applied to adjust for oral RfD; the oral RfD is based on oral absorption effkbncy whkh should not be applied to dermal exposure and dermal CDI.

with soil pathways are 7E-8 and 2E-8, respectively. Hazard indices for the ingestion and dermal contact pathways were estimated to be 0.009 and 0.0008, respectively. Therefore, no COCs were identified for the site trespasser pathways.

Future Site Resident Pathways

Surface soil data (0-1 foot) were used to quantify the risk and hazard for this hypothetical future land use exposure pathway. For noncarcinogenic contaminants evaluated relative to future site residents, hazard was computed separately to address child and adult exposure. Assuming residences were constructed on this landfill, the ILCR was estimated to be 2E-6 and 4E-7 for the incidental ingestion and dermal contact exposure pathways, respectively. Beryllium accounted for approximately 70% of the total ILCR, and PCB Aroclors 1248 and 1254 were secondary contributors. Beryllium individually accounted for 1.6E-6 ILCR (ingestion), and was reported in only one sample (01S13001) of 27 analyzed. Like beryllium, PCB Aroclors 1248 and 1254 were each reported at only one sample location (e.g., Aroclors 1248 and 1254 were reported in samples 01S7101 and 01S7801, respectively). ILCR estimated without beryllium would be less than 1E-6. Beryllium could be considered a COC for sample location 01S13001, assuming residential exposure would be isolated to that location. The intent of this BRA is to represent the entire site, and COPCs reported at only one sample location do not represent sitewide exposure. Therefore, COCs were identified on a sitewide basis. No COCs were identified for the future site resident exposure pathways based on ILCR.

The overall hazard indices for the ingestion of soil and dermal contact with soil pathways for the future site resident adult were estimated to be 0.01 and 0.003, respectively. For the future site resident child, overall hazard indices for the ingestion of soil and dermal contact with soil pathways were estimated to be 0.1 and 0.008, respectively. Therefore, no COCs were identified for the future site resident exposure pathways based on the total hazard index.

No COCs were identified for the future site resident exposure scenario assuming sitewide residential exposure.

10.1.5.5 Groundwater Pathways

Exposure to groundwater onsite was evaluated exclusively under a future site resident scenario (assuming groundwater will be used as a potable water source). Ingestion through potable use and inhalation of volatilized contaminant exposure pathways were evaluated. For non-carcinogenic contaminants evaluated relative to future site residents, hazard computations were performed separately to address child and adult exposure. The shallow and intermediate water-bearing zones monitored during the RI were combined for assessment. The deep water-bearing zone was monitored by three wells. The inhalation pathway was not included in the deep groundwater evaluation because no volatile contaminants were reported in the wells sampled. Tables 10-32 and 10-33 present the computed carcinogenic risk and HQs for potable use exposure and volatilized contamination inhalation pathways for the shallow and intermediate groundwater zones. Table 10-34 presents the computed carcinogenic risk and hazard quotients for potable use ingestion exposure for the deep groundwater zone. Since no volatile organic chemicals were identified as **COPCs** in deep groundwater, inhalation was not assessed.

10.1.5.5.1 Shallow and Intermediate Groundwater

Future Site Resident Pathways

The ILCR estimated for the future site resident was **4E-4** for the groundwater ingestion pathway. The primary carcinogenic **COC** is arsenic (individual ILCR = 2.74E-4), and secondary contributors were vinyl chloride, benzene, **1,1,2,2-tetrachloroethane,** and **1,4-dichlorobenzene.** Assuming groundwater is used as a potable source, these chemicals were identified as **COCs** based on their contributions **to** ILCR.

Table 10-32
Hazard Quotients and Incremental Lifetime
Cancer Risks- Ingestion of Shallow and Intermediate Groundwater
NAS Pensacola, Site 1
Pensacola, Florida

Chemical	Slope Factor Used (mg/kg/day)-1	Reference Dose used (mg/kg/day)	Future Use: Potential Future Resident Adult Hazard Quotient	Future Use: Potentiel Future Resident Child Hazard Quotient	Future Use: Potential Future Resident Iwa ILCR (a)
1,1-Dichloroethane	ND	0.1	0.002	0.01	NA
1,2-Dichlorobenzene	ND	0.09	0.002	0.004	NA
1,2-Dichloroethene (total)	ND	0.009	0.01	0.02	NA
1,1,2,2-Tetrachloroethane	0.2	ND	NA	NA	4.08E-06
1.4-Dichlorobenzene	0.024	0.229 •	0.001	0.002	2.64E-06
1,1,2-Trichloroethane	0.057	0.004	0.004	0.01	5.40E-07
2-Methylnaphthalene	ND	0.04	0.001	0.003	NA
Aluminum	ND	1	0.01 2	*0.03*	NA
Arsenic	1.5	**0.0003**	1.12	2.62	2.74E-04
Barium	ND	0.07	0.04	0.10	NA
Benzene	0.029	0.00171 •	0.42	0.99	1.14E-05
Bis(2-ethylhexyl)phthalate	0.01 4	0.02	**0.001**	0.003	**1.85E-07**
Bromoform	0.0079	0.02	0.002	0.004	1.50E-07
Cadmium	ND	**0.0005**	0.1 6	**0.37**	NA
Chlorobenzene	ND	*0.02*	0.1 6	**0.38**	NA
Chloroethane	ND	0.4	0.0001	**0.0003**	NA
Chloroform	0.0061	0.01	0.01	0.02	2.1 5E-07
Chromium	ND	1	**0.0003**	0.001	NA
Copper	ND	0.0371	0.01	0.02	NA
Dieldrin	16	5E-05	0.002	0.01	9.85E-07
Manganese	ND	0.005	0.23	0.54	NA
Naphthalene	ND	0.04	0.004	**0.009**	NA
Nickel	ND	0.02	0.04	0.10	NA
Trichloroethena	0.01 1	0.006	0.003	0.007	1.04E-07
Vinyl Chloride	1.9	ND	NA	NA	6.96E-05
Xylenes (total)	ND	2	0.0002	0.0004	NA
Zinc	ND	0.3	0.04	0.10	NA
Hazard Index			2	5	
Total Risk					4E-04

NOTES:

a Incremental lifetime cancer risk (ILCR) is based on the lifetime weighted average (Iwa) of an adult age 7-31 and child age 1-6.
ND Not determined due to lack of information.
NA Not applicable due to the lack of appropriate toxicological values.
• Indicates an inhalation dope factor or reference dose was used as e surrogate oral value.

Table 10-33
Hazard Quotient8 and Incremental Lifetime
Cancer Risks- Inhalation of Volatilized Shallow and Intermediate Groundwater Contaminants
NAS Pensacola, Site 1
Pensacola, Florida

Chemical	Slope Factor Used (mg/kg/day)-1	Reference Dose Used (mg/kg/day)	Future Use: Potentid Future Resident Adult Hazard Quotient	Future Use: Potentid Future Resident Child Hazard Quotient	Future Use: Potentid Future Resident Iwa ILCR (a)
1,1-Dichloroethane	ND	0.143	0.002	0.004	NA
1,2-Dichlorobenzene	ND	0.04	0.003	0.01	NA
1,2-Dichloroethene (total)	ND	0.009 *	0.01	0.02	NA
1,1,2,2-Tetrachloroethane	0.203	ND	NA	NA	4.1E-06
1.4-Dichlorobenzene	0.024 *	0.229	0.001	0.002	**2.6E-06**
1,1,2-Trichloroethane	0.056	0.004 *	0.004	0.01	5.3E-07
Benzene	0.029	0.00171	0.42	0.99	1.1E-05
Bromoform	0.00385	0.02 *	0.002	0.004	7.3E-08
Chlorobenzene	ND	0.00571	**0.58**	1.34	NA
Chloroethane	ND	2.80	0.00002	**0.00004**	NA
Chloroform	0.0805	0.01 *	0.01	0.02	2.8E-06
Trichloroethene	0.006	0.006 *	0.003	0.007	5.7E-08
Vinyl Chloride	0.3	ND	NA	NA	1.1 E-05
Xylenes (total)	ND	0.0857	0.004	0.01	NA
Hazard Index			1	2	
Total Risk					3E-05

NOTES:

e Incremental lifetime cancer risk (ILCR) is based on the lifetime weighted average (Iwa) of an adult age 7-31 and child age 1-6.

ND Not determined due to lack of information.

NA Not applicable due to the lack of appropriate toxicological values.

* Indicates an ingestion slope factor or reference dose was used as a surrogate inhalation value.

Table 10-34

Hazard Quotients and Incremental Lifetime
Cancer Risks- Ingestion of Deep Groundwater
NAS Pensacola, Site 1
Pensacola, florida

Chemicel	Slope Factor Used (mg/kg/day)-1	Reference Dose Used (mg/kg/day)	Future Use: Potential Future Resident Adult Hazard Quotient	Future Use: Potential Future Resident Child Hazard Quotient	Future Use: Potential Future Resident Iwa ILCR (a)
Manganese	ND	0.005	0.49	1.2	NA
Hazard Index			*0.5*	1	
Total Risk					NA

NOTES:

a Incremental lifetime cancer risk (ILCR) is based on the lifetime weighted average (Iwa) of an edult age 7-31 and child age 1-6.

ND Not determined due to lack of information.

NA Not applicable due to the lack of appropriate toxicological values.

The computed shallow/intermediate groundwater hazard indices for the future child and adult resident potable use ingestion pathway were 2 and 5, respectively. Arsenic, benzene, manganese, chlorobenzene, cadmium, barium, nickel, and zinc were the identified COCs for the child receptor, and are listed in descending order of contribution. This same list and order of contribution (except for nickel) were identified as COCs for the adult receptor.

Assuming groundwater will be used as a potable source, the carcinogenic risk estimated for the inhalation of volatilized groundwater contaminants exposure pathway was projected to be 3E-5. Carcinogenic COCs identified are vinyl chloride, 1,1,2,2-tetrachloroethane, 1,4-dichlorobenzene, benzene, and chloroform. The groundwater contaminant inhalation pathway hazard indices for child and adult pathways were estimated to be 2 and 1, respectively. Two COCs were identified for these pathways based on the hazard index: chlorobenzene and benzene. For both receptors, chlorobenzene accounts for approximately 60% of the pathway hazard index.

10.1.5.5.2 Deep Groundwater

The future site resident pathway was addressed for the deep groundwater pathway assuming the deep water-bearing zone will be used as a potable water source. No VOCs were detected in this water-bring zone, so ingestion is the sole exposure pathway addressed. No carcinogenic COPCs were reported in deep groundwater, the ILCR was not estimated, and no COCs were identified for this pathway based on ILCR. Hazard indices estimated for the child and adult residential exposure scenarios were 1 and 0.5, respectively. Manganese was identified as a COC based on the child exposure pathway HI.

10.1.5.5.3 Surface Water

A preliminary assessment of Site 1 surface water was performed in this BRA (i.e., prior to the formal assessment in the Site 41 BRA) using the child trespasser (age 7-16) scenario, assuming receptors swimming/wading in the wetlands would be in contact with the maximum concentrations reported in Site 1 surface water. Tables 10-35 and 10-36 show the ILCR and

Table 10-35
Hazard Quotients and Incremental Lifetime
Cancer Risks- Ingestion of Surface Water
NAS Pensacola, Site 1
Pensacole, Florida

Chemical	Slope Factor Used (mg/kg/day)-1	Reference Dose Used (mg/kg/day)	Future Use: Trespassing Child (age 7-16) Hazard Quotient	Future Use: Trespassing Child (age 7-16) ILCR (a)
1.4-Dichlorobenzene	0.024	0.229 •	0.0000 11	8.47E-09
Arsenic	1.5	0.0003	0.014	9.00E-07
Benzene	0.029	0.00171 •	0.001 4	1.02E-08
Chlorobenzene	ND	0.02	0.00043	NA
Manganese	ND	0.005	0.037	NA
Hazard Index			0.05	
Total Risk				9E-07

NOTES:

a Incremental lifetime cancer risk (ILCR) is based on the lifetime weighted average (lwa) of an adult age 7-31 and child age 1-6.

ND Not determined due to lack of information.

NA Not applicable due to the lack of appropriate toxicological values.

• Indicates an inhalation slope factor or reference dose was used as a surrogate oral value.

Table 10-36
Hazard Quotients and Incremental Lifetime
Cancer Risks- Inhalation of Volatilized Surface Water Contaminants
NAS Pensacola, Site 1
Pensacola, florida

Chemical	Slope Factor Used (mg/kg/day)-1	Reference Dose Used (mg/kg/day)	Future Use: Trespassing Child (age 7-16) Hazard Quotient	Future Use: Trespassing Child (age 7-16) ILCR (a)
1+Dichlorobenzene	0.024 •	0.229	0.0000 11	8.5E-09
Benzene	0.029	0.00171	0.0014	1.0E-08
Chlorobenzene	ND	0.0057 1	0.001 5	NA
Hazard Index			0.003	
Total Risk				2E-08

NOTES:

a Incremental lifetime cancer risk (ILCR) is based on the lifetime weighted average (lwa) of an adult age 7-31 and child age 1-6.

ND Not determined due to lack of information.

NA Not applicable due to the lack of appropriate toxicological values.

• Indicates an ingestion slope factor or reference dose was used as a surrogate inhalation value.

hazard indices estimated for the preliminary assessment of Site 1 surface water. ILCR was estimated to be 9E-7 and 2E-8 for the ingestion and inhalation exposure pathways, respectively. The hazard indices for the ingestion and inhalation pathways were estimated to be 0.05 and 0.003, respectively. No COCs were identified for Site 1 surface water exposure pathways.

10.1.5.5.4 Sediment

A preliminary assessment of Site 1 sediment was performed in this BRA (i.e., prior to the formal assessment in the Site 41 BRA) using the child trespasser (age 7-16) scenario, assuming receptors swimming/wading in the wetlands would be in contact with the maximum concentrations reported in Site 1 sediment. For the preliminary assessment of Site 1 sediment, Tables 10-37 and 10-38 show the ILCR and hazard indices estimated for the incidental ingestion and dermal contact pathways, respectively. ILCR was estimated to be 9E-8 and 2E-8 for the incidental ingestion and dermal contact exposure pathways, respectively. The hazard indices for the incidental ingestion and dermal pathways were estimated to be 0.002 and 0.0004, respectively. No COCs were identified for Site 1 sediment exposure pathways.

10.1.5.5.5 Receptor/Pathway Risk Evaluation

Table 10-39 provides a synopsis of individual pathway hazard indices and carcinogenic risk for each current or potential future receptor type. It can be seen from the presentation that neither the potential future site workers nor the potential child trespasser had an individual pathway (or combined single medium pathways) with an HI exceeding 0.05 or an ILCR greater than 9E-7. The cumulative pathway hazard index and cancer risk for the trespasser was estimated to be 1E-6, which is equal to the FDEP and USEPA point of departure for risk. Arsenic accounted for greater than 99% (9E-7) of the ILCR estimated for the surface water pathway, which is the highest risk estimate for the trespasser scenario. No individual exposure pathway or chemical exceeded the 1E-6 point of departure. Risk and hazard estimates for the trespasser and site

Table 10-37
Hazard Quotients and Incremental Lifetime Cancer Risks
Incidental Sediment Ingestion
NAS Pensacola, Site 1
Pensacola, Florida

Chemical	Oral RfD Used (mg/kg-day)	Oral SF Used (mg/kg-day)-1	Trespassing Child (age 7-16) Hazard Quotient	Trespassing Child (age 7-16) ILCR
Aluminum	1	ND	0.00042	NA
Arsenic	0.0003	1.5	0.0014	9.3E-08
Manganese	0.14	ND	0.000039	NA
Hazard Indices			0.002	
Total Risk				9E-08

NOTES:

ND Not Determined due to lack of available information.
lwa Lifetime weighted average; used to calculate excess carcinogenic riok, RAGS Parts A and E.
ILCR Incremental Lifetime excess Cancer Risk.
NA *Not* applicable due to the lack of appropriate toxicological values.

Table 10-38
Hazard Quotients and Incremental Lifetime Cancer Risks
Dermal Contact with Sediment
NAS Pensacola, Site 1
Pensacola, Florida

Chemical	Oral to Dermal Adjustment	Oral RfD Used (mg/kg-day)	Oral SF Used (mg/kg-day)-1	Trespassing Child (age 7-16) Hazard Quotient	Trespassing Child (age 7-16) ILCR
Aluminum	0.2	1	ND	0.000083	NA
Arsenic	0.2	0.0003	1.5	0.00028	1.8E-08
Manganese	0.2	0.14	ND	0.0000076	NA
Hazard Indices				0.0004	
Total Risks					2E-08

NOTES:

NO Not determined due to lack of available information.
lwa Lifetime weighted average; used to calculate excess carcinogenic risk, RAGS Parts A and
ILCR Incremental Lifetime excess Cancer Risk.
NA Not applicable due to the lack of appropriate toxicological values.
- Dermal to absorbed dose adjustment factor is applied to adjust for oral RfD; the oral RfD is on oral absorption efficiency which should not be applied to dermal exposure and dermal CDI.

Medium/Pathway	Chemical	Potentid Future Resident Adult Hazard Quotient	Potentid Future Resident Child Hazard Quotient	Potentid Future Resident Iwa KCR	Site Trespasser Hazard Quotient	ILCR	Site worker Hazard Quotient	ILCR	Identification of COCs	
Soil Incidental Ingestion	**Aluminum**	0.005	0.05	NA	0.00127	NA	0.0020	NA		
	Beryllium[m]	NA	NA	1.6E-06	NA	4.6E-08	NA	1.8E-07		2'
	Cadmium (food)	0.004	0.035	NA	0.00087	NA	0.001	NA		
	Lead	NA	NA	NA	NA	NA	NA	NA		
	Manganese	0.0004	0.0037	NA	0.00009	NA	0.00014	NA		
	Aroclor-1248	NA	NA	2.9E-07	NA	8.4E-08	NA	3.2E-08		
	Aroclor-1254	0.0018	0.02	3.2E-07	0.00043	9.4E-09	0.00066	3.6E-08		
	Aroclor-1260	NA	NA	7.0E-08	NA	2.0E-08	NA	7.9E-09		
Soil Incidental Ingestion Pathway Totd		0.01	0.1	2E-06	0.003	7E-08	0.004	3E-07		
Soil Dermal Contact Pathway	Aluminum	0.0011	0.0026	NA	0.00025	NA	0.0008	NA		
	Beryllium	NA	NA	1.6E-07	NA	9.2E-09	NA	7.4E-08		
	Cadmium (food)	0.00077	0.0018	NA	0.00017	NA	0.0005	NA		
	Lead	NA	NA	NA	NA	NA	NA	NA		
	Manganese	0.00008	0.0002	NA	0.000018	NA	0.00006	NA		
	Aroclor-1248	NA	NA	1.1E-07	NA	6.6E-09	NA	5.3E-08		
	Aroclor-1254	0.002	0.0034	1.3E-07	0.00034	7.4E-09	0.0011	5.9E-08		
	Ardor-1280	NA	NA	2.7E-08	NA	1.6E-09	NA	1.3E-08		
Soil Dermal Contact Pathway Total		0.003	0.008	4E-07	0.0008	2E-08	0.002	2E-07		
Shallow/Intermediate Groundwater Ingestion Pathway	1,1-Dichloroethane	0.002	0.01	NA	NA	NA	NA	NA		
	1,2-Dichlorobenzene	0.002	0.004	NA	NA	NA	NA	NA		
	1,2-Dichloroethene (total)	0.01	0.02	NA	NA	NA	NA	NA		
	1,1,2,2-Tetrachloroethane	NA	NA	4.1E-06	NA	NA	NA	NA		2
	1,4-Dichlorobenzene	0.001	0.002	2.6E-06	NA	NA	NA	NA		2
	1,1,2-Trichloroethane	0.004	0.01	5.4E-07	NA	NA	NA	NA		
	2-Methylnaphthalene	0.001	0.003	NA	NA	NA	NA	NA		
	Aluminum	0.012	0.03	NA	NA	NA	NA	NA		
	Arsenic	1.12	2.62	2.7E-04	NA	NA	NA	NA	1	2
	Barium	0.04	0.10	NA	NA	NA	NA'	NA	1	
	Benzene	0.42	0.99	1.1E-05	NA	NA	NA	NA	1	2
	Bis(2-ethylhexyl)phthalate	0.001	0.003	1.9E-07	NA	NA	NA	NA		
	Bromoform	0.002	0.004	1.5E-07	NA	NA	NA	NA		
	Cadmium	0.16	0.37	NA	NA	NA	NA	NA	1	
	Chlorobenzene	0.16	0.38	NA	NA	NA	NA	NA	1	
	Chloroethane	0.0001	0.0003	NA	NA	NA	NA	NA		
	Chloroform	0.01	0.02	2.2E-07	NA	NA	NA	NA		
	Chromium	0.0003	0.001	NA	NA	NA	NA	NA		
	Copper	0.01	0.02	NA	NA	NA	NA	NA		
	Dieldrin	0.002	0.01	9.9E-07	NA	NA	NA	NA		

Table 10-39
Summary of Carcinogenic Risk and Noncarcinogenic Hazard and Identification of Chemicals of Concern
NAS Pensacola Site 1
Pensacola, Florida

Medium/Pathway	Chemical	Potential Future Resident Adult Hazard Quotient	Potential Future Resident Child Hazard Quotient	Potential Future Resident Lifetime ILCR	Site Trespasser Hazard Quotient	Site Trespasser ILCR	Site Worker Hazard Quotient	Site Worker ILCR	Identification of COCs
	Manganese	0.23	0.64	NA	NA	NA	NA	NA	1
	Naphthalene	0.004	0.009	NA	NA	NA	NA	NA	
	Nickel	0.04	0.10	NA	NA	NA	NA	NA	
	Trichloroethene	0.003	0.007	1.0E-07	NA	NA	NA	NA	
	Vinyl Chloride	NA	NA	7.0E-06	NA	NA	NA	NA	**2**
	Xylenes (total)	0.0002	0.0004	NA	NA	NA	NA	NA	
	Zinc	0.04	0.10	NA	NA	NA	NA	NA	
Shallow/Intermediate Groundwater Ingestion Pathway Total		2	6	4E-04	NA	NA	NA	NA	
Shallow/Intermediate Groundwater Inhalation Pathway	1,1-Dichloroethane	0.002	0.004	NA	NA	NA	NA	NA	
	1,2-Dichlorobenzene	0.003	0.01	NA	NA	NA	NA	NA	
	1,2-Dichloroethene (total)	0.01	0.02	NA	NA	NA	NA	NA	
	1,1,2,2-Tetrachloroethane	NA	NA	4.1E-06	NA	NA	NA	NA	**2**
	1,4-Dichlorobenzene	0.001	0.002	2.6E-06	NA	NA	NA	NA	**2**
	1,1,2-Trichloroethane	0.004	0.01	6.3E-07	NA	NA	NA	NA	
	Benzene	0.42	0.99	1.1E-05	NA	NA	NA	NA	1 **2**
	Bromoform	0.002	0.004	7.3E-08	NA	NA	NA	NA	
	Chlorobenzene	0.68	1.34	NA	NA	NA	NA	NA	1
	Chloroethane	0.00002	0.00004	NA	NA	NA	NA	NA	
	Chloroform	0.01	0.02	2.8E-06	NA	NA	NA	NA	**2**
	Trichloroethene	0.003	0.007	**5.7E-08**	NA	NA	NA	NA	
	Vinyl Chloride	NA	NA	1.1E-05	NA	NA	NA	NA	**2**
	Xylenes (total)	0.004	0.01	NA	NA	NA	NA	NA	
Shallow Groundwater Inhalation Pathway Total		**1**	**2**	**3E-05**	**NA**	**NA**	**NA**	**NA**	
Ingestion of Deep Groundwater Pathway	**Manganese**	**0.49**	**1.2**	**NA**	**NA**	**NA**	**NA**	**NA**	**1**
Deep Groundwater Ingestion Pathway Total		0.6	1	NA	NA	NA	NA	NA	
Surface Water Incidental Ingestion Pathway	1,4-Dichlorobenzene	NA	NA	NA	0.000011	8.5E-09	NA	NA	
	Arsenic	NA	NA	NA	0.014	9.0E-07	NA	NA	
	Benzene	NA	NA	NA	0.0014	1.0E-08	NA	NA	
	Chlorobenzene	NA	NA	NA	0.00043	NA	NA	NA	
	Manganese	NA	NA	NA	0.037	NA	NA	NA	
Surface Water Incidental Ingestion Pathway Total		NA	NA	NA	0.05	9E-07	NA	NA	
Surface Water Inhalation Pathway	1,4-Dichlorobenzene	NA	NA	**NA**	0.000011	8.5E-09	NA	**NA**	
	Benzene	NA	NA	**NA**	0.0014	1.0E-08	NA	**NA**	
	Chlorobenzene	NA	NA	NA	0.0016	NA	NA	NA	

Medium/Pathway	Chemical	Potential Future Resident Adult Hazard Quotient	Potential Future Resident Child Hazard Quotient	Potential Future Resident lwa ILCR	Site Trespasser Hazard Quotient	Site Trespasser ILCR	site Worker Hazard Quotient	site Worker ILCR	Identification of COCs
Surface Water Inhalation Pathway Total		NA	NA	NA	0.003	2E-08	NA	NA	
Sediment Incidental Ingestion Pathway	Aluminum	NA	NA	NA	0.00042	NA	NA	NA	
	Arsenic	NA	NA	NA	0.0014	9.3E-08	NA	NA	
	Manganese	NA	NA	NA	0.000039	NA	NA	NA	
Sediment Incidental Ingestion Pathway Totd		NA	NA	NA	0.002	9E-08	NA	NA	
Sediment Dermal Contact Pathway	**Aluminum**	NA	NA	NA	0.000083	NA	NA	NA	
	Arsenic	NA	NA	NA	0.00028	18E-08	NA	NA	
	Manganese	NA	NA	NA	0.0000076	NA	NA	NA	
Sediment Dermal Contact Pathway Total		**NA**	**NA**	**NA**	**0.0004**	**2E-08**	**NA**	**NA**	
All Pathways Cumulative Total Risk/Hazard w/Shallow GW		**3**	**8**	**4E-04**	**0.06**	**1E-06**	**0.01**	**5E-07**	
All Pathways Cumulative Total Risk/Hazard w/Deep GW		**0.5**	**1**	**3E-06**	**0.06**	**1E-06**	**0.01**	**5E-07**	

NOTES:

NA **Indicates** not applicable.
LWA **Indicates** lifetime weighted average.
ILCR Incremental Lifetime **excess** cancer risk.
1 Chemical is a COC by virtue of prqected child resident noncarcinogenic hazard.
2 Chemical **is a** COC by virtu? of projected future resident lifetime weighted average carcinogenic risk.
3 Chemical is a COC by virtue of projected trespasser non-carcinogenic hazard.
4 Chemical is a COC by virtue of prqected trespasser carcinogenic riek.
6 Chemical **is a** COC by virtue of prqected site worker non-carcinogenic hazard.
8 Chemical **is** e COC **by** virtue of prqected site worker carcinogenic risk.
* Beryllium could be considered a COC *at* only one sample location; beryllium was reported in only one of **27** samples.

worker receptors were within the acceptable carcinogenic risk range. These projections indicate that neither receptor group is at significant risk of deleterious health effects resulting from RME to all media. These receptor groups do not warrant further consideration with respect to evaluating the necessity for remedial action.

Assuming groundwater will be used as a potable water source, the future site resident projections indicate that excess cancer risk and noncancer hazard may be posed through exposure to shallow/intermediate groundwater and deep groundwater. Considering the frequency of detection, exposure to surface soil (ingestion and dermal contact) under potential future residential conditions did not result in unacceptable risks and/or hazards for the adult, child, and/or combined receptor under lifetime weighted average lwa conditions. The HI and the excess carcinogenic risk for pathways associated with the groundwater media were estimated to exceed USEPA and FDEP goals and/or thresholds. Assuming shallow/intermediate groundwater will be used as a potable source, the cumulative pathway hazard indices for the future site resident adult and child were 3 and 8, respectively. The cumulative pathway carcinogenic risk for the future site resident was 4E-4. The deep groundwater exposure pathway for these hypothetical future receptors (ingestion of groundwater only) did not produce carcinogenic risk projections in excess of the point of departure. However, an HI of 1 was computed for the future site resident child. As a result, both the shallow and intermediate, and the deep groundwater media will be addressed in establishing remedial goal options.

10.1.6 Risk Uncertainty

This section presents and discusses the uncertainty inherent in the risk assessment process in addition to medium- and exposure pathway-specific influences. Risk assessment sections are discussed separately below, and specific examples of uncertainty sources are included where appropriate. Alternative risk projections are also included which provide estimates of the range of risk. These alternative risk results are based on Central Tendency (CT) exposure (average

or 50th percentile) rather than RME as presented in Section 10.1.5, Risk Characterization for comparison.

General

Uncertainty is a factor in each step of the preceding exposure and toxicity assessments. Overall, uncertainties associated with the initial stages of the risk assessment process become magnified when they axe combined with other uncertainties. For example, the use of the 95th percentile UCL mean as the EPC is a method of reducing uncertainty with respect to falsely concluding that insignificant risk is posed. However, a "safety factor" based on the standard deviation and number of samples is included in the UCL. During the risk characterization process, individual chemical risk is added to determine the incremental excess cancer risk for each exposure pathway. Individual risk projections were calculated based on the UCL, and the "safety factor" of the incremental risk is the sum of all the individual "safety factors". This multiplicative influence on conservatism is inherent in the risk assessment process, and is also evident in the uncertainty factor and modifying factor applied to RfDs. It is not possible to eliminate all uncertainties; however, recognizing of the uncertainties is fundamental to understanding and subsequently using of risk assessment results.

This section presents the uncertainty of site-specific and medium/pathway-specific factors introduced as part of the risk assessment process, in addition to other factors influencing the uncertainty of the calculated incremental excess cancer risks and hazard quotients/indices. It is important to note that the exposure pathways selected in Section 10.1.3, Exposure Assessment, are extremely conservative. The landfill is not projected for residential use.

Assumptions axe made as part of the risk assessment process based on population studies and USEPA guidance. This guidance divides the assumptions into two basic categories: the upper bound (90 to 95th percentile) and the mean or 50th percentile CT exposure assumptions. As discussed in the Exposure Assessment section (10.1.3), the RME exposure is based on the upper

bound assumptions, and the CT exposure is based on mean assumptions. Therefore, risk/hazard calculated using RME exposure assumptions are generally overestimates rather than underestimates. The following paragraphs discuss sources and effects of uncertainty pertinent to each exposure pathway evaluated.

Risk Based Screening

Before addressing risk/hazard for all chemicals detected, comparison to screening values was performed to focus the BRA on COPCs which individually exceed those values. This comparison was performed in accordance with technical reviewers' preferences. Screening information was obtained from USEPA Region IV and FDEP guidance.

Exposure pathways and contaminants were initially eliminated from the BRA based on the criteria agreed upon by USEPA, FDEP, and the Navy. The maximum concentration of a chemical detected in a particular medium was compared to the corresponding screening value. As discussed previously in this BRA, the comparison was made using the most conservative screening value provided by USEPA Region 111, USEPA Region IV, and FDEP for each exposure medium. Residential screening values were used for all surface soil and groundwater comparisons. In addition, maximum concentrations of volatile compounds detected in all soil samples were compared to screening values based on the soil-to-air exposure pathway. Although some potential exists for the sum effect of exposures to numerous constituents near the screening values to induce toxic effects, the fact that maximum concentrations detected were used as screening concentrations in concert with low range risk/hazard thresholds provides an adequately conservative screening format, and as a result, the potential for adverse cumulative effects from the detected chemicals eliminated from the formal assessment is considered low.

Comparison to Reference Concentrations (Background)

Because the objective of the BRA is to estimate the excess cancer risk or health hazard posed by COPCs, a comparison to reference (background) concentrations was performed subsequent

to screening values comparison. The maximum concentration reported for each chemical which exceeded its corresponding screening value was compared to two times the mean reference concentration, if available. Low frequency of detection could indicate a contaminant should not be addressed in the BRA; however, all detected chemicals which failed the screening comparisons were included as COPCs. This approach was selected as a conservative screening approach, and COPCs were evaluated further for frequency of detection or consideration relative to essential nutrient status, where necessary, as part of the medium-specific uncertainty discussions. Other sources of uncertainty are discussed below.

A few background sample locations were used to develop reference concentrations which represent NAS Pensacola. Reference concentrations are not site-specific and, therefore, may not account for local soil composition or groundwater conditions.

Two datasets exist for the reference monitoring wells. An alternative sampling technique (low-flow purging and sampling) was introduced before to the second phase of groundwater sampling. Using data sampled according to the previous (bailer) technique would likely grossly overestimate exposure to contaminants in groundwater. Quiescent sampling data correlate well with filtered bailer sampling, and quiescent data from background wells were used to derive reference concentrations. These reference concentrations are lower than those calculated using the original dataset.

Groundwater reference concentrations (using quiescent sampling data) were compared to corresponding maximum concentrations detected onsite. The use of quiescent data is more conservative and less likely to eliminate chemicals detected onsite from consideration as COPCs because the threshold concentrations are lower. Both reference and site samples were collected in 1994. Additional uncertainty is introduced by comparing site data to nonspecific reference data. Although the reference concentrations are specific to NAS Pensacola, they are not site-specific. The limited number of reference samples and sample locations decreases the

confidence in fixed reference concentrations as natural variability'in media composition may not be fully characterized.

Quality of Data

Groundwater

As described in previous sections of this RI report, the data quality objective was CLP level IV for all Site 1 sampling. During RI Phase I, typical Teflon bailer groundwater sampling techniques were employed to sample monitoring wells. USEPA introduced a low-flow purging and sampling technique, and this method was employed by USEPA and E/A&H in 1994 to obtain an additional dataset for selected wells. Wells were selected based on contaminant concentrations with focus placed on impacted groundwater areas. The data obtained through the low-flow purging and sampling technique (a partial dataset collected by USEPA) were used for this assessment. Use of the original dataset obtained through high-disturbance bailer sampling methods would tend to produce overestimates with respect to exposure quantification due to increased potential for sediment-bound compounds/elements being entrained in groundwater samples. Although use of the limited quiescent sampling dataset could bias EPCs high due to the elimination/exclusion of marginally affected areas, quiescent data were used to estimate the groundwater exposure in accordance with RME ideology.

Due to the proximity of Pensacola Bay and Bayou Grande, saltwater intrusion should be considered a source for typical seawater constituents. Many inorganic COPCs are commonly detected in seawater, sediment, and marine organisms. One example is arsenic. This naturally occurring element is present in edible marine organisms to such an extent that hematologic analysis *can* detect elevated arsenic in individuals who frequently eat seafood. Saltwater intrusion is possibly a source of arsenic detected in groundwater, and thus risk management decisions relative to inorganic contaminants must consider this natural source. This subject is discussed in more detail in Sections 7 and 8, Nature and Extent of Contamination.

Soil

In addition to the conservative assumptions made in this assessment, significant uncertainty is present in the soil exposure pathway due to the sampling dates (1993) of the data used in the risk calculations, and the foci of sample locations. Sample foci were areas where material is near the surface and/or chemical wastes were reportedly disposed. Therefore, the data are upwardly biased. Large areas of surface soil at Site 1 are likely to contain unimpacted native fill material. Trenching data from the landfill were used in this assessment. Surface soil (0 to 1 foot) data were used to quantify risk/hazard for all exposure pathways other than the potential future site worker. Due to these factors, the data are conservatively biased. The resultant EPCs are likely gross overestimates of the contamination to which receptors will be chronically exposed.

Characterization of Exposure Setting and Identification of Exposure Pathways

Uncertainty in the exposure setting and pathways exists due to the highly conservative assumptions (i.e., future residential use) recommended by USEPA Region IV when assessing potential future and current exposure. NAS Pensacola is currently fenced and under guard by the Navy, and the likelihood of chronic exposure to trespassers is extremely low. The corresponding exposure assumptions are therefore highly conservative. Potential future use exposure pathways are not expected to be completed as the site is to remain inactive for the foreseeable future. Exposure pathways were selected by USEPA and the Navy as an extremely conservative estimate of risk/hazard onsite. The result would tend to be an overestimate of risk/hazard under anticipated use conditions.

Determination of Exposure Concentrations

Based on the guidance provided by USEPA, EPCs are those concentrations used to estimate CDI. The uncertainty associated with EPCs primarily stems from their statistical determination or imposition of maximum concentrations, described below.

Statistical Estimation of Exposure Point Concentrations

USEPA provided supplemental guidance which outlines a statistical estimation of EPC. These calculated concentrations are 95% UCL mean concentrations which are based on certain assumptions. USEPA makes the assumption that most (if not all) environmental data are lognormally distributed. Uncertainty exists in this assumption because many environmental data are neither normally nor lognormally distributed.

The UCL calculation is provided in the Supplemental Guidance to RAGS: Calculating the Concentration Term, May 1992. This calculation includes a statistical value, the H-statistic. **This** statistic is based on the number of samples analyzed for each COPC and the standard deviation of the results. To obtain this number, a table must be referenced, and the value must be interpolated (an estimation) from the table. The equation for the H-statistic has not been provided in the supplemental guidance, nor does the document referenced in the guidance provide the equation. Although the statistic appears to be non-linear, a linear assumption was made to facilitate interpolation of the statistic for each COPC addressed in the BRA.

Linear interpolation is a good estimate of **H;** however, it is important to note that the formula and **H** are natural log values, and H is applied as a multiplier. The effect of multiplying natural log numbers is not equivalent to multiplying untransformed values. While data are log transformed, adding two numbers is the equivalent of multiplying the two numbers if they were not transformed. The effect of multiplying a number while in log form is exponential, and H is applied as a multiplier. In summary, using this method to calculate the UCL leads to an overestimation **of** exposure and often provides concentrations greater than the maximum concentration detected onsite.

Although RAGS advocates the use of neither worst-case scenarios nor maximum concentrations as EPCs, using the H-statistic often results in use of the reported maximum concentration as EPC. The lesser of the maximum concentration and the UCL is used as the **EPC.** Summation

of risk based on maximum concentrations leads to overestimation of risk/hazard, especially in the case of low detection frequency or spatially segregated COPCs. This concept is further discussed below.

Frequency of Detection and Spatial Distribution

Because of the influence of standard deviation on EPC, low frequency of detection can cause COPCs to be inappropriately addressed in the risk assessment. More specifically, COPCs detected only once or twice in all samples analyzed (having concentrations in excess of the RBCs and reference concentrations) would be expected to have relatively higher standard deviation as concentration variability or range widens. Higher standard deviation results in a high H-statistic, and this typically leads to a UCL greater than the maximum concentration detected onsite. Using the maximum reported concentration as EPC, or including a COPC reported at only one sample location, may not be appropriate when EPC is assumed to be homogeneous. Specific frequency of detection uncertainty is discussed on a medium-specific basis in subsequent paragraphs.

For example, beryllium was reported in only one surface soil sample and accounts for the majority of the ILCR estimated for the surface soil exposure pathways. The intent of this BRA is to assess Site 1 as a whole, and beryllium was not detected at a frequency of detection which would support that assumption. Beryllium was detected at only one of 27 sample locations, and the location is between fill locations. It is uncertain whether the landfill is the source of the beryllium detected. Therefore, the use of the maximum beryllium concentration to estimate exposure at Site 1 inappropriately biases the risk assessment. Beryllium exposure estimates are overestimates assuming sitewide exposure. Assuming a residential scenario, beryllium could be identified as a COC at one sample location.

Volatile COPCs were detected in groundwater at the edge of the landfill, and based on the frequency of detection, VOC contamination is not uniform. Generally forming a crescent-shaped curve around the top of the landfill, the wells at the northwest, north, and northeast perimeter

of the landfill produced samples with the highest VOC concentrations for COCs in shallow and intermediate groundwater. In summary, the southern portion and perimeter of the landfill appears to be less contaminated than the other portions. For a detailed discussion, refer to Section 8, Nature and Extent of Contamination. Therefore, chronic exposure potential is limited for a well screened in the shallow/intermediate zone.

Toxicity Assessment Information

There is a generally recognized uncertainty in human risk values developed from experimental data primarily due to the uncertainty of data extrapolation in the areas of: (1) high to low dose exposure and (2) animal data to human experience. Conservative safety factors are included to reduce the likelihood of underestimating the potential to elicit toxic effects, and extrapolation between species typically overestimates the potential for toxic effects because of the safety factors.

The degree of chemical absorption from the gut or through the skin or the amount of soil contact is not known with certainty. Generally accepted default values provided in USEPA guidance were used. However, little guidance or data are on the dermal absorption of particulate-bound chemicals. In the risk assessment conducted for the study area, the dermal pathway was assumed to contribute to overall CDI for the soil pathway, although the transdermal transport of each COPC has not been quantified experimentally.

Slope factors were determined for many chemicals which may or may not be genotoxic, and slope factors have not been determined for all exposure routes. Therefore, cancer inducing potential may be grossly overestimated. Due to developing science, some COPCs may not be recognized or slope factors might not have been determined which could lead to underestimates of potential carcinogenicity.

The uncertainty of toxicological values from the IRIS and HEAST databases (provided by USEPA) are summarized in Table 10-29 (previously presented). The uncertainty factors assigned to these values account for acute to chronic dose extrapolation, study inadequacies, and sensitive subpopulations among other factors. Although uncertainty factors for a specific compound may be 1,000 or higher, these safety factors are applied by USEPA to assist in guaranteeing the overall assessment of risk/hazard is conservative in favor of human health protection. In the presence of such uncertainty, the USEPA and the risk assessor are obligated to make conservative assumptions, so the chance is very small for the actual health 'risk to be greater than what is determined through the risk assessment process. On the other hand, the process is not to yield absurdly conservative risk values that have no basis in reality.

Evaluation of Chemicals for Which No Toxicity Values Are Available

In addition to the typical uncertainties inherent in toxicity values, parameters which do not have corresponding RBCs due to the lack of approved toxicological values were included in the CDI calculation data. This information was provided to facilitate risk/hazard projections should toxicological values become available in the future. In addition, many essential nutrients were detected above reference concentrations but were not considered COPCs.

Quantification of Risk/Hazard

As indicated by the discussions above, the uncertainty and variability inherent in the risk assessment process is great. In addition, many site-specific factors have affected the uncertainty of this assessment. Exposure pathway-specific sources of uncertainty are discussed below.

soil

No soil COCs were identified assuming future residential use of the landfill. No COCs were identified for any soil exposure scenario or pathway. As discussed in exposure setting uncertainty discussion, the actual potential for chronic exposure to the soil is low. Soil pathways addressed in this BRA are highly conservative. Soil was assessed under typical future site

residents, potential future site worker, and current/future trespass scenarios. The risk/hazard was not adjusted for percent area affected, and uniform exposure to all areas was assumed. This approach is highly conservative and would positively bias risk projections.

Variability related to soil RME concentrations was controlled through the use of the lesser of the maximum and 95% UCL mean chemical concentrations for each COPC to compute risk/hazard. Another factor which introduces variability in the soil exposure pathways is the use of 1993 data for this BRA, as discussed in the Quality of Data section. Uncertainty is introduced when using data collected over two years. According to USEPA, these UCL/maximum values provided a reasonable estimate of maximum exposure concentrations, assuming uniform exposure to all soil. As discussed previously in the Frequency of Detection section, the detection frequency could have a significant effect on the computed risk/hazard posed for the soil exposure pathways. Soil EPCs are often maximum concentrations due to the UCL calculation method employed in this BRA. In addition, use of these UCL values can be similar to using soil maximum concentrations, which is highly conservative due to the improbability of focused exposure to an infinitesimally small, theoretically derived hot spot.

The ILCR estimated for the surface soil exposure pathways exceeded 1E-6, the FDEP risk threshold. As previously discussed, beryllium accounted for the majority of the ILCR, and was reported at only one of 27 surface soil locations sampled. Without beryllium, the ILCR estimate would be less than 1E-6. It would be inappropriate to assume that a compound having a low detection frequency represents a large area such as Site 1. Assuming a residential scenario, beryllium could be considered a COC at one location sampled. However, the landfill is not projected for residential use. The location where beryllium was detected was between the fill areas at Site 1, and some uncertainty exists with respect to the landfill being the source of beryllium reported. No COCs were identified for the residential soil exposure pathways.

Groundwater

The primary source of uncertainty in the groundwater exposure pathway is the potable use assumption, which represents a highly conservative approach to assessing the significance of groundwater impacts. The combined shallow/intermediate water-bearing zone (WBZ) is not currently used onsite as an industrial or potable water source, nor is it anticipated to be in the future. Assuming homes were constructed on the landfill and the residents installed unfiltered wells for potable use is an extremely conservative assessment of future aquifer use. The deep WBZ was assessed separately under the same assumptions, but the shallow and intermediate WBZs were combined. If the future use scenario were to exist, and a future potable well was screened exclusively in the shallow or intermediate WBZ, a change in the estimated risk/hazard could be expected.

There is no identifiable aquitard between shallow and intermediate zones, and a residential well would require higher yield than a monitoring well. Thus, it is likely that any residential well would be screened across the two upper WBZs to maximize the volume of groundwater that could be extracted without inordinate drawdown, and that well (like most residential wells) would be filtered. It is important to emphasize the fact that the future use scenario is not expected based on Navy plans for the base or Site 1. This exposure pathway was addressed as an extremely conservative risk estimate for future land use under the residential exposure scenario.

Supplemental guidance was presented in draft form in June 1994 by USEPA Region IV in order to streamline the approach used to address inhalation of contaminants via the groundwater exposure pathway. According to the draft supplemental guidance, the CDI for the inhalation pathway is equivalent to that of ingestion pathway where 2 liters of groundwater are ingested daily.

According to the draft guidance, the risk/hazard posed by the pathways is cumulative; two times the oral ingestion pathway CDI has been proposed as an equivalent calculation for the cumulative ingestion and inhalation exposure pathways. Previously, these pathways were calculated separately using chemical-specific factors and pathway-specific exposure assumptions. In addition to these factors, this draft method does not consider fugacity (i.e., the propensity for a substance to "break free" from the containing medium) as part of the suggested calculation. This proposed method does include the inhalation reference dose or slope factor, but it is applied to the ingestion formula.

An approach similar to that applied to soil for limiting RME uncertainties was taken for groundwater. It would be implausible to expect an individual to be chronically exposed to the maximum concentration of each groundwater chemical. Substitution of the 95% UCL mean concentration (where possible) for each chemical provides a reasonably conservative estimate of the chronic concentrations to which an individual may be exposed via the groundwater pathway. Spatial analysis shows that inorganic and organic COPCs did not consistently coexist, and detections appeared to be random rather than suggestive of a defined plume.

Many essential nutrients were detected in the shallow, intermediate, and deep WBZs. These essential nutrients would be expected due to possible saltwater intrusion and the proximity of Pensacola Bay. In addition to these nutrients, arsenic would be expected to be present (as it is in seafood). Arsenic did not exceed its federal MCL or FPDWS at the maximum concentration detected. At the EPC, arsenic poses 3.2E-4 excess cancer risk, approximately 80% of the total risk.

Groundwater metals concentrations were obtained from unfiltered samples. As mentioned previously, filtration would likely be a part of any system deriving water from the shallow WBZ for potable use. As stated in Section 9, Fate and Transport, of this report, the groundwater in this aquifer has been shown to be highly turbid and to contain natural iron, manganese, and

sodium concentrations exceeding FSDWS. A large portion of the aquifer yields dark brown, highly organic pore water with an acrid H_2S odor, which could have been a result of reduced manganese and iron. Based on natural qualities, the aquifer does not appear suitable as a drinking water supply either in impacted or unimpacted areas.

As discussed for exposure to surface soil, uniform exposure was assumed for all monitoring well data from Site 1. Percent area affected was not applied to the risk projections, and this is a highly conservative approach, especially in the case of low frequency of detected COPCs. As discussed above, the likelihood that the aquifer'would be used as a drinking water supply is extremely low. Also previously discussed is the Navy's intention for continued operations, which indicates the area will remain a limited access area. Since COCs were identified assuming potable water use by site residents, the conservatism and resulting overestimation of risk projections are substantial. All assumptions regarding the evaluation of shallow and intermediate groundwater and deep groundwater as potential sources of potable water are the same for this risk assessment.

Using average (50th percentile) exposure assumptions, CT analysis was performed for groundwater as an indication of the variability of risk and hazard estimates. The exposure duration is reduced to two and seven years for the child and adult, respectively. Ingestion rates are also reduced from 2 liters per day (L/d) to 1.4 L/d for adults and 0.5 l/d for children. The exposure frequency is also adjusted to the 50th percentile value for exposure to groundwater. The RME exposure frequency is 350 days/year, and the CT exposure frequency is reduced to 234 days/year. In addition, an adjustment of 75% is applied to the ingestion rates for the dietary fraction of water consumed to account for other possible sources (canned drinks, bottled water, etc.) The CT CDI and resulting risk projections for shallow and intermediate (combined aquifer for Site 1) and deep groundwater are presented in Tables 10-40 and 10-41, respectively. The inhalation pathway was also assessed for shallow and intermediate CT, and these tables are

Table 10-40
Central Tendency Chronic Daily Intakes for Future Residents
Ingestion and Inhalation of Shallow and Intermediate Groundwater
NAS Pensacola, Site 1
Pensacola, Florida

Chemical	Exposure Point Concentration (mg/L)	Future Use: Resident Adult H-CDI (mg/kg/day)	Future Use: Resident Child H-CDI (mg/kg/day)	Future Use: Resident Iwa C-CDI (mg/kg/day) (a)
1,1-Dichloroethane	0.008	7.69 E-05	2.56E-04	4.84E-05
1,2-Dichlorobenzene	0.005	4.8 1E-05	1.60E-04	3.02E-05
1,2-Dichloroethene (total)	0.00303	2.9 1E-05	9.71 E-05	1.83E-05
1,1,2,2-Tetrachloroethane	0.001	1.32E-05	4.39E-05	8.29E-06
1,4-Dichlorobenzene	0.007	7.10E-05	2.37E-04	4.46E-05
1,1,2-Trichloroethane	0.0006374	6.13E-06	2.04E-05	3.85E-06
2-Methylnaphthalene	0.002143	2.06E-05	6.87E-05	1.30E-05
Aluminum	0.45	4.32E-03	1.44E-02	2.71 E-03
Arsenic	0.01 23	1.18E-04	3.94E-04	7.42E-05
Barium	0.1 1293	1.09E-03	3.62E-03	6.8 3E-04
Benzene	0.0264	2.54E-04	8.46E-04	1.59E-04
Bis(2-ethylhexyl)phthalate	0.000889	8.55E-06	2.85E-05	5.37E-06
Bromoform	0.0012749	1.23E-05	4.09E-05	7.7 1E-06
Cadmium	0.002865	2.76E-05	9.18E-05	1.73E-05
Chlorobenzene	0.12	1.1 5E-03	3.85E-03	7.25E-04
Chloroethane	0.002	1.92E-05	8.41 E-05	1.21 E-05
Chloroform	0.002373	2.28 E-05	7.61E-05	1.43E-05
Chromium	0.0105936	1.02E-04	3.40E-04	6.40E-05
Copper	0.0101 996	9.81 E-05	3.27E-04	6.1 7E-05
Dieldrin	0.000004	3.98E-08	1.33E-07	2.50E-08
Manganese	0.042009	4.04E-04	1.35E-03	2.54E-04
Naphthalene	0.005399	5.1 9E-05	1.73E-04	3.26E-05
Nickel	0.030824	2.96E-04	9.88E-04	1.86E-04
Trichloroethene	0.000637	6.1 3E-06	2.04E-05	3.85E-06
Vinyl Chloride	0.002462	2.37E-05	7.89E-05	1.49E-05
Xylenes (total)	0.01 2807	1.23E-04	4.1 1E-04	7.74E-05
Zinc	0.4614	4.44E-03	1.48E-02	2.79 E-03

NOTES:

a Carcinogenic chronic daily intake is based on the lifetime weighted average (Iwa) of an adult age 7-31 and a child age 1-6.
CDI Chronic daily intake in units of mg/kg/day.
H-CDI CDI for hazard quotient.
C-CDI CDI for excess cancer risk.

Table 10-41
Central Tendency Chronic Daily Intakes for Future Residents
Ingestion and Inhalation of Deep Groundwater
NAS Pensacola, Site 1
Pensacola, Florida

Chemical	Exposure Point Concentration (mg/L)	Future Use		
		Resident Adult H-CDI (mg/kg/day)	Resident Child H-CDI (mg/kg/day)	Resident lwa C-CDI (mg/kg/day) (a)
Manganese	0.0901	8.66E-04	2.89E-03	5.45E-04

NOTES:

a Carcinogenic chronic daily intake is based on the lifetime weighted average (lwa) of an adult age 7-31 and a child age 1-6.
CDI Chronic daily intake in units of mg/kg/day.
H-CDI CDI for hazard quotient.
C-CDI CDI for excess cancer risk.

included. Volatiles were not detected in deep zone groundwater, so the inhalation exposure pathway does not apply to this WBZ. The specific tables are:

Subject		Table
e	Shallow and intermediate groundwater ingestion/inhalation CDI	10-40
e	Deep groundwater ingestion CDI	10-41
e	Shallow and intermediate groundwater ingestion risk projections	10-42
e	Shallow and intermediate groundwater inhalation risk projections	10-43
e	Deep groundwater risk projections	10-44

As Tables 1042 and 10-43 show, assuming potable use of shallow and intermediate groundwater results in the ingestion HI estimate of 3 for a child and 0.8 for an adult.- The primary contributors to HI are arsenic, benzene, chlorobenzene, manganese, and cadmium. Analyzed under CT assumptions, this exposure pathway slightly exceeds the 1E-4 risk level. Although the maximum reported arsenic concentration does not exceed the corresponding MCL, arsenic accounts for 1.1E-4 of the ILCR estimated for the ingestion pathway. CT analysis for the ingestion of shallow and intermediate groundwater pathway exceeds the USEPA and FDEP risk and hazard index thresholds (ILCR = 1E-6 and HI = 1, respectively) for the child scenario.

CT analysis for the inhalation pathway of shallow and intermediate groundwater also exceeds USEPA and FDEP criteria for risk and hazard. The primary contributors to the hazard index are chlorobenzene and benzene. Based on CT analysis, ILCR estimated for the inhalation of contaminants in groundwater (1E-5) does not exceed the upper bound USEPA acceptable risk range of 1E-6 to 1E-4. However, the estimated ILCR does exceed the FDEP risk threshold of 1E-6. 1,1,2,2-Tetrachloroethane, 1,4-dichlorobenzene, vinyl chloride, and benzene account for approximately 90% of the total estimated ILCR for the inhalation pathway.

Table 10-42
Central Tendency Hazard Quotients and Incremental Lifetime
Cancer Risks- Ingestion of Shallow and Intermediate Groundwater
NAS Pensacola, Site 1
Pensacola. florida

Chemical	Slope Factor Used (mg/kg/day)-1	Reference Dose Used (mg/kg/day)	Future Use: Potential Future Resident Adult Hazard Quotient	Future Use: Potential Future Resident Child Hazard Quotient	Future Use: Potential Future Resident Iwa ILCR (a)
1.1-Dichloroethane	ND	0.1	0.0007 7	0.0026	NA
1.2-Dichlorobenzene	ND	0.09	0.00053	0.001 8	NA
1,2-Dichloroethene (total)	ND	0.009	0.003	0.01 1	NA
1,1,2,2-Tetrachloroethane	0.2	ND	NA	NA	1.66E-06
1,4-Dichlorobenzene	0.024	0.229 •	0.0003	0.0010	1.07E-06
1.1.2-Trichloroethane	0.057	0.604	0.00 15	0.0051	2.20E-07
2-Methylnaphthalene	ND	0.04	0.00052	0.0017	NA
Aluminum	ND	1	0.0043	0.014	NA
Arsenic	1.5	0.0003	0.39	1.3	1.11E-04
Barium	ND	0.07	0.01 6	0.052	NA
Benzene	0.029	0.00171 •	0.15	0.49	4.63 E-06
Bis(2-ethylhexyl)phthalate	0.01 4	0.02	0.00043	0.001 4	7.52E-08
Bromoform	0.0079	0.02	0,00061	0.0020	6.09E-08
Cadmium	ND	0.0005	0.055	0.18	NA
Chlorobenzene	ND	0.02	0.058	0.19	NA
Chloroethane	ND	0.4	0.000048	0.0001 6	NA
Chloroform	0.0061	0.01	0.0023	0.0076	8.75E-08
Chromium	ND	1	0.00010	0.00034	NA
Copper	ND	0.0371	0.0026	***0.0088***	NA
Dieldrin	16	5E-05	0.00080	0.0027	4.00E-07
Manganese	ND	0.005	0.081	0.27	NA
Naphthalene	ND	0.04	0.0013	0.0043	NA
Nickel	ND	0.02	0.01 5	0.049	NA
Trichloroethene	0.01 1	0.006	0.0010	0.0034	4.24E-08
Vinyl Chloride	1.9	ND	NA	NA	2.83E-05
Xylenes (total)	ND	2	0.000062	0.0002	NA
Zinc	ND	0.3	0.01 5	0.049	NA
Hazard Index			***0.8***	**3**	
Total Risk					1E-04

NOTES:

a Incremental lifetime cancer risk (ILCR) is based on the lifetime weighted average (Iwa) of an adult age 7-31 and child age 1-6.

ND Not determined due to lack of information.

NA Not applicable due to the lack of appropriate toxicological values.

• Indicates an inhalation slope factor or reference dose was used as a surrogate oral value.

Table 10-43
Central Tendency Hazard Quotients and Incremental Lifetime Cancer Risks
Inhalation of Volatilized Shallow and Intermediate Groundwater Contaminants
NAS Pensacola, Site 1
Pensacola, Florida

Chemical	Slope Factor Used ..ng/kg/day)-1	Reference Dose used (mg/kg/day)	Futuro Use: Potential Future Resident Adult Hazard Quotient	Potential Future Resident Child Hazard Quotient	Potential Future Resident Iwa ILCR (a)
1,1-Dichloroethane	ND	0.143	0.0005	0.002	NA
1,2-Dichlorobenzene	ND	0.04	0.0012	0.0040	NA
1,2-Dichloroethene (total)	ND	0.009 •	0.0032	0.01 1	NA
1,1,2,2-Tetrachloroethane	0.203	ND	NA	NA	1.7E-06
1,4-Dichlorobenzene	0.024 •	0.229	0.00031	0.0010	1.1E-06
1,1,2-Trichloroethane	0.056	0.004 •	0.0015	0.005	2.2E-07
Benzene	0.029	0.00171	0.1 5	0.49	4.6E-06
Bromoform	0.00385	0.02 •	0.00061	0.0020	3.0E-08
Chlorobenzene	ND	0.00571	0.20	0.67	NA
Chloroethane	ND	2.86	0.000007	0.00002	NA
Chloroform	0.0805	0.01 •	0.0023	0.008	1.2E-00
Trichloroethene	0.006	0.008 •	0.0010	0.003	2.3E-08
Vinyl Chloride	0.3	ND	NA	NA	4.5E-06
Xylenes (total)	ND	0.0857	0.00 14	0.0048	NA
Hazard Index			0.4	1	
Total Risk					1E-05

NOTES:

a Incremental lifetime cancer risk (ILCR) is basad on the lifetime weighted average (Iwa) of an adult age 7-31 and child age 1-6.
ND Not determined due to lack of information.
NA Not applicable due to the lack of appropriate toxicological values.
• Indicates an ingestion slope factor or reference dose was used as a surrogate inhalation value.

Table 10-44
Central Tendency Hazard Quotients and Incremental Lifetime
Cancer Risks-Ingestionof Deep Groundwater
NAS Pensacola, Site 1
Pensacola, Florida

Chemical	Slope Factor Used (mg/kg/day)-1	Reference Dose Used (mg/kg/day)	Futuro Use: Potential Future Resident Adult Hazard Quotient	Potential Future Resident Child Hazard Quotient	Potential Future Resident Iwa ILCR (a)
Manganese	ND	0.005	**0.17**	0.6	NA
Hazard Index			***0.2***	***0.6***	
Total Risk					NA

NOTES:

a Incremental lifetime cancer risk (ILCR) is based on the lifetime weighted average (Iwa) of an ad age 7-31 and child age 1-6.

ND Not determined due to lack of information.

NA Not applicable due to the lack of appropriate toxicological values.

Table 10-44 presents the risk and/or hazard results for ingestion of deep groundwater under CT conditions. Manganese, the sole COC identified in deep groundwater, resulted in hazard indices of 0.2 and 0.6 for the future site resident adult and child, respectively. These hazard indices do not exceed the FDEP and USEPA threshold for HI.

These results, when compared to the same results under RME conditions, are approximately 50% less for the adult receptor and 35% less for the child receptor. Therefore, some variability is evident based on CT exposure estimates. No carcinogenic risk results were calculated for manganese under CT conditions.

Few COCs are identified for the residential exposure pathways (potential future use) only, and the COPCs identified are based on conservative assumptions for all exposure pathways. The COCs are summarized in Section 10.1.7.

10.1.7 Risk Summary

The human health risk associated with exposure to environmental media at NAS Pensacola Site 1 was assessed for hypothetical current child trespassers, a future site worker, and future site residents. The exposure media considered in these assessments included surface soil (0 to 1 foot depth interval), surface and subsurface soil (all depth intervals), shallow/intermediate groundwater, and deep groundwater. As discussed in Section 10.1.5 of this BRA, it was determined that the risk and/or hazard associated with exposure to all environmental media (and combinations thereof) did not exceed USEPA and FDEP's risk and hazard thresholds for the trespassing child and the potential future site worker scenarios. Based on these findings, no COCs were identified relative to these receptor groups. Site 1 groundwater is not currently used as a potable water source or for any industrial uses. Therefore, current receptors were not evaluated with respect to the groundwater media.

The hypothetical future site resident was evaluated with respect to soil and groundwater using a surface soil dataset and two separate groundwater datasets. Surface soil data consist of samples collected from zero to 1 foot soil depth intervals, and the two groundwater datasets consisted of data from the combined shallow/intermediate and deep groundwater depths. Exposure to the shallow/intermediate groundwater medium presented an unacceptable risk and hazard via the ingestion and inhalation exposure pathways.

For surface soil, beryllium was reported at a concentration which represents greater than 1E-6 risk. However, beryllium was reported at a location between fill areas at Site 1 and was reported in only one sample of 27 collected. Risk estimated without beryllium does not exceed 1E-6. Therefore, no soil COCs were identified for the hypothetical future site resident. Table 10-45 summarizes the pathways of concern and associated COCs.

As shown in Table 10-45, the combined shallow/intermediate groundwater pathway hazard indices (ingestion and inhalation exposures) for the future site resident child were estimated to be 3 and 8 for the site resident adult, respectively. The combined potential groundwater carcinogenic risk for ingestion and inhalation of groundwater was computed to be 4E-4. The primary noncarcinogenic COCs for groundwater ingestion are arsenic, barium, benzene, cadmium, chlorobenzene, manganese, nickel, vinyl chloride, and zinc. Arsenic accounts for the majority of the hazard index, followed by benzene, chlorobenzene, and manganese. The primary carcinogenic COCs identified for ingestion of groundwater include arsenic, vinyl chloride, and benzene. Arsenic was the primary contributor to the estimated risk. Arsenic contributes 70% of the total combined carcinogenic risk for the site resident, followed by vinyl chloride and benzene, which contribute approximately 21% and 0.6% of the risk, respectively.

Table 10-45
Receptor Summary of Carcinogenic Risk and Non-carcinogenic Hazard
NAS Pensacola She 1
Pensacola, Florida

Medium/Pathway	Potential Future Resident Adult Hazard Quotient	Potential Future Resident Child Hazard Quotient	Potential Future Resident Iwa ILCR	Site Trespasser Hazard Quotient	Site Trespasser ILCR	Site Worker Hazard Quotient	Site Worker ILCR
Soil Incidental Ingestion Pathway Total*	**0.01**	**0.1**	*** 2E-06**	0.003	7E-08	**0.004**	**3E-07**
Soil Dermal Contact Pathway Totd	**0.003**	**0.008**	**4E-07**	0.0008	2E-08	**0.002**	**2E-07**
Shallow/Intermediate Groundwater Ingestion Pathway Totd	**2**	**5**	**4E-04**	**NA**	**NA**	**NA**	**NA**
Shallow Groundwater Inhalation Pathway Total	**1**	**2**	**3E-05**	**NA**	**NA**	**NA**	**NA**
Deep Groundwater Ingestion Pathway Total	**0.5**	**1**	**NA**	**NA**	**NA**	**NA**	**NA**
Surface Water Incidentd Ingestion Pathway Total	**NA**	**NA**	**NA**	0.05	9E-07	**NA**	**NA**
Surface Water Inhalation Pathway Total	**NA**	**NA**	**NA**	0.003	2E-08	**NA**	**NA**
Sediment Incidentd Ingestion Pathway Totd	**NA**	**NA**	**NA**	0.002	9E-08	**NA**	**NA**
Sediment Dermal Contact Pathway Total	NA	NA	NA	0.0004	2E-08	NA	NA
All Pathways Cumulative Total Risk/Hazard w/Shallow GW	**3**	**8**	**4E-04**	**0.06**	1E-06	0.01	5E-07
All Pathways Cumulative Totd Risk/Hazard w/Deep GW	0.5	1	3E-06	0.06	1E-06	0.01	5E-07

NOTES:

NA Indicates not applicable.
LWA Indicates lifetime weighted average.
* Beryllium could be considered a COC at only one sample location: beryllium was reported in only one of 27 samples.
\- Although the trespasser ILCR was estimated to be 1E-6, no COCs were identified. Arsenic in surface water was the primary contributor to ILCR, which accounted for less than 1E-6 ILCR.
ILCR Incremental lifetime excess cancer risk.

The deep groundwater pathway hazard indices (ingestion only) for the future site resident child and adult were calculated as 1 and 0.5, respectively. Since no volatile organic chemicals were identified in deep groundwater, risk and/or hazard via the inhalation pathway was not computed. Manganese was the sole contributor to the hazard via ingestion of deep groundwater.

Surface water and sediment were assessed preliminarily in this BRA. Sediment and surface water were sampled to determine if a potential contaminant for migration exists from groundwater at Site 1 to the surrounding wetlands. As discussed in Sections 7, 8, and'l 1 of this RI, wetlands 3 and 16 are possibly being impacted by organic compounds reported in Site 1 groundwater. The wetlands will be characterized as part of the Site 41 Wetlands Investigation RI, and risk to human health and the environment will be addressed in that investigation. However, a preliminary assessment was performed using the currently available data for Site 1 surface water and sediment. These media were assessed assuming an adolescent child (age 7 to 16) trespasser (swimming/wading) scenario. Based on the maximum concentrations reported for all wetlands sampled, surface water risk and hazard were estimated to be 9E-7 and 0.05 for the combined incidental ingestion and inhalation exposure pathways. Sediment exposure was estimated for the incidental ingestion and dermal contact exposure pathways, which resulted in combined risk and hazard estimates of 1E-7 and 0.002, respectively. The preliminary risk and hazard estimates did not exceed USEPA and FDEP risk and hazard thresholds of 1E-6 and 1.

Assuming groundwater will be used as a potable water source, the COCs listed in Table 10-39 (previously presented) were determined to be the only chemicals that may warrant consideration during feasibility study development based on the hazard and risk calculations in this report.

10.1.8 Remedial Goal Options

Remedial goal options (RGOs) are chemical concentrations computed to equate with specific risk and/or hazard goals that may be established for a particular site. RGOs were calculated for all groundwater COCs that have either a combined ILCR of 1E-6 (or greater) or a HI of 1.0 (or

greater) for the combined inhalation and ingestion of groundwater pathway. In accordance with USEPA Supplemental RGO Guidance, RGOs were calculated at 1E-4, 1E-5, and 1E-6 risk levels for carcinogenic COCs and hazard quotient goals of 10, 1, and 0.1 for noncarcinogenic COCs. Tables 10-46 and 10-47 provide the groundwater RGOs for shallow and deep groundwater, respectively. Where appropriate, notes regarding specific RGOs are provided. It is important to note the concentrations of some COCs, such as arsenic, do not exceed the corresponding *ARAR.* In these cases, the most appropriate RGO is the *ARAR.* The ICLR is greater than the upper bound USEPA threshold, 1E-4. However, the maximum concentration of arsenic detected was less than the corresponding MCL.

CT assessment was only performed for pathways of concern (i.e., groundwater) and was previously presented in Section 10.1.6 in Tables 10-40 through 10-44.

10.2 Ecological Risk Assessment

The ecological risk assessment is a key component of the BRA. Its purpose is to develop a qualitative and/or quantitative ecological appraisal of the actual or potential effects of contamination at Site 1 on the ecosystem. The assessment considers environmental media and exposure pathways that could result in unacceptable levels of exposure to flora and fauna now or in the foreseeable future. The approach to assessing risk components at Site 1 was based on USEPA (1994) *Ecological Risk Assessment-Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments,* USEPA (1989) *Risk Assessment Guidance for Superfund. Volume 11-Environmental Evaluation Manual,* (USEPA 1989b) and USEPA/630/R-921001 *Framework for Ecological Risk Assessment* (USEPA 1992a).

Impacted soil and groundwater from landfill activities are discussed in Sections 7 and 8 of this report. This information has been used to determine ecological risks associated with the site. In addition, a cursory examination of the potential for effects of site activities to local wetland receptors will also be presented.

Table 10-46
Remedial Goal Options for Shallow/Intermediate Groundwater
NAS Pensacola, Site 1
Panaacola, florida

Chemical	Carcinogenic Rirk-Based RGOs Risk Goal 1E-4	1E-05	1E-06	Hazard-Bared RGOs Hazard Goal 10	1	0.1	EPC (mg/L)	Reference Concentration (mg/L)	ARAR (mg/L)	Source
1,1,2,2-Tetrachloroethane	0.01 7	0.0017	0.00017	NA	NA	NA	0.0014	NA	0.0002	FDWS-C
••1,4-Dichlorobenzene	0.14	0.014	0.0014	17.9	1.79	0.1 79	0.0074	NA	0.075	FPDWS
**Arsenic*	0.0045	0.00045	0.000045	0.047	0.0047	0.00047	0.01 2	ND	0.05	FPDWS
••Barium•	NA	NA	NA	11.0	1.10	0.1 10	0.1 13	ND	2	FPDWS
Benzene	0.19	0.01 9	0.0019	0.27	0.027	0.00267	0.026	NA	0.001	FPDWS
**Cadmium*	NA	NA	NA	0.078	0.0078	0.00078	0.0029	ND	0.005	FPDWS
• *Nickel•	NA	NA	NA	3.1	0.3 1	0.03 1	0.0308	ND	0.1	FPDWS
••Chlorobenzene	NA	NA	NA	3.1	0.31	0.03 1	0.1 2	NA	0.1	MCL • monoohlorobenzene
• 'Manganese •	NA	NA	NA	0.78	0.078	0.0078	0.042	0.021 5	0.05	FSDWS
Vinyl chloride	0.0035	0.00035	0.000035	NA	NA	NA	0.0025	NA	0.001	FPDWS
••Chloroform	0.0072	0.00072	0.000072	1.6	0.1 6	0.01 6	0.0024	NA	0.006	FDWS-C

NOTES:

NA Indicates an RGO war not applicable for this chemical under risk and/or hazard-based conditions.
ND Indicates the chemical was not detected in reference (background) wells.
FPDWS florida Primary Drinking Water Standard, FSDWS means florida Secondary Drinking Water Standard.
FDWS-C florida guidance concentration based on carcinogenicity.
• Indicates the inhalation pathway was not considered in establishing RGOs.
** Indicates the EPC is greater than the corresponding ARAR.
- Noncarcinogenic hazard based RGOs ware computed based on the future child rite resident rcenario with combined ingestion and inhalation exposure (where applicable).
- Carcinogenic risk-based RGOs were computed based on the future site resident lifetime weighted average scenario with combined ingestion and inhalation exposure (where applicabla).

Table 10-47
Remedial God Options for Deep Groundwater
NAS Pensacola, Site 1
Pensecola, florida

Chemical	Carcinogenic Risk-Based RGOs Risk Goal 1E-4	1E-05	1E-08	Hazard-Based RGOs Hazard God 10	1	0.1	EPC (mg/l)	Reference Concentration (mg/l)	ARAR (mg/l)	Source
Manganese	NA	NA	NA	0.00	0.000	0.0000	0.090	0.0215	0.05	FSDWS

NOTES:

NA Indicates an RGO was not applicable for this chemical under risk and/or hazard based conditions.
ND Indicates the chemical was not detected in reference (background) wells.
FSDWS florida Secondary Drinking Water Standard.
- Non-carcinogenic hazard based RGOs were computed based on the future child Site resident scenario with combined ingestion and inhalation exposure (where applicable).
- Carcinogenic risk-based RGOs were computed based on the future Site resident lifetime weighted average scenario with combined ingestion and inhalation exposure (where applicable).

Problem Formulation

10.2.1 Environmental Setting

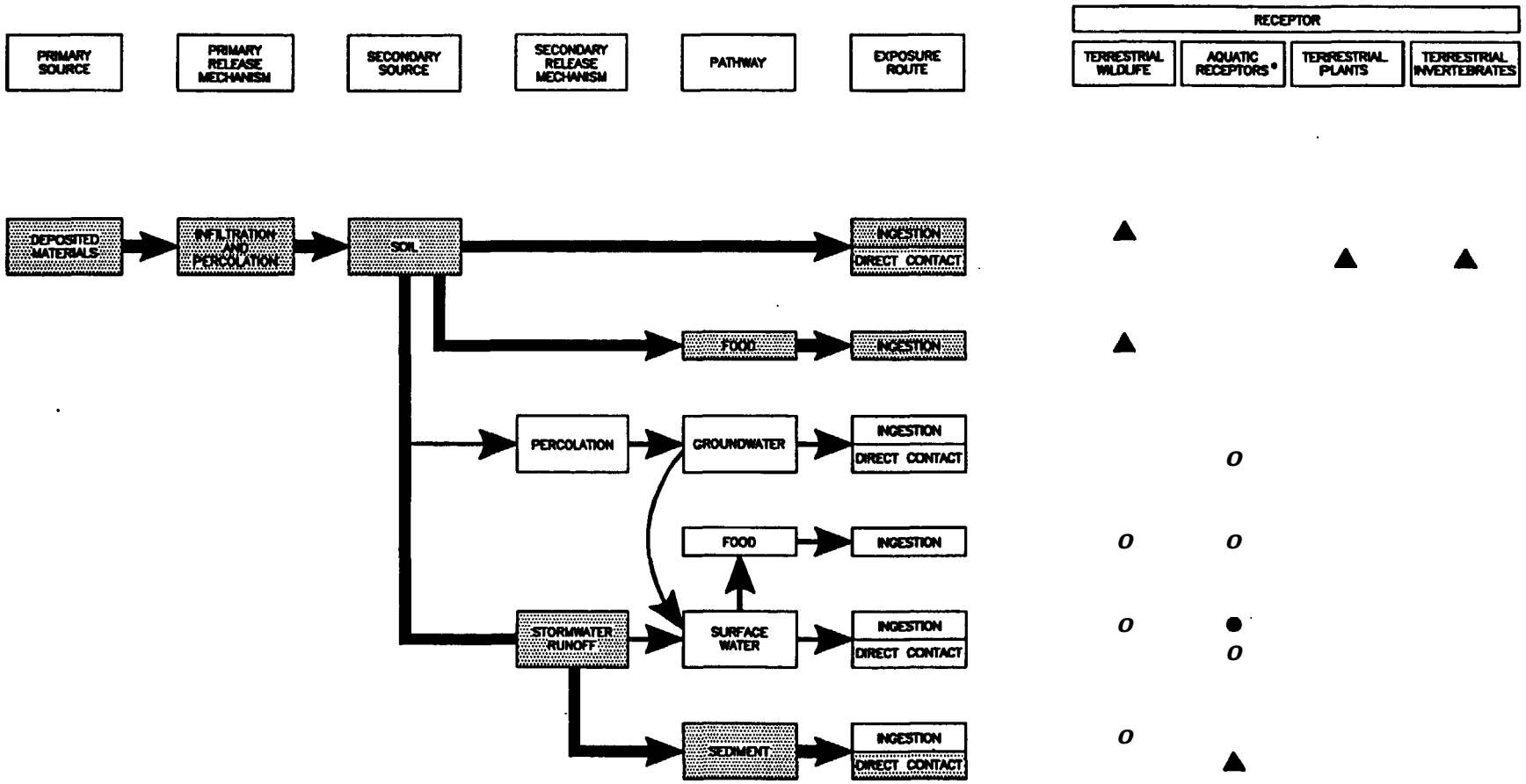
Section 4.3 of this report contains the results of a Phase I Habitat and Biota survey of the site. In general, Site 1 is classified as a successional slash/sand pine community, typical to many coastal areas of northwest Florida. In the past 20 to 40 years, the entire area within the landfill boundary has been clear cut and replanted. These silviculture practices have resulted in sand pine-dominated stands containing opportunistic understory species. Major faunal receptor species associated with this habitat are small mammals, passerine birds, amphibians, and reptiles. In addition, shorebirds are expected to use this area intermittently.

10.2.2 Conceptual Model

Figure 10-3 presents a conceptual model of the contaminant pathways from source to ecological receptors for Site 1. For this risk assessment only exposure routes directly related to soil pathways will be evaluated. Subsequent remedial investigations will be directed at wetlands and associated bayou areas to evaluate the potential for effects to receptors through aqueous pathways. Also direct impacts to plants are not included in this assessment but transfer mechanisms are considered in food chain transfer analyses and information related to specific contaminant toxic mechanisms to vegetation are discussed.

10.2.3 Selection of Ecological Chemicals of Potential Concern

Previous sections of this report discuss past waste disposal practices at Site 1 that may have impacted the surrounding ecosystem. COCs resulting from landfill activities have been identified and quantified using CLP protocol TAL/TCL analyses on soil and groundwater samples. Soil samples were collected at 27 locations across the site. Specifically, surface soil samples were collected from 16 monitoring well clusters, generally around the landfill perimeter, and 11 locations within its landfill boundary, where test trenching was performed.



* AQUATIC RECEPTORS = INVERTEBRATES, PLANTS, ALGAE, AMPHIBIANS, AND FISH

NOTE: HATCHED BOXES AND BOLD ARROWS INDICATE SELECTED PATHWAY

BASELINE RISK ASSESSMENT
SITE 1
NAS PENSACOLA
PENSACOLA, FLORIDA

FIGURE 10-3

CONTAMINANT PATHWAY MODEL FOR ECOLOGICAL RECEPTORS, OPERABLE UNIT 1

DWG DATE: 8/10/95 | DWG NAME: 1FIGFLOW

For ecological risk, only the results from surficial soil (0 to 1 foot bls interval) are addressed. It is presumed, even considering root development in the lower strata, that most biological effects will be limited to the upper zone. Based on the transient or mobile nature of the site's biological components, it is assumed that detected parameter concentrations both inside and outside the landfill's perimeter carry the same "weight-of-effect." Therefore, mean concentrations (of detected parameter concentrations only) and maximum values from all locations are used in this assessment. Although groundwater has been monitored, water table depth (approximately 5 to 15 feet bls) across the site precludes assessing ecological impacts from this medium immediately within the site. Potential ecological effects of groundwater migration from Site 1 to associated wetlands is discussed in general, but a more in-depth assessment will be completed during the Bayou Grande Remedial Investigation (Site 40).

Inorganic parameters detected in site surface soil exceeding twice the maximum concentration in reference sample concentrations, or not detected in reference samples, are identified as Ecological Chemicals of Potential Concern (ECPC) (Table 1048). Any constituent detected in less than 5 percent of the samples was not considered as an ECPC. Any organic constituent detected in greater than five percent of the samples was considered an ECPC. With few exceptions, ECPCs having highest concentrations were found from locations within the landfill boundary at test trenches (see Section 7.1 for a discussion of surface soil quality). Calcium, magnesium, potassium, and sodium were not included in the screening process as they are naturally occurring nutrients.

VOCS

VOCs were detected in samples from four locations at Site 1, three of which were within the landfill boundary. No VOCs were detected in reference samples. Total VOCs concentrations ranged from 1.0 to 280.0 $\mu g/kg$ with a mean of 80 $\mu g/kg$. Specific ECPCs from this compound group include acetone, chloroform, 1,1,1-trichloroethane, tetrachloroethene, and toluene.

Table 10-48
Selection of Ecological Contaminants of Potential Concerns (ECPCs) for Surface Soil
Site 1

Parameter	Frequency of Detection	RC	Minimum Detected	Maximum Detected	Mean	ECPCs
Inorganics (mg/kg)						
Aluminum	26/27	3833	733	13600	2320	Yes
Arsenic	2/27	1.56	0.9	1.1	1	No
Barium	19/27	4.63	1.4	20.4	4.9	Yes
Beryllium	1/27	0.41	0.61	0.61	0.61	No[1]
Cadmium	3/27	1.0	5.2	99	36.9	Yes
Chromium (total)	12/27	6.13	2.2	86.4	24.2	Yes
Cobalt	2/27	1.87	2.1	2.8	2.4	Yes
Copper	9/27	5.74	3.1	54.9	16.2	Yes
Cyanide	1/27	0.52	0.62	0.62	0.62	No[1]
Iron	27/27	2745	46.4	42300	3013	Yes
Lead	23/27	7.32	0.9	441	32	Yes
Manganese	19/27	21.36	2.3	191	20.3	Yes
Mercury	3/27	0.1	0.18	.81	0.51	Yes
Nickel	3/27	6.38	14.1	25.5	19.9	Yes
Selenium	1/27	0.62	0.73	0.73	0.73	No[1]
Vanadium	16/27	5.83	2.1	23	4.3	Yes
Zinc	26/27	16.87	1.5	219	21.7	Yes

Table 10-48
Selection of Ecological Contaminants of Potential Concerns (ECPCs) for Surface Soil
Site 1

Parameter	Frequency of Detection	RC	Minimum Detected	Maximum Detected	Mean	ECPCs
Volatiles (µg/kg)						
1,1,1-Trichloroethane	1/27	NA	1.0	1.0	1.0	No'
Acetone	1/27	NA	280	280	280	No'
Chloroform	1127	NA	2.0	2.0	2.0	No'
Tetrachloroethene	1/27	NA	6.0	6.0	6.0	No'
Toluene	3/27	NA	1.0	16.0	10.3	Yes
Semivolatiles (µg/kg)						
2,4-Dimethylphenol	1/27	NA	3500	3500	3500	No'
4-Methylphenol	1127	NA	1200	1200	1200	No'
Benzo(a)anthracene	1/27	NA	55	55	55	No'
Benzo(a)pyrene	1/27	NA	50	50	60	No'
Benzo(b)fluoranthene	3/27	NA	55	130	81.7	Yes
Benzo(g,h,i)perylene	1/27	NA	48	48	40	No'
Benzo(k)fluoranthene	3/27	NA	65	130	81.7	Yes
Butylbenzylphthalate	1127	NA	71	71	71	No'
Chrysene	1/27	NA	57	67	57	No'
fluoranthene	1/27	NA	110	110	110	No'

Table 10-48
Selection of Ecological Contaminants of Potential Concerns (ECPCs) for Surface Soil
Site 1

Parameter	Frequency of Detection	RC	Minimum Detected	Maximum Detected	Mean	ECPCs
Indeno(1,2,3-cd)pyrene	1/27	NA	47	47	47	No[1]
Phenanthrene	1/27	NA	38	38	38	No[1]
Pyrene	1/27	NA	73	73	73	No[1]
bis(2-chloroethyl)ether	1/27	NA	230	230	230	No[1]
Pesticides and PCBs (µg/kg)						
4,4'-DDD	12/27	NA	0.078	16	2.03	Yes
4,4'-DDE	11/27	NA	0.120	66	17.26	Yes
4,4'-DDT	12/27	NA	0.340	99	20.41	Yes
Aldrin	3/27	NA	0.120	1.4	0.57	Yes
Dieldrin	6/27	NA	0.19	20	4.9	Yes
Endosulfan I	1/27	NA	.061	.061	.061	No[1]
Endosulfan II	1/27	NA	0.34	0.34	0.34	No[1]
Endosulfan sulfate	6/27	NA	0.120	1.0	0.44	Yes
Endrin	6/27	NA	0.099	0.580	0.26	Yes
Endrin aldehyde	4/27	NA	0.170	2.9	1.04	Yes
Endrin ketone	2/27	NA	0.270	1.6	0.94	Yes
Heptachlor epoxide	5/27	NA	0.081	1.4	0.54	Yes
alpha-BHC	1/27	NA	0.130	0.130	0.130	No[1]

Table 10-48
Selection of Ecological Contaminants of Potential Concerns (ECPCs) for Surface Soil
Site 1

Parameter	Frequency of Detection	RC	Minimum Detected	Maximum Detected	Mean	ECPCs
alpha-Chlordane	6/27	NA	0.064	130	24.40	Yes
deka-BHC	1127	NA	0.20	0.20	0.20	No[1]
gamma-BHC (Lindane)	1/27	NA	0.21	0.21	0.21	No[1]
gamma-Chlordane	6/27	NA	0.250	110.0	18.8	Yes
Aroclor 1248	1127	NA	190	190	190	No[1]
Aroclor 1254	1/27	NA	310	310	310	No[1]
Aroclor 1260	3/27	NA	4.7	130	48	Yes

Key:
mg/kg = Milligrams per kilogram.
µg/kg = Micrograms per kilogram.
NA = Not applicable, RCs calculated for inorganics only.
RC = Reference concentration calculated from background data as two times the mean concentration.
1 = Detected in less than 6% of the samples collected.

Aluminum

Aluminum was detected at **26** of the **27** locations and the mean concentration of **2320** mg/kg was less than the reference concentration. Aluminum concentrations exceeded. the reference concentration at only at two locations.

Barium

Barium was detected at **19** of the **27** locations across the site and the mean concentration slightly exceeded the reference concentration. The mean concentration was similar to the reference concentration of **4.63** mg/kg. Five of the sampled locations had concentrations which exceeded the reference concentration.

Cadmium

Cadmium was detected in samples from three locations within the landfill boundary, ranging in concentration from **5.2** to 99.0 mg/kg with a mean of **36.9** mg/kg. Cadmium was not detected in reference samples.

Chromium

Chromium was detected at **12** locations with a mean concentration of **24.2** mg/kg and ranging from **2.2** to **86.4** mg/kg. Elevated chromium concentrations occurred in samples from three locations within the landfill boundary.

Copper

Copper was detected at nine locations. At three of these, concentrations exceeded twice reference values. Copper concentrations ranged from **3.1** mg/kg to **54.9** mg/kg with a mean of **16.2** mg/kg.

Aluminum

Aluminum was detected at 26 of the 27 locations and the mean concentration of 2320 mg/kg was less than the reference concentration. Aluminum concentrations exceeded. the reference concentration at only at two locations.

Barium

Barium was detected at 19 of the 27 locations across the site and the mean concentration slightly exceeded the reference concentration. The mean concentration was similar to the reference concentration of 4.63 mg/kg. Five of the sampled locations had concentrations which exceeded the reference concentration.

Cadmium

Cadmium was detected in samples from three locations within the landfill boundary, ranging in concentration from 5.2 to 99.0 mg/kg with a mean of 36.9 mg/kg. Cadmium was not detected in reference samples.

chromium

Chromium was detected at 12 locations with a mean concentration of 24.2 mg/kg and ranging from 2.2 to 86.4 mg/kg. Elevated chromium concentrations occurred in samples from three locations within the landfill boundary.

Copper

Copper was detected at nine locations. At three of these, concentrations exceeded twice reference values. Copper concentrations ranged from 3.1 mg/kg to 54.9 mg/kg with a mean of 16.2 mgkg.

Iron

Iron was detected at all 27 locations. The mean concentration of 3,013 ppm was above the reference concentration, with a range of 46.4 to 42,300 mgkg.

Lead

Lead, detected in samples from 23 locations, was somewhat ubiquitous across the site. Elevated lead concentrations were in samples collected from two locations within the landfill boundary. Concentrations ranged from 0.9 to 441 mg/kg with a mean of 32.0 mg/kg.

Manganese

Manganese was detected at 19 of the 27 locations. The overall mean of 20.3 mg/kg was slightly lower than the reference concentration.

Mercury

Elevated mercury concentrations were in samples from three locations within the landfill boundary. Concentrations ranged from 0.18 to 0.81 mg/kg with a mean of 0.51 mg/kg. Mercury was not detected in reference samples.

Nickel

Elevated nickel concentrations were in samples from three locations within the landfill. Concentrations averaged 19.9 mg/kg and ranged from 14.1 to 25.5 mg/kg.

Vanadium

Vanadium was detected at 16 of the 27 sampling locations. Concentrations ranged from 2.1 to 23 mg/kg and averaged 4.3 mg/kg.

zinc

Zinc was ubiquitous across'the site, detected in samples from 26 locations. Concentrations averaged 21.7 mg/kg and ranged from 1.5 to 219.0 mg/kg. Elevated zinc concentrations were detected in samples from two locations within the landfill boundary.

10.2.4 Contaminant Fate and Transport

Surface soils across the site consist of fine- to medium-grained quartz sand with minor amounts of silt. This soil type is typically low in organic material with high permeability and low pH. These factors most likely limit development of a microbial community, thereby reducing the likelihood of microbial decomposition of sorbed organic contaminants. The fate of these contaminants then will be expected to: 1) remain in the soil to undergo degradation and/or 2) migrate downward. Surface detrital material, from leaf litter, provides a substantial organic source that could result in higher contaminant concentrations in surface soil. It is important to note that during surface soil sampling, leaf litter was removed before collecting samples. This suggests that overall contaminant concentrations may have been higher if litter was composited with the soil sample.

In addition, contaminants sorbed to surface soil conceivably could be transported via air or surface water runoff. However, both of these pathways are unlikely as major routes. Contaminants are not expected to spread far via surface runoff due to the highly permeable nature of the sandy substrate. The physical adsorption of contaminants to soil particles and organic material also limits horizontal migration. Migration via air pathways could be significant only as it relates to dispersal of upper soil layer particles during high winds typical to coastal areas. Because sand particles are relatively large and heavy, extended migration through this route is not expected.

Stressor Characteristics

Inorganics

In general, heavy metals adversely affect survival, growth, reproduction, development, and metabolism of both terrestrial and aquatic invertebrate species, but effects are substantially modified by physical, chemical and biological variables. Most heavy metals do not biomagnify. In contact tests with terrestrial earthworms the order of toxicity for heavy metals, from most toxic to least toxic, was copper > zinc > nickel = cadmium > lead.

Arsenic naturally occurs and, with respect to cycling in the environment, is constantly changing. Many inorganic arsenicals are known teratogens and are more toxic than organic arsenicals (Eisler, 1988). Soil biota appear to be capable of tolerating and metabolizing relatively high concentrations (microbiota to 1,600 ppm) of arsenic (Wang et al., 1984). But, adverse effects to aquatic organisms have been reported at concentrations of 19 to 48 ppb in water. Arsenic does not appear to magnify along the aquatic food chain.

Cadmium is a relatively rare heavy metal. It is a known teratogen and carcinogen and probably a mutagen, and has been implicated as the cause of severe deleterious effects on fish and wildlife (Eisler, 1985). Birds and mammals are comparatively resistant to the biocidal properties of cadmium. Freshwater organisms appear to be the most susceptible group to cadmium toxicity and this is modified significantly by water hardness. Adsorption and desorption processes are likely to be major factors in controlling cadmium concentrations in natural waters. Adsorption and desorption rates of cadmium are rapid on mud solids and particles of clay, silica, humic material, and other naturally *occurring* solids.

Hexavalent chromium (Cr VI) produces more adverse effects to biota than does the trivalent phase. In clayey sediments, trivalent chromium dominates and benthic invertebrate bioaccumulation is limited (Neff et al. 1978). The solubility and potential bioavailability of

waste chromium added to soils through sewage sludge, are modified by soil pH and organic complexing substances (James and Bartlett, 1983).

'Copper is an essential micronutrient, and therefore, it is readily accumulated by aquatic organisms. It is a broad spectrum biocide, which may be associated with both acute and chronic toxicity.

In soil, lead concentrates in organic-rich surface horizons (NRCC 1973). Estimated residence time of lead in soils is about 20 years (Nriagu 1978). In sediments, lead is primarily found is association with iron and manganese hydroxides and may also form associations with clays and organic matter. Under oxidizing conditions, lead tends to remain tightly bound to sediments, but be released into the water column under reducing conditions (Jaagumagi 1990). Lead may accumulate to relatively high levels by aquatic biota.

In natural waters zinc speciates into the toxic aquo ion, other dissolved chemical species, and various inorganic and organic complexes and is readily transported. Most zinc introduced into aquatic environments is eventually partitioned into the sediments. Reduced conditions enhance zinc's bioavailability.

Mercury is a known mutagen, teratogen and carcinogen. It adversely affects reproduction, growth and development, motor coordination and metabolism. Mercury has a high potential for bioaccumulation and biomagnification, and is slow to depurate. Organomercury compounds produce more adverse effects than inorganic mercury compounds. Inorganic mercury can be modified to organic mercury compounds through biological transformation processes.

No information was available on the toxicological effects associated with barium or silver contamination in soils and sediments.

Organics

Polycyclic aromatic hydrocarbons (PAH) vary by molecular weight. With increasing molecular weight, aqueous solubility decreases and the log Kow increases, suggesting increased solubility in fats, a decrease in resistance to oxidation and reduction, and a decrease in vapor pressure (Eisler 1987). Accordingly, PAHs of different molecular weight vary substantially in their behavior and distribution in the environment and in their biological effects. In water, PAHs either evaporate, disperse into the water column, become incorporated into sediments or undergo degradative processes such a photooxidation, chemical oxidation, and biological transformation by bacteria and animals (Neff 1979).

Most environmental concern has focused on PAHs that range in molecular weight from 128.16 (naphthalene) to 300.36 (coronene). Generally, lower molecular weight (LMW) PAH compounds, containing 2 or 3 aromatic rings, exhibit significant acute toxicity but are not carcinogenic. High molecular weight (HMW) PAH compounds, 4 to 7-rings, are significantly less toxic, but are demonstrably carcinogenic, mutagenic, or teratogenic to aquatic species. PAHs show little tendency to biomagnify in food chains because most are rapidly metabolized (Eisler 1987). Very little information is available on food chain adverse effects as a result of soil PAH contamination.

Organochlorine pesticides have been used extensively in the U.S. *since* the 1940's. They appear to be ubiquitous in the environment being found in surface waters, sediments and biological tissues. They are readily absorbed by warm-blooded species and degradatory products are frequently more toxic than the parent form. Food chain biomagnification is usually low, except in some marine mammals. In soil invertebrates, organochlorine pesticides *can* accumulate to levels higher that those in the *surrounding* soil, and residues may in turn be ingested by birds and other animals feeding on earthworms (Beyer and Gish, 1980). Most environmental effects studies have been directed at mammals and birds.

PCBs are distributed worldwide with measurable concentrations recorded in fishery and wildlife resources from numerous locations (Eisler 1986). They are known to bioaccumulate and to biomagnify within the food chain and to elicit biological effects such as death, birth defects, tumors, and a wasting syndrome. In terrestrial environments, PCBs are rapidly metabolized from the soil into the terrestrial food chain (McKee 1992). Subsoil dwelling organisms may directly absorb PCBs and food chain transfer to lower-level vertebrate species can potentially occur.

10.2.5 Exposure Pathways and Assessment

Infaunal Invertebrates

The primary exposure pathway to infaunal invertebrates will be through the direct contact with surface soil. *An* assessment endpoint of a well-balanced soil infaunal community will be qualitatively measured by comparing literature data to actual soil concentrations.

Terrestrial ***Wildlife***

For terrestrial wildlife species, exposure would include direct dermal contact, ingestion of soil particles, and food-chain transfer. Small mammals could contact contaminated soil if the area is used as a migratory corridor or if animals burrow into it. The contact time, and thus exposure, will be limited when animals are crossing the area, but could be lengthy if burrows are established. Dermal contact by small reptiles and amphibians would be similar to that for mammals. Although insect populations at Site 1 appear to be limited, direct exposure to grounddwelling species could provide a link for contaminant transfer to higher-level predators.

The assessment endpoint selected for terrestrial wildlife at Site 1 is the maintenance of well-balanced terrestrial wildlife populations and communities. *As* a measure of the assessment endpoint selected, results of laboratory toxicity studies in literature that relate the oral dose of a contaminant with adverse response to growth, reproduction, or survival were used.

Selected measurement endpoint species include American robin (*Turdus migratorius*) and bobcat (*Lynx rufus*). Both of these species could potentially occur at Site 1.

To assess biotransfer of contaminants along food chains the total potential dietary exposure (PDE) has been estimated for the two representative wildlife species, American robin and bobcat. The PDE is calculated based on the predicted concentrations of the ECPCs in food items that the species would consume, the amount of soil it would ingest, the relative amount of different food items in its diet, body weight, and food ingestion rate (Table 10-49). The concentrations of ECPCs in food items are estimated based upon literature reported bioaccumulation factors (BAFs), which are a ratio of the ECPC concentration in dietary items to the concentration in soil. The BAFs reported for avian and mammalian species are reported ratios of ECPCs in the tissue of the animals to the concentrations of ECPCs in their diets.

The site foraging factor (SFF) allows for consideration of the frequency of feeding in the site area by estimating the acreage of the site relative to the receptors feeding range and by considering the fraction of the year the receptor would be exposed to site contaminants.

Vegetation

Woody and herbaceous vegetation at Site 1 could likely incorporate certain detected constituents (metals) through processes such as uptake/accumulation, translocation, adhesion, or biotransformation. Terrestrial herbivores could ingest plant-borne constituents.

10.2.6 Ecological Effects Assessment

Infaunal Invertebrates

Potential adverse ecological effects to soil invertebrates from identified ECPCs are predicted based on available literature. Because soil ARARs are unavailable for effects levels, effects studies are used for comparative qualitative assessments only.

Table 10-49
Wildlife Contaminant Exposure Model for Surface Soil
Site 1

Food Contaminant Concentration (mg/kg) = BAF' X Soil Contaminant Concentration (mg/kg)

Soil Exposure (SE) (mg/kg) = (% of diet in soil) X Soil Contaminant Concentration (mg/kg)

PDE (mg contaminant/kg BW/day) = $\frac{[P_1 \times T_1 + P_2 \times T_2 + \ldots P_n \times T_n + SEI \times IR_{diet} \times SFF}{BW}$

where:

P_n — percent of diet composed in food item N,

T_n — tissue concentration in food item N (mg/kg), (Food Contaminant Concentration)

IR_{diet} = food ingestion rate of receptor (kg food per day)

SFF = site foraging factor (assumed 1.0 for all receptors at Site 1)

BW = receptor body weight (kg)

1 = BAF from Table 10-51

Terrestrial Wildlife

Potential adverse effects associated with the identified ECPCs to small bird and mammal species is based on food uptake potential. Available reference toxicity values (RTVs) were determined for the two species selected. The RTV relates the dose of a respective ECPC in an oral exposure with an adverse effect. The lethal RTV has been determined to be one-fifth of the lowest reported LD50 value for the most closely related test species. One fifth of an oral LD50 value is considered to be protective of lethal effects for 99.9 percent of individuals in a test population (USEPA, 1986). It is assumed that this level of risk to individuals within the terrestrial wildlife populations at Site 1 is acceptable.

A sublethal RTV is also identified that represents a threshold for sublethal effects. Sublethal effects are defined as those that impair or prevent reproduction, growth, or survival. The sublethal RTV reflects the assessment endpoint chosen as the basis for establishing risk.

Vegetation

Toxicity to terrestrial plants from soil contaminants is qualitatively evaluated. Risk potentials are discussed relative to literature studies and general information on phytotoxic mechanisms by selected ECPCs.

10.2.7 Risk Characterization

Infaunal Invertebrates

Studies related to toxicological effects present concentration information in several forms (i.e., μg/g, μg/kg, mg/kg). For comparison and ease of reading, data presented in the following sections has been presented in either ppm or ppb concentrations.

Little information exists on the toxic effects to terrestrial organisms from VOCs. Primarily, the only information available are effects studies related to human health from inhalation of specific compounds by laboratory animals. Impact from the limited Occurrence and low concentrations

of volatile compounds observed across the site is difficult to assess but it is predicted that little to no effect to terrestrial species will occur.

Although some of the semivolatiles found in Site 1 soil are considered carcinogenic to mammals, very few field studies exist on their toxicity to terrestrial fauna. Generally, PAHs break down in natural systems via photodegradation and microbial transformation. Neuhauser, et al. (1986) found that specific phenol compounds (4-nitrophenol, 2,4,6-trichlorophenol, phenol) were somewhat toxic to earthworms, with PAHs being relatively less toxic than other semivolatile compounds studied. Artificial soil tests produced lethal concentration (LC_{50}) values for fluorene and phenol near 200 ppm and 50 to 100 ppm, respectively. Callahan, et al. (1994), found similar results in their study on toxicity of 62 chemicals to several earthworm species. Fluorene is considered to be acutely toxic at certain concentrations but it is not considered a carcinogen. It is important to note that measured field sampling variability and soil chemical matrices can greatly influence toxicological effects of PAH compounds.

A low risk to infaunal communities from PAH concentrations in Site 1 soil is predicted based on the spatial infrequency of detection and relatively low concentrations observed. Only at trench location 01S7201 were PAHs prevalent; however, the accumulative concentration (4,700 ppb) is below the levels of significant effect as found by Neuhauser, et al. (1986) or Callahan, et al. (1994). Most of the compounds observed at this location were high molecular weight PAHs and would not be prone to accumulation by lower-level invertebrate species. Risks related to uptake by terrestrial vertebrate species will be addressed later.

Most toxicological studies on terrestrial infaunal organisms have been directed at measuring pesticide effects (Table 10-50). Earthworm toxicology and response information is the most prevalent. In a study by Beyer and Gish (1980), persistence of DDT, dieldrin, and heptachlor were observed in earthworms from field study plots. Investigators agree that earthworms can

Table 10-50
Summary of Chemical Effects Studies on Terrestrial Receptors

Study	Organisms	Measured Parameter	Effects Level	Measured Response
Parmelee et al. (1993)	Nematode/microarthropods	Copper	200 ppm	Significant decline in numbers
Neuhauser et al. (1986)	earthworm *Eisenia* foetida	Copper salts	643 ppm	LC_{50}
		Zinc salts	662 ppm	LC_{50}
		Nickel salts	757 ppm	LC_{50}
		Cadmium salts	1843 ppm	LC_{50}
		Lead salts	6,000 ppm	LC_{50}
		4-Nitrophenol	38 ppm	LC_{50}
		Fluorene	173 ppm	LC_{50}
		Phenol	401 ppm	LC_{50}
Roberts & Dorough (1984)	*Eisenia* foetida	Cadmium chloride	10-100 $\mu g/cm^2$	LC_{50}
		Copper sulfate	10-100 $\mu g/cm^2$	LC_{50}
		Lead nitrate	10-100 $\mu g/cm^2$	LC_{50}
Malecki et al. (1982)'	*Eisenia* foetida	Cadmium	250 ppm	Growth difference to control
		Nickel	440 ppm	Growth difference to control
		Copper	1,320 ppm	Growth difference to control
		Zinc	2,800 ppm	Growth difference to control
		Lead	21,600 ppm	Growth difference to control

Table 10-50
Summary of Chemical Effects Studies on Terrestrial Receptors

Study	Organisms	Measured Parameter	Effects Level	Measured Response
Strait (1984)	Mite *Platynothrus peltifer*	Copper	200 ppm	Population decrease
van Straalen et al. (1989)	Mites	Cadmium	> 128 ppm	Mortality
McKee (1992)	Terrestrial epigeic[b] Invertebrates	PCBs	120,000 ppm	No community structure effects
Callahan, et al. (1991)	earthworms *L. terrestris*	DDT	400 ppb	No detectable concentration in tissue from soil concentrations
		DDD	700 ppb	
		DDE	200 ppb	
Menzie et al. (1992)	*E. foetida*	DDT	1,000 [4,000][c] ppb	Survival; no effect for LC_{50} test
		DDD	1,000 112,0001' ppb	
		DDE	1, 0 W[2,000][c] ppb	
Miller et al. (1985)	Earthworm	Copper	644 ppm	EC_{50}
		Zinc	628 ppm	EC_{50}
	Microtox (15 min.)	Copper	0.28-0.42 ppm	Photo reduction
		Zinc	1.6 ppm	Photo reduction
Paine et al. (1993)	Crickets *Acheta domesticus*	PCB	1,200 ppm	LC_{50}
Reinecke & Nash (1984)	earthworm *Allolobophora caliginosa* *Lambricus rubellus*	Dioxin	< 5 ppm	No mortality
			> 10 ppm	Lethality
Beyer et al. (1985)	*Eisenia foetida*	Methyl Mercury	25 ppm 5 ppm	100% mortality 21% mortality

Table 10-50
Summary of Chemical Effects Studies on Terrestrial Receptors

Study	Organisms	Measured Parameter	Effects Level	Measured Response
Abbasi and Soni (1983)	earthworm *Octochaetus pattoni*	Inorganic Mercury	0.79 ppm 5 ppm	50% mortality 100% mortality
Rhett et al. (1988)	*Eisenia foetida*	PCB	240 ppm	LC_{50}
Nielson (1951)	earthworms	Copper	150 ppm	Population reduced by 1/2
			260 ppm	Population eliminated
Van Rhee (1967)	earthworms	Copper	85 ppm	Gradual decline of population
Ma (1982)	*Lumbricus rubellus*	Copper chloride	1,000 ppm	6-wk LC_{50}

Notes:
1 = Growth effects levels are average of at least five of six compounds; metal acetate; metal carbonate; metal chloride; metal nitrate; metal oxide, metal sulfate.
2 = Carabidae, entobeyidae, formicidae, gryllidae and staphylinidae.
3 = Average soil concentration levels [maximum values].

accumulate pesticides to concentrations found in residence soil. Callahan, et al. (1991), showed very good soil-to-tissue correlation (R = .725), with accumulation of DDT in single earthworms up to 22 ppm. Beyer and Gish (1980) found that earthworms accumulated DDTR to 32 ppm. Barker (1958) associated poisoning (lethality) of robins with 60 ppm DDTR in earthworms, and Collett and Harrison (1968) found that blackbirds and thrushes were impacted at residues near 20 ppm. At concentrations observed in their study, Callahan, et al. (1991), suggested that a feeding rate by robins of 10 to 12 earthworms in as many minutes (as observed by Mcdonald, 1983) could provide a sufficient concentration of contamination for impacts to robins. Callahan, et al. (1991), also found that chlordane, as other pesticides, was taken up rapidly by earthworms. In Callahan, et al. (1991), total DDT concentrations greater than 1,000 ppm in soil, along with documented long half-life information (5.7 years DDT), indicated a long-term significant risk to receptors.

Total pesticide concentrations never exceeded 425 ppb across Site 1. When compared to Callahan, et al.'s (1991) results, it appears that Site 1 surface soils present no risk to infaunal species with regard to detected concentrations. Information on risks to reptile and amphibians is limited and, therefore, the risk to these receptors has not been determined.

Risk factors associated with PCBs are similar to those for pesticides. After acute mortality, food chain biomagnification and transfer are the most important issues to be considered when assessing long-term risk. Concentrations at Site 1 (mean = 128.7 ppb) are well below the 100 to 300 ppm range indicated by Paine, et al (1993), as a benchmark value for mortality in terrestrial insects. Also, Rhett, et al. (1988), observed LC_{50} values for earthworms treated with PCBs at 240 ppm. MeKee (1992) reported that soil invertebrate community structure was not reduced by exposure to PCB-contaminated soil (maximum concentrations to 120,000 ppm wet weight) based on family level classification of invertebrates.

Studies of metal toxicity to terrestrial receptors have been directed at infaunal ecosystems or avian biology. Information on relative metal toxicities to earthworms was provided by Roberts and Dorough (1984) where, along with 90 other chemicals, *three* metal salts (cadmium chloride, copper sulfate, and lead nitrate) were tested. The results showed that these heavy metal salts fell into the "very toxic" category, with LC_{50} values in the 10 to 100 $\mu g/cm^2$ range. Although these concentrations (more specifically, application doses) may be relative to earthworms, it is improper to apply them to upper-level trophic species. Studies indicate that some degradation products become increasingly more toxic to earthworms and less toxic to upper-level vertebrates. Other studies on toxicities of metal salts to earthworms have been conducted by Neuhauser, et al. (1986), and Malecki, et al. (1982). In the former study, metal nitrate compounds were relatively toxic to earthworms in this order; copper> zinc> nickel> cadmium> lead. Mean LC_{50} values were 643, 662, 757, 1,843 and 6,000 ppm, respectively. In the latter study, six chemical forms of each metal were chosen to cover a broad range of solubility and to represent the forms likely to be found in the soil. Overall cadmium was most toxic, followed by nickel, copper, zinc, and lead. It appears obvious from the results of these two studies that the form of the metal in soil in a major consideration in judging effects of their concentrations on soil biota.

Ma (1984) investigated sublethal effects of copper in soils to growth, cocoon production, and litter breakdown activity for Lumbricus *rubellus*. Cocoon production and litter breakdown activity were significantly reduced at 131 ppm copper and mortality was first observed at concentrations near 300 ppm.

Parmelee, et al. (1993), found that total nematode/microarthropod (mostly mites) numbers declined in soil having copper concentrations above *200* ppm; omnivore-predator nematodes and specific microarthropod groups were significantly reduced at 100 ppm copper.

Metal concentrations observed in surface soil at Site 1 are well below those cited in the literature as posing ecological risk. Even considering metal forms that could be available, it does not appear that metal concentrations present a risk to terrestrial infaunal receptors.

Most toxicological information reviewed for this portion of the risk assessment dealt with earthworms and other infaunal species. It is important to note that soil at Site 1 is predominantly sandy and may not support these specific-type organisms. Although species found in the sandy environment may not be the same as those dealt with in the literature, the ecological niche which they occupy should be similar and, therefore, comparison to toxicological concentrations should be applicable.

Terrestrial Wildlife

Risks for the representative wildlife species associated with ingestion of surface soil and food are quantitatively evaluated using Hazard Quotients (HQ), which are calculated for each ECPC by dividing the estimated dietary exposure concentration (PDE) by the toxicological benchmark (RTV). Hazard Indices (HI) are determined for each representative wildlife species by summing the HQs for all ECPCs. When the estimated PDE is less than the RTV (HQ < 1), the contaminant exposure is assumed to fall below the range considered to be associated with adverse effects for growth, reproduction, and survival and no risks to the wildlife populations are assumed. When the HQ or HI is greater than one, a discussion of the ecological significance is included and risk is assumed. When HIs are greater than 1, an evaluation of the HQs comprising the HI was completed.

For the two representative terrestrial wildlife species PDEs were calculated using available bioaccumulation data (Table 10-51) for ECPCs presented in Table 10-48. Exposure parameters and assumptions for the two representative species (Table 10-52) were used to calculate the food contaminant concentration. Using the model for prediction of contaminant exposure presented in Table 10-49, PDE values were obtained. HQs for both lethal and sublethal effects for ECPCs

Table 10-51
Available ECPC[1] Bioaccumulation Factors for Food Items at Site 1

Analyte	Plant	Terrestrial Invertebrate	Mammal	Bird
Semivolatiles				
Benzo(b)fluoranthene	0.008 [c]	0.032 [b]	5.25E-02 [a]	NA
Benzo(k)fluoranthene	0.007 [c]	0.025 [b]	7.08E-02 [a]	NA
Pesticides/PCBs				
Aroclor-1260	0.013 [c]	1.2 [d]	1.00E+00 [y]	1.0 [z]
alpha-Chlordane	0.027 [t]	0.8 [i]	7.10E-01 [y]	0.71 [sa]
gamma-Chlordane	0.027 [t]	0.8 [i]	7.10E-01 [y]	0.71 [aa]
4,4'-DDE	0.02 [c]	0.98 [p]	2.91E+00 [y]	2.91 [f]
4.4'-DDT	0.027 [t]	0.98 [p]	2.91E+00 [y]	2.91 [f]
Dieldrin	0.049 [c]	1.2 [q]	7.10E-01 [y]	0.71 [h]
Endrin ketone	0.032 [c]	0.72 [i]	7.10E-01 [y]	0.71 [aa]
Inorganics				
Barium	0.56 [w]	0.77 [u]	3.40E-01 [v]	0.45 [x]
Cadmium	33.0 [k]	1.4 [e]	2.06E+00 [l]	0.38 [m]
Copper	0.78 [n]	0.16 [d]	6.00E-01 [k]	0.45 [x]
Lead	0.0 [k]	0.22 [o]	5.40E-01 [q]	0.45 [x]
Manganese	0.56 [w]	0.77 [u]	3.40E-01 [w]	0.45 [x]
Mercury	0.56 [w]	0.34 [r]	1.00E-02 [s]	2.33 [s]

Table 10-51
Available ECPC[1] Bioaccumulation Factors for Food Items at Site 1

Analyte	Plant	Terrestrial Invertebrate	Mammal	Bird
Zinc	0.61 [n]	1.77 [d]	2.06E+00 [q]	0.45 [x]

Notes:

[a] = Calculated using the following equation (Travis and Arms, 1988). unless otherwise noted: log BAF = log Kow-7.6; result multiplied by average of ingestion rates for non-lactating and lactating test animals. There is an uncertainty involved in using this equation for PAHs, because this study did not use any PAHs in the regression analysis.
[b] = Marquerie et al. (1987) as cited in Beyer (1990). Mean of values. Converted to wet weight assuming 90% bodyweight as water.
[c] = Calculated using the following equation in Travis and Arms (1988) for analytes with log Kows > 5: log (Plant Uptake Factor) = 1.588-0.578 log Kow.
[d] = BCF for earthworms from Diercxsens, et al. (1985).
[e] = Mean of values reported for soil invertebrates in MacFadyen (1980) converted from dry weight to wet weight.
[f] = Whole body pheasant BAF for 4.4'-DDT presented in USEPA (1985), derived from Kenaga (1973).
[g] = Average of values reported for soil invertebrates in Edwards and Thompson (1973).
[h] = Jeffries and Davis (1968).
[i] = Value reported fer endrin from Gish (1970).
[k] = Levine et al. (1989).
[l] = Mean of values reported for Sorex *araneus* in MacFadyen (1980).
[m] = Based on accumulation of cadmium in kidneys of Europena quail in Pimentel et al. (1984).
[n] = Median of values reported from Levine et al. (1989).
[o] = Geometric mean of BAF values (fresh wt. worm/day wt. soil) for worms and woodlice (USEPA 1985). Freshweight tissue concentrations calculated assuming 90% body water content;
[p] = Beyer and Gish (1980) reported dry weight to wet weight ratio.
[q] = Mean of values for Microtus *agrestis* and *Apodemus sylvaticus* in MacFadyen (1980).
[r] = Value from USEPA (1985) sludge document.
[s] = USEPA (1985)
[t] = Assumed value based on average of BAFs calculated for other pesticides and PCBs.
[u] = Assumed value based on average of BAFs reported for other metals.
[v] = Assumed value based on average of reported BAFs for Cd, Cu, Pb and Hb.
[w] = Assumed value based on average of reported BAFs for As. Cu. Hg and Zn.
[x] = Assumed value based on average of reported BAF values for Cd and Se.
[y] = Value for mammal unavailable. Bioaccumulation assumed to be the same as values reported for birds.
[z] = Assumption
[aa] = Assumed value based on reported BAF for dieldrin.
ECPC = Ecological Contaminants of Potential Concern.

Table 10-52
Exposure Parameters and Assumptions for Representative Wildlife Species at Site 1

Representative Wildlife Species	Trophic Status	Prey in Diet (%)					Incidental Soil Ingestion %	Home Range (acres)	ED	Site Foraging Frequency (SFF)	Ingestion Rate (kg/day)	Body Weight (kg)
		Inverts	Plants	Small Mammals	Herpeto-fauna	Small Birds						
American robin	Small Carnivorous Bird	83	7	0	0	0	10	1.04	1	1.00E+0	0.01	0.077
Bobcat	Predatory Mammal	0	0	48	0	49	3	8042	1	1.00E+0	0.5	11.2
SITE AREA:	80 acres											

Notes:
ED = Exposure Duration (percentage of year receptor is expected to be found at study area exposed as a factor, ie., 100% = 1.0)
SFF = Site areas (acres) times exposure duration divided by Home Range (HR); cannot exceed 1.0

were determined and are presented in Tables 10-53 and 10-54, and HI values for each representative species were determined.

With the exception of cadmium, all HQs determined for representative wildlife species were less than 1 for both lethal and sublethal effects. The HQ for cadmium of 5.1 for sublethal effects to American robin was the major influence for a HI of 6.3. As cadmium was found at only three of 27 locations across the site, with only one having a significant concentration (i.e. 99 mg/kg), it is predicted that overall site risk from cadmium contamination is low.

Vegetation

Limited information exists on toxic effects of soil contamination to plants in natural environments. Most literature containing effects information deals with herbicide or fungicide application programs. Beyer, et al. (1985) demonstrated that only a small portion of all metals measured in soil became incorporated in plant foliage. In their study, the origin for plant metal residues was suggested to have come primarily from aerial deposition. Table 10-55 presents phytotoxic effects levels for arsenic, lead, and zinc for several species. Effects levels vary depending on specific soil physico-chemical conditions such as pH, organic content, and cation-exchange-capacity.

Arsenic availability to plants is typically highest in coarse-.textured soils having little cation-exchange-capacity and lowest in clay having organic material, and containing iron, calcium and phosphate (NRCC, 1978). Cadmium appears to be taken up by plants in soil's that have abnormally high cadmium residues. For chromium, Towill, el al.'s (1978) study showed no phytoxic effects to plants for elevated chromium levels.

Like other metals the bioavailability of lead in soil to plants is enhanced by reduces soil pH, reduced organic matter, and reduced iron oxides and phosphorus content (NRCC, 1973).

Table 10-53
Hazard Quotients for Potential Sub-lethal Effects for Wildlife Species Associated with Maximum Exposure Concentrations of ECPCs in Soil at Site 1

Analyte	Max Conc (mg/kg)	American Robin			Bobcat		
		PDE	RTV	HQ	PDE	RTV	HQ
Barium	20.4	1.6E00	NA	NC	3.8E-01	NA	NC
Cadmium	99.0	5.1E+01	1.0E+01	5.1E00	5.3E00	2.2E+01	2.5E-01
Copper	54.9	2.3E-00	1.1E+01	2.0E-01	1.3E00	1.5E+02	8.6E-03
Lead	441.0	1.8E+01	1.3E+02	1.5E-01	1.0E+01	5.2E+02	1.9E-02
Manganese	191.0	2.1E+01	NA	NC	3.5E00	9.3E+02	3.8E-03
Mercury	0.81	4.8E-02	6.4E-02	7.5E-01	4.2E-02	1.0E-01	4.2E-01
Zinc	219.0	5.0E+01	NA	NC	1.9E00	1.6E+02	1.2E-02
Benzo(b)fluoranthene	.130	2.4E-03	NA	NC	NC	NA	NC
Benzo(k)fluoranthene	.130	2.4E-03	NA	NC	NC	NA	NC
DDE	.016	2.3E-03	3.9E-01	5.9E-03	8.3E-03	NA	NC
DDT	.099	1.4E-02	1.4E-01	1.0E-01	1.2E-02	3.5E+03	3.5E-06
Dieldrin	.020	3.5E-03	NA	NC	6.4E-04	NA	NC
Aroclor 1260	.130	1.3E-02	9.0E-01	1.4E-02	5.8E-03	1.6E+03	3.4E-06

Table 10-53
Hazard Quotients for Potential Sub-lethal Effects for Wildlife Species Associated with Maximum Exposure Concentrations of ECPCs in Soil at Site 1

Analyte	Max Conc (mg/kg)	American Robin			Bobcat		
		PDE	RTV	HQ	PDE	RTV	HQ
alpha-Chlordane	.130	1.3E-02	NA	NC	4.2E-03	NA	NC
gamma-Chlordane	.110	1.1E-02	NA	NC	3.5E-03	NA	NC
				HI = 6.3E00			HI = 7.1E-01

Notes:
Max Conc = Maximum Concentration of Analyte (mg/Kg)
PDE = Potential Dietary Exposure (mg/Kg/BW) calculated based on equation in Table 10-49.
RTV = Reference Toxicity Valve (mg/Kg BW/day) = Lowest reported LOAEL from Appendix J for closest related species.
HQ = Hazard Quotient = The PDE divided by the RTV.
HI = Hazsrd Index ($HQ_1 + HQ_2 + ..HQ_n$).
NA = Not Available
NC = Not Calculated
1 = BAF data for Birds (Food item) not available.

Table 10-54
Hazard Quotients for Potential Lethal Effects for Wildlife Species Associated with Maximum Exposure Concentrations of ECPCs in Soil at Site 1

Analyte	Max Conc	American Robin			Bobcat		
		PDE	RTV	HQ	PDE	RTV	HQ
Barium	20.4	1.6E00	NA	NC	3.8E-01	NA	NC
Cadmium	99.0	5.1E+01	NA	NC	5.3E00	4.5E+01	1.2E-01
Copper	54.9	2.3E00	NA	NC	1.3E00	NA	NC
Lead	441.0	1.8E+01	4.9E+03	3.7E-03	1.0E+01	4.4E+01	2.2E-01
Manganese	191.0	2.1E+01	NA	NC	3.5E00	4.5E+01	7.8E-02
Mercury	0.81	4.8E-02	2.5E00	1.9E-02	4.2E-02	2.0E-01	2.1E-01
Zinc	219.0	5.0E+01	NA	NC	1.9E00	5.0E+02	3.7E-03
Benzo (b) fluoranthene'	.130	2.4E-03	NA	NC	NC	NA	NC
Benzo (k) fluoranthene'	.130	2.4E-03	NA	NC	NC	NA	NC
DDE	.016	2.3E-03	NA	NC	8.3E-03	1.6E+02	5.2E-05
DDT	.099	1.4E-02	1.2E+02	1.2E-04	1.2E-02	1.2E+01	1.0E-03
Dieldrin	.020	3.5E-03	9.6E00	3.6E-04	6.4E-04	1.3E+01	4.9E-05
Aroclor 1260	.130	1.3E-02	NA	NC	5.8E-03	1.0E+02	5.8E-05

Table 10-54
Hazard Quotients for Potential Lethal Effects for Wildlife Species Associated with Maximum Exposure Concentrations of ECPCs in Soil at Site 1

Analyte	Max Conc	American Robin			Bobcat		
		PDE	RTV	HQ	PDE	RTV	HQ
alpha-Chlordane	.130	1.3E-02	NA	NC	4.2E-03	NA	NC
gamma-Chlordane	.110	1.1E-02	NA	NC	3.5E-03	NA	NC
				HI = 2.3E-02			HI = 5.1E-01

Notes:

Max Conc	=	Maximum Concentration of Analyte (mg/Kg)
PDE	=	Potential Dietary Exposure (mg/Kg/BW) calculated based on equation in Table 10-49.
RTV	=	Reference Toxicity Valve (mg/Kg BW/day) = 116th of lowest reported LD50 from Appendix J for closest related species.
HQ	=	Hazard Quotient = The PDE divided by the RTV.
HI	=	Hazard Index ($HQ_1 + HQ_2 + ..HQ_n$).
NA	=	Not Available
NC	=	Not Calculated
1	=	BAF data for Birds (Food item) not available.

Table 10-55
Phytotoxic Responses to EVPCs in Soil

Study	Organisms	Measured Parameter	Effects Level	Measured Response
USEPA (1987)	*Acerrubrum*, Red Maple	Zinc	100 mglkg	Lethal to seedlings
USEPA (1987)	*Quercus rubra*, Oak	Zinc	100 mglkg	Lethal to seedlings
NRCC (1978)	Canadain crops	Arsenic	25-85 mglkg	Depressed crop yield
	Oryza sativum, Rice	Arsenic (disodium methylaesonate)	50 mglkg	75% decrease yield
Sadiq (1985)	Corn plant	Lead	800 mglkg	No elevated concentration in plants
Keishnayya and Bedi (1986)	*Cassia*, spp., Weeds	Lead	500 mglkg	90% reduced pollen germination
Miller et al. (1985)	Radish (seed germination)	Copper	47 ppm	EC 50
		Zinc	53 ppm	EC 50
	Cucumber (seed germination)	Copper	55 ppm	EC 50
		Zinc	61 ppm	EC 50

Studies have shown that there is no convincing evidence that terrestrial vegetation is important in food chain biomagnification of lead (USEPA, 1985). Chang, et al. (1983) observed that zinc uptake was lower in coarse loamy soils than in fine loamy soils. The phytotoxic nature of copper to crop production has been studied relative to application rates (Hirst, et al. 1961). Little information exists on mercury effects to higher plants (Eisler, 1987).

Studies by USEPA (1980), Lee and Grant (1981), Wang and Meresz (1982) and Edwards (1983) generally conclude five points for PAH's effects to plants. First, plants can absorb PAHs from soil through roots to other parts. Second, lower molecular weight compounds are absorbed more readily than higher molecular weight compounds. Third, above-ground parts have higher residue levels which are most likely attributable to airborne deposition. Fourth, PAH-induced phytotoxic effects are rare. Fifth, higher plants can catabolize benzo(a)pyrene and possible other PAH compounds, and finally, plant up-take of PAHs is most likely not a significant pathway to terrestrial vertebrate species.

For PCBs, Klekowski (1982) suggested that there was no evidence of genetic damage to terrestrial plants at a PCB-contaminated site in Massachusetts.

Eilser (1990) noted that there was little information available on phytotoxicity of Chlordane and that there was little evidence to indicate accumulation by crop plants. In soils, Chlordane is mostly immobile and there is only a limited capacity for translocation into edible portions of food crops (NRCC, 1975).

Very little risk to vegetative species at Site 1 is predicted based on the phytotoxicity information reviewed. Although the maximum values for lead and zinc are above the effects levels observed in studies, the mean concentrations suggests that the risk potential across the site is low. No effects from organic constituent concentrations is expected across the site.

10.2.8 Groundwater Risks

Surface water and sediment samples were collected in or hydraulically upgradient of wetlands associated with Site 1 (see Section 8.3) to assess its potential for impact to wetlands. Given the site's physical setting (i.e., sandy, highly permeable surface soil), the greatest potential threat to wetlands is the discharge of site-impacted groundwater.

In Wetland 1, both benchmark values for lead were exceeded for surface water and sediment. Also, aluminum and iron surface water concentrations exceeded federal criterion. However, before implying "risk" based on these exceedances, other factors need to be considered. Although the water concentration was twice the criteria, no information on the chemical form of lead in the water was determined. Metals exist in water in both the soluble and insoluble forms. The ratio of these two forms is dependent on physicochemical (temperature, pH, and hardness) conditions of the water and many times, in natural waters, the insoluble form is most abundant. Since the soluble form is the most bioavailable and potentially toxic, consideration of risks from total lead concentrations may be misinterpreted.

In Wetland 3 SSVs were exceeded in sediment for cadmium, lead, and DDT at Station 01M0301 (see Tables 8-6 and 8-7) and pesticide concentrations were high in sediments at Station 01M0303. Although SSVs were exceeded, no indication of surface water quality degradation was apparent. This suggests that contaminants may be sequestered in sediments. It is well understood that most chemical toxicity occurs in the aqueous phase. Release of inorganic constituents would occur if water pH decreased rapidly or if ionic composition changed (Demayo, et al. 1982). Desorption of neutral organic chemicals from sediment could occur if sediments were resuspended (Mackay and Powers 1987). Also biochemical transformation of organics may play a part in chemical availability.

Aluminum and iron water quality criteria were exceeded at all three stations in Wetland 3. These two metals appear to be chronically elevated in groundwater across NASP and it is suggested that high concentrations are geogenic rather than anthropogenic in nature.

Like Wetland 3, surface water criteria were exceeded for aluminum and iron at Wetland 16 but no SSVs were exceeded.

Sediment values from Wetland 18 exceeded SSVs for arsenic, lead, endrin and alpha chlordane, and again aluminum and iron criteria were exceeded in surface water samples. Like Wetland 3 surface water concentrations did not reflect suspected contamination found in sediment.

Based on review of the factors that may affect availability of chemicals, and a critical assessment of the concentrations observed during the 1994 sampling activity, no appreciable ecological effects are expected from groundwater discharge to wetlands near Site 1. Again, a more detailed risk assessment of wetlands near Site 1 will be made during the Site 41 remedial investigation.

10.2.9 Uncertainty

General uncertainties are associated with the ecological risk assessment for Site 1.

- Degradation of chemicals has not been considered in the ECPC selection process.
- Specific effects to biota within the area are unknown.
- Acute and chronic effects data on some ECPCs was unavailable.
- Synergistic or antagonistic effects cannot be quantified.

- For some ECPCs, only assumptions relative to similar compounds or classes of elements can be made.

- Use of related species for risk determination may over or under estimate risk to selected representative wildlife species.

- No evaluation of dermal or inhalation exposure pathways was made.

- Maximum exposure scenarios and concentrations may tend to overestimate risk potentials.

- On occasion, BAFs were assumed due to lack of information.

- Actual occurrence of selected wildlife species within the contaminated area is uncertain.

- Food ingestion rates in food chain analyses may be a source of uncertainty to exposure.

10.2.10 Risk Summary

Risk to terrestrial infaunal communities from soil contamination at Site 1 is low. Maximum concentrations were not at levels which would indicate acute or chronic impairment.

A potential sub-lethal risk to passerine bird species from soil cadmium concentrations exists based on the model prediction. But, the model was extremely conservation in nature (i.e., maximum concentrations used), and actual risk is likely lower based on the limited spatial distribution of cadmium. No risk to mammal species from soil concentration is predicted.

Elevated concentrations of contaminants at locations 01S8001 and 01S8201 suggest that ecological risk may be higher for these areas compared to the site overall. Focused remedial

measures (i.e., small-scale removal action or surface barrier/cap installation) may be considered to reduce risk to terrestrial species at these locations.

No risk to vegetation is predicted as a result of soil concentrations.

Overall risks from groundwater to the wetlands associated with Site 1 appear relatively low. Although several SSV and water quality criteria were exceeded, none were appreciably high and only aluminum and iron in water appeared to be spatially significant. The wetlands are presently being investigated for the Site 41 Remedial Investigations.

11.0 CONTAMINANT FATE AND TRANSPORT

11.1 Sources of Contamination

The RI has identified contamination within the boundaries of the former landfill. Sections 7 and 8 of this report discuss the nature and extent of parameters detected at Site 1 in 1993 and 1994, respectively. A limited amount of soil contamination was detected in the 0- to 1-foot surface soil depth interval inside the landfill boundary. Higher concentrations of detected parameters were present within the subsurface landfill waste interval (occurring at depths varying from 2 to 18 feet bls). Surface soil inside the landfill boundary generally consists of highly permeable silty sandy soil with varying amounts of decaying organic cover (leaves and straw). Landfill wastes include heterogeneous deposits of construction rubble; burned and unburned domestic refuse; industrial refuse including plastic, glass, metal, and crushed drums; clayey-silty sludge; and tar/sludge. Native soil (fine- to medium-grain quartz sand) immediately beneath the waste intervals appears to be unimpacted or only slightly impacted compared to the overlying fill at most sampling locations; however, one location (trench 6) contained observably contaminated soil down to the water table, and another location (trench 9) indicated landfill waste extended below the shallow water table in this area.

As discussed in Section 7.1, surface soil samples collected from test trenches within the landfill boundary generally exhibited elevated concentrations of all analytical parameter groups (inorganics, VOCs, semivolatiles, pesticides, and PCBs) compared to surface soil outside the landfill and background soil samples. Because the surface soil interval sampled at each trench location consisted of the overburden/cover material that was reworked and graded into place during landfill activities, these samples should be considered generally representative of surface conditions across the interior of the landfill. Small amounts of landfill waste likely were co-mingled to some degree with the cover material during the grading process, potentially producing the generally low contaminant concentrations in surface soil, compared to contaminants in the underlying waste interval. However, surface samples from locations 01S8001 and 01S8201 represent discrete sources of surface soil contamination

associated with surface features — the mounds of soil and the collapse feature at each locality, respectively — in these respective areas.

As discussed in Section 7.2, concentrations of all analytical parameter groups were identified in landfill waste samples collected during test trenching. The highest concentrations as compared to all trenching samples were detected in waste samples from trench 3, inorganics, VOCs, semivolatiles, pesticides, and PCBs; trench 4, semivolatiles; trench 6, VOCs and semivolatiles; trench 7, VOCs, semivolatiles, and PCBs; trench 8, PCBs; trench 11, PCBs; and trench 12, inorganics, VOCs, and semivolatiles. These areas would appear to represent the greatest potential threat to groundwater. Notably, efforts were made to sample landfill areas posing the greatest environmental risks (based on CSS findings). However, because of the landfill's size and the sampling location's distribution, these areas are not considered isolated, but rather may represent parameter concentrations potentially present throughout the heterogeneous waste interval. Therefore, no particular test trench should be considered an isolated, separable source; more over, broader source areas should be considered when addressing contaminant migration (e.g., the landfill's central portion versus the northern or southern portions).

11.2 Contaminant Migration

11.2.1 Leaching from Soil/Waste to Groundwater

Parameters detected in Site 1 soil and/or waste samples (solid media) may enter groundwater by two mechanisms: They may leach by downward percolation of precipitation through the solid media toward the water table, or from continual contact of groundwater with solid media at or near a fluctuating water table. In general, native soil at Site 1 is very permeable, with rapid infiltration and minimal contact time between percolating water and soil above the water table. However, some trench wastes are composed of fine-grained material (sludges, clayey-ash residue, or silty-clayey sand), that would have lower permeabilities, resulting in longer contact with percolating water. Any substantial leaching and downward migration would extend

impacted soil to the water table. However, most native soil samples from immediately beneath the waste interval yielded very low to non-detect parameter concentrations. This suggests either: 1) the waste material is tightly retaining parameter constituents where present, and minimal leaching is occurring, 2) downward migrating contaminants are not retained by the native soil, but pass directly to groundwater, or 3) leacheable fractions have already been flushed to groundwater and current groundwater quality represents reasonable worst-case conditions.

Impacted soil and/or landfill waste material extended into the water table in trenches 6 and 9. At trench 6, petroleum hydrocarbon stained soil was encountered above and in direct contact with the shallow water table (6 to 8 feet bls). This soil contained concentrations of aromatic and aliphatic volatiles, chlorinated aromatic semivolatiles, and PAHs. At trench 9, waste material extended into the water table. Solid media in these trenches are in continuous contact with shallow groundwater, allowing for maximum contact time for phase partitioning to the aqueous medium. An unfiltered shallow groundwater grab sample collected from trench 9 contained concentrations of several heavy metals (antimony, cadmium, chromium, lead, mercury, and nickel) and the VOC benzene exceeding MCLs. However, this sample was very turbid, which likely contributed to the concentrations of detected parameters.

The potential for contaminant migration through soil depends on several physical parameters of the soil, including total organic carbon (TOC), cation exchange capacity (CEC), pH, and redox potential, and on the chemical characteristics of the contaminants. Most semivolatiles, pesticides, and PCBs are generally considered to have limited to very limited potential for migration due to their low solubility and high affinity for soil particles and organic carbon. VOCs are considered more mobile, but also have a moderate affiity for organic carbon. Physical analyses of waste interval material and underlying native soil sampled generally indicate higher TOC content (up to 3,000 mg/kg) in the waste than the native soil (50 mg/kg to 250 mg/kg, see Appendix C). Analyses of most trench waste/native soil pairs show good to strong correlations between higher TOC values and high organic concentrations in the waste, and lower

TOC values and low to non-detect organic concentrations in the underlying native soil. The mobility and potential for migration of metals depends on pH, redox potential, TOC, and CEC of the bearing soil. CEC analyses consistently indicate higher CEC values for the waste interval (up to 14.0 meq/100g) than the underlying native soil (0.2 meq/100g to 5.2 meq/100g). Correspondingly, inorganic analytical results show a higher metals concentration in the waste, and a low to non-detect metals concentration in the underlying native soil. While the waste interval has been determined to be the source of contamination, its elevated TOC and CEC values also may allow it to retain or bind an appreciable amount of contaminants contained therein. The low to non-detect concentrations in the underlying native soil may result from minimal downward contaminant migration due to the retention properties of the waste interval, and/or a lower retention capability of the underlying native soil as contaminants pass through it with minimal partitioning to the soil.

Based on the distribution of detected parameters in groundwater, the landfill's most recently filled (early to mid-1970s era) central portion appears to be the primary source for organics (VOCs, semivolatiles, and minor amounts of pesticides) currently detected in shallow and intermediate samples. However, the southwestern portion (1950s era) also appears to be a source of organics (VOCs and semivolatiles) in both shallow and intermediate samples from the southwestern landfill boundary. The relatively lower parameter concentrations detected in the landfill's northern portion (1960s era) either are associated with relatively lower concentration sources in this area, or are the result of downgradient adjective contaminant migration from the central portion of the site. This distribution could be due to a higher overall volume of wastes within the central portion, the relative youth of that portion compared to the older and perhaps more leached sections, or spatial positioning of the monitoring well array.

The actual leachability of waste interval material was evaluated through TCLP analyses of test trench samples. These waste samples consisted of the following materials: sandy soil with domestic and burned waste from trench 2; sandy soil with clayey-ash from trench 3; tar waste

and stained sandy soil from trench **4;** heavily fuel-stained sandy soil from trenches 6A, 6B, and 6C; sandy soil with industrial and domestic waste from trenches 7, 8, and 9; sandy soil with industrial and burned waste from trench **11;** and sandy **soil** with tar-like sludge material from trench **12.** All samples except those from trench **12** yielded no leachable target constituents above TCLP reporting limits. The sample from trench **12** yielded 376 μg/L tetrachloroethane. Based on the TCLP results, it can be inferred that landfill wastes **are** presently not leaching gross concentrations of contamination (above TCLP reporting limits) to site groundwater, at the **10** of the **11** tested locations. However, it must be recognized that TCLP reporting limits (ppm) are higher than CLP limits (ppb) and that the reported list of TCLP analytical parameters is not as comprehensive as the TAL/TCL list. Therefore, lower concentrations of target contaminants or non-TCLP parameters may be leaching from the wastes to site groundwater. Furthermore, portions of the landfill not investigated by invasive methods may contain more leachable wastes than those encountered during this investigation. However, groundwater quality **data** do not indicate that the last two items **are** occurring to any appreciable degree.

11.2.2 Surface Water Transport

The generally high soil permeabilities around Site 1 limit substantial contamination transfer via surface water flow. During the RI, overland flow was not observed within the landfill boundary. Two intermittent creeks lie within wetlands outside the landfill, as shown on Figure **2-2.** One creek approximately 50 to 100 feet east of the landfill's central portion (depending upon precipitation amounts), channels intermittent flow northeastward to the Beaver Pond. The other originates approximately 500 feet west of the landfill's central portion and channels intermittent flow northwestward to Bayou Grande. Neither has been observed to receive direct surface water runoff from the landfill, but rather **are** apparently fed by groundwater seepage during **periods** of high water table. A third dry stream bed is in the site's northern portion, immediately south and leading to Bayou Grande Pond. No surface water was observed in this stream **bed** during the investigation.

Contaminant transfer from soil to intermittent stream waters would occur by sediment transport via surface drainage, or the same soil leaching processes discussed above via soil to groundwater, and groundwater to surface water pathways, mediated by groundwater quality characteristics. Because surface waters are fed primarily by groundwater, creek surface water quality may be expected to approximate local shallow groundwater conditions. However, surface water samples collected from site wetlands during 1994 sampling activities indicate wetland surface water has not been greatly impacted by site groundwater. Only relatively low concentrations (with respect to ambient water quality criteria) of inorganics, volatiles, and semivolatiles were detected in surface water samples. Additionally, native soil (sample 01S5602) from the dry stream bed south of Bayou Grande Pond yielded no leachable target constituents above TCLP reporting limits. Based on these results, significant concentrations of contamination are not currently being transported via the surface water pathway at Site 1.

11.2.3 Groundwater Transport

Groundwater analytical results indicate organic compounds are leaching or have leached from the landfill and are migrating via the groundwater pathway. Additionally, a limited number of elevated inorganic concentrations (with respect to ARARs) were detected in 1994 samples from the site's center, along the landfill's eastern and western boundaries. The highest organic compound concentrations were identified in both shallow and intermediate groundwater samples from the perimeter of the central, 1970- era portion of the landfill. Based on piezometric measurements, groundwater contaminants appear to be migrating radially north, east, and west from the landfill's central portion toward Bayou Grande. Downward vertical hydraulic gradients between shallow and intermediate groundwater depths, generally equivalent in magnitude to lateral gradients, indicate a strong tendency for downward contaminant migration in conjunction with lateral movement. Parameter concentrations detected at intermediate depth are likely a consequence of this downward flow component. The presence of a 8- to 20-plus-foot thick,

low-permeability clay layer between intermediate and deep monitored zones likely inhibits downward contaminant migration into deep groundwater as is supported by the absence of organic compounds or elevated inorganics in deep groundwater samples.

The groundwater contaminant migration rate may be conservatively estimated to equal groundwater velocity. Based on groundwater velocities calculated and presented in Table 6-5, the rate of contaminant movement from the landfill's central portion toward the east, north, and west is expected to be approximately 0.17 to 5.01 ft/day in shallow groundwater, and approximately 0.08 to 3.38 ft/day in intermediate groundwater (see Section 6.2, Site Hydrologic Results). Based on this information, contaminants leaching to shallow groundwater from the landfill's central portion potentially have migrated across the site's full northwestern, northern, and northeastern extents to Bayou Grande during the approximately 20-year period since the landfill was closed.

The high suspended solid and organic content in natural pore water beneath Site 1 may affect contaminant transport due to possible partitioning of organic contaminants onto carbonaceous material, and of metals onto organic material or clay. The variable pH of site groundwater, ranging from slightly acidic (as low as 4.15) to neutral (as high as 7.25) may also affect the partitioning of organic and metal contaminants. Therefore, contaminant movement may in part be attenuated by the ability of the particulate matter to move with groundwater, resulting in lower migration rates.

11.3 Potential Receptors and Impacted Media

The primary medium impacted by site activity has been the surficial zone of the Sand-and-Gravel Aquifer. This zone's shallow and intermediate monitoring wells have consistently yielded impacted groundwater. Concentrations of several organic compounds in RI samples exceeded drinking water standards and generally are comparable to those reported in previous studies. Limited elevated inorganic concentrations were also detected in 1994 samples. Impact on

groundwater emanating from the landfill's central 1970s portion appears to be the most significant. Both impacted and unimpacted groundwater in the surficial zone is highly turbid (as noted during 1993 sampling) and contains natural iron, manganese, and sodium concentrations exceeding FSDWS. A large portion of this zone yields dark brown, highly organic pore water with an acrid H_2S odor. Moreover, background concentrations of regulated metals also exceed drinking water standards. Based on natural groundwater characteristics, the surficial zone does not appear suitable as a drinking water supply either in impacted or unimpacted areas. Groundwater from the surficial zone is not presently used or anticipated to be used for that purpose.

Bayou Grande receives discharge from groundwater flowing west, north, and northeast from the site and is a potential impacted media of Site 1. This coastal water has been classified by the FDEP as a Class III water body, indicating its use maintaining a well-balanced fish and wildlife population. Potential impacts of past landfill activities on Bayou Grande will be addressed in an upcoming RI/FS (Site 40).

Other potentially impacted media include the surface waters and wetlands associated with Beaver Pond and Golf Course Pond east of the landfill, the intermittent creek west of the landfill, and Bayou Grande Pond and North Pond to the north. These bodies are potentially threatened by impacted groundwater discharges via direct seepage or intermittent creek flow during wet seasons. However, overland runoff from the landfill into these bodies is unlikely due to the high surface soil permeability. The results of this investigation indicate current impact to these areas is relatively low (with regard to sediment and surface water quality criteria). Potential impacts of past landfill activities on these water bodies and wetlands will be further addressed in an upcoming RI/FS for the NAS Pensacola wetlands (Site 41).

12.0 CONTAMINATION AND RISK SUMMARY

Site 1 RI objectives were to identify the source, nature, extent, and magnitude of contaminants in groundwater; to characterize surface soil inside and outside the landfill area, and the landfill contents; and to facilitate the evaluation of human health and ecological risk posed by contaminated site media through the BRA process. The following discussion summarizes the RI findings. The RI conclusions and recommendations are presented in Section 13.

For comparison, background soil and groundwater results were used to calculate RCs considered representative of ambient conditions at NAS Pensacola (see Sections 5.1 and 5.2 for a discussion of reference or background sample collection). Inorganic parameters detected in site groundwater and soil samples are discussed in the following sections relative to these concentrations (see Sections 7 and 8 for a detailed discussion of the nature and extent of detected parameters for 1993 and 1994 sampling events, respectively). RCs are equal to two times the mean concentration for each detected inorganic parameter. Parameter concentrations exceeding RCs (as well as MCLs and/or FGGCs for groundwater) are discussed as elevated.

12.1 Surface Soil

Based on analytical results of surface soil (0- to 1-foot depth interval) samples collected across the site, generally low-concentration-surface-soil contamination appears to be limited to the landfill interior. Samples from around its perimeter indicate soil quality outside the landfill is generally comparable to that of reference (background) sampling locations, with minor exceptions. However, surface samples collected from test trench locations within the landfill boundary frequently contained elevated concentrations of metals and organic compounds (semivolatiles, pesticides, and PCBs) exceeding those detected in reference and perimeter samples. Elevated parameter concentrations detected in trench surface soil samples were as follows:

- Concentrations of one or more of the metals barium, cadmium, chromium, lead, mercury, nickel, silver, and zinc were detected in samples from test trenches 2, 3, 5, 10, and 12. Samples from trenches 2, 10, and 12, in the landfill's northern, southeastern, and southwestern portions, respectively, had the highest metals concentrations.

- Semivolatiles — including several aromatic, phenol, and pyrene compounds — were detected in samples from trenches 2, 3, 5, 6, 8, and 10. Samples from trenches 2 and 12 had the highest concentrations of semivolatiles.

- Pesticides were detected in the majority of the surface soil samples collected outside and inside the landfill boundary. Most concentrations of pesticides at the site are comparable to those in reference samples. Relatively higher concentrations were reported for samples collected outside the landfill along the golf course's margin, and from trench trenches 2, 3, 10, and 12. Trenches 2 and 3 are in the landfill's northern portion; trenches 10 and 12 are in the southern portion. Pesticides detected along the golf course's margin are likely attributable to routine surface application. However, those detected at trench locations are likely associated with past waste disposal (landfill) activities.

- PCBs were detected in samples from trenches 1, 2, 6, 8, and 9. The highest concentrations were reported for the samples from trench 1, along the landfill's northwestern margin; trench 2, in the northernmost portion; and trench 8, in the central portion.

Except for *two* locations (trenches 10 and 12), samples collected within the landfill boundary consisted of the overburden/cover material that was reworked and *graded* into place over wastes during landfill activities. Because landfill wastes likely were co-mingled to some degree with the cover material during the grading process, potentially scattering contaminants across

significant portions of the landfill, the low concentrations of detected parameters in these samples should be considered representative of general surface soil conditions within the boundary. However, surface samples from trenches 10 and 12 in the southern portion were associated with specific surface features (mounds of soil at trench 10 and the collapse feature at trench 12) rather than overburden/cover material, and represent discrete areas of surface soil contamination.

12.2 Landfill Wastes

Test trenching at 13 locations across the landfill generally confirmed historical information regarding the nature of activities at Site 1. An interval of landfill waste was encountered at most test trenches, beneath a 1- to 3-foot thickness of sandy soil overburden/cover material. These wastes consisted of heterogeneous deposits of construction rubble; burned and unburned domestic refuse; industrial refuse including plastic, glass, metallic refuse, and crushed drums; clayey-silty sludge; and tar/sludge. However, no subsurface wastes were encountered in test trenches 10 or 13 (see Section 7.2). Only construction debris was in test trench 1 in the northwestern portion. Native soil (fine- to medium-grained quartz sand) immediately beneath the base of waste intervals appears to be unimpacted or only slightly impacted relative to the overlying fill at most sampling locations; however, one test trench (trench 6) contained visibly impacted soil down to the water table, and another (trench 9) indicated the base of the landfill waste interval extended below the shallow water table there.

In the 1970s-era portion of the landfill, wastes are contained in fill trenches appearing to be oriented approximately east to west across the site's central portion. No specific orientation of waste deposits was discernible in the northern (1960s-era) and southern (1950s-era) landfill portions. However, wastes encountered in the northern (test trenches 2 and 3) and southern (trench 11) portions were charred, appearing to have been burned before covering.

Concentrations of all analytical parameter groups were identified in landfill waste samples collected during test trenching. Relatively higher parameter concentrations (as compared to all trenching samples) were detected in waste samples from trench 3 (inorganics, VOCs, semivolatiles, pesticides, and PCBs), trench 4 (semivolatiles), trench 6 (VOCs and semivolatiles), trench 7 (VOCs, semivolatiles, and PCBs), trench 8 (PCBs), trench 11 (PCBs), and trench 12 (inorganics, VOCs, and semivolatiles). These areas would appear to represent the greatest potential threat to groundwater. Notably, efforts were made to sample landfill areas posing the greatest environmental risks (based on the CSS findings). Due to the landfill's size and the distribution of sampling locations, these areas are not considered isolated, but rather may represent parameter concentrations potentially present throughout the heterogeneous waste interval. Therefore, no particular test trench should be considered an isolated, separable source; moreover, broader source areas should be considered when addressing contaminant migration (e.g., the landfill's central portion versus the northern or southern portions).

Leachability of waste interval material was evaluated through TCLP analyses of test trench samples. All samples except those from trench 12 yielded no leachable target constituents above TCLP reporting limits. The sample from trench 12 yielded 376 $\mu g/L$ tetrachloroethene. Based on the TCLP results, it can be inferred that landfill wastes do not appear to be leaching gross concentrations of contamination (above TCLP reporting limits) to site groundwater at 10 of the 11 tested locations.

12.3 Groundwater

Surficial zone groundwater was determined to flow generally northward, toward Bayou Grande and associated tidal inlets and ponds, where discharge to surface water features likely is occurring. Analysis of 1993 and 1994 piezometric data indicates shallow and intermediate well depth intervals should be considered part of the same flow system. The nature and magnitude of detected parameters in each of these depth intervals generally is comparable. For organizational purposes, the following summary is presented by parameter groups. Reference

Samples were collected during each sampling event (1993 and 1994), allowing the calculation of sampling event-specific RCs. Site groundwater results for each year have been compared to the respective RCs. Additionally, 1993 groundwater sample results have been compared to 1994 results to note any apparent temporal trends in site groundwater quality.

Inorganics

Elevated metals concentrations (relative to drinking water standards) frequently were detected in shallow and intermediate groundwater samples collected (with Teflon bailers) in 1993. FPDWS MCL for arsenic, beryllium, chromium, lead, mercury, and nickel, and FSDWS MCLs for aluminum, iron, and manganese were exceeded in shallow and intermediate samples. Vanadium detected in both intervals commonly exceeded the FGGC for this parameter. However, metals concentrations detected in 1993 site samples only infrequently exceeded RCs calculated from background samples. Furthermore, comparable concentrations of metals (also exceeding MCLs) were detected in 1993 reference samples. Additionally, samples from the shallow and intermediate wells hydraulically upgradient (south) of the site proper generally exhibited metals concentrations comparable to or greater than those detected in samples conventionally collected farther downgradient, within the site proper.

Few distinct trends in the distribution of 1993 inorganic groundwater concentrations are evident. Comparable metal concentrations were detected in both shallow and intermediate samples. In general, the areal distributions of these concentrations in shallow and intermediate samples are sporadic, varying by both parameter and well depth interval. Although groundwater flow across the site consistently has been determined to be northward in the surficial zone, no commensurate concentration gradient in any of the metals concentrations is evident. The 1993 groundwater samples (site and reference) were notably turbid to varying degrees. Given the lack of clear trends or significant difference in site versus background concentrations, relatively higher concentrations detected in 1993 samples are apparently the result of metals adsorbed to suspended particulates (entrained finer-grained aquifer matrix) in the turbid samples.

Metal were also commonly detected in 1994 site groundwater samples collected via the quiescent (low flow peristaltic) sampling technique. Only samples collected from two shallow wells, 01GS64 and 01GGM39, contained metals concentrations (cadmium, chromium, and nickel) exceeding FPDWS/USEPA primary drinking water standard MCLs. Aluminum, iron, and manganese were frequently detected in all depth interval samples at concentrations exceeding secondary drinking water MCLs. However, RCs calculated for aluminum and iron also exceeded MCLs. Arsenic, barium, calcium, cobalt, iron, magnesium, manganese, potassium, sodium, vanadium, and zinc exceeded RCs in either shallow and/or intermediate samples. Shallow and intermediate samples exceeding the greatest number of MCLs and/or RCs (six or more) were collected as follows: from the site's central portion (01GGM33, 01GGM35, 01GI59, 01GI28); the landfill's eastern boundary (01GG34 and 01GS64); the western boundary (01GI61), the northwestern boundary (01GI46); and the site's eastern margin (01GGM39). Based on 1994 analytical results, the greatest impact to site groundwater quality with respect to inorganics appears to be in these areas.

Inorganic concentrations detected in 1993 samples were greatly reduced, or detected less frequently (or not at all) in 1994 samples. Inorganics occurring at reduced concentrations (lower mean or maximum) and/or frequency in 1994 samples included aluminum, antimony, arsenic, beryllium, chromium, cobalt, copper, lead, mercury, nickel, vanadium, and zinc. The significant reduction of inorganic concentrations in 1994 shallow and intermediate groundwater samples is apparently the result of the quiescent sampling technique (used in 1994) and the correspondingly low groundwater turbidity observed in 1994 samples.

Metals concentrations in 1993 samples from the site's deep wells, while below FPDWS MCLs, were elevated compared to those reported for reference deep supply wells. However, deep site wells monitor the uppermost portion of the main producing zone while background supply wells are screened significantly deeper. The difference in the deep well metals concentrations may be attributable to the difference in the screened interval depth for these wells (i.e., two different

zones with different physical/chemical properties). Additionally, inherent turbidity differences due to well design and nature of operation (supply wells versus monitoring wells) likely affect the concentrations of metals detected in each of these well groups. Deep well samples collected in 1994 contained notably lower concentrations of several metals, further supporting the hypothesis that relatively higher concentrations are due to higher turbidity. Overall, both data sets (1993 and 1994) do not indicate site activities have impacted deep groundwater quality.

Organics

Analytical results from both 1993 and 1994 sampling events confirm organic compounds are present in shallow and intermediate groundwater beneath the landfill. Available information regarding past activities at the site indicates large volumes of heterogeneous industrial wastes were disposed of across the entire landfii area, resulting in a multitude of potential contaminant sources. The nature, extent, and distribution of detected organics in site groundwater is consistent with the presence of numerous heterogeneous sources.

Several volatile and semivolatile organic compounds were detected in shallow and intermediate Site 1 groundwater samples. No organic compounds were detected in deep groundwater samples from the site. Pesticides also were detected in a limited number of shallow groundwater samples. Most detected concentrations of individual compounds were relatively low; however, FPDWS MCLs for specific compounds were exceeded. The distribution of organics in site groundwater extends toward Bayou Grande, west and north of the site, and beneath the golf course, east-northeast of the site. However, no organics were detected in the shallow and intermediate depth wells recently (June 1994) installed downgradient (northeast) of the site, on the golf course's opposite side. In general, the highest concentrations of organic compounds were in samples from the site's central portion, along the western and eastern landfill margins. This information indicates the central, 1970s-era portion of the landfill is the primary source of these compounds. However, the locations of relatively higher or lower concentrations of individual organics often vary by compound as well as by depth interval (shallow versus

intermediate samples). Furthermore, due to numerous spatial inconsistencies (i.e., variations in detected parameter concentrations across the site), specific trends in the concentrations of detected organics indicating distinct plumes of individual compounds are not readily discernible in the data.

Volatiles: Several aromatic and aliphatic VOCs were detected sitewide in shallow and intermediate groundwater. The highest concentrations of these compounds occurred in samples from the site's central portion, along the landfill's eastern and western boundary, during both 1993 and 1994. Aromatics were detected more frequently and generally at higher concentrations than aliphatics. The aromatics benzene and chlorobenzene, and the aliphatics tetrachloroethene (1993 only), trichloroethene, vinyl chloride, and 1,2-dichloroethene were detected at concentrations exceeding FPDWS MCLs. Benzene, the most frequently detected VOC exceeding MCLs, was present in samples collected across the site at relatively higher concentrations (ranging up to 80.0 μg/L) than tetrachloroethene, trichloroethene, and vinyl chloride (maximum detected concentrations 4.0 μg/L, 5.0 μg/L, and 23.0 μg/L, respectively). Concentrations of chlorobenzene and 1,2-dichloroethene exceeding MCLs (maximum concentrations 120 μg/L and 170 μg/L, respectively) were detected relatively infrequently. The remaining aliphatic VOCs exceeding MCLs (tetrachloroethene, trichloroethene, and vinyl chloride) were also detected in relatively few site samples.

Overall, VOCs were detected at comparable concentrations in both 1993 and 1994 groundwater samples. For VOCs exceeding MCLs in shallow groundwater, benzene and chlorobenzene were detected with similar frequency in both years; however, vinyl chloride was detected less frequently in 1994 samples. The distribution of benzene and chlorobenzene detected in both years was comparable; however, 1994 samples contained lower maximum concentrations of all three VOCs (benzene, chlorobenzene, and vinyl chloride). For intermediate groundwater, benzene and chlorobenzene were detected at comparable concentrations and frequency during

both years. However, vinyl chloride was detected more frequently (in intermediate samples), but at lower concentrations, in 1994 than 1993.

Semivolatiles: Several chlorinated aromatic, PAH, and phenolic semivolatile compounds were detected in shallow and intermediate groundwater samples. The distribution of semivolatiles in site groundwater generally is consistent with the distribution of VOCs, indicating that the landfill's central, 1970s-era portion is also the primary source of these compounds. In 1993, comparable concentrations of chlorinated aromatics were detected in shallow and intermediate samples. The distribution of these compounds primarily across the site's central portion also was similar in both sample groups. In 1994, slightly lower concentrations of chlorinated aromatics were detected in shallow samples than in intermediate ones; however, the distribution of these compounds primarily across the site's central portion was also similar in both sample groups. The highest concentrations of these compounds were detected in samples from the central portion, adjacent to the landfill boundary, during both sampling events.

PAHs and phenolic compounds also were detected primarily across the central portion of the site. Samples from the northern portion exhibited few detections of these compounds in 1993 and none in 1994. PAHs and phenolic compounds generally were detected more frequently and at slightly higher concentrations in intermediate samples than in shallow ones during both years. The relatively higher concentrations in intermediate samples are likely the result of downgradient (lateral) and downward (vertical) transport having occurred between the shallow and intermediate depth zones given the age of the landfill (active from the 1950s to mid 1970s). Samples from the central and east central portions contained the highest concentrations of these compounds. The only detected semivolatile approaching a regulatory standard was pentachlorophenol. A single concentration of pentachlorophenol equal to the 1.0 μg/L MCL for this parameter was detected in an intermediate sample collected from the southcentral portion of the site.

Notable differences in detected semivolatile concentrations were observed between 1993 and 1994 groundwater samples. For shallow groundwater, detected total chlorinated aromatics concentrations were comparable between years; however, both total phenolic and PAH compounds were generally detected at lower concentrations in 1994 samples. For intermediate groundwater, total chlorinated aromatics and PAHS were detected at generally comparable concentrations while phenols were detected less frequently and at lower concentrations in 1994 samples.

Pesticides: Only limited amounts of pesticides were detected in site groundwater during both years. Pesticides were detected in only two shallow groundwater samples during each year. In 1993, a single relatively low concentration of alpha-Chlordane (0.004 μg/L) was detected in sample 01GGM35 from the site's center, and 4,4'-DDE and 4,4'-DDT concentrations (0.064 μg/L and 0.014 μg/L, respectively) in sample 01GS58 from the site's southeastern margin. In 1994, a single relatively low concentration (0.0043 μg/L) of alpha-BHC was detected in sample 01GGM34 from the center of the site, along the landfill's eastern boundary, and a comparable concentrations of dieldrin (0.0076 μg/L) was detected in sample 01GS71 from the newly installed shallow well downgradient of the landfill area. Based on geographic proximity, the dieldrin, 4,4'-DDE, and 4,4'-DDT detections are likely associated with routine pesticide application to the golf course; however, the presence of alpha-Chlordane and alpha-BHC may indicate a limited degree of localized impact from landfill wastes to shallow groundwater at the site's center.

Pesticide concentrations detected in 1993 and 1994 samples were very comparable. During each year, these low concentration detections were few in number and limited to the shallow depth interval. Specifically, alpha-Chlordane and alpha-BHC were detected in 1993 and 1994, respectively, at approximately the same magnitude in the same general area of the site — the central to east central portion. The remaining concentrations (4,4'-DDE and 4,4'-DDT) detected along the golf course boundary in 1993 were not duplicated in 1994.

12.4 Wetland Sampling

In general, only lead and pesticide concentrations were of consequence in sediment samples collected near or within the selected wetlands. Several parameters (arsenic, cadmium, lead, dieldrin, endrin, DDT, and alpha-Chlordane) exceeded Region IV SSVs. However, most exceedences were relatively small; most detected concentrations were of the same order of magnitude as respective SSVs. Furthermore, no NAS Pensacola-specific reference concentrations are currently available for comparison; (wetland RCs are to be developed during the Site 41 RI), therefore, actual ambient conditions in these areas are not known. For several wetlands, analytical results from this study did not agree with those from ESD's study (ESD 1992). This finding is not unexpected given the heterogeneity of these media.

Analytical results of surface waters associated with wetlands near Site 1 did not reveal significant concentrations of either organic or inorganic constituents. Low concentrations of volatile and semivolatile compounds (7.0 ppb or less) were detected in surface water samples collected from Wetlands 3 and 16. Except for lead at Wetland 1, where the chronic freshwater criteria were exceeded, no other water quality criteria were exceeded by detected concentrations.

12.5 Human Health and Ecological Risk Summary

Human Health Risk

The human health risk associated with exposure to environmental media at NAS-Pensacola Site 1 was assessed for hypothetical current child trespassers, a potential future Site worker, and potential future Site residents. The exposure media considered in these assessments included surface soil (0 to 1 foot depth interval), surface and subsurface soil (all depth intervals), shallow/intermediate groundwater and deep groundwater. As discussed in Section 10.1.5 of this BRA, it was determined that the risk and/or hazard associated with exposure to all environmental media (and combinations thereof) was within USEPA's generally acceptable ranges for the trespassing child and the potential future site worker. Based on these findings, no COCs were identified relative to these receptor groups. Groundwater is not currently used as a potable water

source or for any industrial uses. Therefore, current receptors were not evaluated with respect to the groundwater media.

The hypothetical future Site resident was evaluated with respect to soil and groundwater using a surface soil dataset and two separate groundwater datasets based on combined shallow/intermediate and deep groundwater depths. Exposure to the shallow/intermediate groundwater medium presented an unacceptable risk and/or hazard via the ingestion and inhalation exposure pathways. No unacceptable risk and/or hazard was projected for exposure to surface soil or surface and subsurface soil.

The combined shallow/intermediate groundwater pathway hazard indicies (ingestion and inhalation exposures) for the future Site resident child were computed as 29 and 13 for the Site resident adult. The combined potential groundwater carcinogenic risk for ingestion and inhalation of groundwater was computed to be 4E-4. The primary non-carcinogenic COCs for groundwater ingestion are arsenic, barium, cadmium, iron, manganese, nickel, and chlorobenzene. The primary carcinogenic COCs identified for ingestion of groundwater include arsenic, vinyl chloride, and benzene.

The primary non-carcinogenic COCs for inhalation of groundwater are benzene and chlorobenzene. No carcinogenic COCs were identified for the inhalation of groundwater exposure pathway.

The deep groundwater pathway hazard indices (ingestion only) for the future Site resident child and adult were calculated as 1 and 0 (less than 0.05), respectively. Since no volatile organic chemicals were identified in deep groundwater, risk and/or hazard via the inhalation pathway was not computed. Manganese was the sole contributor to the hazard via ingestion of deep groundwater.

Ecological Risk

Species at Site 1 are not considered to be at risk based on the contaminant concentrations observed. Community-level effects are considered negligible due to the suspected lack of contaminant transfer discussed previously, and due to the confined areas of contamination. Information from the Florida Natural Areas Inventory shows no threatened or endangered (T&E) species will be impacted at Site 1. In addition, no T&E species' habitats were observed in or around the site.

Surface water and sediment samples were collected in or hydraulically upgradient of wetlands associated with Site 1 to assess its impact on wetlands. Given the site's physical setting (i.e., sandy, highly permeable surface soil), the greatest potential threat to wetlands is the discharge of site-impacted groundwater to these features.

In Wetland 1, both benchmark values for lead were exceeded for surface water and sediment. However, risk from lead in Wetland 1 sediment is most likely low. The SSV was exceeded only slightly; no measure of risk was intended by establishing these SSVs.

In Wetlands 3 and 18, several SSVs were exceeded by wetland sediment and surface water. Although SSVs were exceeded, no indication of water quality degradation was evident. This suggests that contaminants are immobilized in sediments with limited toxic effects.

No appreciable ecological risks from groundwater discharge to wetlands near Site 1 are currently apparent. A more detailed risk assessment of Site 1 wetlands will be made during the Site 41 investigation.

Specific effects to overall biota within the area are unknown. This issue is compounded by a lack of available data on soil acute and chronic toxicity for some of the COCs identified. Elevated concentrations of contaminants at locations 01S8001 and 01S8201 indicate ecological

risk may be higher for these areas compared to the site overall.

13.0 CONCLUSIONS AND RECOMMENDATIONS

The Site 1 RI has adequately assessed the nature and extent of soil and groundwater contamination and provided sufficient initial aquifer parameter data for remediation. A feasibility study is recommended for the site to evaluate potential alternatives for future site management decisions. Recognizing that the site contains numerous contaminant sources, E/A&H recommends the landfill be addressed as a whole with regard to remedial alternatives (as opposed to individual delineation and treatment of potentially numerous "hot spots" or "micro plumes"). If groundwater extraction is determined necessary, more quantifiable hydrologic testing should be performed at the site as part of a pre-design phase of remedial design/remedial action (RD/RA) to obtain reliable long-term, high-volume withdrawal data for the surficial zone. The following conclusions concerning site conditions are based on the findings of this investigation:

Based on analytical results, the tar pit does not appear to be a source of contamination impacting site soil or shallow groundwater. However, this feature does pose some degree of physical hazard to humans and wildlife due to its proximity to recreational areas (camping areas and natures trails) and animal habitats. Therefore, removing this feature and the associated stained soil are recommended to eliminate a potential hazard.

Soil media inside the landfill's boundary has been impacted by past landfill activities. Buried waste within the landfill has been characterized as containing notable concentrations of all analyzed parameter p u p s (inorganics, VOCs, semivolatiles, pesticides, and PCBs). However, with only one exception, TCLP results of the waste do not indicate appreciable leaching is currently occurring at tested locations. Given the age of the landfill (approximately 20 to 40 years) and these results, apparently only minimal concentrations of waste constituents, if any, are presently leaching to underlying groundwater. Surface soil quality outside the landfill boundary appears to be generally comparable to reference soil conditions. However, surface soil

within the landfill's boundary does appear to have been impacted by landfill activities, resulting in elevated concentrations of inorganic and organic constituents.

The nature and extent of landfill-impacted groundwater have been evaluated at the site. Relatively low concentrations of inorganic and organic constituents are present in the surficial zone (shallow and intermediate wells depths) beneath the site. A comparison of groundwater analytical results from samples collected in 1993 (with Teflon bailers) versus those collected (via quiescent sampling techniques) in 1994 indicate 1993 inorganic results were greatly affected (biased) due to sample turbidity. Based on 1994 analytical results, the greatest impact to site shallow and intermediate groundwater quality with respect to inorganics appears to be limited to the center of the site, along the landfill's eastern, western, and northwestern boundaries. Except for aluminum, iron, and manganese (indicated by background data to naturally occur at elevated concentrations), inorganic concentrations exceeding ARARs are generally limited to areas within and around the landfill's perimeter.

Organic constituents have consistently been detected at relatively low (near MCUFGGC) concentrations in surficial groundwater. Consistent with the distribution of elevated inorganics, the highest concentrations of organics were detected in the center of the site, and along the landfill's eastern and western boundaries. Relatively lower organic concentrations extend downgradient from the landfill to areas along Bayou Grande's coastline, adjacent wetlands, and east-northeast beneath the golf course. However, no elevated inorganics or organics (except for a single low pesticide concentration) were detected in samples collected from the most downgradient, recently installed monitoring wells (June 1994) located across the golf course opposite the landfill. This information indicates the extent of organic-impacted groundwater migrating east-northeast from the landfill is limited to the area beneath the adjacent golf course. As with inorganics, organic concentrations exceeding ARARs are generally limited to areas within and around the landfill's perimeter.

Exposure to the shallow/intermediate groundwater medium presented an unacceptable risk and/or hazard via the ingestion and inhalation exposure pathways for the hypothetical future Site resident. No unacceptable risk and/or hazard was projected for exposure to surface soil or surface and subsurface soil.

The primary non-carcinogenic COCs for groundwater ingestion are arsenic, barium, cadmium, iron, manganese, nickel, and chlorobenzene. The primary carcinogenic COCs identified for ingestion of groundwater include arsenic, vinyl chloride, and benzene.

The primary non-carcinogenic COCs for inhalation of groundwater are benzene and chlorobenzene. No carcinogenic COCs were identified for the inhalation of groundwater exposure pathway.

Since no volatile organic chemicals were identified in deep groundwater, risk and/or hazard via the inhalation pathway was not computed. Manganese was the sole contributor to the hazard via ingestion of deep groundwater.

Ecological Risk

Species at Site 1 are not considered to be at risk based on the contaminant concentrations observed. Community-level effects are considered negligible due to the suspected lack of contaminant transfer, and due to the confined areas of contamination. Information from the Florida Natural Areas Inventory shows no threatened or endangered (T&E) species will be impacted at Site 1. In addition, no T&E species' habitats were observed in or around the site.

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14.0 REFERENCES

This section has been extensively revised. For readability this section has not been bolded or bracketed.

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FLORIDA PROFESSIONAL GEOLOGIST SEAL

I have read and approve of this Final Remedial Investigation Report at NAS Pensacola Site 1 and seal it in accordance with Chapter 492 of the Florida Statutes. In sealing this document, I certify the geological information contained in it is true to the best of my knowledge and the geological methods and procedures included herein are consistent with currently accepted geological practices.

Name:	Brian E. Caldwell
License Number:	#1330
State:	Florida
Expiration Date:	July 31, 1996

B E Caldwell

Brian E. Caldwell

1-2-96

Date