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Expedited Site Assessment Tools For Underground Storage Tank Sites

A Guide For Regulators

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Chapter II

Expedited Site Assessment Process

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Exhibits

Chapter II
Expedited Site Assessment Process

The expedited site assessment (ESA) process is a framework for rapidly characterizing underground storage tank (UST) site conditions for input into corrective action decisions. This framework has been described with other names including accelerated site characterization, rapid site characterization, and expedited site investigation. An ESA is conducted in a single mobilization that typically covers several days and is made up of the following features:

- Field-generated data and on-site interpretation;
- A flexible sampling and analytical program; and
- Senior staff in the field who are authorized to make sampling and analytical decisions.

The ESA process contrasts with conventional site assessments (CSAs) in which a significant amount of analysis and data interpretation is completed off-site at a later date. As a result, CSAs can:

- Take weeks or months to generate a preliminary report;
- Require several phases of investigation; and
- Delay corrective action decisions for months and sometimes years.

ESAs have been made possible in recent years by the development of improved, cost-effective methods for rapid collection and field analysis of soil, soil-gas, and groundwater samples. When appropriate, conventional sampling and analytical methods can also be used in the ESA process. For example, an air rotary drilling rig may be used in consolidated material, or off-site certified laboratory analysis may be used on a limited basis to verify field analytical methods. The ESA process emphasizes the appropriate use of technologies in a way that minimizes the time required for complete characterization and maximizes the data available for making corrective action decisions.

Exhibit II-1 presents a comparison of CSAs and ESAs. The focus for a CSA is usually on installing groundwater monitoring wells that are sited with limited subsurface information. The sampling and analysis plan is typically rigid and defines the number of wells and their location. Most data analysis and synthesis are performed off-site and may take weeks or months to complete. The results of the assessment are usually focused on mapping the boundaries of the groundwater plume rather than the source areas or locating the most significant contaminant mass. In addition, the approach to mapping generally ignores the 3-dimensional nature of contaminant migration. Consequently, the CSA process

Exhibit II-1
Comparison Of Conventional And Expedited Site Assessments

Process Component	Conventional Site Assessments	Expedited Site Assessments
Number of phases of investigation	Multiple	Single
Field management	Manager typically in office; junior staff in field.	Manager in field with experienced staff.
Technical strategy	Focus on plan view map; sampling location based on limited information. Sampling locations are pre-determined.	Use of multiple, complementary technologies; sampling locations depend on existing data; minimal well installation; locating most significant contaminant mass in 3-dimensions.
Work plan	Rigid plan	Flexible plan
Data analysis	Interpretation of data is weeks or months later.	Regular (hourly/daily) interpretation of data.
Innovative technologies (*i.e.*, direct push and field analytical methods)	May or may not be used; not integrated into process.	Standard practice, allows on-site iterative process.

Source: Modified from Burton, 1995

tends to be time consuming, the total costs tend to be relatively high, and the site conditions reported are often incomplete or incorrect.

In contrast, the ESA process uses senior scientists as field managers to conduct the entire assessment. Both types of assessments evaluate existing data to develop an initial conceptual model of site conditions, however, with ESAs the sampling and analysis plan is dynamic. As new site information is generated, it is used to direct the assessment. The field-generated data are used to update and refine the conceptual model as the assessment proceeds. In this way, data gaps are filled, and anomalies are resolved, prior to demobilization. The ESA is complete when the data being obtained and the 3-dimensional characterization of the site are in agreement.

In recent years, Risk-Based Corrective Action (RBCA) has been recognized by regulators and industry as a valid approach to dealing with the enormous number of petroleum-contaminated sites. RBCA is a process that utilizes risk and exposure assessment methodology to help UST implementing agencies make determinations about the extent and urgency of corrective action and about the scope and intensity of their oversight of corrective action by UST owners and operators (EPA, 1995). The American Society for Testing and Materials (ASTM) RBCA standard (ASTM, 1995b) describes a three-tiered approach to site evaluations in which each tier requires more extensive site-specific data.

ESAs can be integrated with RBCA evaluations because the ESA process is a method of obtaining accurate site information that is necessary for making an appropriate corrective action decision. The first two RBCA tiers can be evaluated in a single mobilization as part of a standard ESA, provided the investigator has the cooperation of the appropriate regulatory agency. The data needs for a Tier 3 evaluation can also be acquired in the same mobilization; however, because of the complexity and cost of the data needed for this level of evaluation, investigators must be prepared for this tier level prior to mobilization and there should be a method for rapidly acquiring authorization from the implementating agency. A list of the data requirements for corrective action evaluations is provided in Appendix A which is located at the end of the manual. This information can be collected during an ESA and used in the RBCA process.

This chapter is divided into two major sections. The first section walks the reader through the steps in the ESA process and discusses how this process compares with conventional site assessments. The second section presents an example of an actual ESA and compares it with a CSA that occurred at the same site. This section illustrates how innovative data collection techniques and field analysis methods can be used with the ESA process to complete a site assessment quickly, while providing enough information to make remediation decisions. The ESA process described in this chapter and referenced throughout the manual is based on the provisional Accelerated Site Characterization standard by ASTM (ASTM, 1995c) and State of Texas guidance (TNRCC, 1995).

Expedited Site Assessment Process Steps

The flowchart in Exhibit II-2 depicts the ESA process in seven steps. While many of the steps are similar to those in a CSA, the activities within the highlighted box labeled "Implement On-Site Iterative Process" are unique to an ESA. These activities include:

- Collect and analyze field data;
- Refine the conceptual model as new data are produced; and
- Modify the sampling and analysis program when necessary.

In an ESA, a field manager is responsible for this entire process. Information about regional and site-specific geology/hydrogeology as well as knowledge of petroleum fate and transport are necessary for making and revising sampling and analysis decisions on-site. An ESA field manager must, therefore, have extensive site assessment experience and knowledge about all aspects of the ESA.

Step 1: Establish Site Assessment Objectives

The general objectives for any site assessment are to understand the:

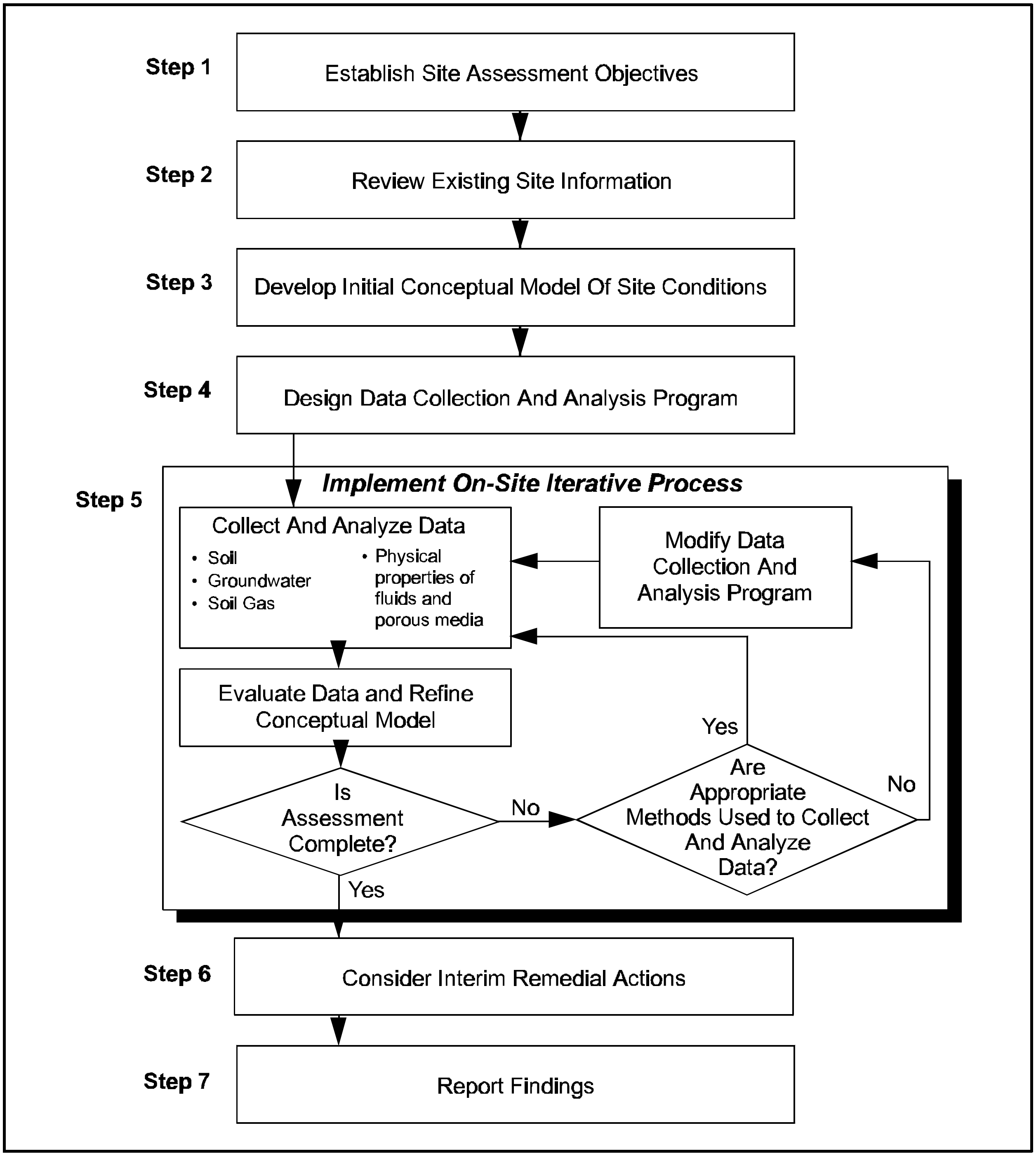
- Geology/hydrogeology of the site;
- Nature and extent of contamination; and
- Migration pathways and points of exposure.

The site-specific objectives may be to determine the existence of contamination, investigate suspected contamination, or evaluate known contamination. The objectives selected will dictate the priority of the type of samples to be collected and analyzed. For example, an ESA for an initial response action will focus on defining immediate hazards, while an assessment for a specific corrective action technology will focus on the parameters that affect the system design and performance.

Step 2: Review Existing Site Information

Both CSAs and ESAs require a review of existing site information before mobilization. However, existing site information is especially important in an

Exhibit II-2
Expedited Site Assessment Process



Source: Modified from ASTM, 1995c.

ESA because this information is required for the selection of sampling equipment, analytical methods, and strategies for the initial round of sampling. A list of potential sources of historical site information is provided in Exhibit II-3. The review of existing information should include past and current land use, potential sources of contamination, potential migration pathways and receptors, and likely geologic and hydrogeologic conditions. If the investigation includes a RBCA evaluation, potential future land uses would generally also be investigated.

Step 3: Develop Initial Conceptual Model Of Site Conditions

Based on existing site information, a field manager develops an initial conceptual model before any field work is begun. This model is a basic compilation of the field manager's understanding of existing conditions. A site map is used for developing the initial sampling and analysis program. An example of an initial conceptual model represented on plan view maps and a cross-section are provided in Exhibit II-4 on page II-15. The graphics can be drawn by hand or generated on a computer to be revised as the assessment progresses. On these maps, the field manager should include suspected geologic and hydrogeologic conditions; suspected contaminant source areas; and potential migration pathways, receptors, and sampling constraints (*e.g.*, utilities, depth to bedrock).

Step 4: Design Data Collection And Analysis Program

Prior to mobilization, the field manager makes use of the conceptual model to design a data collection and analysis program. This program, which is also referred to as the work plan, should be flexible so that the field manager can adjust the location, quantity, depth, and type of samples based on the developing conceptual model.

The data collection and analysis program is a general work plan which may be informally written or simply discussed by the field manager with the appropriate individuals, such as regulators or the responsible party. For example, the plan may seek to identify appropriate sampling tools and analytical methods, define the contaminant source area, and assess the property boundaries for potential off-site or on-site migration. The field manager may need to make minor adjustments in the program and the scope of work, within a specified funding level. The need for changes in the program is clarified as the understanding of the site conditions evolves.

Exhibit II-3
Sources And Types Of Site History Information

Sources	Records/Documents	Types Of Available Information
Owner/ operator records	Inventory records, deeds, detailed site maps, spill and release incident reports, historic photographs, and environmental consulting reports	Details regarding the storage, use, accidental release, and disposal of petroleum products in USTs, site features
Municipal and/or county offices	Records at the following departments: Tax assessor, fire, public works, building, utility, sewer, sanitation, and public health	Information on current and past owners, site history, UST permits, maps of drainage features, and investigation and incident reports
State government	State environmental agency; regional water quality board; health department; and fire marshal	Information on active and inactive UST sites, enforcement documents, and reports on LUSTs
Federal government	U.S. EPA	Site investigation and incident reports, UST and RCRA records
	U.S. Geological Survey	Topographic and geologic maps, geologic/hydrogeologic reports, aerial photographs
	Natural Resources Conservation Service (NRCS) and Agricultural Stabilization and Conservation Service (ASCS)	Aerial photographs and detailed information about soil properties available locally
Universities, libraries	Theses, archives, and historical information	Information on-site development, land use, site activities, geology, and hydrogeology
Key personnel (*e.g.*, owner, employees)	Interviews	Information regarding all aspects of site history, especially spills, overfills, and leaks
Miscellaneous	Aerial photographs: Listings of available public and private aerial photographs for given locations and periods are available from the National Cartographic Information Center in Reston, Virginia	Information regarding site development, land use, manufacturing activities, pipeline and UST locations
	Fire insurance maps dating back to the 1800s which depict the location of manufacturing facilities and potential fire hazards (*e.g.*, USTs) locations are available for all regions of the U.S. from the Sanborn Map Company in Pelham, New York	Information regarding site development, land use, waste disposal locations, manufacturing activities, UST locations

Source: Modified from Cohen and Mercer, 1993

In some instances, the first data are collected with surface geophysical measurements. Depending on the site conditions, surface geophysical methods may be able to provide initial information about the location of buried objects, the geologic and hydrogeologic conditions, and the location of floating and residual product. This information will influence the selection of sampling tools, sampling locations, and the analytical program. The applicability of surface geophysical methods, such as ground penetrating radar, electromagnetics, and magnetometry, is discussed in Chapter III of this manual.

Soil-gas surveys are also a useful method for obtaining a large amount of site data quickly. They can play a role in ESAs by providing information on the presence, type, and general location of contamination which can help focus more precise sampling activities. Moreover, at some sites the health risk posed by the upward migration of hydrocarbon vapors through the vadose zone is greater than the risk posed by groundwater contamination. Vapor-phase pathways of contaminant migration are especially important where there are thick unsaturated zones and subsurface structures (*e.g.*, basements, parking garages). Information obtained in these surveys can also help in the design of remediation technologies such as soil vapor extraction. A complete discussion of the types of soil-gas surveys and their applicability to UST sites is presented in Chapter IV.

For all site assessments, at least one type of media--soil, soil gas, or groundwater--must be sampled. Selection of the appropriate sampling tools depends primarily on site conditions, sample depth, local geology, availability, and cost. Direct push (DP) tools (steel rods that are pushed or driven into the ground) can be used in unconsolidated materials to collect these samples or to take *in situ* measurements using specialized DP probes. At other locations, an air rotary or hollow stem auger (HSA) drilling rig may be required. A complete discussion of DP applicability and associated sampling equipment appears in Chapter V.

As mentioned earlier, an ESA requires the use of field analysis. Selection of the appropriate method(s) for a particular site will depend on a variety of factors including the analyte to be measured, the quality of the data, the ease of its use, as well as cost, availability, and the speed with which it provides the data. Typically, an ESA utilizes several analytical methods of varying quality on a large number of samples in order to increase resolution of the contaminant plume. Examples of commonly used methods include immunoassay test kits, colorimetric test kits, and portable gas chromatographs (GC). These methods and selection criteria are discussed in Chapter VI.

Acquiring access to properties neighboring a leaking underground storage tank (LUST) site is an issue of concern in many site assessments, whether expedited or conventional. Often, property owners will deny access to site investigators, and legal methods must be pursued in order to collect soil, soil-gas, and/or groundwater samples. When conducting an ESA, it is best to acquire permission to sample neighboring properties, and any necessary permits, prior to mobilization. Although, acquiring access prior to mobilization may not always be possible, ESAs will continue to have at least two advantages over CSAs. First, it is often easier to convince a property owner to allow investigators to collect samples over a short period of time (*i.e.*, hours or days) as opposed to allowing access for several mobilizations over a period of weeks or months. Second, by conducting an ESA, investigators will know within days whether they will require off-site access. When conducting a CSA, this information may not be known until much later.

Step 5: Implement On-Site Iterative Process

The on-site iterative process depicted as Step 5 in Exhibit II-2 is unique to ESAs. As more data are obtained, the field manager refines the conceptual model. Although CSAs contain iterative processes, it is the ESA process that requires this work to be completed on-site during a single mobilization. The on-site iterative process is made up of two substeps: Collecting and analyzing the data, and evaluating the data to refine the conceptual model. If, during the course of the investigation, the field manager discovers that the sampling tools and/or analytical methods are inappropriate for the site conditions, he/she can amend the data collection and analysis program. Several iterations of this process can be completed in a day and, when this method is applied with the appropriate tools, a typical gasoline station site can usually be completely assessed in two to four days.

Substep 1: Collect And Analyze Data

The data collection and analysis program is an intensive, short-term, field investigation. The program and conceptual model are refined based on on-site measurements and observations. In order to ensure that these measurements are accurate, the field manager checks the field-generated data, usually by developing a quality control (QC) plan for the methods used. Examples of QC include instrument calibration, blank results, and control samples. In addition, field managers should check data by comparing results from different analytical methods (*e.g.*, field GC with immunoassay test kit) or by comparing results from other media. The validation process is important for the development of the conceptual model because it helps to resolve anomalous data.

Substep 2: Evaluate Data And Refine Conceptual Model

A key aspect of an ESA is the regular evaluation and refinement of the conceptual model. As the initial sample collection and analysis is conducted, certain conditions are anticipated based on the initial conceptual model. These conditions may include the concentrations and locations of contaminants, soil type, or depth to groundwater. As measurements are taken, variances become apparent between anticipated conditions and actual measurements. The conceptual model is then refined to include the current measurements and minimize the variances.

Modify The Data Collection And Analysis Program

If, after refining the conceptual model, the field manager determines that the methods used to collect and analyze data are not appropriate, then he/she must modify the collection and analysis program. Modification may involve selecting different sample collection technologies or different analytical methods. For example, a DP rig may be unable to penetrate semi-consolidated material located on the site and a HSA rig may be needed, or a contaminant that was not expected (*e.g.*, a solvent) may be discovered, necessitating the use of new field analytical methods. Because all the analysis is completed on site in an ESA, timely modification of procedures is possible. Various analytical methods should, therefore, be readily available so that procedures can be quickly changed if necessary.

Complete Expedited Site Assessment

An ESA is complete when the conceptual model:

- Fits the regional geological/hydrogeological setting;
- Is consistent with data collected; and
- Can be used to predict subsurface conditions.

Sometimes a technical reviewer who has not been part of the field team can provide an objective evaluation of how well the conceptual model correlates with the site data.

Step 6: Consider Interim Remedial Actions

One of the major advantages of an ESA is that it makes rapid and accurate interim remedial actions possible. These actions should follow state guidance (*e.g.*, preapproval may be required), however, many times remedial measures can take place immediately after the field work of an ESA is completed and before a formal report is submitted. For instance, an ESA may define the location of a significant quantity of free product or it may indicate that a contaminant plume is approaching a public drinking well. Because a formal report may take two weeks to write and review of the report may take longer, an interim remedial action can prevent a significant quantity of contaminants from spreading. If appropriate actions are undertaken in a timely manner, potential adverse affects to human health and the environment can be avoided, and the long-term cost of remediation can be minimized.

Step 7: Report The Findings

As with any site assessment, a report is written when the field work is completed. Because a greater quantity of data will be collected with a ESA than is possible with a CSA, an ESA should provide a more comprehensive representation of the site conditions. An ESA report will demonstrate an understanding of the 3-dimensional distribution of contamination, define the geological/hydrogeological site conditions, and identify migration pathways and points of exposure. As a result, ESAs provide a better basis for selection of appropriate corrective action options in significantly less time than is required with CSAs.

Conventional And Expedited Site Assessment Examples

The following is an example of how a well planned CSA and an ESA would proceed at the same site. The scenario is based on two actual assessments at one site, however, the details have been modified in order to provide the reader with a comparison. The CSA focused on installing a limited number of groundwater monitoring wells as part of a multiple-phase assessment. The ESA focused on a 3-dimensional definition of site conditions to develop and refine the conceptual model.

Release Scenario

In 1995 an UST system was being replaced at a service station in order to meet the 1998 tank upgrade requirements. The system consisted of two 10,000-gallon steel tanks and piping that had been installed in 1965. When they were removed, both tanks and their associated piping showed signs of significant corrosion, and the soils were stained with gasoline. The pit and the piping trench were over-excavated to remove some contamination, but stained soils remained. The release was reported to the state environmental department (SED), which then ordered that a site assessment be conducted.

Step 1: Establish Site Assessment Objectives (ESA And CSA)

The objectives for this assessment are the same for both an ESA and a CSA: Define the source area, characterize the site geology/hydrogeology, and delineate the extent of contamination in soil and groundwater. In addition, the major migration pathways and points of exposure also need to be determined in order for the state and the owner to make corrective action decisions.

Step 2: Review Existing Site Information (ESA And CSA)

In both the ESA and the CSA for this site, a review of background information was completed, however, the focus differed. In the CSA, information was reviewed in order to select the best location of three monitoring wells. In the ESA, the background information was reviewed in order to develop a 3-dimensional conceptual model of site conditions which were then plotted on maps and used to guide the investigation.

Site Interviews

The current owner stated that he bought the facility in 1984 and did not have any information about the use of the site prior to 1965. He knew that the tanks and piping were in need of upgrading but had no indication that they were leaking. Five tank and line tightness tests had been performed between 1988 and 1994, and none indicated a problem. The owner was not aware of any noticeable inventory losses. He was also not able to locate any site plans that would indicate migration pathways.

Employees stated that they did not notice any obvious inventory losses. However, after the tank and piping were removed, the employees did notice significant corrosion on the north side of the tank and on some of the pipes. The employees also stated that all product lines were removed.

Site Geology

Since two 10,000-gallon tanks had just been excavated, the geologist had a clear view of the site stratigraphy. The excavation was 20 feet deep, 30 feet long, and 25 feet wide. The soil was composed of silt and clay, and it appeared to have a low hydraulic conductivity. The pit did not intercept groundwater.

Inventory Records Search

Inventory records were analyzed but did not prove helpful because of incomplete and inconsistent information.

Receptor Survey

A survey of potential downgradient receptors indicated no wells within 0.5 mile, but several industrial buildings with basements were located nearby.

Other Environmental Investigations

The site assessment personnel reviewed state corrective action reports for possible upgradient sources and for regional geological information. They found a report from a LUST site 0.5 mile upgradient. In reviewing the report, the site assessment personnel noted that buried stream channels existed in the region.

Geologic Reports

Site assessment personnel reviewed USGS maps and reports, State Geologic Survey, Soil Conservation Service, and the local Water Service and found:

- Regional depth to groundwater is 20 to 30 feet below ground surface (bgs);
- Regional groundwater flow is to the north;
- Silts and clays are the predominant regional soil type; and
- Buried stream channels occur within the silts and clays and have a northwest regional orientation.

Step 3: Develop Initial Conceptual Model Of Site Conditions (ESA And CSA)

Based on the review of existing regional and site data, investigators developed an initial conceptual model of the site geology, hydrogeology, nature and extent of contamination, contaminant migration pathways, and points of exposure. This initial conceptual model is presented in Exhibit II-4. For the CSA site assessment personnel used this information to locate monitoring wells, to determine the approximate depth to be drilled, and to analyze data when available. For the ESA, the field manager incorporated the information onto site maps in the field as the assessment proceeded. These maps served as a basis for the working hypothesis of the site geology, hydrogeology, and extent of contamination. Sample locations were selected to test these hypotheses and resolve anomalies while on site.

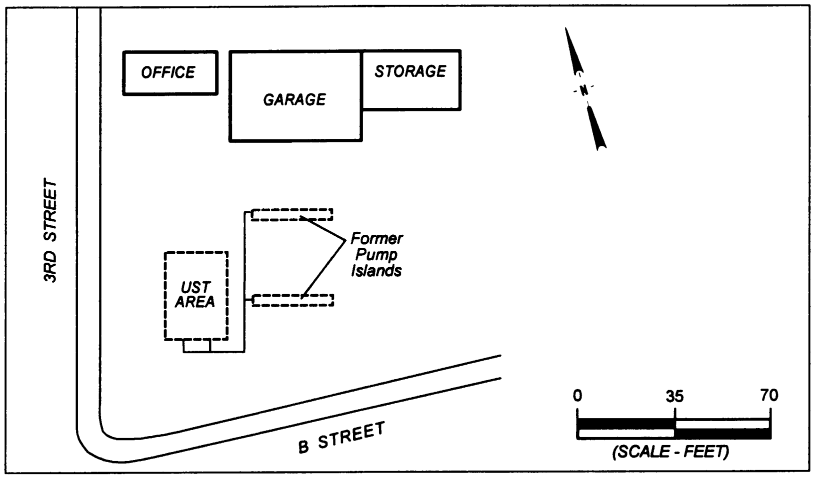
Geology

Regional fluvial deposits are oriented NW. Sands in these units are typically 2 to 15 feet thick and are surrounded by silt and clay. Granitic bedrock occurs at a depth of approximately 500 feet bgs.

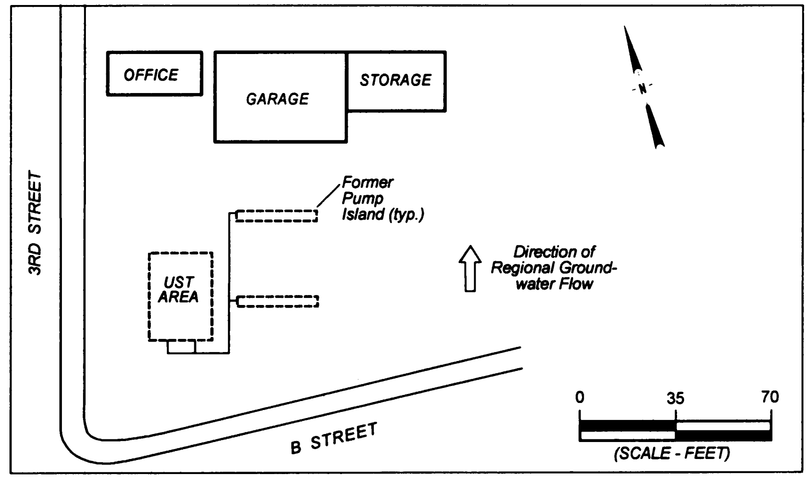
Hydrogeology

Unconfined groundwater occurs regionally within the unconsolidated sediments at depths ranging from 20 to 30 feet bgs. Regional groundwater flows

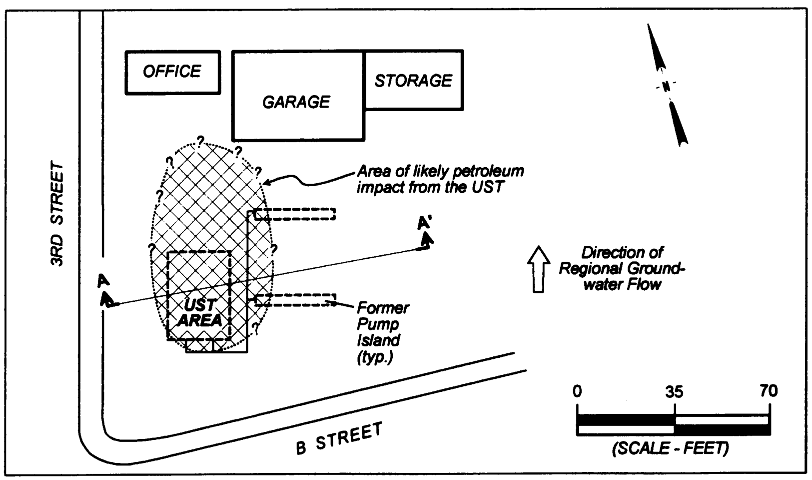
Exhibit II-4
Initial Conceptual Model (Both CSA and ESA)



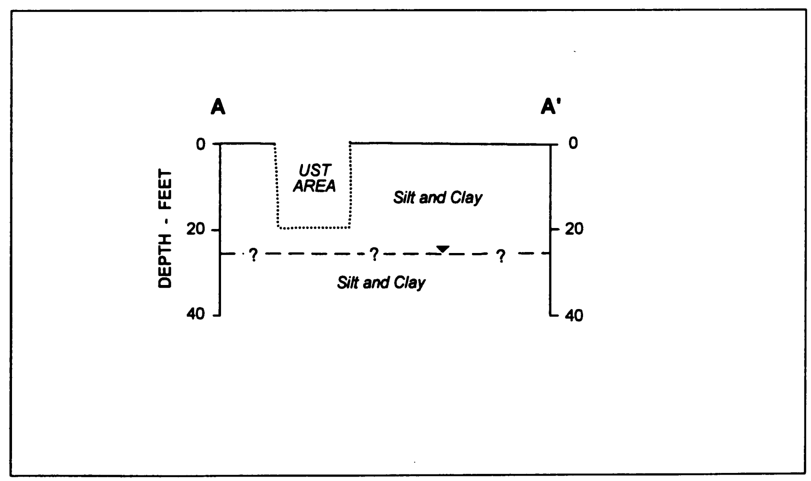
a. SITE PLAN



b. REGIONAL GROUNDWATER FLOW DIRECTION



c. AREA OF LIKELY PETROLEUM IMPACT FROM THE UST



d. CROSS SECTION A-A'

to the north, however, localized groundwater flow patterns occur through more permeable buried stream channels.

Source Area And Extent Of Contamination

Locations of the tanks, subsurface piping, on-site utility lines, and areas of artificial fill were compiled onto the site map. The relative magnitude of the petroleum release was estimated to be small (perhaps 300 gallons) because no significant loss of product was noticed, and field observations indicated a slow leak. The extent of contamination was believed to be contained on-site if the plume had not reached a buried stream channel. If a preferential pathway had been intercepted by the plume, contamination may have migrated off-site.

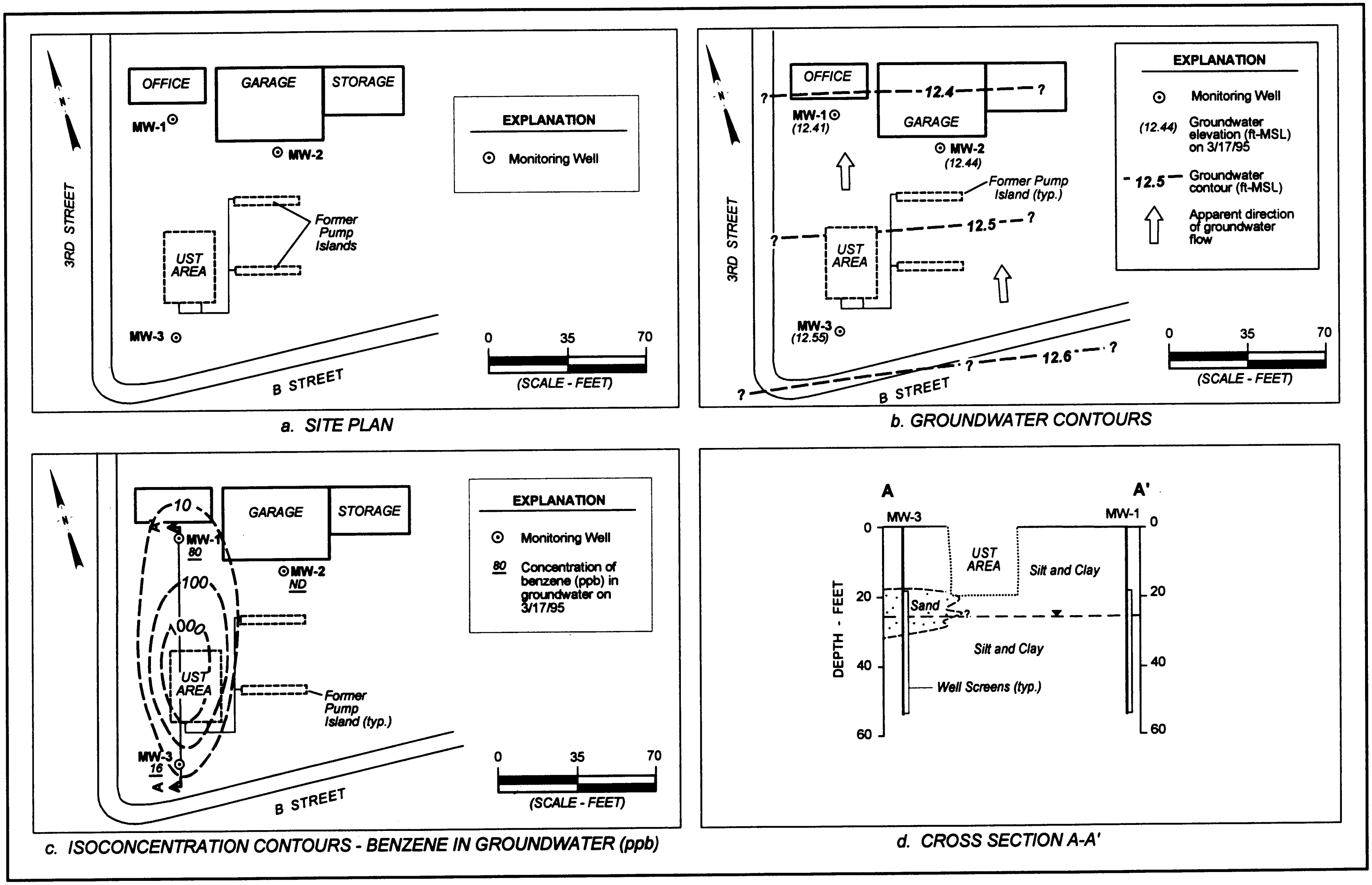
Step 4: Design Data Collection And Analysis Program (CSA)

Before beginning the field investigation, the site assessment managers must develop a data collection and analysis program for the field work. This program is also referred to as the initial work plan. From this point, the two site assessments begin to differ. The remainder of the CSA is presented first. The results are compared with the summary of the ESA that follows.

Conventional Site Assessment Work Plan

A hollow stem auger (HSA) drill rig was selected to collect soil samples and install 4-inch monitoring wells. Two wells would be installed downgradient from the USTs and pump islands, and a third would be installed upgradient from the tank excavation. Because the direction of regional groundwater flow is to the north, the wells would be placed in the locations designated on the map in Exhibit II-5a. A split-spoon sampler would be used to collect soil every 5 feet and, if screening analysis with a portable flame ionization detector (FID) indicated contamination, samples would be sent off-site for laboratory analysis. If no contamination was indicated through FID screening, a soil sample close to the water table would be sent to a laboratory. All soil samples would be logged with information about the vadose zone (*e.g.*, thickness, soil type, porosity, structure, stratigraphy, heterogeneities, moisture content, and location of contaminants). Groundwater samples from the three wells would also be analyzed off-site. Soil samples would be analyzed for both BTEX and TPH, while groundwater samples would be analyzed for BTEX.

Exhibit II-5
Final CSA Conceptual Model (First Phase)



Step 5: Field Work (CSA)

During days one and two, the three monitoring wells (MW) were installed. Soil profiles from the two downgradient monitoring wells indicated only silt and clay sediments. The soil profile from the upgradient monitoring well (MW-3) indicated 10 feet of sand starting at 20 feet bgs. No soil contamination was detected at any of the locations; therefore, only three soil samples (one from each boring) were collected and sent off-site for further analysis.

On the third day, the geologist returned with an assistant to develop the wells. On the fourth day the groundwater level in MW-3 had fully recovered (because it was screened in sand) and was sampled. The two downgradient wells screened in silt and clay took a week to recover. All wells were then sampled, including MW-3 for a second time. The geologist received the laboratory analytical results four weeks after samples were collected (standard turnaround time) and then spent another week preparing a report for the SED and facility owner.

Step 6: Consider Interim Remedial Actions (CSA)

Prior to the assessment, the SED requested that the tank pit and piping trenches be over-excavated in order to remove contaminants from the source area. Because so little information was obtained from the CSA, the site assessment manager could not recommend additional interim remedial actions.

Step 7: Report The Findings (CSA)

The geologist submitted the report eight weeks after the assessment was requested. The maps in Exhibit II-5 show the findings. The major conclusions of the report are as follows:

- Groundwater depth is 26 feet bgs, and the flow appears to be north.

- The extent and quantity of contamination at this site is unknown.

- Additional investigation is needed in neighboring properties to better delineate the contaminant plume.

- The extent of the sand lens penetrated by MW-3 should be further investigated.

Step 4: Design Data Collection and Analysis Program (ESA)

The ESA used a very different process from the CSA; as a result, the findings of the ESA were more complete. The scope of work of the ESA included the following equipment and activities.

Direct Push Sampling

The field manager selected a DP rig for sampling of soil and groundwater because the subsurface materials were unconsolidated and the depth of investigation was relatively shallow. A cased system (Chapter V, Direct Push Technologies) was selected because of its capability to quickly collect continuous core samples. In unconsolidated material, this equipment can generate up to 200 feet of continuous cores per day.

Field Analysis

After obtaining permission from the state environmental department, the field manager contracted the services of a certified mobile laboratory to perform the analytical testing using state approved methods. Soil samples would be analyzed for both BTEX (by the mobile laboratory using EPA Method 8021 (GC/PID)) and total petroleum hydrocarbons as gasoline (TPH-g) (using Modified EPA Method 8015 (GC/FID)), while groundwater samples would be analyzed for BTEX only. The mobile laboratory selected could process up to 25 samples/day.

Soil Screening

All soil samples would be screened in the field for total organic volatiles (TOVs) via ambient air measurements using an FID. An FID was used because of its high sensitivity to gasoline vapors (0.1 ppm_v). Soil samples would be analyzed by the mobile laboratory either whenever soil screening indicated contamination or just above the water table if soil screening did not indicate contamination.

Groundwater Sampling

Groundwater samples would be collected and analyzed by the mobile laboratory at every probe location. Between six and eight temporary monitoring points would also be installed with DP equipment in order to determine hydraulic gradient and obtain groundwater samples over time.

Physical Properties

Continuous cores would be collected at each probe location. Every core would be logged and recorded by a geologist. Logs would include the vadose zone thickness; soil type and estimate of porosity; structure; stratigraphy; heterogeneities; moisture content; and location of constituents of concern. In addition, soil samples would be collected for off-site analysis of total organic carbon (TOC), bulk density, and moisture content to make more accurate estimates of contaminant migration potential. The aquifer flow direction and gradient would be determined from water level measurements, and hydraulic conductivity would be determined from slug tests conducted with 1.5 inch temporary monitoring points. Groundwater quality indicators (*e.g.*, pH, total dissolved solids, electrical conductivity) would be measured using portable meters. Dissolved oxygen would also be measured, using a flow-through cell, to provide information about biodegradation of petroleum compounds. Groundwater samples would also be sent to an off-site laboratory for analysis of biodegradation indicators (NO_3, SO_4, Fe, Mn^{2+}, CH_4, and CO_2). These parameters would help evaluate the potential for contaminant migration and biodegradation.

Communicating Project Status

The field manager agreed to update the owner and SED with the status of the ESA at the end of each field day. The field manager had a pager and portable telephone to communicate with all project participants whenever necessary.

Permits

The field manager obtained the necessary permits for drilling borings with DP probes and installing monitoring points. The field manager also obtained an encroachment permit from the city and filed a traffic plan with the county public works department in order to collect samples off-site under 3rd Street and B Street, if necessary.

Utility Clearance

Delineating the location of on-site utilities had already been completed for the tank excavation, however, the field manager suspected that a few off-site samples would be needed. A utility service was contacted and returned to the site to delineate the surrounding off-site utilities. This activity was supervised by the field manager so that the areas to be sampled would be well marked.

Step 5: Implement On-Site Iterative Process (ESA)

The field investigation was completed in 3 days by using the iterative process depicted in Exhibit II-2. Soil and groundwater samples were collected and analyzed; the conceptual model was refined on-site; and subsequent sampling and analysis helped to finalize the assessment.

Day 1: Conduct Initial Investigation

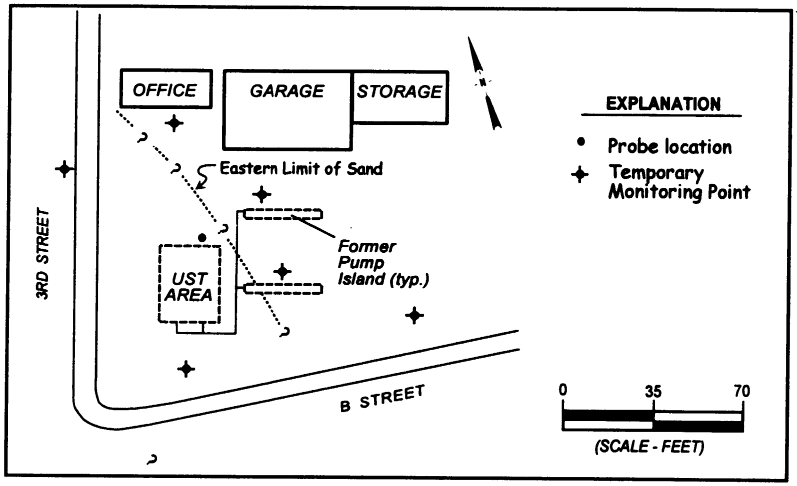
On the first day of the field investigation, the following activities were conducted:

- Continuous soil cores were collected and logged at seven locations to a depth of 20 to 40 feet.
- Six 1.5-inch-diameter temporary monitoring points were installed to measure the groundwater elevation and to define groundwater flow direction.
- Twenty soil samples were analyzed for BTEX and TPH by the mobile laboratory.
- Seven groundwater samples were collected and analyzed for BTEX by the mobile laboratory.
- Three soil samples were collected and preserved for off-site analysis of total organic carbon (TOC), bulk density, and moisture content to evaluate the potential for contaminant migration.
- Two groundwater samples were collected and preserved for off-site analysis of water quality to evaluate *in situ* biodegradation of contaminants. Dissolved oxygen was measured in the field.

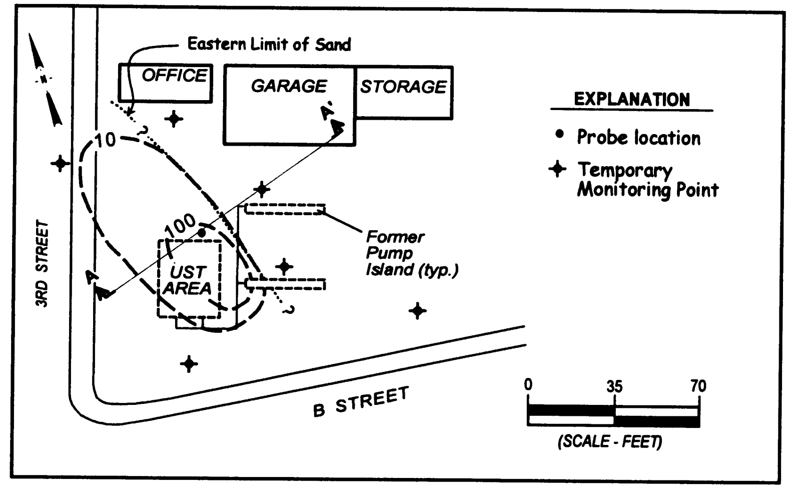
Information obtained on Day 1 was compiled on field drawings shown in Exhibit II-6. The key findings included the following:

- The UST area was the major source of contamination. Soil below the tanks was contaminated with gasoline, and an inch of free product was discovered above the water table.

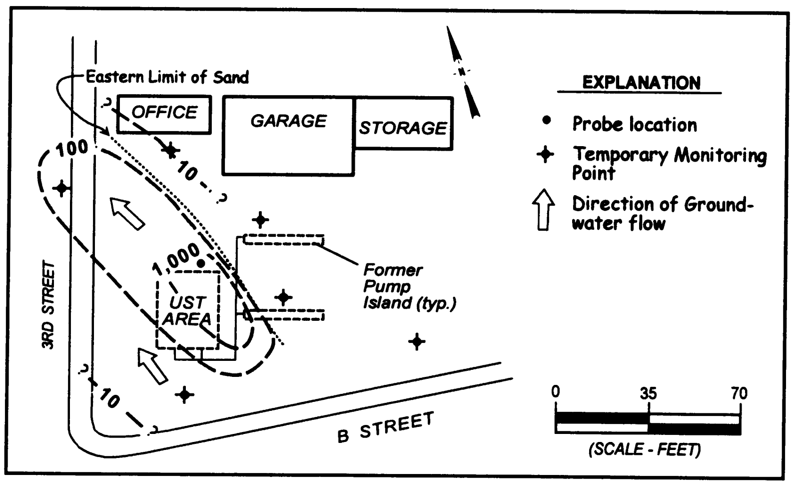
Exhibit II-6
ESA Conceptual Model After Day 1



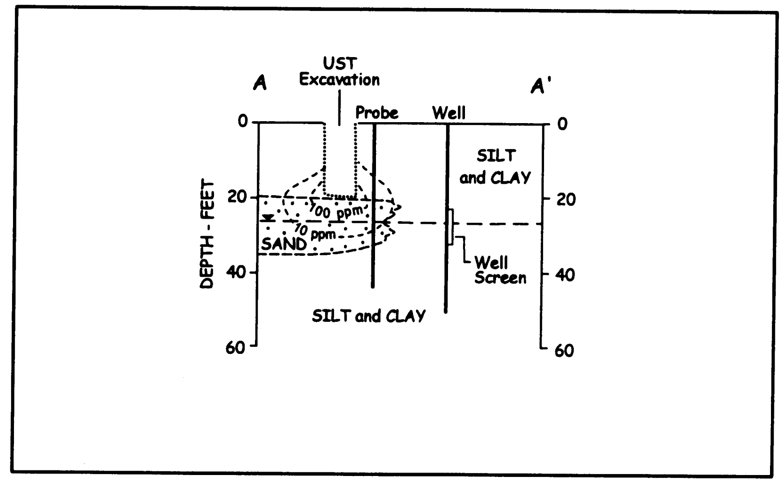
a. SITE PLAN



b. BTEX IN SOIL @ 20' (ppm)



c. ISOCONCENTRATION CONTOURS - BENZENE IN GROUNDWATER (ppb)



d. CROSS SECTION A-A' WITH BTEX IN SOIL

- Although there was significant contamination around the dispensers and piping, petroleum had not migrated to the water table in this area because of the low hydraulic conductivity of the surrounding soils.

- A buried stream channel was defined at depths between 20 and 33 feet bgs in four locations.

- Isoconcentration contours of benzene in the groundwater samples clearly indicated a northwest orientation and probable migration of dissolved contaminants within the sand unit.

Indications of a possible off-site source were also discovered. Benzene concentrations in groundwater upgradient from the former UST area were anomalously high, and the chromatograms indicated a higher ratio of toluene to benzene than from the sample downgradient from the UST area.

Days 2 And 3: Refine Conceptual Model

Characterization of the site continued on Days 2 and 3 to refine the conceptual model. The information was compiled on-site maps presented in Exhibit II-7. By the end of Day 3:

- Seventeen additional continuous core samples were collected.

- Two additional temporary monitoring points were installed.

- Fourteen groundwater samples were analyzed by the mobile laboratory.

- Twenty-five soil samples were analyzed by the mobile laboratory.

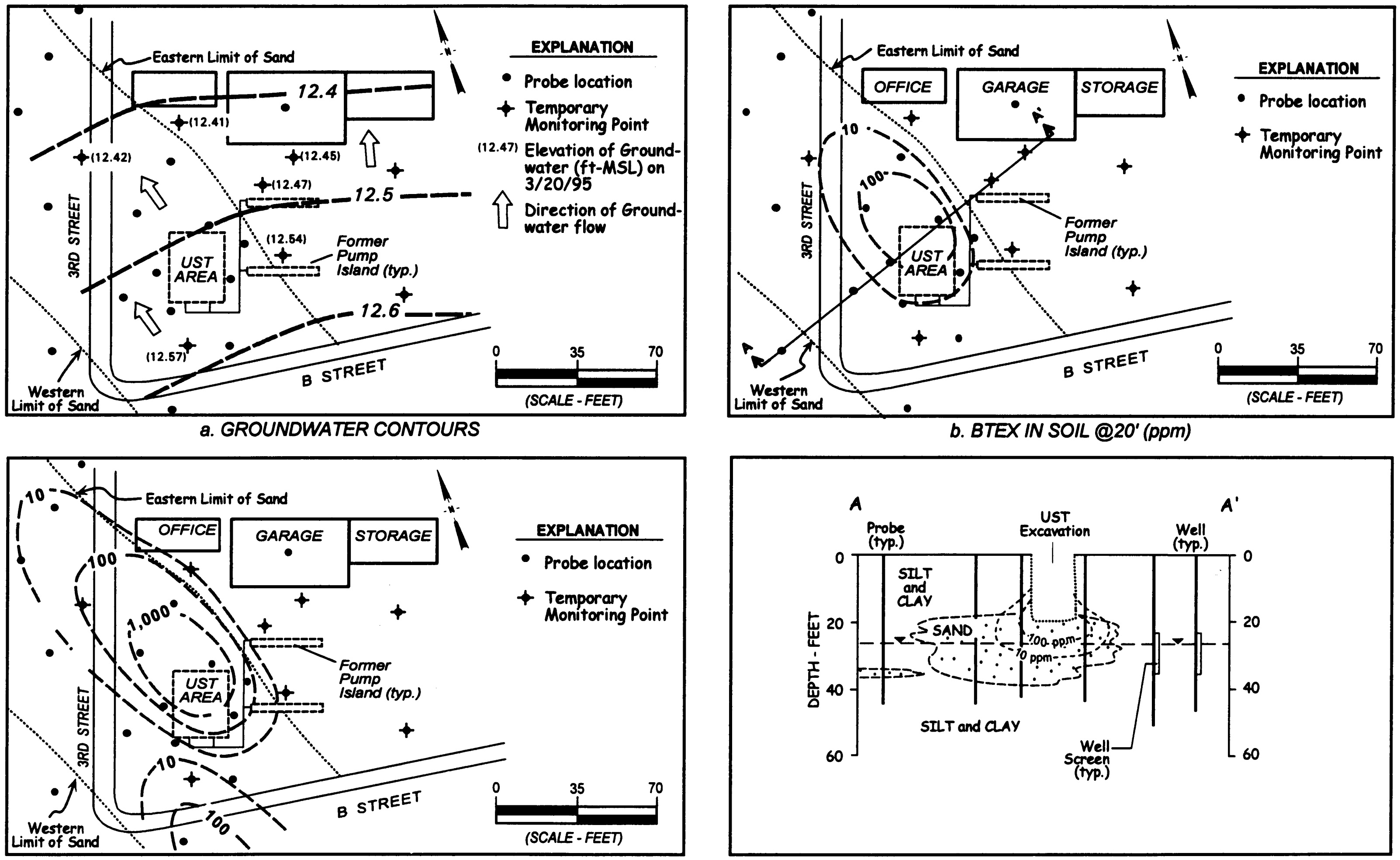
By the end of Day 3, the following information was determined:

- The eastern and western limits of the buried stream channel were defined.

- The eastern and northern portions of the site were shown to be underlain entirely by silt and clay. Groundwater was not contaminated in these locations.

- Contours of BTEX in soil showed that the highest levels of contamination were directly beneath the former UST excavation. Analysis of groundwater samples showed that the dissolved plume of benzene extended off-site toward the north-northwest, beneath 3rd Street.

Figure II-7
Final ESA Conceptual Model After Day 3



a. GROUNDWATER CONTOURS

b. BTEX IN SOIL @20' (ppm)

c. ISOCONCENTRATION CONTOURS - BENZENE IN GROUNDWATER (ppb)

d. CROSS SECTION A-A' WITH BTEX IN SOIL

- The tank backfill material was found to be in direct contact with a buried stream channel.

- Two more soil and groundwater samples were collected upgradient from the site to investigate the anomalous analytical data collected during Day 1. Although the soil samples were clean, the groundwater samples confirmed the initial suspicion of an off-site source.

- Water elevations measured in the temporary monitoring points indicated that groundwater within the silt and clay flows toward the north, consistent with the regional groundwater flow direction. As expected, groundwater in the buried stream channel flowed toward the northwest.

- Low dissolved oxygen levels were found in the core of the plume. There was also a significant reduction in dissolved BTEX concentrations in groundwater downgradient from the USTs.

Finalize Conceptual Model

By the end of the third day, the conceptual model had been developed in sufficient detail to meet the objectives of the project. No anomalies remained, and new DP probes yielded expected geologic information and analytical results. Moreover, the site data, including the geologic units, groundwater depth and flow direction, and upgradient impacts, were consistent with the regional setting.

Decommission Site

Before de-mobilizing, two of the eight temporary monitoring points were removed, and the resulting holes were filled with bentonite grout. The remaining six temporary monitoring points were left in place for one year (to provide additional groundwater elevation and analytical data) before they were removed.

Step 6: Consider Interim Remedial Actions (ESA)

After evaluating the data obtained in the three-day ESA, the field manager consulted with the SED to determine if any interim remedial actions should be taken. Since the contaminant plume did not pose an immediate threat to human health or the environment, and free product was not likely to spread significantly before a permanent corrective action technology was selected and implemented, they decided that there was no need to take additional interim remedial actions beyond the over-excavation of the contaminated soil in the tank pit and piping trenches that had occurred prior to the assessment. Because of the limited volume of gasoline discovered at the site, the SED determined that free product recovery was not appropriate to implement.

Step 7: Report The Findings (ESA)

Two weeks after the field work was complete, the field manager submitted a report to the SED and the site owner. The main findings for this investigation were:

- The USTs were the primary source of contamination. Contamination around associated piping was not continuous to groundwater.
- Approximately 600 gallons of petroleum had been released. An inch of free product was on the water table, and a dissolved plume had migrated off-site. The areal and vertical extent of BTEX concentrations in soil and groundwater was defined.
- A buried stream channel was the primary migration pathway for the petroleum release.
- A potential upgradient source of dissolved hydrocarbons was identified.
- *In situ* biodegradation of petroleum hydrocarbons is occurring beneath the site.

Analysis Of Conventional And Expedited Site Assessments

The ESA presented in this example cost significantly more than the CSA; however, the CSA is only an initial investigation and would require at least one more mobilization (probably two or three) for the site to be adequately characterized. In contrast, the ESA is complete. The one report would be enough for a regulator and facility owner to make effective corrective action decisions. A direct comparison of the costs is, therefore, not possible with the data provided. However, if the CSA was completed to provide enough information to make an accurate corrective action decision, the number of wells and the analyses would have probably cost significantly more than the ESA.

The primary advantage of an ESA is that it provides the user with rapid, accurate information about the extent of contamination and migration pathway so that effective remedial decisions can be made after only one mobilization. Although the initial cost of an ESA is often higher than the first phase of a CSA, the final cost is often much less. These savings are the result of:

- Characterization of a site in a single mobilization;
- Optimal placement of permanent monitoring wells;
- Effective corrective action measures being undertaken and optimized (*e.g.*, improved location of air sparging points and soil vapor extraction wells);
- Reduction in the administrative costs of writing and reviewing reports; and
- Reduced sampling and analysis of unnecessary and poorly placed monitoring wells.

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