NAVAL FACILITIES ENGINEERING COMMAND
Washington, DC 20374-5065

# Site Specific Report
## SSR-2511-ENV

# NAVAL WEAPONS INDUSTRIAL RESERVE PLANT DALLAS LONG-TERM MONITORING DEVELOPMENT CASE STUDY

September 1999

Prepared for
Department of the Navy RAO/LTM Optimization Working Group

FINAL

# NAVAL WEAPONS INDUSTRIAL RESERVE PLANT DALLAS LONG-TERM MONITORING DEVELOPMENT CASE STUDY

Prepared for:
Naval Facilities Engineering Service Center
Port Hueneme, California

Prepared by:
Radian International
115 Longview Drive
Los Alamos, New Mexico 87544

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## TABLE OF CONTENTS

**Page**

## LIST OF FIGURES

**Page**



## LIST OF TABLES

**Page**

## LIST OF ACRONYMS

| | |
|---|---|
| ACL | alternate concentration limit |
| AOC | area of concern |
| bgl | below ground level |
| CMS | Corrective Measures Study |
| COC | chemical of concern |
| DCE | dichloroethene |
| DNAPLs | dense nonaqueous phase liquids |
| DON | Department of the Navy |
| DPT | direct-push technology |
| EPA | Environmental Protection Agency |
| GIS | geographic information system |
| GOCO | Government-owned, contractor-operated |
| IAS | initial assessment study |
| IRP | Installation Restoration Program |
| IWC | Industrial Waste Concentrate |
| ml/min | milliliter per minute |
| LTM | long-term monitoring |
| MCL | Maximum Contaminant Level |
| MNA | monitored natural attenuation |
| NAS | Naval Air Station |
| NWIRP | Naval Weapons Industrial Reserve Plant |
| PCB | polychlorinated biphenyl |
| PCE | perchloroethene |
| POC | point of compliance |
| QA/QC | quality assurance/quality control |
| RCRA | Resource Conservation and Recovery Act |
| RFA | RCRA Facility Assessment |
| RFI | RCRA Facility Investigation |
| RI | Remedial Investigation |
| SARA | Superfund Amendments and Reauthorization Act |
| SVOCs | semivolatile organic compounds |
| SWMU | solid waste management unit |
| TAL | Total Analyte List |
| TCE | trichloroethene |
| TCL | Total Compound List |
| TI | technical impracticability |
| TNRCC | Texas Natural Resource Conservation Commission |
| TPH | total petroleum hydrocarbons |
| USGS | US Geological Survey |
| VOCs | volatile organic compounds |

# EXECUTIVE SUMMARY

## ES.1 Purpose of the Case Study

The main purpose of this case study is to provide: (1) specific guidance and direction to the Naval Weapons Industrial Reserve Plant (NWIRP) in Dallas, Texas, regarding the required elements of a groundwater compliance plan, and (2) recommendations for continual streamlining of a monitoring program. A discussion of closeout strategy for the installation is also presented. In addition, best practices that have been implemented at NWIRP Dallas and may be incorporated into the strategy of other facilities are documented in this case study.

## ES.2 Optimization Approach

This case study focuses on ways to reduce the resources expended at NWIRP Dallas for groundwater monitoring without compromising program and data quality. This evaluation includes an assessment of five basic areas:

- The number of monitoring points;
- The efficiency of current field procedures;
- The duration and frequency of monitoring;
- The analyte list and analytical methods; and
- Reporting and data management protocols.

## ES.3 Installation and Program Background

NWIRP Dallas is a government-owned, contractor-operated (GOCO) facility located in Grand Prairie, Texas, between Dallas and Fort Worth. It covers 314 acres on the shoreline of Mountain Creek Lake and is adjacent to Naval Air Station (NAS) Dallas, which is now closed. The primary mission of the installation, which was built in 1941, has been military aircraft manufacturing. The installation is currently operated by Northrop Grumman.

Environmental work began at NWIRP Dallas in the 1980s. During a Resource Conservation and Recovery Act (RCRA) Facility Assessment (RFA) conducted in the early 1990s, 16 solid waste management units (SWMUs) and 6 areas of concern (AOCs) were identified. The RFA determined that contamination to the groundwater has resulted from activities at these SWMUs and AOCs, which include wastewater treatment, waste and hazardous material storage, waste disposal and incineration, and manufacturing.

An RCRA Facility Investigation (RFI) was conducted from 1993 to 1994. The investigation results indicated that there is one large plume of groundwater contamination by chlorinated solvents and other volatile organic compounds (VOCs) covering 80% of the installation. Consequently, the installation has been treated as one site.

An RCRA Part B permit was issued by the Texas Natural Resource Conservation Commission (TNRCC) to NWIRP Dallas in April 1994. The Part B permit specified that stabilization measures be implemented to stop further off-site migration of the contaminated plume.

## ES.4 Best Practices Already in Place

There are several examples of practices that NWIRP Dallas has already put in place to optimize their periodic groundwater monitoring program. The following items may be evaluated by other installations seeking to reduce costs associated with their own long-term monitoring (LTM) or periodic monitoring programs:

- NWIRP Dallas has implemented micropurging to increase sample quality and, in many cases, eliminate metals as chemicals of concern (COCs).

- The installation has analyzed groundwater monitoring data from sampling events, performed trend analysis, and contoured the data to make recommendations for program improvements.
- NWIRP Dallas used geostatistics to demonstrate that 58 monitoring wells could be removed from the program without compromising program quality.
- The installation currently handles all of its data electronically to facilitate data management and visualization.
- NWIRP Dallas proactively initiated a site-wide background study for metals.
- The installation has employed the help of outside government agencies to assist in evaluation and treatment of the contaminated groundwater plume.

## ES.5 Site Closeout Strategy

Several strategies for negotiating eventual site closeout should be considered now, as the monitoring program is about to start. These include the following:

- Continue to aggressively pursue the application of monitored natural attenuation (MNA) for the contaminated plume.
- Initiate discussions with TNRCC to establish alternate concentration limits (ACLs) for the groundwater plume, with Mountain Creek Lake as the point of compliance.
- Consider expanding the Stabilization System Performance Evaluation Reports to include graphical presentation of additional cost and performance metrics.
- Initiate discussions with the regulatory agencies to establish measurable decision criteria defining the meaning of technical and/or cost impracticability for NWIRP Dallas.
- Continue to evaluate innovative in situ groundwater treatment remedies as possible cost-effective alternatives to conventional pump and treat for source removal.

## ES.6 Monitoring Program Design

On the basis of the optimization strategy summarized in Section ES.2, several suggestions for the design of the monitoring program at NWIRP Dallas are offered:

- Exclude approximately 80% of the installation monitoring points from the monitoring program, using TNRCC guidance to identify those points that should be included.
- Following a year of quarterly sampling, pursue a reduction of sampling frequency to semiannually for point-of-compliance (POC) and corrective action observation wells, and annually for upgradient and background wells.
- Continue using micropurging techniques, but refine the placement of dedicated tubing intakes to ensure purging from the most productive zones, thus eliminating vertical flow within the wells.
- Decrease the analyte list to VOCs and metals of concern, including hexavalent chromium.
- Pursue coordination of the monitoring database with a geographic information system (GIS) application.
- Focus on graphical and tabular reporting formats and minimize the amount of text submitted in quarterly reports.

TNRCC regulations require that requests for modifications to an issued groundwater compliance plan be submitted following a specific format. These requests must be accompanied by a fee, the amount of which depends on the extent of the proposed modifications. Therefore, it is important to have a thorough periodic evaluation of the monitoring program so that modification requests can be minimized to the extent possible.

## ES.7 Benefits

The benefits of applying the above recommendations include a potential cost savings of almost $130,000 per sampling round, as compared with the cost of sampling all monitoring points for target compound list (TCL) organics and target analyte list (TAL) metals. During the second year of sampling, additional cost savings, estimated at $65,000 per year, may be realized by decreasing monitoring frequency. The cost associated with requesting a compliance plan modification, including labor, should be substantially less than the amount saved. These estimated savings do not consider additional savings associated with data validation, management, and reporting.

# 1.0 INTRODUCTION

The following sections explain the purpose, approach, and content of this long-term monitoring (LTM) development case study for Naval Weapons Industrial Reserve Plant (NWIRP), Dallas, TX.

## 1.1 Purpose and Objectives

The Installation Restoration Program (IRP) at NWIRP Dallas has not yet progressed to the LTM stage. However, the installation currently has nearly 300 groundwater monitoring wells and, pursuant to Resource Conservation and Recovery Act (RCRA) requirements, will be required to submit a groundwater compliance plan to the State of Texas within the next calendar year.

This compliance plan must detail the strategy and approach to groundwater monitoring for the entire installation. *Thus, the main purpose of this case study is to provide specific guidance and direction to NWIRP Dallas regarding the required elements of a groundwater compliance plan and recommend ways to continually streamline a monitoring program.*

The specific objectives of this report are to:

- Evaluate the groundwater compliance plan requirements and recommend ways to avoid costs that can be realized without compromising data quality;
- Assess the site closeout strategy and decision-making process and recommend ways to optimize them; and
- Document best practices that have been implemented by the installation and may be incorporated into the strategies of other bases.

## 1.2 Document Organization

Section 1.3 outlines the approach that is followed to formulate optimization recommendations for the monitoring program. The remainder of the document is organized as follows:

**Section 2.0, Location, Background, and Physical Setting of NWIRP Dallas—** This section gives the general location of the installation and describes the local geology, hydrology, and geography.

**Section 3.0, Program Background and Site Closeout Strategy for NWIRP Dallas—**This section describes the status and regulatory framework of monitoring of the site-wide groundwater plume. Best management practices that have already been implemented for this program are also discussed, along with key site strategy considerations.

**Section 4.0, Development of a Monitoring Program—**This section discusses the elements of a monitoring program and recommends ways to develop and maintain a streamlined groundwater monitoring program.

**Section 5.0, References—**This section provides a list of the documents cited in this case study.

## 1.3 Optimization Approach

This case study focuses on ways to reduce the resources expended at NWIRP Dallas for groundwater monitoring, without compromising program and data quality. There are five general optimization strategies that may be used to increase cost effectiveness of monitoring programs:

- Reducing the number of monitoring points;
- Ensuring efficient field procedures;
- Reducing monitoring duration and/or frequency;
- Simplifying analytical protocols; and
- Streamlining data management and reporting.

Figure 1-1 shows a graphic representation of the above process. In addition, Table 1-1 includes more detailed rationale for each of these strategies, as they apply to the future NWIRP Dallas monitoring program.

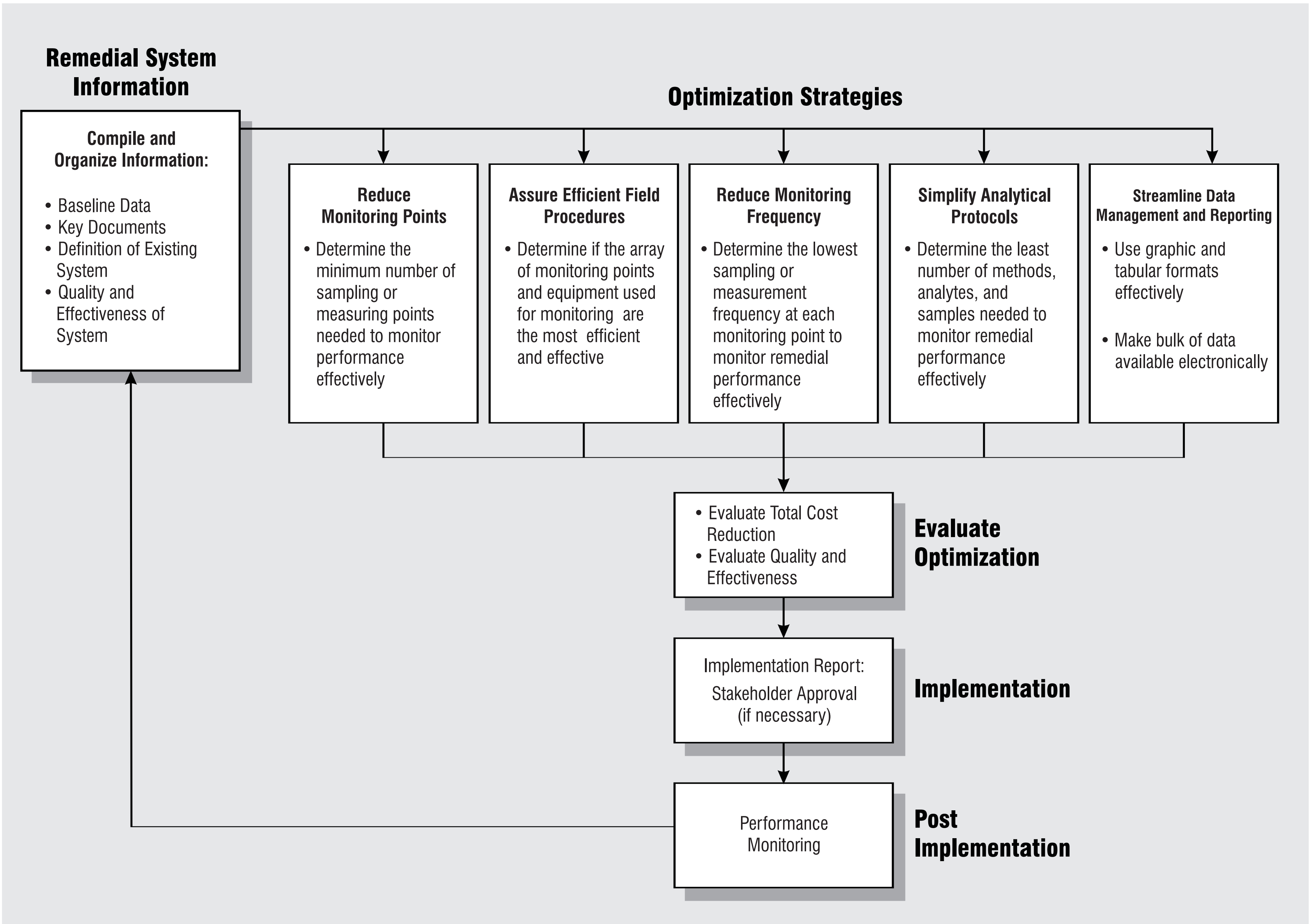



**Figure 1-1. LTM Program Optimization Process**

**Table 1-1**
**Application of the LTM Program Optimization Strategies to NWIRP Dallas**

| Optimization Strategy | Example Data for NWIRP Dallas | Example Optimization Rationale |
|---|---|---|
| Reduce the number of monitoring points | Constituent concentrations collected at a specific monitoring point (e.g., contaminant concentrations in a particular groundwater monitoring well) | • If points were not sampled, the same decisions about contaminant extent or remedial performance can be made with data from other points in the monitoring system.<br>• The contamination has been drawn away from the monitoring point by the remedial action.<br>• Concentrations obtained at other monitoring points are more representative and reliable than at this monitoring point.<br>• The potential for lateral or vertical migration to this monitoring point has been eliminated or decreased; therefore, monitoring the point is unnecessary.<br>• Concentrations at this monitoring point have reached and consistently remained below the cleanup goal; continued sampling is not necessary.<br>• The concentrations obtained from this point have historically been redundant with adjacent points (i.e., identical or similar results). |
| | Nonchemical data measured at a monitoring point (e.g., water level measurements) | • The measurements from this location have stabilized (leveled off in four or five most recent events); therefore, additional measurements from the point are unnecessary.<br>• Measurements obtained from this point have historically been redundant with adjacent points.<br>• The same decision about contaminant extent or remedial performance could have been made with data from the remaining monitoring points if this point was not measured. |
| | Sampling or measuring point depth | • Sampling or measurements are no longer required at a specific depth because vertical migration is observed not to be occurring or cleanup at that particular depth is complete. |
| Reduce measurement frequency | Contaminant concentrations in samples | • The data collected from one season, or one time of day, are more representative of conditions than other times; therefore, sample/measure at the most representative time only.<br>• Concentrations or measurements have stabilized or reached an asymptotic level; changes can be monitored with sampling at a lesser frequency. |
| | Velocity of contaminant migration in soil gas or percolating water (from permeability and gradient data) | • The monitoring frequency can be decreased such that time between sample collections is more than the minimum time interval necessary for the contaminant to migrate between monitoring points. |

**Table 1-1**
**(Continued)**

| Optimization Strategy | Example Data for NWIRP Dallas | Example Optimization Rationale |
|---|---|---|
| Simplify analytical protocols | Constituent concentration data collected at a particular monitoring point | • Sampling methods currently being performed can be deleted if the method is not needed to demonstrate cleanup progress, remedial performance, or natural attenuation.<br>• The total time interval of sampling for undetected, “potential” analytes should be limited; delete analyses for potential contaminants if they have not been detected in the first year of samples (not to include degradation products).<br>• Analyses should be performed only with the method(s) appropriate for indicator compounds or elements that are most indicative of contaminant extent. |
| | Historical quality control assessments | • Precision, accuracy, representativeness, and completeness of methods have been historically demonstrated; quality control sampling and analyses can be reduced with no loss of quality. |
| Ensure efficient field procedures | Data acquisition methods | • Measuring points that are not open (e.g., screened) at the proper depth or horizontal location to provide accurate measurements should not be monitored.<br>• Purging and sampling methods should be the most cost-effective methods available without compromising sample quality.<br>• An automated recording device/data logger/telephonic transmitter may be added to critical locations to improve the timing of measurements and save labor costs over the time interval of monitoring. |

# 2.0 LOCATION, BACKGROUND, AND PHYSICAL SETTING OF NWIRP DALLAS

## 2.1 Location of NWIRP Dallas

NWIRP Dallas is located in Grand Prairie, Texas, between Dallas and Fort Worth. Figure 2-1 shows the location of the installation and the vicinity.

## 2.2 Installation Background

NWIRP Dallas is a government-owned, contractor-operated (GOCO) facility, currently operated by Northrop Grumman. The primary mission of the installation, which was built in 1941, has been military aircraft manufacturing. It currently covers 314 acres on the shoreline of Mountain Creek Lake and is adjacent to Naval Air Station (NAS) Dallas, which is now closed.

Environmental work began at NWIRP Dallas in the 1980s. During an RCRA Facility Assessment (RFA) conducted in the early 1990s, 16 solid waste management units (SWMUs) and 6 areas of concern (AOCs) were identified. The RFA determined that contamination to the groundwater has resulted from activities at these SWMUs and AOCs, which include wastewater treatment, waste and hazardous material storage, waste disposal and incineration, and manufacturing.

An RCRA Facility Investigation (RFI) was conducted from 1993 to 1994. The investigation results indicated that there is one large plume of groundwater contamination by solvents and other volatile organic compounds (VOCs) covering 80% of the installation. Consequently, the installation has been treated as one site. A summary of the RFI findings is given in Table 2-1. Additional information on investigation activities is presented in Sections 3.1 and 3.2.

## 2.3 Physical Setting of NWIRP Dallas

The following sections describe the geology, hydrogeology, and geography at NWIRP Dallas.

### 2.3.1 Site Geology

NWIRP Dallas is in the Blackland Prairie district of the Central Lowlands of north-central Texas. Site geology is typical of this district, with subsurface soils of unconsolidated alluvial material overlying consolidated sedimentary rock. The following description of the site geology is taken from the *Final Stabilization Work Plan, NWIRP, Dallas, Texas* (Ensafe/Allen&Hoshall, October 1995).

**Unconsolidated Material—**Total thickness of unconsolidated deposits underlying NWIRP Dallas varies from 12 to 75 feet. These unconsolidated deposits are composed of two or three discernible fining-up sequences. Clays are generally encountered in the upper 10 to 20 feet of each sequence, and sporadically from this point to the base of the sequence. The uppermost unit, described as alluvial terrace deposits, consists of gravel, sand, silt, and clay that were deposited in the Trinity River floodplain.

**Consolidated Material—**Cretaceous age sedimentary units underlie the surface deposits. The uppermost of these units beneath NWIRP Dallas is the Eagle Ford Shale, located 15 to 65 feet below ground level (bgl). The Eagle Ford Shale is predominately dark gray shale that weathers to highly plastic clay. This is considered to be a confining unit overlying the Woodbine Formation. In Dallas County, the Eagle Ford Shale thickness is reported to range from 140 to 500 feet bgl, depending on its location within the outcrop area and local erosional features. Beneath the Eagle Ford lies the Woodbine Group, which is approximately 300 feet thick in the area of NWIRP Dallas.

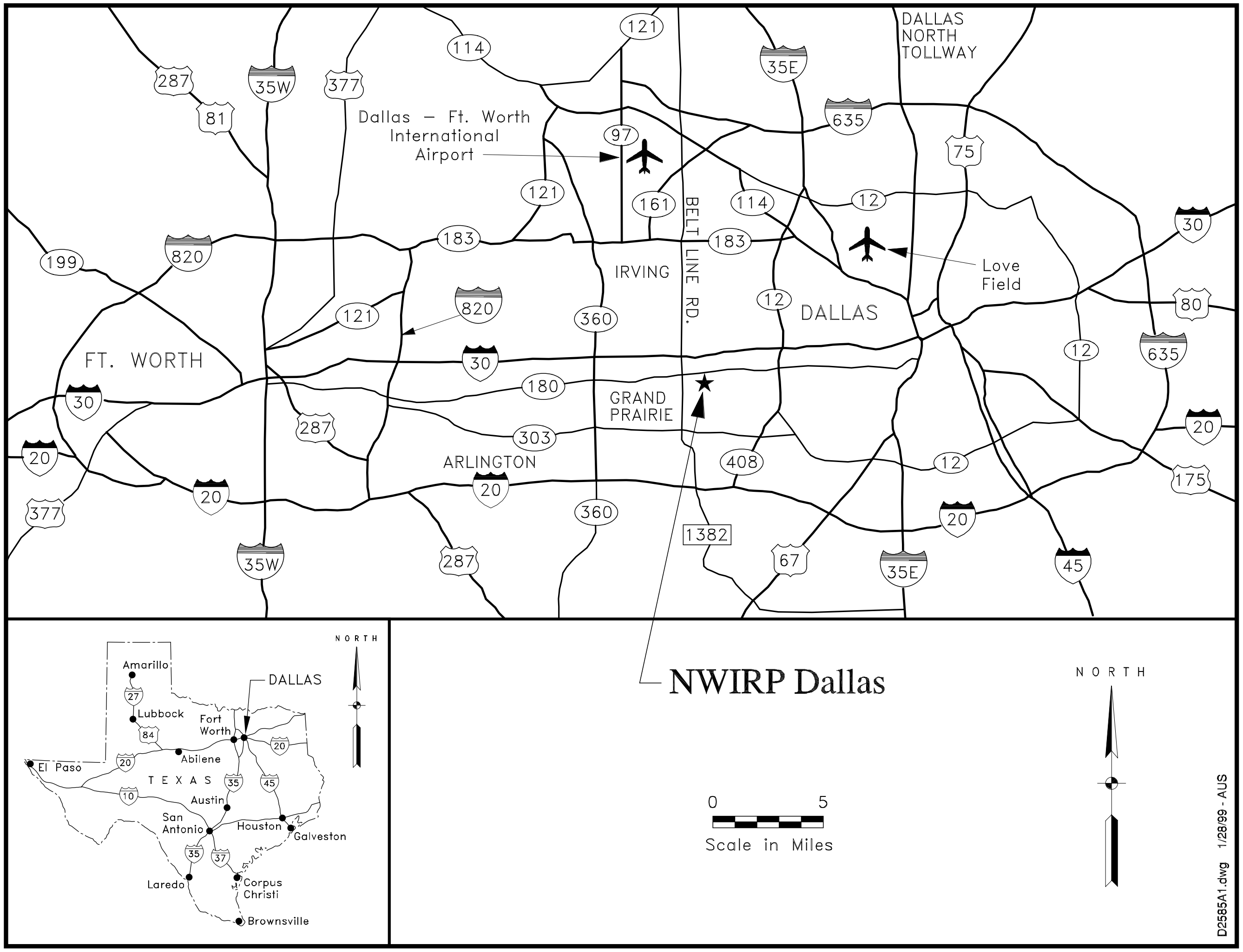



**Figure 2-1. General Location Map of NWIRP Dallas and Vicinity**

**Table 2-1**
**Summary of RFI Findings for NWIRP Dallas**

| Site | Significant Findings |
|---|---|
| SWMU 1/6 Industrial Wastewater Treatment Plant and Cyanide Treatment Eductor. | Metals from a former pipeline leak and SVOCs and pesticides/PCBs from historic treatment activities in the old sludge drying beds were found in shallow soils. VOCs were detected in groundwater at the site, although it was not determined whether these were directly related to SWMUs 1 and 6. |
| SWMU 4/19 Salvage Yard and Former Crushed Drum and Firebrick Burial Site | Reported firebrick and crushed drum burial activities at this site do not appear to have adversely impacted the soil or groundwater. However, waste oil runoff has affected a small area of soil southeast of the salvage yard and has also affected a small ditch leading toward Mountain Creek Lake. VOCs were detected in groundwater at the site; however, they appear to be related to the larger site-wide plume of AOC 18. |
| SWMU 5 Old and New Cyanide Drum Storage Cage | No significant contamination or other evidence of a release was found during the investigation. |
| SWMU 8 Waste Alcohol Tanks | The waste alcohol tanks have been removed. Only a limited amount of contaminated soil was found during tank removal, and this soil was excavated and disposed of off site. The facility operator will issue a report on removal activities to the TNRCC. |
| SWMU 10 Jet Fuel Burn Pit | TPH contamination was found in soil samples down to 4 feet. Groundwater samples contained trace levels of TCE and DCE, but this contamination is likely the leading edge of the facility wide TCE groundwater plume associated with AOC 18 and a possible source near SWMU 12.<br>A review of previous studies confirmed the presence of a second jet fuel burn pit at NWIRP Dallas. |
| SWMU 11 Jet Fuel Trap | Sampling at this site was limited to groundwater. No evidence of a significant release was found. |
| SWMU 12 Closed Incinerator and Old Drum Storage Area | SVOCs, metals, pesticides/PCBs, and TPH were found in soils and sludge at this site. The highest levels were found in an area of sludge and fill east of the former incinerator.<br>Groundwater samples collected south of this site, in an old drum storage area, contained high levels of VOCs. |
| SWMU 13 West Drainage Lagoon | SVOCs, metals, TPH, and pesticides/PCBs were found in soil and lagoon sediment samples at this site. However, these compounds do not appear to be leaching into the shallow aquifer.<br>Surface water samples contained TCE. TCE concentrations decreased between the lagoon inlet and the outlet; however, low concentrations of TCE ($< 10\ \mu g/L$) were found in surface water at the lagoon discharge point. |
| SWMU 14 East Drainage Lagoon | SVOCs, metals, TPH, pesticides/PCBs, herbicides, and VOCs were found in soil and lagoon sediment samples at this site. However, these compounds do not appear to be leaching into the shallow aquifer.<br>Surface water samples contained TCE. The concentrations decreased between the lagoon inlet and outlet; however, low concentrations of TCE ($< 10\ \mu g/L$) were found in surface water at the lagoon discharge point. |
| SWMU 15 Former Acid Neutralization Pit | The former pit location was identified and its boundaries have been defined. VOCs, SVOCs, TPH, and chromium were found in soil and groundwater samples collected near this site. |

| Site | Significant Findings |
|---|---|
| SWMU 16 Former Refuse Burn Pit | The former pit location was identified and no evidence of the materials reportedly handled in the pit was identified. However, significant concentrations of TCE were found in groundwater samples near this site. However, it does not appear that the former pit is the source of the TCE. |
| SWMU 17/3 Industrial Sludge Waste Drum Burial Site and Solid Waste Storage Area | No evidence of drums was found during this or previous investigations. However, metals, TPH, and SVOCs were found in soils in the general area.<br>The solid waste storage area appeared to be in good condition during this investigation and no evidence of a release was found. |
| SWMU 18 Rubble Fill Area | Elevated levels of metals were detected in soil and groundwater samples from this site. VOCs were also detected in groundwater. An area of what may have been sludge mixed with construction debris was found in one boring. |
| AOC 12 MEK Aboveground Storage Tank Area | MEK was not found in soil and groundwater samples from this site. However, the levels of VOCs detected in groundwater suggest a release may have occurred in this area. |
| AOC 14 Manufacturing Building 1 | Metals and VOCs were detected in soil and groundwater samples from this site. The high concentrations of VOCs detected in groundwater appear to be associated with current and former degreasing operations both inside the building and in the surrounding areas of the plant. |
| AOC 15 Manufacturing Building 6 | High concentrations of TCE and other chlorinated VOCs were found in groundwater near this site. This contamination appears to be associated with current and former degreasing operations in the area. |
| AOC 16 Waste Petroleum, Oil, and Liquids (POL) Spill Site | Metals and SVOCs were detected in soil samples from the site; however, no pattern was evident. High concentrations of VOCs were found in groundwater at this site. The VOCs were present in all of three fining-up sequences. |
| AOC 17 Industrial Waste Concentrate (IWC) Pipeline Leak | No evidence of a release was found during this investigation. The affected area appears to have been well excavated following the leak and replaced with clean backfill. |
| AOC 18 TCE Area | The nature and extent of the facility-wide chlorinated VOC groundwater plume have been generally defined. Eleven potential source areas were identified. |
| Offsite NAS Dallas Investigation | VOCs were identified in groundwater beneath NAS Dallas. The extent of the plume extending east beneath NAS Dallas property was not delineated as part of the RFI. |
| Offsite Mountain Creek Lake Investigation | Mountain Creek Lake is being thoroughly studied by the USGS and the Navy as part of a separate investigation. However, during the RFI compounds found in lagoon sediments have been found in Mountain Creek Lake sediments near NWIRP Dallas. |
| Offsite 14th Street Investigation | Wells installed in and west of 14th Street SE have identified a potential off-site source area for chlorinated VOCs in groundwater. This source does not appear to be related to Navy activities at NWIRP. |

AOC = Area of concern
DCE = Dichloroethene
MEK = Methyl ethyl ketone
PCBs = Polychlorinated biphenyls
SVOCs = Semivolatile organic compounds
TPH = Total petroleum hydrocarbons
USGS = United States Geological Survey
VOCs = Volatile organic compounds
SWMU = Solid waste management unit
TCE = Trichloroethene
TNRCC = Texas Natural Resource Conservation Commission

### 2.3.2 Site Hydrogeology

NWIRP Dallas contains three thin water-bearing zones above the Eagle Ford Shale. The potentiometric groundwater surface of the shallow water-bearing zone, shown in Figure 2-2, lies approximately 2 to 35 feet bgl. The shallow and intermediate zones vary from 2 to 10 feet thick. A third, deeper water-bearing zone overlies the Eagle Ford Shale at 50 to 65 feet bgl and varies from 1 to 5 feet thick. Thin silty clay layers separate the three water-bearing zones in many areas and act as aquitards. These silty clay layers vary in thickness across the site and in many areas are discontinuous, allowing communication between the water-bearing zones. In all areas, the third water-bearing zone is confined below by the Eagle Ford Shale. Pump, slug, and specific gravity test data from 32 site locations yielded a geometric mean hydraulic conductivity of 5.9 ft/day. The groundwater above the Eagle Ford shale flows to the southeast, toward Mountain Creek Lake.

Beneath the Eagle Ford Shale are three deeper aquifers. Regionally, the Woodbine is classified as a secondary aquifer capable of supplying relatively small quantities of water in the area of the Trinity River Basin. This aquifer overlies the Paluxy and Twin Mountains aquifers.

The Eagle Ford Shale in this region is 100 to 200 feet thick, preventing the contamination from the shallower water-bearing zones from migrating into deeper aquifers. *Therefore, the three regional aquifers located beneath the Eagle Ford Shale—the Woodbine, Paluxy, and Twin Mountains—are very unlikely to be affected by contaminants from NWIRP Dallas.*

**Surface water**—Mountain Creek Lake is an artificial surface water body that provides cooling water to a power plant located across the lake from NWIRP Dallas. All of the shallow groundwater at NWIRP Dallas is thought to discharge into surface water bodies, including Mountain Creek Lake, a small drainage located at the installation, and two artificial lagoons. All of the shallow groundwater discharged on site eventually flows into Mountain Creek Lake.

### 2.3.3 Site Geography

**Current and Future Land Use**—The area around NWIRP Dallas is developed for several miles in all directions, including the cities of Dallas, Fort Worth, and Irving. The population of the Dallas-Fort Worth metropolitan area is approximately 3.5 million people.

Although NWIRP Dallas is located in a predominately industrial area, there is a housing development situated directly to the west of the installation. A light industrial area located to the northwest of NWIRP Dallas includes machine shops and a dry cleaners. Located further out from the installation are salvage yards and some recreational facilities. The mix of land use currently present in the vicinity of NWIRP Dallas is not anticipated to change significantly in the foreseeable future.

**Current and Future Water Use**—The thin water-bearing zones present above the Eagle Ford Shale are not clean producers of water, and are therefore not used as a drinking water source. The underlying Woodbine aquifer supplies water for domestic, municipal, and industrial use. The water use situation is not expected to change in the near future.

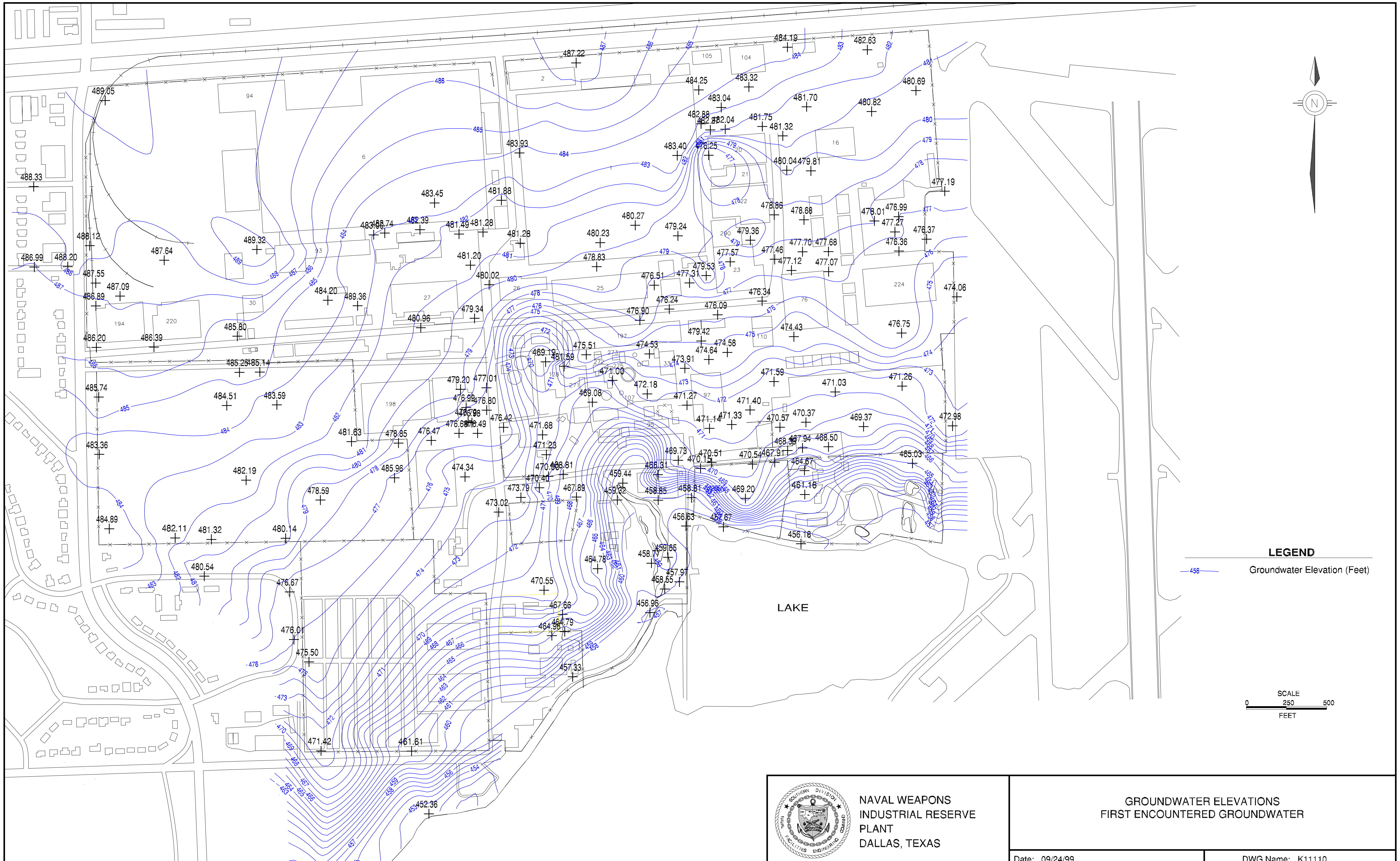



**Figure 2-2. Potentiometric Map of the Shallow Water Bearing Zone at NWIRP Dallas**

# 3.0 PROGRAM BACKGROUND AND CLOSEOUT STRATEGY

The following sections outline the IRP background and regulatory framework, site activity status, best practice information, and site closeout strategy for NWIRP Dallas.

## 3.1 Program Background and Regulatory Framework

The initial investigation activities for the IRP at NWIRP Dallas began in 1985. A Phase I remedial investigation (RI) was conducted in 1989, and a subsequent site-wide RFI began in June 1993 and was completed in late 1994. Nearly 300 groundwater monitoring wells have been installed over the course of these and other investigations; a contaminated groundwater plume covering approximately 80% of the installation has been delineated. The chemicals of concern (COCs) for the plume include trichloroethene (TCE), perchloroethene (PCE), 1,1-dichloroethene (DCE), 1,2-DCE, vinyl chloride, and chromium. Concentrations of contaminants in some hotspots (up to 100,000 ppb of TCE) indicate that free-phase dense nonaqueous phase liquids (DNAPLs) are likely to be present within the aquifer.

Groundwater underlying the installation discharges to Mountain Creek Lake, and sediment contamination in this lake has been linked to activities at NWIRP Dallas. However, to date, no chlorinated compounds have been detected in the lake water.

An RCRA Part B permit was issued by the Texas Natural Resource Conservation Commission (TNRCC) on April 29, 1994, to Vought Aircraft Company, then the operator of NWIRP Dallas. Currently, Northrop Grumman operates NWIRP Dallas.

The Part B permit specified that stabilization measures be implemented to stop further off-site migration of the contaminated plume. These plume stabilization measures were outlined in the *Final Stabilization Work Plan, Naval Weapons Industrial Reserve Plant, Dallas, Texas* (Ensafe/Allen&Hoshall, October 1995), and consisted of designing and installing three separate groundwater pump and treatment systems at AOCs 1 through 3. This work plan was approved, with modifications, on March 8, 1995.

The systems were subsequently constructed and began operation in the third quarter of calendar year 1996. Groundwater is extracted from AOCs 1 and 2 by means of recovery wells. Shallow bedrock at AOC 3 necessitated the installation of a recovery trench. The aboveground portion of all three systems consists of a tray air stripper. The treated groundwater from all three systems is discharged to the sanitary sewer and the vapors are discharged directly to the atmosphere. Quarterly performance monitoring for these systems, which is mandated by TNRCC, has been conducted since early 1997.

Currently, the installation is conducting a corrective measures study (CMS), which is scheduled to be completed in late calendar year 1999. As required by RCRA and the TNRCC, a site-wide groundwater compliance plan must be approved after the CMS is finalized. This plan will define the monitoring strategy and approach for NWIRP Dallas.

Groundwater cleanup standards for NWIRP Dallas will be finalized upon completion of the CMS and groundwater compliance plan. TNRCC regulations currently specify three levels of Risk Reduction Standards. Standard 1 entails cleanup and closure up to background levels. Standard 2 requires closure to pre-calculated health-based levels, which default to maximum contaminant levels

(MCLs). Standard 3 requires that a comprehensive risk assessment be conducted.

## 3.2 Site Activity Status

In 1980, the Department of the Navy (DON) began programs consistent with U.S. Environmental Protection Agency (EPA) requirements to manage wastes at NWIRP Dallas. As part of these programs, the initial assessment study (IAS) was conducted in 1985. Following this, a confirmation study was conducted in 1987, and the Phase I RI was conducted in 1989. The RFA was conducted in the early 1990s, and the RFI took place during 1993-1994. All of these studies were part of the DON IRP designed to identify and clean up environmental contamination.

Most of the investigation work at NWIRP Dallas was conducted during the 1993-1994 RFI, when over 200 wells and 70 direct-push technology (DPT) and cone penetrometry points were installed. In general, wells were sampled at least once following installation.

In July and August 1994, a site-wide round of sampling that included approximately 70% of all site wells was conducted.

Additional wells and DPT points installed in early 1995 to mid-1996 focused on off-site characterization. This effort included approximately 10 wells and 30 to 40 cone penetrometry points, and resulted in the discovery of a plume moving on site. This plume is believed to originate from the light industrial area directly northwest of the installation.

In July 1997, over 20 more monitoring wells were installed on the installation, generally in variable-depth clusters. These were installed to help the United States Geological Survey (USGS) better characterize the shallow aquifer.

In September 1997, another site-wide round of sampling was conducted. Approximately 200 of the site wells were sampled at this time. A statistical approach based on contaminant concentrations was used to identify 58 wells that were not necessary to determine plume shape, and therefore could be eliminated from the sampling effort.

## 3.3 Best Practices Already in Place

There are several examples of practices that NWIRP Dallas has already put in place to optimize their periodic groundwater monitoring program. The following items may be evaluated by other installations seeking to reduce costs associated with their own LTM or periodic monitoring programs:

- NWIRP Dallas has implemented micropurging to sample monitoring wells. This practice has enabled NWIRP to eliminate wells once thought to contain high levels of metals from target AOCs. Previous sampling methods disturbed the sediment in the wells and resulted in artificially high concentrations of metals in nonfiltered samples.
- The installation has analyzed groundwater monitoring data from sampling events, performed trend analysis, and contoured the data in order to recommend program improvements.
- NWIRP Dallas has effectively used geostatistics to demonstrate that 58 monitoring wells can be removed from the program with no loss in data quality or adverse impact on decision making.
- The installation has implemented a custom database to electronically manage their IRP data. This tool facilitates tracking of contaminant concentrations and groundwater gradients and flow direction.

- NWIRP Dallas proactively initiated a site-wide background study for metals that is currently awaiting approval from the regulators.
- The installation has employed the help of outside government agencies (e.g., the USGS) to construct a regional groundwater flow model and evaluate the effectiveness of monitored natural attenuation (MNA) for the treatment of the contaminated groundwater plume.

## 3.4 Site Closeout Strategy Considerations

### 3.4.1 Implementation of Monitored Natural Attenuation

Through work done by the USGS, NWIRP Dallas is already investigating the potential applicability of MNA for the passive treatment of portions of their contaminated plume. Although it is unlikely that MNA can serve as the sole remedy for the entire plume, it is an excellent approach for cost-effective treatment when combined with other complementary actions, such as limited source removal, institutional controls, and partial plume containment.

**Recommendation:** NWIRP Dallas should continue to aggressively pursue the application of MNA for the contaminated plume.

### 3.4.2 Establishment of Alternate Concentration Limits

Some portion of the contaminated groundwater at NWIRP Dallas currently discharges to Mountain Creek Lake, a primary surface water body. This condition offers the possibility for the installation to establish less stringent groundwater cleanup criteria known as Alternate Concentration Limits (ACLs). The process for establishing ACLs is presented in the Superfund Amendments and Reauthorization Act (SARA) Section 121(d).

Two primary requirements must be satisfied in order to establish an ACL: (1) the surface water quality of the receiving water body cannot be measurably degraded, and (2) there cannot be any points of human exposure to the contaminated groundwater prior to its reaching the surface water. If these conditions are met, then the allowable ACL for the plume is the groundwater contaminant concentration discharging to the surface water body without degrading its water quality. It is expected that this allowable concentration would be significantly higher than MCLs. Typically, supporting data requirements to establish ACLs include simple mixing zone model results and/or sampling results from the surface water body.

**Recommendation:** Given the possibility of establishing less stringent groundwater cleanup criteria, NWIRP Dallas should begin discussions with TNRCC to establish ACLs for the site-wide groundwater plume, with Mountain Creek Lake as the point of compliance (POC).

### 3.4.3 Potential for Groundwater Technical Impracticability Waiver

Given the hydrogeologic conditions at NWIRP Dallas, along with the current size and extent of the contaminated groundwater plume, it appears unlikely that active treatment techniques will achieve aquifer restoration to acceptable cleanup levels for TCE and other chlorinated solvents throughout the entire plume. Thus, the installation should consider pursuing a technical impracticability (TI) waiver for groundwater in the coming years.

Per established EPA guidance, granting a TI waiver usually requires some degree of source removal and plume containment as part of the overall groundwater remedy. NWIRP Dallas has already implemented partial containment through the plume stabilization actions and is also considering source removal options.

However, it is also the responsibility of NWIRP Dallas to propose the specific qualitative and quantitative TI criteria to the regulatory agencies and community representatives. These criteria should be developed and justified on the basis of detailed analyses of operational cost and performance data for any current or future groundwater treatment systems. EPA policy does not allow justification of TI solely on the basis of cost, but recognizes that in some cases even large expenditures on remedial systems will produce little or no net environmental benefit.

**Recommendation:** NWIRP Dallas should consider expanding the Stabilization System Performance Evaluation Reports to include graphical presentation of additional cost and performance metrics. Additional metrics could include items such as the incremental cost incurred per unit risk reduction, the incremental cost per pound of contaminant removed, cumulative cost versus cumulative mass removed, and/or contaminant mass recovered per unit time. Figure 3-1 shows examples of common cost and performance evaluation plots. In addition, discussions should begin with the regulatory agencies to establish measurable decision criteria defining the meaning of technical and/or cost impracticability for NWIRP Dallas.

#### 3.4.4 Evaluation of Innovative In Situ Groundwater Treatment Technologies

Given the size and scope of the contaminated groundwater plume, it is likely that some form of source removal/treatment will be required as part of the final remedy. However, it is widely known that conventional pump and treat options are often less than effective for this type of application; thus, innovative in situ treatment technologies should be periodically evaluated as alternatives for conventional pump and treat systems. Aggressive removal of source areas can result in vastly accelerated aquifer cleanup times, and thus much lower life-cycle costs. NWIRP Dallas is already moving in this direction with a planned demonstration of an in situ hydrogen-releasing compound for one of the plume hotspots.

**Recommendation:** NWIRP Dallas should continue to evaluate innovative in situ groundwater treatment remedies as possible cost-effective alternatives to conventional pump and treat for hotspot (source) removal. Additional potential technologies include high-vacuum dual-phase extraction, methanotrophic treatment, substrate addition (e.g., molasses or lactic acid), and phyto-remediation.

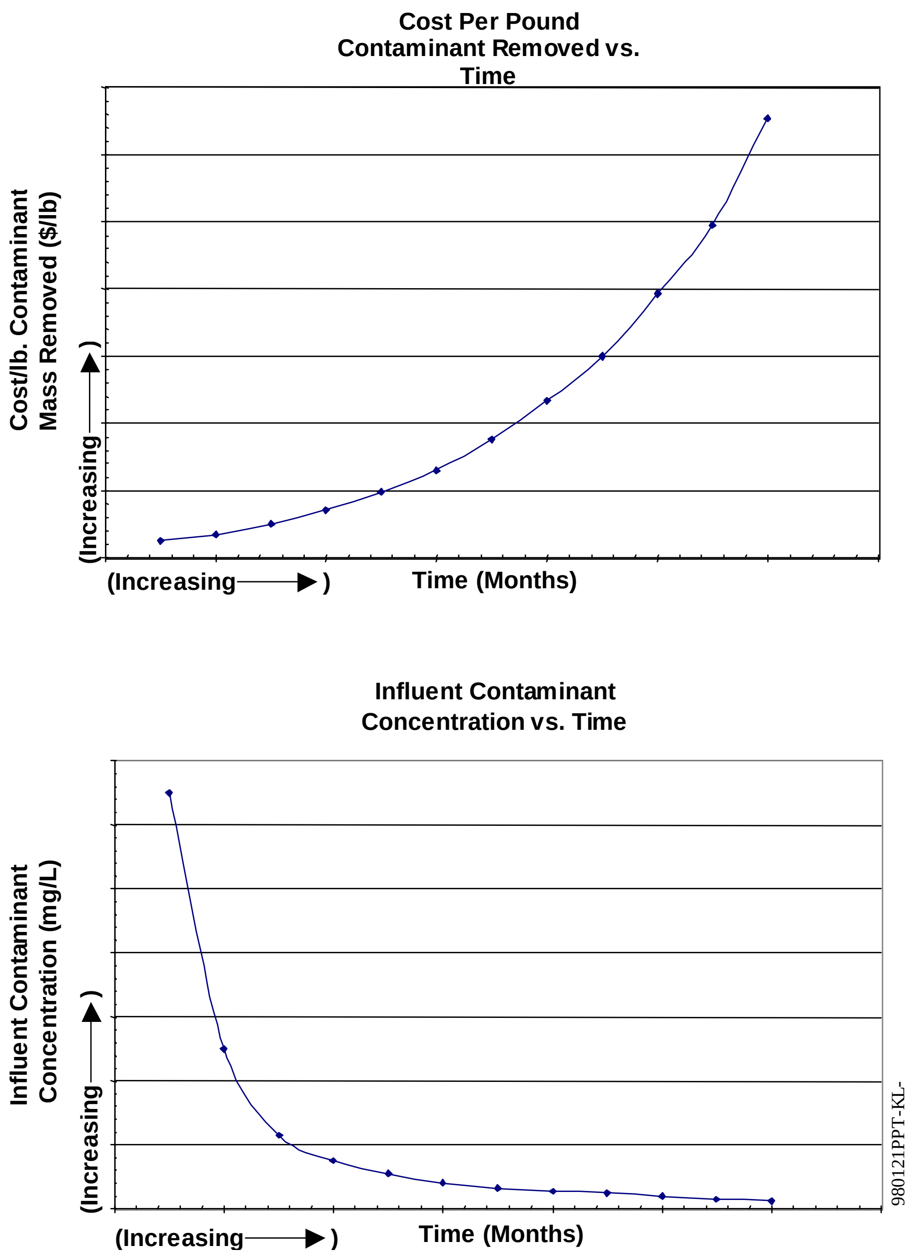



**Figure 3-1. Common Cost and Performance Evaluation Plots**

# 4.0 DEVELOPMENT OF A MONITORING PROGRAM

The following section outlines recommendations for developing a groundwater monitoring program at NWIRP Dallas. Information on evaluating cost savings and program quality is also presented. These suggestions are based on the optimization strategy summarized in Section 1.3 of this case study, as well as TNRCC groundwater compliance plan requirements. A summary of the recommendations is given in Table 4-1. It is important to note that, in evaluating these suggestions, regulatory and community approval must also be considered prior to implementation.

## 4.1 Groundwater Compliance Plan

TNRCC requires the establishment of a groundwater compliance plan, the application for which requires very specific site and proposed program information. This required information includes property issues, present and historical waste management procedures, site geology and hydrogeology, contaminant distributions, proposed water quality standards, and groundwater monitoring procedures. The complete TNRCC checklist for the application is provided as Appendix A to this document. Requirements of the TNRCC groundwater compliance plan are taken into account in the recommendations for groundwater monitoring, presented in Section 4.2.

Each time a modification to an issued groundwater compliance plan is desired, an application for amendment or modification must be submitted to TNRCC. This application must be accompanied by a fee, which depends on the extent of the modifications. For instance, a new groundwater compliance plan application requires a fee of $2000. A major amendment or modification requires a fee of $1000 and a minor modification requires a fee of $500. For this reason, it is important to design a streamlined groundwater compliance program up front, and consolidate subsequent modification requests to the extent possible. It appears that most of the modifications suggested in this case study would be considered minor, however.

## 4.2 Monitoring Program Elements and Design Considerations

Since there is not currently a formal monitoring program in place at NWIRP Dallas, the following subsections outline the elements of designing and implementing a cost-effective monitoring program.

### 4.2.1 Identify Appropriate Monitoring Points

One of the most effective ways to minimize LTM costs is to identify and sample only those points that are necessary to track contaminant movement at the site. This not only saves labor in the field, it reduces analytical, data management, and reporting costs. Given the current number of wells on site, this strategy is the most important one that can be applied to designing the monitoring program at NWIRP Dallas. In the first year of an LTM program, it is more valuable to have quarterly data from a smaller number of carefully chosen wells than to have data from less frequent sampling of a large number of wells. This is because a more detailed statistical analysis of time trends and potential seasonal influences is possible with quarterly data from a representative subset of wells.

Figure 4-1 shows the distribution of monitoring wells at NWIRP Dallas. The last round of sampling at the installation was conducted in 1997 and included over 200 wells. This is far more than the number necessary to implement a successful monitoring program. According to TNRCC requirements for a groundwater compliance plan, the groundwater monitoring network shall include background wells, POC wells,

## Table 4-1. Summary of Recommendations for Monitoring at NWIRP Dallas

| Strategy | Recommendations | Potential Cost Savings/Benefits |
|---|---|---|
| **Monitoring Point Reduction** | Reduce the monitoring network to include only those wells required by the TNRCC groundwater compliance plan (i.e., background wells, point-of-compliance wells, and corrective action observation wells), along with off-site wells to maintain community relations and a small number of supplemental wells. A total of 56 wells are recommended for inclusion in the monitoring program (see Table 4-2). | Approximately 80% of the wells at the installation can be eliminated from the monitoring program, saving approximately 80% of analytical and field labor costs. At approximately $350 per sample, analytical costs are reduced from $100,000 to $20,000 per sampling round. On the basis of the ability of a two-person crew to sample 8 wells/day, at $45 per hour per person, labor costs can be decreased from $25,000 to approximately $5000 per sampling round. |
| **Duration and Frequency Reduction** | 1. Set up an annual review period with the state to continually assess when monitoring may be stopped at the installation.<br>2. Following a year of quarterly sampling, decrease the frequency. Tailor sampling frequency to the function of the well. POC and corrective action observation wells may need to be sampled semiannually, but upgradient, background, and supplemental wells may be dropped to annually. | If approximately half the monitored wells are decreased to semiannual sampling, while the other half are decreased to annual sampling, over 60% of analytical costs can be saved in the second year of sampling. On the basis of analytical costs of $350/sample for 60 samples per round, an annual savings of $52,000 can be realized in analytical costs alone. Field labor costs will likewise be decreased from approximately $20,000 to $8000 annually, and mobilization and demobilization costs will be halved by eliminating two quarterly sampling rounds. |
| **Field Procedures and Equipment Efficiency Improvements** | Continue to use micropurging techniques to meet current EPA and TNRCC guidelines. Install dedicated Teflon® tubing in each monitoring well at a known depth, based on the drilling logs, in an effort to tap the most productive zone of the well and eliminate vertical flow during purging. Limit drawdown to 0.3 ft. | Although NWIRP Dallas has already realized much of the benefit of micropurging (i.e., reduced labor costs and increased sample quality), implementing the recommendation may further improve sample quality and consistency by ensuring that purging and sampling take place from within a set interval, both within and between sampling rounds. |
| **Reducing the Number of Analytes** | 1. Decrease analyte list to VOCs, metals, and hexavalent chromium.[a]<br>2. Eliminate any analytes that have not been detected in four rounds of sampling, including analytes detected below the sample specific detection limit or attributable to laboratory contamination. | 1. Eliminating all but the most representative analytes will not only save a significant amount of the analytical budget, but will decrease costs associated with data management and reporting. By not analyzing TCL semivolatile compounds and pesticides and PCBs, $460 per sample can be saved. This amounts to almost 60% of the analytical budget, or nearly $28,000 per sampling round of 60 wells.<br>2. Less extraneous data will also result in clearer, more concise monitoring reports and data presentations. |
| **Data Analysis Tools** | Pursue coordination of monitoring database with a GIS application. | Benefits of this approach may include expedited regulator buy-in and, potentially, expedited site closeout. The more ways there are to visualize the data, the better the decisions that can be made using the data. |
| **Report Streamlining** | Focus on graphical and tabular formats and minimize the amount of text submitted. Highlight important data in tables and combine site maps to the extent possible. | Further streamlining the reporting procedure will save labor costs for both reporting and reviewing documents. Copying and material costs will also be reduced. In addition, the clarity of site data should be enhanced. |

[a]Recommendation made by sampling contractor.

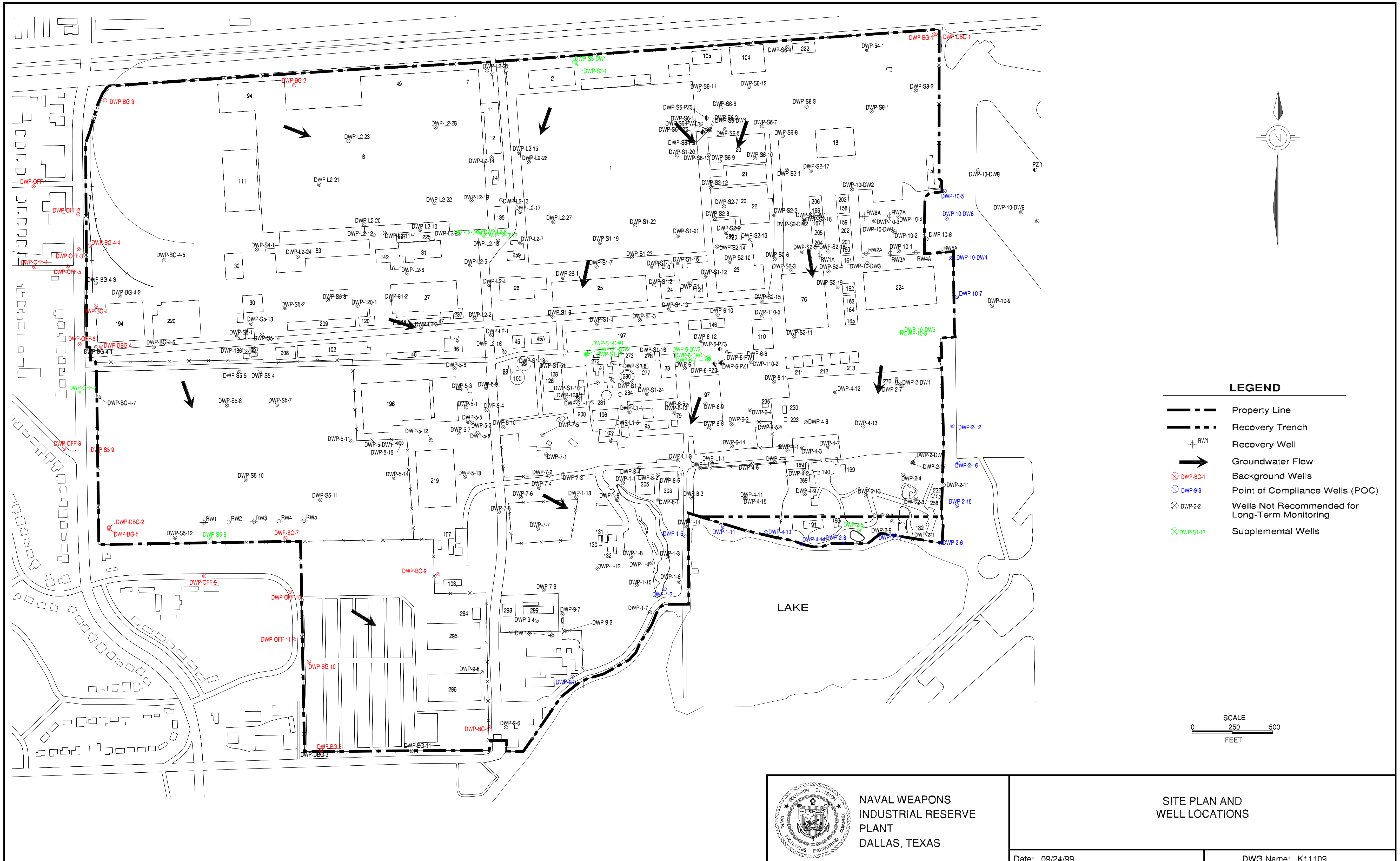



**Figure 4-1. Site Layout for NWIRP Dallas**

corrective action observation wells, and "supplemental" wells. Sampling of supplemental wells is optional. Corrective action observation wells are used to identify trends in contaminant concentrations over time in representative portions of the contaminated area away from the POC(s). Supplemental monitoring points may be necessary to assess movement of contaminants that could affect remedial system performance or to predict corrective action end points as a result of corrective action performance or natural attenuation. These supplemental wells largely benefit the facility owner. The number and location of supplemental wells are not discussed in the TNRCC procedures, and no specific requirements pertain to the monitoring of supplemental wells. In general, supplemental wells may be used with corrective action observation wells to determine the rate and direction of plume migration, as required by the TNRCC.

The following paragraphs describe strategies for identifying specific wells that should be included in the monitoring program. Table 4-2 gives the identification numbers for examples of these wells and the justification for including them in the program. Figure 4-1 shows their locations.

Environmental personnel at NWIRP Dallas have worked towards decreasing the number of wells to be included in their monitoring program. In this effort, geostatistics were employed to eliminate wells from the program on the basis of not affecting plume shape. Another consideration was the inclusion of all off-site wells and all property line wells in order to avoid public relations issues. In addition, all intermediate and deep sequence wells were included in the monitoring network because of their limited number and the information they provide on vertical distribution of contaminants. This is a very sound technical approach. However, on the basis of the TNRCC requirements, many additional wells can be excluded from the program. The first step is to identify wells that are necessary.

**Off-Site Wells**—Since public relations appears to be an issue, all 11 of the off-site wells (DWP-OFF-1 through 11) should remain within the program, although they are up- or side-gradient and several are within a few hundred feet of each other. All of these wells are distributed just outside of the western boundary of the installation.

**Background Wells**—There are 16 upper sequence wells that are identified as background wells (DWP-BG-1 through 5, DWP-BG-7 through 10, and DWP-BG-4-1 through 4-7), and 4 deep sequence wells (DWP-DBG-1, 2, 4, and 6). These wells are distributed along the northern, western, and southwestern boundaries of the installation. Because local groundwater flow direction is predominately toward Mountain Creek Lake, bordering the installation to the southeast, the background wells are located in up- and side-gradient positions.

All of the deep sequence background wells should be retained as part of the monitoring program. The deep wells at NWIRP Dallas are important for tracking potential contaminant migration into deeper portions of the aquifer. Only four of these deep sequence wells are background wells, which are important for evaluating the water quality of the deeper aquifer where it moves onto the installation. These four wells are distributed with one on the northeast corner (DWP-DBG-1), one on the west side (DWP-DBG-4), one on the southwest corner (DWP-DBG-2), and one to the south (DWP-BG-6).

In general, the shallow sequence wells are also distributed evenly around the up- and side-gradient boundaries of the installation. The exceptions to this are the eight background wells (DWP-BG-4 and DWP-BG-4-1 through 4-7) that are located fairly close together (within a 700-foot

## Table 4-2

## Wells Suggested for Inclusion in the NWIRP Dallas Monitoring Program

| Well ID | Justification |
|---|---|
| DWP-OFF-1 | Off-site well. |
| DWP-OFF-2 | Off-site well. |
| DWP-OFF-3 | Off-site well. |
| DWP-OFF-4 | Off-site well. |
| DWP-OFF-5 | Off-site well. |
| DWP-OFF-6 | Off-site well. |
| DWP-OFF-7 | Off-site well, shallow corrective action observation well for AOC-1. |
| DWP-OFF-8 | Off-site well. |
| DWP-OFF-9 | Off-site well. |
| DWP-OFF-10 | Off-site well. |
| DWP-OFF-11 | Off-site well. |
| DWP-BG-1 | Shallow background well. |
| DWP-BG-2 | Shallow background well. |
| DWP-BG-3 | Shallow background well. |
| DWP-BG-4 | Shallow background well. |
| DWP-BG-5 | Shallow background well. |
| DWP-BG-7 | Shallow background well. |
| DWP-BG-8 | Shallow background well. |
| DWP-BG-9 | Shallow background well. |
| DWP-BG-10 | Shallow background well. |
| DWP-DBG-1 | Deep background well. |
| DWP-DBG-2 | Deep background well. |
| DWP-DBG-4 | Deep background well. |
| DWP-BG-6 | Deep background well. |
| DWP-9-3 | Shallow POC well. |
| DWP-1-2 | Shallow POC well. |
| DWP-1-5 | Shallow POC well, corrective action observation well for AOC-3. |
| DWP-1-11 | Shallow POC well, corrective action observation well for AOC-3. |
| DWP-4-10 | Intermediate POC well, corrective action observation well for AOC-3. |
| DWP-4-14 | Intermediate POC well, corrective action observation well for AOC-3. |
| DWP-2-8 | Intermediate POC well, corrective action observation well for AOC-3. |
| DWP-2-5 | Intermediate corrective action observation well for AOC-3. |
| DWP-2-2 | Intermediate corrective action observation well for AOC-3. |
| DWP-2-10 | Intermediate POC well. |
| DWP-2-6 | Intermediate POC well, corrective action observation well for AOC-3. |
| DWP-2-15 | Deep POC well. |
| DWP-2-16 | Deep POC well. |
| DWP-2-12 | Shallow POC well. |
| DWP-10-7 | Shallow POC well. |
| DWP-10-DW4 | Deep POC well. |
| DWP-10-DW6 | Intermediate POC well. |
| DWP-10-5 | Shallow POC well. |

| Well ID | Justification |
|---|---|
| DWP-10-8 | Shallow corrective action observation well for AOC-2. |
| DWP-10-DW5 | Deep corrective action observation well for AOC-2. |
| DWP-55-8 | Shallow corrective action observation well for AOC-1. |
| DWP-S3-1 | Supplemental—shallow upgradient well. |
| DWP-S3-DW1 | Supplemental—deep upgradient well. |
| DWP-L2-8 | Supplemental—shallow in-plume well. |
| DWP-L2-DW2 | Supplemental—intermediate in-plume well. |
| DWP-L2-DW1 | Supplemental—deep in-plume well. |
| DWP-S1-17 | Supplemental—shallow in-plume well. |
| DWP-S1-DW2 | Supplemental—intermediate in-plume well. |
| DWP-S1-DW1 | Supplemental—deep in-plume well. |
| DWP-6-7 | Supplemental—shallow in-plume well. |
| DWP-6-DW2 | Supplemental—intermediate in-plume well. |
| DWP-6-DW1 | Supplemental—deep in-plume well. |

radius) on the western boundary of NWIRP Dallas. A thorough examination of the well logs for these eight wells indicates that DWP-BG-4 is likely to be screened nearest the bottom of the fining upward sequence, where DNAPL contamination may accumulate (personal communication, David Felter, Ensafe Project Geologist, 18 May 1999). In addition, samples from this well contained the highest concentrations of TCE (Ensafe/Allen&Hoshall, September 1996). The central location of this well also makes it the best candidate for monitoring. Therefore, the other seven wells can be eliminated without compromising quality of the monitoring program.

**Point-of-Compliance Wells**—POC wells should be located where groundwater leaves the installation. In the case of NWIRP Dallas, the POC wells will be located primarily along the southeastern installation boundary, near the shore of Mountain Creek Lake. Some wells from along the eastern installation boundary should also be chosen as POC wells (although not all of these are located right on the boundary), and an effort should be made to select shallow, intermediate, and deep POC wells. Recommendations for POC wells are given in Table 4-2.

**Corrective Action Observation Wells**—Although the corrective action observation wells are supposed to be chosen from locations downgradient of the corrective action but away from the POC, two of the three pump and treat systems operating at NWIRP Dallas are located immediately upgradient of the installation boundary. Therefore, there are several instances where a POC well is also identified as a corrective action observation well. Table 4-2 lists the corrective action observation wells for the three AOCs and indicates when these wells also act as POC wells.

**Supplemental Wells**—In addition to the wells required by TNRCC, some supplemental in-plume wells may be chosen to track contaminant concentration trends within hotspots. There are three clusters of wells within the plume that are completed in the three different fining upward sequences. These wells, given in Table 4-2, will be useful for tracking vertical and horizontal contamination. Since they are not required as part of the monitoring program, they may be sampled at whatever frequency is deemed most useful by installation environmental personnel (see Section 4.2.2). Additional wells may be chosen from hotspots within the plume, on the basis of contaminant concentrations, screen location, and productivity.

**Wells to Exclude**—One set of criteria specifically identified in the TNRCC guidance is well integrity and quality. Detailed well design and construction specifications are included with the TNRCC application procedures. Wells that do not meet specifications in terms of construction materials, structural condition, or screen length should be excluded from the monitoring program. An inspection of all wells should be made prior to defining the monitoring network. Any well that is damaged should be properly abandoned. If its location is crucial to the monitoring program, it should be replaced.

Note that TNRCC specifies a maximum screen length of 10 feet for all monitoring wells unless otherwise approved. The majority of the wells on site have 15-foot screens. These wells were installed when little was known about the geology of the site, and the major concern was screening the bottom of a fining upward sequence to identify any free-phase DNAPL (personal communication, Dave Felter, Ensafe Project Geologist, 25 January 1999). TNRCC also specifies that wells included in the monitoring program be screened at appropriate intervals according to the information they are designed to collect; therefore, approval for existing well screen intervals should not be difficult to get.

Following collection of four rounds of data, there are other strategies that can be used to eliminate additional wells from the monitoring program, with approval from the State. One such approach is to conduct a statistical analysis of concentrations in a well to determine whether there is a significant upward or downward trend. The Mann-Kendall nonparametric trend test is an example of a statistical method commonly used for this approach. A discussion of the application of statistics to monitoring programs is given in Appendix B.

**Well Abandonment—**When a network of wells that meets the goals of the monitoring program has been defined, abandoning those wells that do not contribute to the program should be considered. This will eliminate the need to maintain more than 100 wells at the site. However, it will probably be necessary to keep more than the number of wells monitored to allow for proper definition of the potentiometric surface and continued tracking of the plume as it changes shape and size. Wells that are damaged or located very close to other wells screened within similar intervals should be considered for abandonment first.

### 4.2.2 Determine Monitoring Duration and Frequency

Another important approach to minimizing monitoring program costs is to identify a reasonable sampling duration and frequency.

**Duration—**There is currently no duration defined for the monitoring program at NWIRP Dallas. Rather than setting a duration for the monitoring program, an annual review period and decision criteria for stopping monitoring should be specified in negotiations with the State. An example of a decision criterion that may be used to determine when monitoring should be stopped is "following three consecutive rounds of all analytes of concern detected at less than the maximum contaminant levels (MCLs), monitoring at the site will be stopped."

**Frequency—**It is generally accepted practice to conduct quarterly sampling for the first year. Following this, an assessment should be made to determine whether it is reasonable to reduce monitoring to semiannual, or even annual, at some or all of the wells. If, by applying a statistical analysis such as that recommended in Section 4.1 (or some other type of trend analysis), the data indicate that concentration trends in target analytes are not rapidly changing, monitoring may be decreased to semiannually. Following a year of semiannual data collection, a similar analysis should be made to see whether monitoring might be reduced to annual.

The well's purpose should also be considered when determining the frequency at which it needs to be sampled. Downgradient plume-edge wells require more frequent sampling than an upgradient or background well. In-plume wells may also be sampled less frequently than downgradient wells. Once four quarters of baseline data have been collected and the data evaluated, it is recommended that a move to semiannual sampling of downgradient wells and annual sampling of background and in-plume wells be pursued.

### 4.2.3 Ensure Efficient Field Procedures

During the sampling round conducted in September 1997, micropurging techniques were used in a successful attempt to reduce metal concentrations associated with high turbidity in samples. A low flow rate (approx. 100 to 300 ml/min) and peristaltic pumps with dedicated Teflon tubing were used for the micropurging. This approach is consistent with the purging guidelines set forth in the TNRCC groundwater compliance plan application.

The goal of micropurging is to eliminate vertical movement of groundwater within the well casing during purging. In doing this, the well may be purged from one small section of the screened interval, without the mixing of stagnant casing water and fresh formation water. Therefore, purge times and volumes are significantly decreased.

In order to ensure that vertical flow is not being induced within the well during purging, it is recommended that dedicated tubing be fixed in place with the inlet in the highest producing zone in each well. The Teflon tubing should be left in the well so that all subsequent samples come from this same interval. For the best possible determination of where the highest producing zone is, the well logs should be analyzed by a geologist familiar with the installation's subsurface strata and hydrogeology.

Once the dedicated tubing has been fixed in place to tap the wells' best producing zones, pump flow rates should be adjusted as necessary so that drawdown during purging and sampling does not exceed 0.3 ft (Puls and Barcelona, 1995).

### 4.2.4 Identify Representative Analytical Methods

Since analytical costs make up a significant portion of LTM program expenses, streamlining the analytical approach is a viable way to cut overall monitoring program costs. Minimizing the number of analytes at a site, eliminating overlapping analytical methods, and reducing quality assurance/quality control (QA/QC) samples to the minimum required are examples of ways to streamline the analytical program.

**Minimize the Number of Analytes**—Minimizing the number of analytes reported for a site to those necessary for characterizing plume movement not only reduces analytical costs, it reduces data management, validation, interpretation, and reporting costs. Eliminating unnecessary analytes results in clearer, more concise reports.

During the last round of sampling at NWIRP Dallas, total compound list (TCL) organics, total analyte list (TAL) metals, and hexavalent chromium were analyzed. This is a very extensive analyte list, as shown in Appendix C, and is not necessary for monitoring the COCs at the installation. The sampling contractor is currently planning to analyze only VOCs, metals, and hexavalent chromium once a regular monitoring program is in place (personal communication, Jeff James, Ensafe Project Manager, 22 January 1999). This proposed analyte list represents a significant cost savings, compared with the original analyte list: $351/sample versus $811/sample, or a 57% decrease in the analytical budget.

In addition to eliminating entire methods (in this case, methods for SVOCs and pesticides/PCBs), it is worthwhile to consider the elimination of individual compounds within methods. Although this does not always result in significant analytical cost savings, it does save data management, validation, and reporting costs. A review of the site-wide sampling round data that were collected in 1994, 1995, and 1997 was conducted to determine whether further decreases could be made to the analyte lists for VOCs and metals. VOCs that have not been detected above reporting limits and metals that have never exceeded background were identified for elimination from the monitoring program.

On the basis of this analysis, the following ten VOCs may be proposed for elimination from the monitoring program at NWIRP Dallas:

- 1,1,2,2-Tetrachloroethane;
- 1,3-Dichlorobenzene;

- 1,4-Dichlorobenzene;
- Bromoform;
- Bromomethane;
- Dibromochloromethane;
- m&p Xylenes;
- Styrene;
- trans-1,3-Dichloropropene; and
- Vinyl Acetate.

Also on the basis of this analysis, only a few metals can be proposed for elimination from the monitoring program at NWIRP Dallas. Only sodium, magnesium, and manganese have never exceeded the background upper tolerance limits for the site. However, in more recent sampling rounds, the use of micropurging has decreased the concentrations of metals in groundwater samples. Looking only at the 1997 data, it appears that calcium, copper, and iron may also be eliminated from the program on the basis that they do not exceed the expected background values for the site.

**Eliminate Overlapping Methods**—Eliminating overlapping methods saves money and simplifies data interpretation. However, it would not be an issue with the proposed analytical list for monitoring at NWIRP Dallas.

**Decrease QA/QC Samples**—NWIRP Dallas has done an excellent job of streamlining QA/QC costs associated with past sampling rounds. Field duplicates and matrix spike/matrix spike duplicate samples have been collected at a rate of 5%. Equipment blanks have been eliminated by using dedicated sampling equipment.

Trip blanks, which are submitted with each shipment containing samples for volatile parameters, may be decreased by decreasing the number of coolers packed with these types of samples. This may be accomplished by consolidating VOC samples in one cooler and shipping every other day of the sampling round, provided analytical hold times are not approached.

### 4.2.5 Create a Streamlined Report Layout

Report streamlining is also a way to significantly cut LTM costs, especially in a program with quarterly monitoring. An increasingly common approach is to have the LTM contractor submit a ring binder each year. This “living” document is tabbed to provide space for quarterly and semiannual monitoring results once the data are available. Then, on a yearly basis, a more formal annual monitoring report is submitted and inserted in the front of the document. Although the annual reports are submitted in draft and final versions, quarterly or semiannual reports may be submitted only once, or the draft may be submitted electronically.

This approach allows for several other efficiency improvements. First of all, all general “cut and paste” information in the quarterly reports can be eliminated, minimizing the amount of text that must be produced. If only data are submitted, comments are unlikely, thus eliminating the need for a draft. If changes are necessary owing to a data reporting error, replacement pages may be submitted. Raw data, purging logs, and so forth, should be submitted as an appendix, either on a quarterly or annual basis.

Other information, such as sample chain-of-custody forms, should be kept in project folders for reference as necessary. Copying these forms into an appendix of each report takes up space and is of little use to the average reader of the reports.

Focusing on tabular and graphic presentation styles also helps in cutting down on review time. Presenting a summary table of the data, using shading or some other method for highlighting detections that exceed some standard, increases the readability of the information. Appendix D gives examples of tabular and graphic data formats.

### 4.2.6 Use Data Analysis Tools

The management of large amounts of data can be done most effectively in electronic format. NWIRP Dallas personnel are already managing analytical and other data from past sampling events in a custom database. Data from the custom database are imported into Microsoft Access® and used to generate contaminant contour and potentiometric surface maps. These data are also imported into spreadsheet software to graph concentration trends over time.

Although all of these are excellent tools for assessing monitoring programs, there are other ways to interpret and track the behavior of contaminants and allow for more efficient communications with State regulators. One of the most powerful of these tools is a geographic information system (GIS). A GIS package will help display data spatially and can also be used to construct plume or other types of "concentration over area" maps. Presentations to State regulators and the community can be greatly enhanced by real-time contaminant maps. Regulatory buy-in may be obtained during a data visualization meeting, rather than awaiting comments on bulky documents. Appendix D gives examples of the applicability of GIS to monitoring programs.

GIS applications can be linked directly to a database to further streamline data handling and reduce errors associated with redundancy. The current system involving two databases, a spreadsheet, and graphics package could be reduced to one custom database with GIS capabilities.

## 4.3 Evaluation of Program Design

Evaluation of the monitoring program design includes two aspects: (1) the potential effects on data quality and (2) the estimate of total cost avoidance. A brief discussion of each aspect is presented below.

### 4.3.1 Impact on Data Quality

The general strategies of LTM design discussed in this section must be applied so as not to compromise monitoring data quality. Although only a few streamlining measures can be taken prior to the start of the program, more can be implemented following collection of the first year's data.

Some of the suggestions, such as those to streamline reporting and data management, may improve the program through increased clarity and readability of LTM reports and data presentations. As long as these and other measures are implemented following the guidelines presented in this case study, no negative effect on data quality should be expected

### 4.3.2 Estimate of Total Cost Reduction

Because the LTM program at NWIRP Dallas has not begun, costs for the program are not well known. However, by starting with a well-thought-out program and continually reviewing the data and goals in order to optimize monitoring, the program will be conducted cost-effectively.

Using analytical costs from previous sampling rounds, it is estimated that nearly 60% of past per-sample analytical costs can be avoided by focusing on the analytes of concern. The elimination of approximately 80% of installation wells from the monitoring program, as suggested in Section 4.2.1, will save 80% of the initial analytical and field labor budget. These two recommendations alone reduce analytical and field labor costs by almost $130,000. Additional savings that may be realized after a year of monitoring include nearly $65,000 in analytical and field labor if approval can be gained for decreasing monitoring frequency, as outlined in Section 4.2.2. Table 4-1 summarizes some of the relative cost savings and other benefits that may be realized through implementation of the LTM program design strategies outlined in this case study.

## 5.0 REFERENCES


Felter, David, Ensafe Project Geologist, personal communication, 18 May 1999.

Felter, David, Ensafe Project Geologist, personal communication, 15 January 1999.

Ensafe/Allen&Hoshall, *Technical Memorandum: Offsite Southeast Fourteenth Street Investigation, Phase II--NWIRP Dallas*, September 1996.

Ensafe/Allen&Hoshall, *Final Stabilization Work Plan, Naval Weapons Industrial Reserve Plant, Dallas, Texas*, October 1995.

James, Jeff, Ensafe Project Manager, personal communication, 22 January 1999.

Puls, R.W., and M.J. Barcelona, *Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures*, U.S. EPA (OSWER), 1995.

# Appendix A

## TNRCC Groundwater Compliance Plan Application Checklist

**ADMINISTRATIVE AND TECHNICAL EVALUATION CHECKLIST OF THE COMPLIANCE PLAN APPLICATION AND MODIFICATION PROCEDURES DOCUMENT**

**(Revised 06-16-97)**

**TEXAS NATURAL RESOURCE CONSERVATION COMMISSION**

**ADMINISTRATIVE AND TECHNICAL EVALUATION CHECKLIST OF THE COMPLIANCE PLAN APPLICATION AND MODIFICATION PROCEDURES DOCUMENT**
**(TNRCC Industrial and Hazardous Waste Division)**

**This checklist follows the format of the TNRCC Compliance Plan Application and Modification Procedures document and serves as a guideline for that document and the requirements of 40 Code of Federal Regulations (CFR) Part 270 and 30 Texas Administrative Code (TAC) Chapters 305 and 335.**

**FACILITY NAME:** ______________________ **LOCATION:** ______________________

**COMPLIANCE PLAN NO.:** ______________________ **EPA I.D. NO.:** ______________________

**PERMIT NO.:** ______________________ **DATE OF APPLICATION:** ______________________

**REGISTRATION NO.:** ______________________ **DATE APPLICATION RECEIVED:** ______________________

**TYPE OF APPLICATION:** ______________________

**Date Administratively Complete:** ______________________

**Administrative Review by:** ______________________
(signature)
______________________
(printed name)

**Supervisor:** ______________________
(signature)
______________________
(printed name)

**Date Technically Complete:** ______________________

**Technical Review by:** ______________________
(signature)
______________________
(printed name)

**Supervisor:** ______________________
(signature)
______________________
(printed name)

| DESCRIPTION | REGULATION GUIDANCE | SUBMITTED N/A | SUBMITTED Y | SUBMITTED N | TECHNICALLY ADEQUATE Y | TECHNICALLY ADEQUATE N | COMMENT FOOTNOTE 1 |
|---|---|---|---|---|---|---|---|
| **PART I - GENERAL INFORMATION (One original and three copies of application are required)** | 305 C<br>305.50(1) | | | | | | |
| **I.1. Applicant Information** | 305.43 | | | | | | |
| **I.2. Current Owner** | | | | | | | |
| **I.3. Agents and Responsible Parties** | | | | | | | |
| **I.4. Facility Information** | | | | | | | |
| **I.5. Coastal Management Program** | 281 B | | | | | | |
| **I.6. Application Type** | 305 D | | | | | | |
| **I.7. Summary Table of Proposed Changes** | | | | | | | |
| **I.8. Adjacent/Affected Landowners' Address and Map** | 305.45 | | | | | | |
| **I.9. Signed/Notarized Signature Page** | 305.44 | | | | | | |
| **Total Fees $** | 305.53 | | | | | | |

| DESCRIPTION | REGULATION GUIDANCE | SUBMITTED N/A | SUBMITTED Y | SUBMITTED N | TECHNICALLY ADEQUATE Y | TECHNICALLY ADEQUATE N | COMMENT FOOTNOTE 1 |
|---|---|---|---|---|---|---|---|
| **PART II - SITE SPECIFIC INFORMATION** | | | | | | | |
| **II.1. General Site Information** | | | | | | | |
| A. Plan view of facility and property boundary | | | | | | | |
| B. U.S.G.S. topographic map | 305.50<br>270.14(b)(19) | | | | | | |
| C. Landowners list/map (see Part I.8.) | 305.45 | | | | | | |
| **II.2. Waste Management (8.5 x 11" legible maps/lists)** | 305.50 | | | | | | |
| A. HWMUs | 335.156 | | | | | | |
| B. Active SWMUs/wastewater facilities | | | | | | | |
| C. Inactive/closed SWMUs/wastewater facilities | | | | | | | |
| **II.3. Waste Source, Types and Constituents** | 335.159 | | | | | | |
| **II.4. Facility History (see Table II.1)** | | | | | | | |
| **II.5. Site Geology and Hydrogeologic Report** | 270.14(c) | | | | | | |
| A. Site geology and cross-sections | | | | | | | |
| B. Soil and subsurface lithology description | | | | | | | |
| C. Description and extent of soil contamination | | | | | | | |
| D. Description/designation of uppermost saturated zone and aquifer | 335.1<br>FOOTNOTES 2 & 3 | | | | | | |
| E. Geologic/stratigraphic/hydrogeologic information (see Tables II.2, II.3 and II.4) | | | | | | | |
| F. Extent of contamination in each stratigraphic unit | 270.14(c) | | | | | | |
| **II.6. Hazardous Constituents in Ground Water** Appendix IX (see Table II.5) and 3 years of data | | | | | | | |
| **Table II.1 Facility History** | | | | | | | |
| **Table II.2 Major Geologic Formations** | | | | | | | |
| **Table II.3 Stratigraphic Unit Characteristics** | | | | | | | |
| **Table II.4 Aquifer Characteristic Information** | 270.14(c) | | | | | | |
| **Table II.5 Hazardous Constituents/Analytical Methods** | 335.159 | | | | | | |
| **PART III - GW PROTECTION STANDARD** | 335.158-160 | | | | | | |
| **III.1. GWPS** (see Table III.1) | | | | | | | |
| **III.2. Establishing the GWPS** (see Table III.1) | | | | | | | |
| **Table III.1 Proposed GWPS** | | | | | | | |
| **PART IV - COMPLIANCE MONITORING** | 335.165 | | | | | | |
| **IV.1. GW Monitoring Program Description** | | | | | | | |
| A. GW monitoring system information | 335.163 | | | | | | |
| (1) Changes to current monitoring program | | | | | | | |

| DESCRIPTION | REGULATION GUIDANCE | SUBMITTED | | | TECHNICALLY ADEQUATE | | COMMENT FOOTNOTE 1 |
|---|---|---|---|---|---|---|---|
| | | N/A | Y | N | Y | N | |
| (i) Geological/hydrogeological info | | | | | | | |
| (ii) Waste management unit/areas | 335.163(2) | | | | | | |
| (iii) Monitor well construction details | 335.163(3) | | | | | | |
| (iv) Number/location of additional wells | 335.163 | | | | | | |
| (v) Sample handling, COC, procedures | 335.163(4) | | | | | | |
| (vi) Monitoring frequency | 335.165(6,7) | | | | | | |
| (vii) Monitoring parameters | 335.165(1) | | | | | | |
| (viii) Statistical methods/evaluation | 335.163(8,9) | | | | | | |
| (ix) Other Sampling & Analysis Plan info | 335.163(4) | | | | | | |
| (xi) Compliance period | 335.162 | | | | | | |
| (xi) Financial assurance | 335.179 | | | | | | |
| (xii) ACL variance | 335.160(b) | | | | | | |
| (2) Depth/location of wells and piezometers | 335.163 | | | | | | |
| (3) Constituent monitoring list | 335.159 | | | | | | |
| (4) Indicator parameter monitoring list | 335.159 | | | | | | |
| (5) Monitoring frequency | 335.165(6) | | | | | | |
| (6) Provisions for annual reporting | | | | | | | |
| (7) Provisions to determine plume migration | 335.165(11) | | | | | | |
| (8) Compliance period | 335.162 | | | | | | |
| B. Required plans and reports | | | | | | | |
| (1) Sampling & Analysis Plan | 335.163(4) | | | | | | |
| (2) Monitoring System (deficiencies noted) | | | | | | | |
| (i) **Certified** Monitoring System Design | 305.50(7) | | | | | | |
| (ii) **Certified** Well Drilling/Casing Specs | 305.50(7) | | | | | | |
| (3) Geologic and Hydrogeologic Report | | | | | | | |
| (i) Contaminant Plume Map(s) | | | | | | | |
| (ii) Cross Sections (thru POC and plume) | | | | | | | |
| a) Stratigraphic interpretation | | | | | | | |
| b) Lithologic/geologic descriptions | | | | | | | |
| c) Potentiometric surface | | | | | | | |
| d) NAPLs/constituents detected | | | | | | | |
| e) Screened intervals | | | | | | | |
| (iii) Well Construction Diagrams | | | | | | | |
| **IV.2. Waste Management Units Monitored** | | | | | | | |
| A. Map of waste management unit/areas | | | | | | | |

| DESCRIPTION | REGULATION GUIDANCE | SUBMITTED N/A | SUBMITTED Y | SUBMITTED N | TECHNICALLY ADEQUATE Y | TECHNICALLY ADEQUATE N | COMMENT FOOTNOTE 1 |
|---|---|---|---|---|---|---|---|
| (1) Boundary of unit/area | | | | | | | |
| (2) Point of compliance | 335.161 | | | | | | |
| (3) Proposed monitor wells | 335.163 | | | | | | |
| (4) Conduits for subsurface contamination | | | | | | | |
| B. Map of proposed/existing well/soil borings drilled for assessment of contamination | 335.163 | | | | | | |
| **IV.3. Implementation Schedule** | | | | | | | |
| **Table IV.1 Proposed Compliance Monitoring System** | | | | | | | |
| **PART V - CORRECTIVE ACTION PROGRAM** | 335.166-167 | | | | | | |
| **V.1. Type of Corrective Action Proposed** | | | | | | | |
| **V.2. Program Description Technical Report** | | | | | | | |
| A. Recovery Wells | | | | | | | |
| (1) Map of optimum Recovery Well locations | | | | | | | |
| (2) Map of estimated radius of influence | | | | | | | |
| (3) Optimum pumping rate (pump tests) | | | | | | | |
| (4) Well and pump system designs | | | | | | | |
| (5) Collection/storage of contaminated GW | | | | | | | |
| (6) Treatment/disposal of contaminated GW | | | | | | | |
| B. Vapor Extraction System | | | | | | | |
| (1) Map view of system components | | | | | | | |
| (2) Design of vapor extraction system | | | | | | | |
| (3) Description of emission control | | | | | | | |
| (4) Expected effectiveness of the system | | | | | | | |
| (5) Treatability data | | | | | | | |
| (6) Constituents affected by treatment | | | | | | | |
| C. Interceptor Trenches | | | | | | | |
| (1) Map view of the interceptor trench | | | | | | | |
| (2) Construction design | | | | | | | |
| (3) Construction procedures | | | | | | | |
| (4) Description of collection/removal system | | | | | | | |
| (5) Storage/treatment of contaminated GW | | | | | | | |
| (6) Disposal of contaminated GW | | | | | | | |
| D. In-Situ Treatment - Chemical Reaction | | | | | | | |
| (1) Characterization of chemical agents | | | | | | | |
| (2) Laboratory treatability data | | | | | | | |
| (3) Hazardous constituents affected | | | | | | | |

| DESCRIPTION | REGULATION GUIDANCE | SUBMITTED N/A | SUBMITTED Y | SUBMITTED N | TECHNICALLY ADEQUATE Y | TECHNICALLY ADEQUATE N | COMMENT FOOTNOTE 1 |
|---|---|---|---|---|---|---|---|
| (4) By-products produced | | | | | | | |
| (5) Degradation time (constituent/by-product) | | | | | | | |
| (6) Potential human health risks of by-product | | | | | | | |
| (7) Potential damage to ecosystem and physical structures when exposed to by-products | | | | | | | |
| (8) Persistence/permanence of by-products | | | | | | | |
| (9) Chemical reactant injection method and other system design aspects | | | | | | | |
| E. In-Situ Treatment - Bioreclamation | | | | | | | |
| (1) Description of bacteria | | | | | | | |
| (2) Description of nutrients and application | | | | | | | |
| (3) Laboratory data from treatability studies | | | | | | | |
| (4) Degradation time for each constituent | | | | | | | |
| (5) Bacteria/nutrient injection method/delivery | | | | | | | |
| F. Barrier Walls | | | | | | | |
| (1) Laboratory permeability data | | | | | | | |
| (2) Barrier wall materials | | | | | | | |
| (3) Construction design/installation procedures | | | | | | | |
| G. Permeable Treatment Beds | | | | | | | |
| (1) Treatability simulation lab data | | | | | | | |
| (2) Properties of treatment material | | | | | | | |
| (3) Constituents affected, reactions/by-products produced and lifetime of treatment beds | | | | | | | |
| (4) Construction design/installation procedure | | | | | | | |
| H. Other corrective action proposed | | | | | | | |
| **V.3. GW Monitoring/Corrective Action Program** | 335.166(4) | | | | | | |
| A. GW monitoring system description | | | | | | | |
| (1) Changes to GW monitoring program | | | | | | | |
| (i) Geological/hydrogeological info | | | | | | | |
| (ii) Waste management areas/units | 335.163(2) | | | | | | |
| (iii) Monitor well construction details | 335.163(3) | | | | | | |
| (iv) Number/location of additional wells | 335.163 | | | | | | |
| (v) Sample handling, COC, procedures | 335.163(4) | | | | | | |
| (vi) Monitoring frequency | 335.166(4) | | | | | | |
| (vii) Monitoring parameters | 335.166(1)(A) | | | | | | |
| (viii) Statistical methods/evaluation | 335.163(8,9) | | | | | | |
| (ix) Other Sampling & Analysis Plan info | 335.163(4) | | | | | | |

| DESCRIPTION | REGULATION GUIDANCE | SUBMITTED N/A | SUBMITTED Y | SUBMITTED N | TECHNICALLY ADEQUATE Y | TECHNICALLY ADEQUATE N | COMMENT FOOTNOTE 1 |
|---|---|---|---|---|---|---|---|
| (xi) Compliance period | 335.162 | | | | | | |
| (xi) Financial assurance | 335.179 | | | | | | |
| (xii) ACL variance | 335.160(b) | | | | | | |
| (2) Depth/location of wells and piezometers | 335.163 | | | | | | |
| (3) Constituent monitoring list | 335.159 | | | | | | |
| (4) Indicator parameter monitoring list | 335.159 | | | | | | |
| (5) Monitoring frequency | 335.166(4) | | | | | | |
| (6) Provisions for semiannual reporting | 335.166(7) | | | | | | |
| (7) Provisions to determine plume migration | 335.166(4) | | | | | | |
| (8) Compliance period | 335.162 | | | | | | |
| B. Methods for evaluating corrective action | 335.166(4) | | | | | | |
| C. Required plans and reports | | | | | | | |
| (1) Sampling & Analysis Plan | 335.163(4) | | | | | | |
| (2) GW Recovery and Monitoring System Plan | | | | | | | |
| (i) Recovery System Plan | | | | | | | |
| a) **Certified** Recovery System Design | 305.50(7) | | | | | | |
| (ii) Monitoring System Plan | | | | | | | |
| a) **Certified** Monitoring System Design | 305.50(7) | | | | | | |
| b) **Certified** Well Drilling/Casing Specs | 305.50(7) | | | | | | |
| (3) Geologic and Hydrogeologic Report | | | | | | | |
| (i) Contaminant Plume Map(s) | | | | | | | |
| (ii) Cross Sections (thru POC and plume) | | | | | | | |
| a) Stratigraphic interpretation | | | | | | | |
| b) Lithologic/geologic description | | | | | | | |
| c) Potentiometric surface | | | | | | | |
| d) NAPLs/constituents detected | | | | | | | |
| e) Screened interval | | | | | | | |
| (iii) Well Construction Diagrams | | | | | | | |
| **V.4. Waste Management Units/Areas Monitored** | | | | | | | |
| A. Map view of unit/area(s) | | | | | | | |
| (1) Boundary of unit/area | | | | | | | |
| (2) Point of compliance | 335.161 | | | | | | |
| (3) Proposed monitor wells | 335.163 | | | | | | |
| (4) Conduits for subsurface contamination | | | | | | | |
| (5) Corrective action system | | | | | | | |

| DESCRIPTION | REGULATION GUIDANCE | SUBMITTED N/A | SUBMITTED Y | SUBMITTED N | TECHNICALLY ADEQUATE Y | TECHNICALLY ADEQUATE N | COMMENT FOOTNOTE 1 |
|---|---|---|---|---|---|---|---|
| B. Map of proposed/existing well/soil borings drilled for assessment, monitoring, corrective action | 335.163 | | | | | | |
| **V.5. Implementation Schedule** | | | | | | | |
| **V.6. Contingency Procedures** | | | | | | | |
| **Table V.1 Corrective Action/GW Monitoring System** | | | | | | | |
| **PART VI - COST ESTIMATES** | 335.179 FOOTNOTE 4 | | | | | | |
| **General Information** | | | | | | | |
| **Corrective Action Program Worksheet** | | | | | | | |
| **GW Monitoring Worksheet** | | | | | | | |
| **Financial Assurance Summary Worksheet** | | | | | | | |
| **ATTACHMENT A - ALTERNATE CONCENTRATION LIMITS** | 335.160(b,c) FOOTNOTES 5 & 6 | | | | | | |
| **A.1. Potential Adverse Effects on GW Quality** | 335.160(b)(1) | | | | | | |
| A. Physical/chemical characteristics of the waste and potential for migration | | | | | | | |
| B. Hydrogeological characteristics | | | | | | | |
| C. Quantity of GW and flow direction | | | | | | | |
| D. Withdrawal rates/proximity of GW users | | | | | | | |
| E. Current/future uses of GW | | | | | | | |
| F. Existing GW quality, other contamination sources and the cumulative impact | | | | | | | |
| G. Potential health risks to humans | | | | | | | |
| H. Potential damage to ecosystem/structures | | | | | | | |
| I. Persistence/permanence of adverse effects | | | | | | | |
| **A.2. Potential Adverse Effects on Hydraulically Connected Surface-Water Quality** | 335.160(b)(2) | | | | | | |
| A. Waste volume and characteristics | | | | | | | |
| B. Hydrogeological characteristics | | | | | | | |
| C. Quantity/quality of GW and flow direction | | | | | | | |
| D. Pattern of rainfall | | | | | | | |
| E. Proximity to surface waters | | | | | | | |
| F. Current/future uses of surface waters and SWQS | | | | | | | |
| G. Existing surface water quality, other contamination sources and cumulative impact | | | | | | | |
| H. Health risks to humans | | | | | | | |
| I. Potential damage to ecosystem/structures | | | | | | | |
| J. Persistence/permanence of adverse effects | | | | | | | |

| DESCRIPTION | REGULATION GUIDANCE | SUBMITTED N/A | SUBMITTED Y | SUBMITTED N | TECHNICALLY ADEQUATE Y | TECHNICALLY ADEQUATE N | COMMENT FOOTNOTE 1 |
|---|---|---|---|---|---|---|---|
| **ATTACHMENT C - SAMPLING & ANALYSIS PLAN** | 335.163(4,5) FOOTNOTES 2, 3 & 9 | | | | | | |
| **1. Pre-Field Activity** | | | | | | | |
| A. Log book format | | | | | | | |
| B. Reference to CP for well locations/monitoring parameters/frequency | | | | | | | |
| C. Examples of field data log sheet, chain of custody, container labels and seals | | | | | | | |
| D. Health and Safety/Field Emergency Plans | | | | | | | |
| **2. Prior to Purging Well** | | | | | | | |
| A. Procedures to evaluate physical condition of well | | | | | | | |
| B. Procedures to measure GW elevations, well depths, silt and NAPLs | | | | | | | |
| C. Procedures to monitor weather | | | | | | | |
| **3. Sampling Preparation Activity** | | | | | | | |
| A. Well purging methods | FOOTNOTE 7 | | | | | | |
| (1) Contingency plan - wells purged to dryness | | | | | | | |
| (2) Purging equipment, rate and method to determine volume purged | | | | | | | |
| (3) Purging method | FOOTNOTE 7 | | | | | | |
| (4) Micropurge rate 0.1 - 0.5 l/min. Drawdown 0.1 m or less. Screened interval sampled. Inline measurements of redox, dissolved $O_2$ and turbidity stabilized within 10%. | | | | | | | |
| B. Unfiltered samples | FOOTNOTE 8 | | | | | | |
| C. Container type/size/labeling method | | | | | | | |
| D. Sample, field and trip blanks and split sampling procedures (frequency and preservation). Discussion of replicates, duplicates and spikes. | | | | | | | |
| **4. Well Sampling** | | | | | | | |
| A. Well sampling equipment, collection procedures and sampling sequence | | | | | | | |
| B. Field QA/QC and sample preservation | | | | | | | |
| C. Procedures for sampling volatile/semi-volatile organics and inorganics | | | | | | | |
| **5. Post-Sampling Activity** | | | | | | | |
| A. Decontamination procedures | | | | | | | |
| B. Analytical methods and holding times | 335.163(4,5) | | | | | | |
| C. Chain of custody and shipping procedures (COC form requirements identified) | | | | | | | |
| D. Disposal of contaminated equipment/purged GW | | | | | | | |

| DESCRIPTION | REGULATION GUIDANCE | SUBMITTED N/A | SUBMITTED Y | SUBMITTED N | TECHNICALLY ADEQUATE Y | TECHNICALLY ADEQUATE N | COMMENT FOOTNOTE 1 |
|---|---|---|---|---|---|---|---|
| E. Laboratory QA/QC procedures | | | | | | | |
| **NOTIFICATION** (mailing list in 30 TAC 39.13) | | | | | | | |
| New Compliance Plan | 39.103 | | | | | | |
| Renewal (May take on the notification requirements of the appropriate modification or amendment) | 39.103 | | | | | | |
| Major Amendment | 39.103 | | | | | | |
| Minor Amendment | 39.17 | | | | | | |
| Class 1 Modification | 39.105<br>305.69(b) | | | | | | |
| Class 1[1] Modification | 39.105<br>305.69(b) | | | | | | |
| Class 2 Modification | 39.107<br>305.69(c) | | | | | | |
| Class 3 Modification | 39.109<br>305.69(d) | | | | | | |
| Copy of Public Notice | | | | | | | |
| **ADDITIONAL REQUIREMENTS/SUBMITTALS** | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

FOOTNOTE 1 See Administrative and Technical NODs for Comments. Additional comments may be typed or handwritten and attached to the checklist.
FOOTNOTE 2 RCRA Ground-Water Monitoring Technical Enforcement Guidance Document (TEGD), September, 1986, USEPA.
FOOTNOTE 3 RCRA Ground-Water Monitoring: Draft Technical Guidance (TEGD Update), November, 1992, USEPA.
FOOTNOTE 4 Completed Cost Estimate and Summary Worksheets are required.
FOOTNOTE 5 Alternate Concentration Limit Guidance; Part I: ACL Policy and Information Requirements, July, 1987, OSWER Directive 9481.00-6C, USEPA/530-SW-87-017.
FOOTNOTE 6 Alternate Concentration Limit Guidance; Part II: Case Studies, May, 1988, OSWER Directive 9481.00-11, USEPA/530-SW-87-031.
FOOTNOTE 7 NOD required if bailers are proposed as purging method instead of micropurging. Bailers may be allowed upon justification by the facility.
FOOTNOTE 8 NOD required if filtered samples are proposed. Filtered samples may be allowed upon justification by the facility.
FOOTNOTE 9 See the U.S. EPA publication SW-846 Test Methods for Evaluating Solid Waste, Third Edition, November 1986 and later editions/updates.

Shaded Areas are part of the Administrative Evaluation

# Appendix B

## Statistical Applications to Monitoring Programs

Statistical analysis of spatial and temporal trends in groundwater monitoring data typically starts with visual inspection of graphical plots of the results for a well or group of wells over time or as a function of distance from the source. Visual examination of such data is a highly sensitive means of detecting trends or potential trends in the data. Statistical tests can then be used to verify the significance of any observable trends by calculating the likelihood that the trend might have resulted purely from random variability.

A useful tool for assessing the significance of trends noted in visual examination of concentration versus time plots is the Mann-Kendall test. The Mann-Kendall test can be interpreted as a nonparametric test for an increasing or decreasing slope for the line describing concentration as a function of time. The Mann-Kendall test is described in detail in R. O. Gilbert, *Statistical Methods for Environmental Pollution Monitoring* (1987) and is also discussed in the EPA guidance document, *Guidance for Data Quality Assessment, Practical Methods for Data Analysis* (1998, Office of Research and Development, EPA/600/R-96/084). This test is useful because it does not require that data be collected at equally spaced time intervals and it is nonparametric (a *nonparametric* test does not require that the data conform to any particular statistical distribution such as normality or log-normality). It also can accommodate nondetected results since only the relative magnitudes of the results rather than the actual observed values are used.

Specifically, for a given well, the Mann-Kendall trend statistic, *S*, for a single location is calculated as:

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} sign(X_j - X_k),$$

where
$$sign(X_j - X_k) = 1 \quad \text{if } (X_j - X_k) > 0$$
$$sign(X_j - X_k) = 0 \quad \text{if } (X_j - X_k) = 0$$
$$sign(X_j - X_k) = -1 \quad \text{if } (X_j - X_k) < 0$$

In the equations, $X_i$ represents the concentration at time *i*, and *n* is the total number of observations.

A Mann-Kendall trend statistic, *S*, of zero indicates that there is neither an increasing nor a decreasing trend. A positive *S* indicates an increasing trend; negative *S* indicates that the trend is decreasing. As an example, suppose three measurements were taken at times 1, 2, and 3 and that concentrations of 5, 10, and 15 were observed, respectively, at these times. This corresponds to an *S* of +3, which indicates an increasing trend.

However, even if no true trend is present, it is possible to obtain a positive or negative *S*, just due to random variability. A test of statistical significance is a method for assessing whether an observed trend can be attributed to random variability and involves computing a *p* value, which represents the probability that a result as extreme as the observed *S* (an *S* as high in the positive direction or as low in the negative direction) could have occurred just by random chance. If the *p* value is small (typically, less than 0.05, although this varies from one project to another), the trend is said to be statistically significant.

For the Mann-Kendall statistic, the details of the significance test depend on the sample size. For small samples sizes (fewer than 10), an exact test is applied. This exact test is described in Gilbert (1987) and is based on computing all the possible orderings of results that could have occurred, if there were no true trend.

Using the previous example, if there is no true trend, then the three observed results could have occurred in any order, and each possible ordering would have been equally likely. The six possible orderings are (5,10,15), (5,15,10), (10,5,15), (10,15,5), (15,5,10), and (15,10,5). These six orderings correspond to *S* trend statistics of -3, -1, -1, +1, +1, +3, respectively, and each is equally likely if there is no true trend. Thus, the chances of obtaining an observed *S* as high in that obtained in the example above, just due to random chance, is 1/6 or a 16.67% chance. The *p* value corresponding to the observed S=+3 is 0.1667. Thus, in this example, even though a positive test statistic was obtained (in fact, the highest possible test statistic), the result would be concluded to be not statistically significant, using 0.05 as the cut-off between statistical significance and nonsignificance. For this reason, tests for trend typically are not performed on samples of size three or smaller. When four samples are available, the number of possible orderings increases to 24, and it is possible to obtain statistics that are significant at the 0.05 significance level.

Clearly, as the sample size increases, the number of possible orderings increases, and the computation of *p* values can become time- or computer-intensive. Gilbert (1987) provides a table for sample sizes up to 10. If more than 10 samples are available, then an approximate method, which does not require large tables or intensive calculations, can be used to compute the *p* value. The approximation is calculated by first computing the standard error (a measure of uncertainty) associated with *S*:

$$Var(S) = \frac{1}{18}\left[ n(n-1)(2n+5) - \sum_{p=1}^{g} t_p (t_p - 1)(2t_p + 5) \right].$$

Then a standard normal Z statistic is calculated as

$$Z = \frac{S-1}{\sqrt{Var(S)}} \quad \text{if } S > 0$$

$$Z = 0 \quad \text{if } S = 0$$

$$Z = \frac{S+1}{\sqrt{Var(S)}} \quad \text{if } S < 0.$$

Finally, a *p* value is calculated for the *Z* statistic based on percentiles from a standard normal distribution.

The Mann-Kendall trend test is an attractive option for assessing the statistical significance of an observed increasing or decreasing trend. Its strengths lie in the fact that few statistical assumptions (such as normality or log-normality) are required, it is robust against one or two anomalous data values, it can easily accommodate nondetected results, and is easy to interpret. However, one of its strengths is also a potential weakness. That is, the actual concentrations themselves are not taken into account. For example a series of results such as (1,2,3,4,5) is as significant as (1,10,20,100,200). Practically, however, the second scenario is more likely to reflect a true trend than the first. For this reason, the Mann-Kendall trend test is always accompanied by graphical presentations of the data.

Other possible methods for testing for trend include modifications to the Mann-Kendall test for trend to accommodate multiple measurements per well per sampling event or to correct for seasonal effects, as well as a parametric tests for trend based on regression. These modifications to the Mann-Kendall test would be appropriate if pronounced seasonal variation were noted in monitoring data or if duplicate samples were to be included in the analysis. One drawback to correction for seasonal effects is that a longer time series of data is needed before statistical analysis can be usefully implemented.

A regression approach to testing for trend involves constructing a model to predict concentration as a function of time (typically assuming linearity). If the model provides a good fit to the data and there is a predicted increase (or decrease) in concentration as a function of time, then the trend can be said to be significant. Computing *p* values to objectively assess the goodness of the model fit is discussed in the EPA guidance document, *Guidance for Data Quality Assessment, Practical Methods for Data Analysis* (1998, Office of Research and Development, EPA/600/R-96/084), as well as in many standard statistical textbooks such as Mason, Gunst, and Hess (1989), *Statistical Design and Analysis of Experiments*.

Regression analysis can be more strongly biased by outliers such as anomalously high results and requires that nondetects be assigned numerical values. Also, purely linear models may not accurately represent trends in contaminant concentrations, which are often log-normally distributed. Although these limitations can be addressed, additional level of effort is required to assess the statistical properties of the data and properly format all results for the analysis. It is recommended that the Mann-Kendall be applied as the first step in assessing trends. Regression analysis may be appropriate for assigning numerical values to trends identified as significant, as in calculating natural attenuation rates, contaminant mass removal, or rates of plume advance or retreat.

Other relevant statistical tools that do not specifically assess trend but that can be incorporated in the LTM optimization include spatial statistical analysis, statistical tests for outliers, statistical comparisons of populations (e.g., downgradient to upgradient well comparisons), statistical estimation of average or extreme concentrations (for purposes of comparing to regulatory criteria), and multivariate statistical approaches to evaluate concentrations for multiple compounds simultaneously. Many of these tools are discussed in more detail in the EPA's *Guidance for Data Quality Assessment, Practical Methods for Data Analysis* (1998, Office of Research and Development, EPA/600/R-96/084).

Although many of these tests are more appropriate for site assessment and remedial investigation phases of effort, rather than long-term monitoring, they may find application in specific instances. For example, statistical analysis of upgradient and downgradient populations may be useful if site closure is sought despite not having attained MCLs in downgradient wells. If upgradient populations have statistically similar contaminant concentrations, closure may be justified by arguing that no contaminant source remains at the site. Multivariate statistical analysis may be useful in instances where it is suspected that concentrations or trends in concentration of one or more contaminants are related in some way; for example, as in the degradation of TCE and the production of daughter products such as cis-1,2 dichloroethene. Statistical verification of such trends can have important implications for remedial design and operation as well as regulatory approvals.

**References:**

Gilbert, R.O., 1987. *Statistical methods for environmental pollution monitoring*. New York: Van Nostrand-Reinhold.

Mason, R.L., Gunst, R.F., and Hess, J.L., 1989. *Statistical design and analysis of experiments*. New York: Wiley.

EPA, 1998. *Guidance for Data Quality Assessment, Practical Methods for Data Analysis*, Office of Research and Development, EPA/600/R-96/084.

# Appendix C

## Current Analyte List for the NWIRP Dallas Monitoring Program

## Target Compound List (TCL) Volatile Compounds

Chloromethane
Bromomethane
Vinyl Chloride
Chloroethane
Methylene Chloride
Acetone
Carbon Disulfide
1,1-Dichloroethene
1,1-Dichloroethane
1,2-Dichloroethene (total)
cis-1,2-Dichloroethene
trans -1,2-Dichloroethene
Chloroform
1,2-Dichloroethane
2-Butanone
Bromochloromethane
1,1,1-Trichloroethane
Carbon Tetrachloride
Bromodichloromethane
1,2-Dichloropropane
cis-1,3-Dichloropropene
Dibromochloromethane
1,1,2-Trichloroethane
Benzene
trans-1,3-Dichloropropene
Bromoform
4-Methyl-2-pentanone
2-Hexanone
Tetrachloroethene
1,2-Dibromoethane
Toluene
1,1,2,2-Tetrachloroethane
Chlorobenzene
Ethylbenzene
Styrene
Xylenes (Total)
1,2-Dibromo-3-chloropropane
1,3-Dichlorobenzene
1,4-Dichlorobenzene
1,2-Dichlorobenzene
1,2,4-Trichlorobenzene

## Target Compound List (TCL) Pesticides/Aroclors (PCBs)

alpha-BHC
beta-BHC
delta-BHC
gamma-BHC
(Lindane)
Heptachlor
Aldrin
Heptachlor epoxide
Endosulfan I
Dieldrin
4,4'-DDE
Endrin
Endosulfan II
4,4'-DDD
Endosulfan sulfate
4,4'-DDT
Methoxychlor
Endrin ketone
Endrin aldehyde
alpha-Chlordane
gamma-Chlordane
Toxaphene
Aroclor-1016
Aroclor-1221
Aroclor-1232
Aroclor-1242
Aroclor-1248
Aroclor-1254
Aroclor-1260

## Target Compound List (TCL) Semivolatiles

Phenol
bis(2-Chloroethyl) ether
2-Chlorophenol
1,3-Dichlorobenzene
1,4-Dichlorobenzene
1,2-Dichlorobenzene
2-Methylphenol
2,2'-oxybis (1 Chloropropane)
4 Methylphenol
N-Nitroso-di-n-propylamine
Hexachloroethane
Nitrobenzene
Isophorone
2-Nitrophenol
2,4-Dimethylphenol
bis(2-Chloroethoxy) methane
2,4-Dichloropenol
1,2,4-Trichlorobenzene
Naphthalene
4-Chloroaniline
Hexachlorobutadiene
4-Chloro-3-methylphenol
2-Methylnaphthalene
Hexachlorocyclopentadiene
2,4,6-Trichlorophenol
2,4,5-Trichlorophenol
2-Chloronapthalene
2-Nitroaniline
Dimethylphthlate
Acenaphthylene
2,6-Dinitrotoluene
3-Nitroaniline
Acenaphthene
2,4-Dinitrophenol
4-Nitrophenol
Dibenzofuran
2,4-Dinitrotoluene
Diethylphthalate
4-Chlorophenyl-phenyl ether
Fluorene
4-Nitroaniline
4,6-Dinitro-2-methylphenol
N-Nitrosodiphenylamine
4-Bromophenyl-phenyl ether
Hexachlorobenzene
Pentachlorophenol
Phenanthrene
Anthracene
Carbazole
Di-n-butylphthalate
Flouranthene
Pyrene
Butylbenzylphthalate
3,3'-Dichlorobenzidine
Benzo(a)anthracene
Chrysene
bis-(2-Ethylhexy1)phthalate
Di-n-octylphthalate
Benzo(b)fluoranthene
Benzo(k)fluoranthene
Benzo(a)pyrene
Indeno(1,2,3-cd)pyrene
Dibenz(a,h)anthracene
Benzo(g,h,i)perylene

## Target Analyte List (TAL) Metals/Cyanide

Aluminum
Antimony
Arsenic
Barium
Berylium
Cadmium
Calcium
Chromium
Cobalt
Copper
Iron
Lead
Magnesium
Manganese
Mercury
Nickel
Potassium
Selenium
Silver
Sodium
Thallium
Vanadium
Zinc
Cyanide

# Appendix D

## Examples of Tabular and Graphic Format

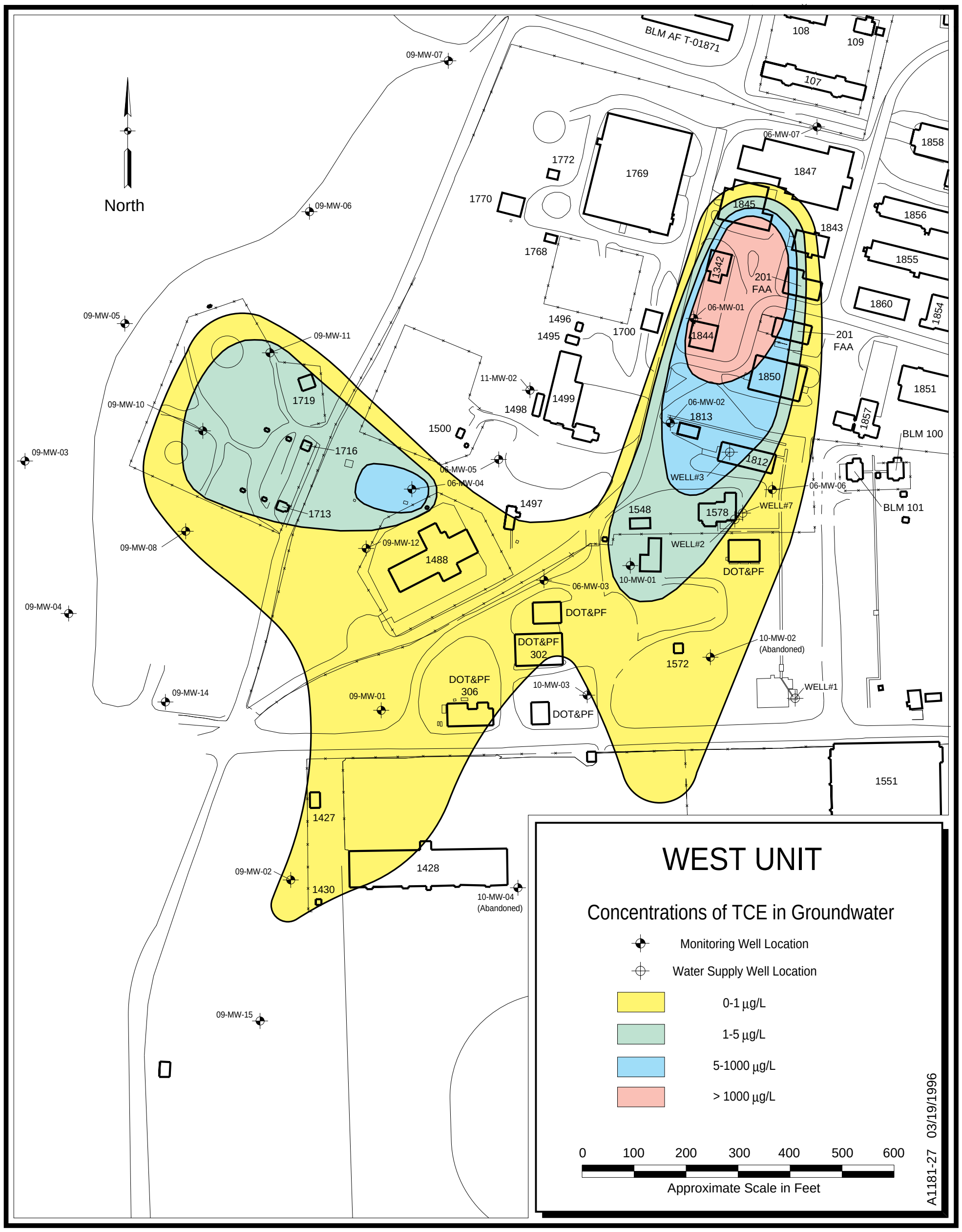
# Tank Farm Groundwater Data—Round 3

| Analyte | Method (units) | Screening Criteria | Location ID | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | 05-MW-02 | 05-MW-03 | 05-MW-04 | 05-MW-05 | 05-MW-06 | 05-MW-07 | 05-MW-11 |
| Gasoline Range Organics | AK101 (ug/L) | NA | ND (50)[a] | 17,000 (50) | 110,000 (50) | 130,000 (50) | ND (50) | 97,000 (50) | 1,200 (50) |
| Diesel Range Organics | AK102 (ug/L) | NA | 40 J (100) | 2,100 (100) | 13,000 (100) | 6,900 (100) | 53 J (100) | 8,700 (100) | 1,200 (100) |
| Acetone | SW8260 (ug/L) | 3,700 RN | 5.01 B (2.09) | 14.4 (2.09) | 745 (522) | 54.2 (31.4) | 2.49 B (2.09) | 56.4 (31.4) | 7.94 (2.09) |
| Benzene | | 5 M | 0.0300 BJ (0.0307) | 4,530[b] (3.07) | 27,200 (30.7) | 41,000 (30.7) | 0.0700 B (0.0307) | 24,400 (15.4) | 10.4 (0.0307) |
| Chloromethane | | 1.4 RC | 0.240 B (0.155) | ND (0.155) | 222 (38.8) | 2.85 (2.32) | ND (0.155) | ND (2.32) | ND (0.155) |
| Dibromochloromethane | | 0.13 RC | ND (0.0283) | ND (0.0283) | ND (7.08) | ND (0.424) | ND (0.0283) | ND (0.424) | ND (0.0283) |
| 1,2-Dichloroethane | | 5 M | 0.710 (0.0791) | 0.840 (0.0791) | ND (19.8) | 35.1 (1.19) | ND (0.0791) | 59.2 (1.19) | 0.450 (0.0791) |
| 1,1-Dichloroethene | | 7 M | ND (0.0806) | ND (0.0806) | 17.5 J (20.2) | ND (1.21) | ND (0.0806) | ND (1.21) | ND (0.0806) |
| Trans-1,3-Dichloropropene | | 0.077 RC | ND (0.0829) | ND (0.0829) | ND (20.7) | ND (1.24) | ND (0.0829) | ND (1.24) | ND (0.0829) |
| Ethylbenzene | | 700 M | ND (0.110) | 330 (3.30) | 810 (27.5) | 741 (1.65) | ND (0.110) | 649 (1.65) | 0.0900 J (0.110) |
| Methylene chloride | | 5 M | 0.210 B (0.151) | 0.930 B (0.151) | 398 (37.8) | 20.2 (2.26) | 0.160 B (0.151) | 3.60 (2.26) | 0.130 BJ (0.151) |
| 4-Methyl-2-Pentanone (MIBK) | | 2,900 RN | ND (0.501) | 2.81 (0.501) | ND (125) | 46.2 (7.52) | ND (0.501) | ND (7.52) | 2.21 (0.501) |
| 1,1,2,2-Tetrachloroethane | | 0.052 RC | ND (0.170) | ND (0.170) | ND (42.5) | ND (2.55) | ND (0.170) | ND (2.55) | ND (0.170) |
| Toluene | | 1,000 M | ND (0.0336) | 2,200 (3.36) | 13,400 (33.6) | 19,100 (33.6) | 0.0500 (0.0336) | 20,200 (16.8) | 2.64 (0.0336) |
| Trichloroethene | | 5 M | ND (0.0439) | ND (0.0439) | ND (11.0) | 4.50 (0.658) | ND (0.0439) | ND (0.658) | ND (0.0439) |
| Total Xylenes | | 10,000 M | ND (0.489) | 1,100 (14.7) | 2,250 (122) | 2,560 (93.1) | ND (0.489) | 3,090 (93.0) | 0.610 (0.489) |

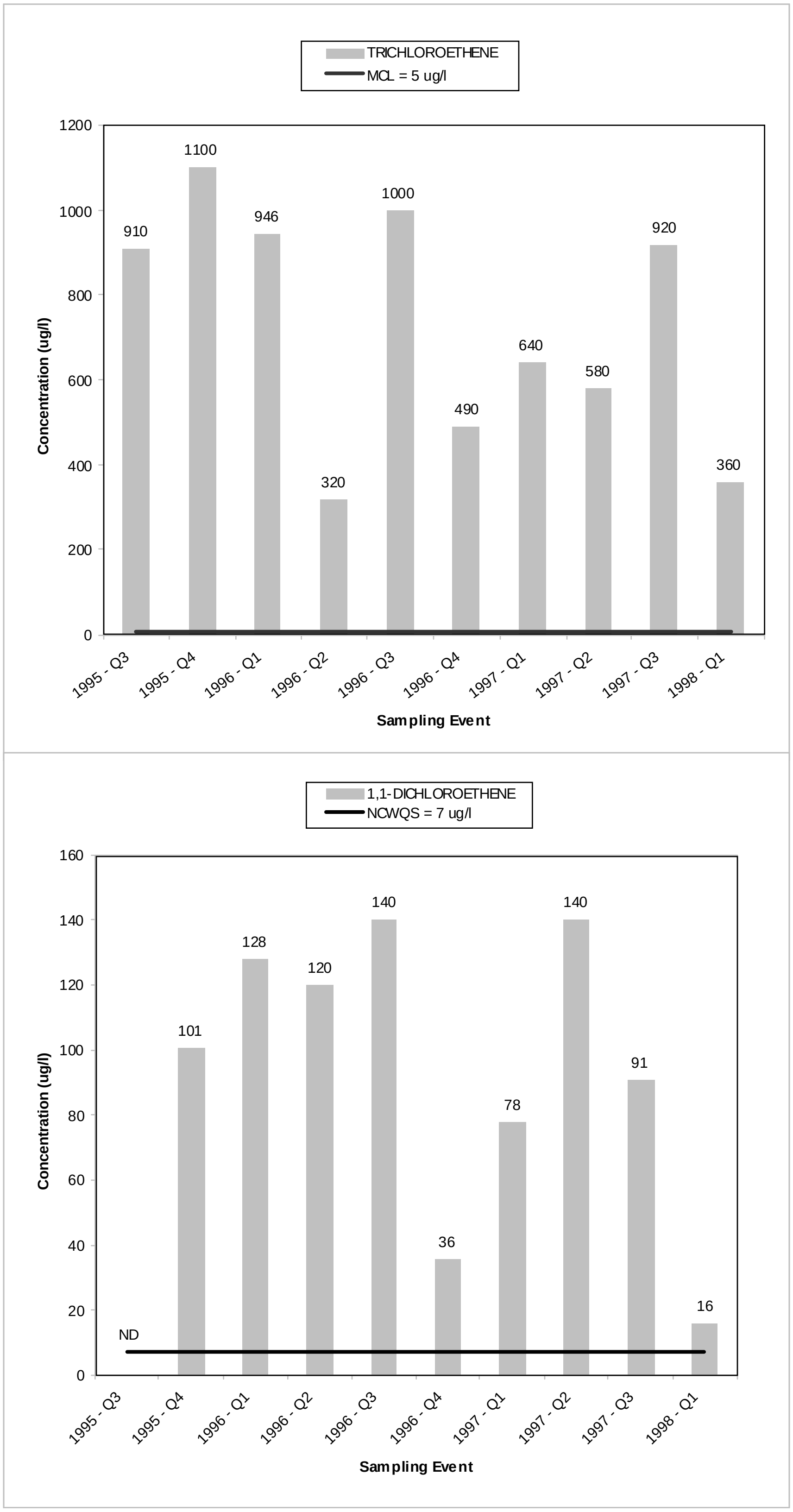
[a]Numbers in parentheses are sample-specific quantitation limits.
[b]Shaded results exceed the screening criteria.

M = Maximum Contaminant Level (MCL).
RC = EPA Region III risk-based criteria, carcinogenic level.
RN = EPA Region III risk-based criteria, non-carcinogenic level.
ND = Not detected at the specified quantitation limit.
J = Detected at a concentration less than the specified detection limit.
B = Detected at concentrations indistinguishable from those detected in laboratory blanks.

**Example 1. Tabular Format with Highlighted Results**
**(Note: These are sample data and do not reflect site conditions at NWIRP Dallas)**




**Example 2. Graphic Format with Contaminant Plume Contouring**
**(Note: These are sample data and do not reflect site conditions at NWIRP Dallas)**




**Example 3. Concentration Tracking Graphs**
**(Note: These are sample data and do not reflect site conditions at NWIRP Dallas)**

## D.0 GIS NOTES

### Example GIS Application Features

The following two pages illustrate screen shots of a GIS application that allows the user to generate plume maps using data from a monitoring program. By selecting an Operable Unit, a contaminant of concern, and a sampling round, a custom query is generated. The concentration data from the query are subsequently contoured and displayed on the screen. A table containing the query data is also displayed.

By clicking on a well, building, source area, or other feature in the GIS display, the user can bring up specific data describing the chosen feature. For example, clicking on a specific well may enable the user to bring up well construction, water level, or contaminant concentration data. Clicking on a site or Operable Unit may bring up pertinent information such as contaminants of concern, site activities, and dates of operation.

Standard GIS functions include the ability to pan, zoom in, zoom out, and other standard navigation tools. All of these features can be used to give an effective presentation, with the ability to provide real-time responses to any data requests the audience may have.

### Example GIS Applications to LTM Programs

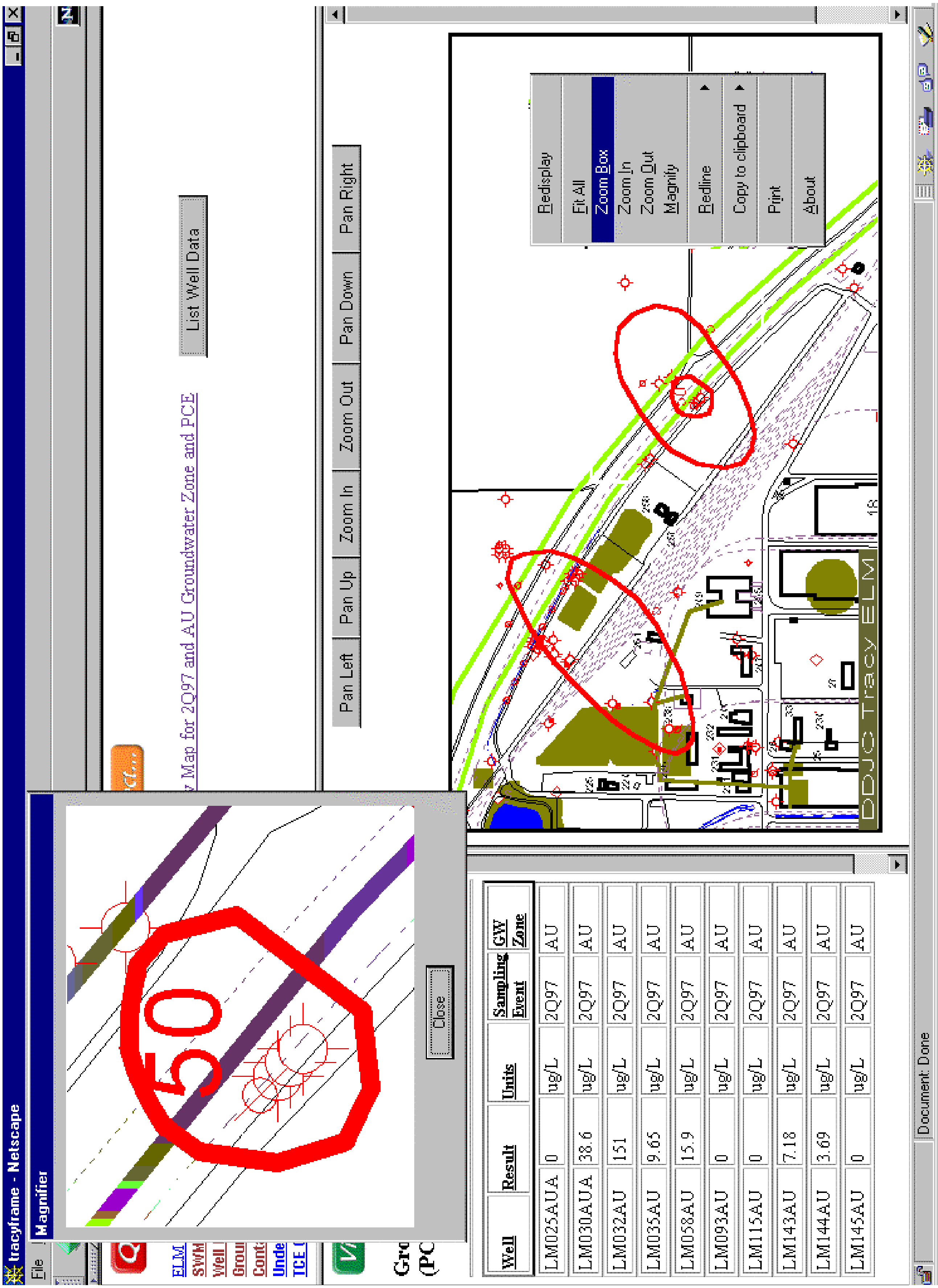
These types of applications have many uses within an LTM program. By being able to continuously track a plume's size and shape, decisions regarding which wells to sample and when to shut down active remediation systems can be made. For instance, consider the following:

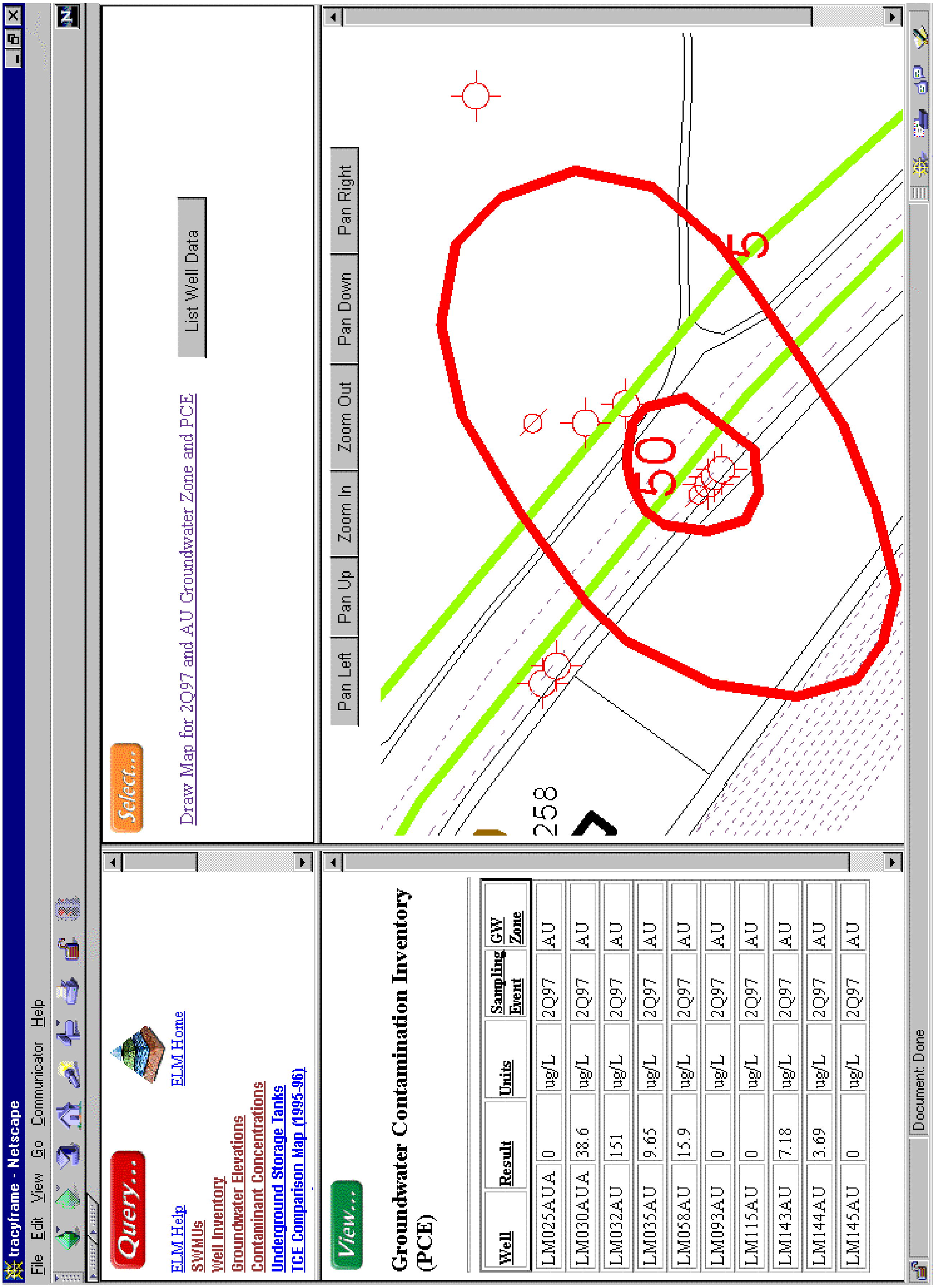
- If a plume is determined to be shrinking, wells once within the plume may become downgradient wells. Further downgradient wells may be eliminated from monitoring.
- If changes to plume size and contaminant concentrations become insignificant over time, consideration may be given to shutting down active remediation and allowing natural attenuation to take place.
- If a plume appears to be growing, additional wells may need to be identified or installed to track the plume edge. In addition, changes may need to be made to the remediation system to prevent off-site migration of contaminants.

Additional uses of this type of system involve tracking of individual monitoring points over time. By querying out several rounds of data for a single monitoring point, either in tabular or graphic format, decisions can be made regarding that monitoring point:

- If contaminant concentrations appear to be decreasing, the well may be eliminated from the program, depending on its location, or monitored less frequently.
- If contaminant concentrations have leveled off, the well may be proposed for less frequent monitoring.
- If contaminant concentrations appear to be increasing, the well should be kept in the LTM program and monitored at the current frequency.

By querying several rounds of analytical data for an entire site, decisions regarding analytical methods may be made. If a given analyte has not been detected in four sampling rounds, it should be proposed for elimination from the LTM program for that site. If no analytes of concern have been detected at concentrations above action levels for two or more rounds, it may be reasonable to propose that the entire site be closed.


tracyframe - Netscape
File
Magnifier
Close
List Well Data
Map for 2Q97 and AU Groundwater Zone and PCE
Pan Left
Pan Up
Zoom In
Zoom Out
Pan Down
Pan Right
Redisplay
Fit All
Zoom Box
Zoom In
Zoom Out
Magnify
Redline
Copy to clipboard
Print
About
DDJC Tracy ELM
Well | Result | Units | Sampling Event | GW Zone
LM025AUA | 0 | ug/L | 2Q97 | AU
LM030AUA | 38.6 | ug/L | 2Q97 | AU
LM032AU | 151 | ug/L | 2Q97 | AU
LM035AU | 9.65 | ug/L | 2Q97 | AU
LM058AU | 15.9 | ug/L | 2Q97 | AU
LM093AU | 0 | ug/L | 2Q97 | AU
LM115AU | 0 | ug/L | 2Q97 | AU
LM143AU | 7.18 | ug/L | 2Q97 | AU
LM144AU | 3.69 | ug/L | 2Q97 | AU
LM145AU | 0 | ug/L | 2Q97 | AU
Document: Done


tracyframe - Netscape
File Edit View Go Communicator Help
Query...
ELM Help
SWMUs
Well Inventory
Groundwater Elevations
Contaminant Concentrations
Underground Storage Tanks
TCE Comparison Map (1995-96)
ELM Home
Select...
Draw Map for 2Q97 and AU Groundwater Zone and PCE
List Well Data
View...
Groundwater Contamination Inventory (PCE)
Well | Result | Units | Sampling Event | GW Zone
LM025AUA | 0 | ug/L | 2Q97 | AU
LM030AUA | 38.6 | ug/L | 2Q97 | AU
LM032AU | 151 | ug/L | 2Q97 | AU
LM035AU | 9.65 | ug/L | 2Q97 | AU
LM058AU | 15.9 | ug/L | 2Q97 | AU
LM093AU | 0 | ug/L | 2Q97 | AU
LM115AU | 0 | ug/L | 2Q97 | AU
LM143AU | 7.18 | ug/L | 2Q97 | AU
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258
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