PROPOSED WORK PLAN
SITE CHARACTERIZATION AND ANALYSIS PENETROMETER SYSTEM PROJECT
NAVAL AIR STATION ALAMEDA

Prepared for

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1.0 INTRODUCTION

The Department of the Navy, Naval Command, Control and Ocean Surveillance Center, RDT&E Division (NCCOSC) has developed a fiber optic sensor system for detection of petroleum hydrocarbons that has been integrated with a cone penetrometer system for use in real-time, subsurface screening of petroleum, oil, and lubricant (POL). This Site Characterization and Analysis Penetrometer System (SCAPS) provides a capability for real-time measurements of POLs to depths up to 150 feet (45 meters) with a vertical spacing of approximately 1 inch (2 centimeters) as the probe is pushed into the ground at a rate of 3 feet/minute (1 meter/minute). A principle advantage of SCAPS over traditional hollow-stem auger collected samples and subsequent laboratory analysis is that the extent of subsurface petroleum hydrocarbon contaminant plumes can be delineated in a more timely and accurate manner because the method provides much improved real-time vertical spatial resolution (centimeter scale) of the distribution of the contaminant. This provides for more timely and accurate estimates of the location and volume of material that may require remediation.

Pursuant to agreement between NCCOSC and Department of the Navy, Western Division, Naval Facilities Engineering Command (WESTDIV), this proposed work plan describes the SCAPS and the investigative methods proposed for subsurface investigation of hydrocarbon impacts at Site 13, the former oil refinery at Naval Air Station (NAS) Alameda, located in Alameda, California.

The overall objectives of the use of the SCAPS at Alameda include the following:

1. Preliminary delineation of the vertical and lateral extent of POL at the NAS Alameda, Site 13 former oil refinery;

2. Comparison of the data obtained using the SCAPS to the results obtained during previous investigations at the former oil refinery; and

3. Comparison of data collected with the SCAPS to samples collected by traditional hollow stem auger techniques and subsequent laboratory analysis. It is understood that WESTDIV will conduct remedial investigation activities at Site 13 to be based, in part, on the SCAPS data. The remedial investigation activities will include use of a hollow stem auger drill rig to collect soil samples and subsequent analysis of the soil samples by traditional U.S. Environmental Protection Agency (EPA) techniques.

2.0 BACKGROUND

This section describes general background information regarding Naval Air Station Alameda.

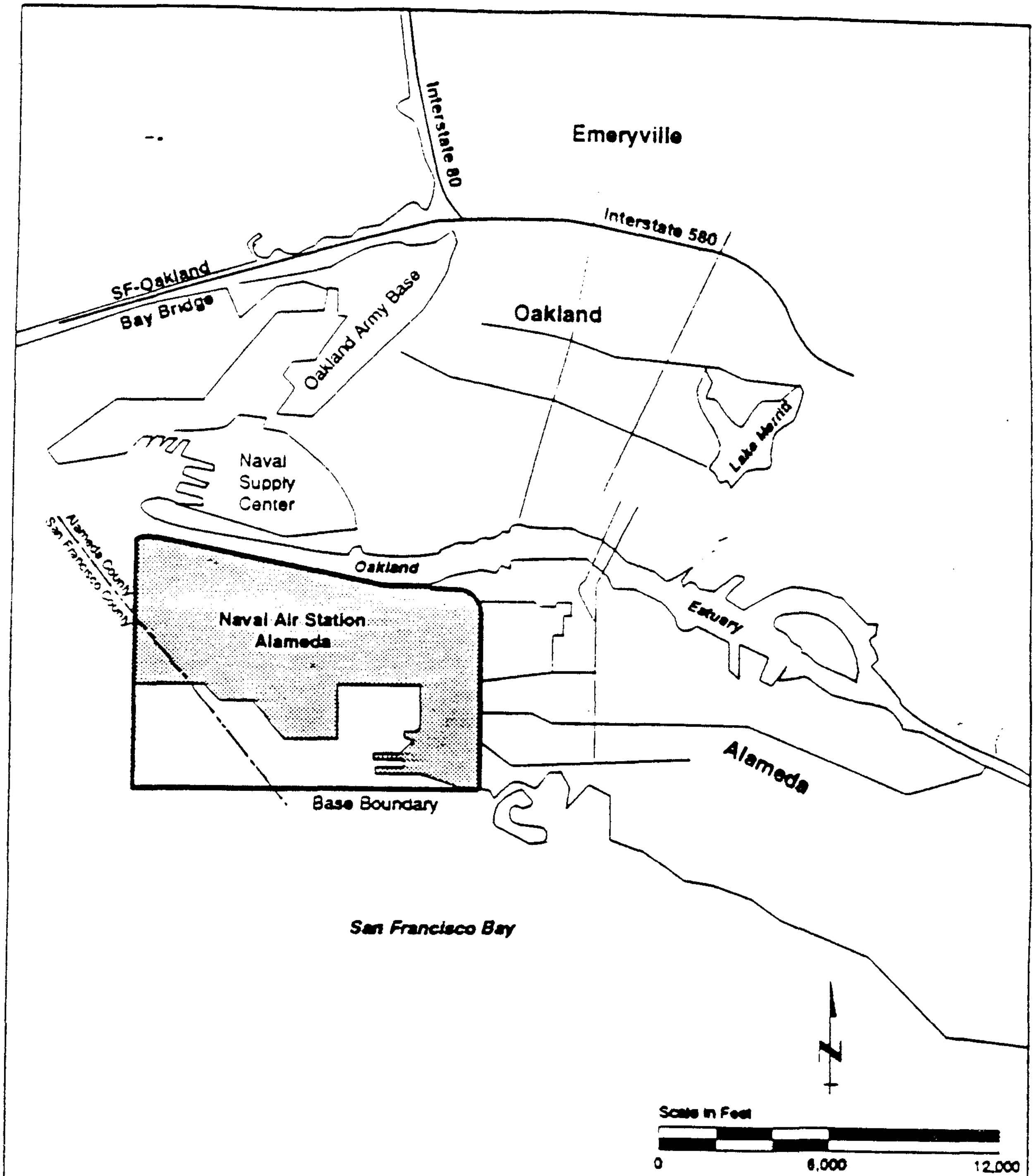
2.1 SITE LOCATION

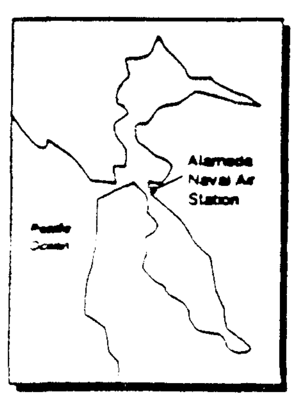
Naval Air Station Alameda is located at the western end of Alameda Island, in Alameda and San Francisco counties, California. The general location of Alameda Island is depicted on Figure 1. Alameda Island lies along the eastern side of San Francisco Bay, adjacent to the city of Oakland. The air station occupies 2,634 acres and is approximately 2 miles long and 1 mile wide. Most of the eastern portion of the air station is developed with offices and industrial facilities; runways and support facilities occupy the western portion of the station.

Originally a peninsula, the land that is now Alameda Island was isolated from the mainland in 1876, when a channel was created through the tip of the peninsula, linking San Leandro Bay with the main portion of San Francisco Bay. Dredging was conducted to deepen the canal and allow commercial and industrial traffic to and from the island's early industrial sites. These sites included a borax processing plant and an oil refinery, the Pacific Coast Oil Refinery, which is now known as Site 13, former oil refinery.

The U.S. Army acquired the land from the city of Alameda in 1930 and began construction activities in 1931. In 1936, the U.S. Navy acquired title to the facility and began construction of the air station in response to the military buildup in Europe prior to World War II. After entry of the U.S. into the war in 1941, more land was acquired adjacent to the air station. Following the end of the war, the Navy returned NAS Alameda to its original mission of providing support for fleet aviation activities.

Site 13 at NAS Alameda is located as shown on Figure 2. Site 13 lies within an area formerly occupied by the Pacific Coast Oil Refinery. The refinery operated from 1879 to 1903, and refinery wastes and asphaltic residues were reportedly disposed of at the site (Canonie, 1990).

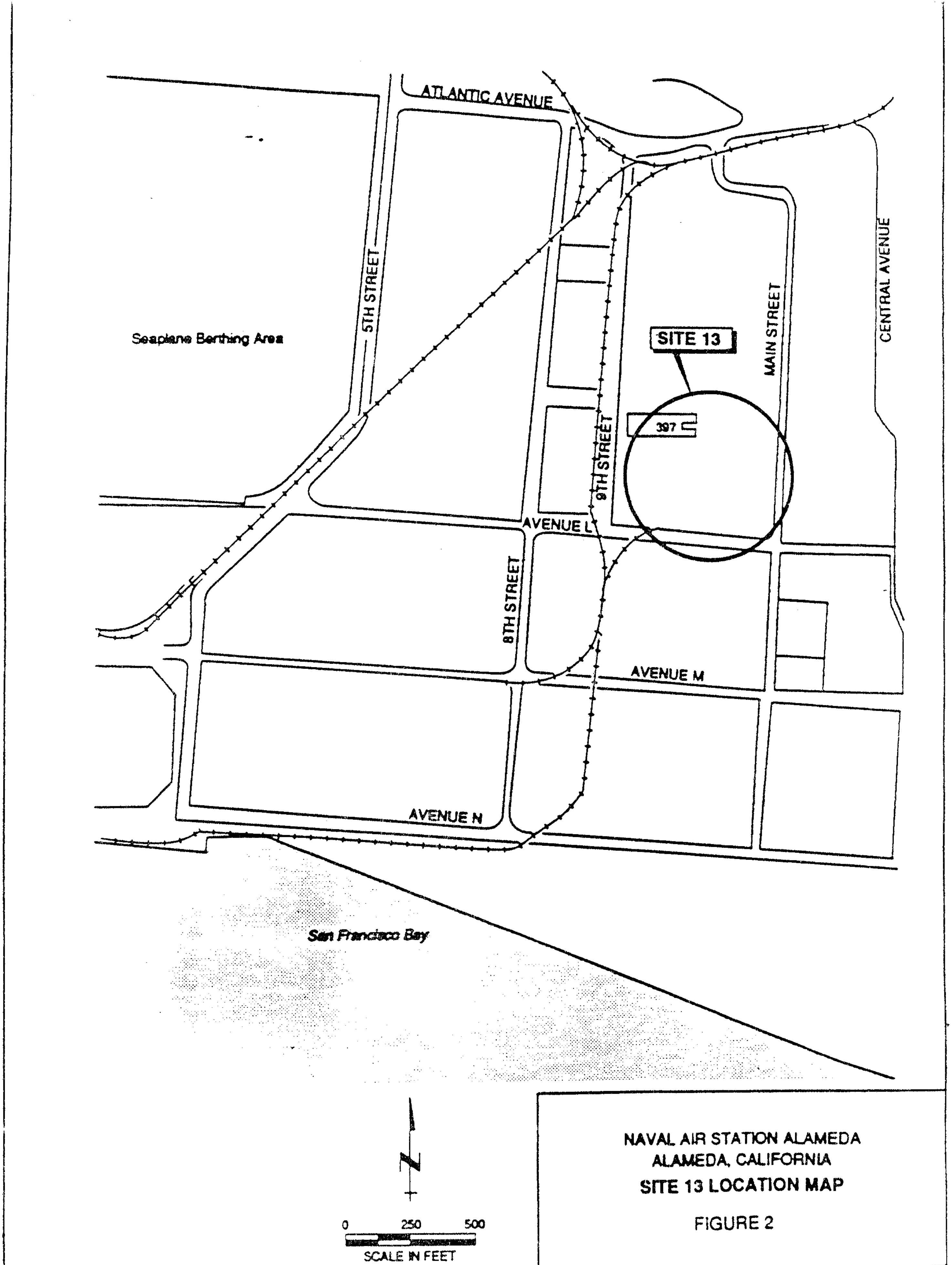




NAVAL AIR STATION ALAMEDA
ALAMEDA, CALIFORNIA

LOCATION MAP

FIGURE 1



NAVAL AIR STATION ALAMEDA
ALAMEDA, CALIFORNIA
SITE 13 LOCATION MAP

FIGURE 2

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2.2 GEOLOGY

Alameda Island is located within the San Francisco Bay basin, which lies within the Coast Range physiographic province of California. The island lies at the foot of a gently westward-sloping plain that extends from the Oakland/Berkeley Hills on the east to the shore of San Francisco Bay on the west. Alameda Island is underlain by approximately 400 to 500 feet of unconsolidated sediments unconformably overlying consolidated, Jurassic/Cretaceous Franciscan Formation bedrock (Rogers and Figuers, 1991). The unconsolidated units from oldest to youngest, are Pliocene to late Pleistocene terrestrial and estuarine deposits, late Pleistocene estuarine deposits, late Pleistocene/Holocene alluvial and eolian deposits, and Holocene estuarine deposits (Atwater et al., 1977). These units are roughly equivalent to the Alameda, San Antonio, and Posey formations; the Merritt Sand; and the Young Bay Mud described by previous authors (Trask and Rolston, 1951; Radbruch, 1957).

Alameda is a topographically flat base comprising approximately two square miles. At Site 13, the former oil refinery, hydraulic fill is approximately 10 feet thick at the western edge and thins eastward to approximately 5 feet thick. The hydraulic fill predominantly consists of dark brown to brown, silty fine sand and clayey fine sand with minor amounts of clay and gravel. The Holocene Bay Mud Unit underlies the fill in the western portion and at the southeast corner of Site 13. Where present, the Holocene Bay Mud Unit is typically encountered between 9 and 11 feet below ground surface (bgs) and consists of a dark gray silty clay with iron oxide stains near the top. Merritt Sand deposits underlie the Holocene Bay Mud Unit at approximately 12 feet bgs, where the Holocene Bay Mud Unit is present. In areas where the Merritt Sand is directly overlain by hydraulic fill, it occurs at depths between 5 and 11 feet bgs. The Merritt Sand consists predominantly of orange-brown silty to clayey fine sand. Groundwater is encountered beneath the site at approximately 6 feet bgs and is most likely under tidal influences. Figure 2 presents a location map for Site 13.

3.0 TENTATIVELY IDENTIFIED SITE

One site has tentatively been identified at NAS Alameda for potential deployment of the SCAPS. This site is Site 13, the former Pacific Coast Oil Refinery. This site has been contaminated with refinery waste. Previous investigation has indicated that soils at Site 13 have elevated levels of Total

Petroleum Hydrocarbons (TPH), volatile organic compounds (VOC), semi-volatile organic compounds (SVOC), and phenolic compounds in soils from the surface to the ground water. The petroleum hydrocarbons and SVOCs are compounds and groups of compounds that are appropriate for detection with the SCAPS. Additionally, the soil at Site 13 is considered to be sufficiently unconsolidated for penetration with the system.

4.0 SCAPS DESCRIPTION

The following sections provide a detailed description of the SCAPS.

4.1 OVERVIEW

The SCAPS includes a suite of surface geophysical equipment, survey and mapping equipment, and special penetrometers with sensors for petroleum hydrocarbon/polynuclear aromatic hydrocarbon contaminant detection. The penetrometer system is mounted in a specially-engineered truck designed with protected work spaces to allow access to toxic and hazardous sites while minimizing exposure of the work crew. The SCAPS "screening" penetrometers are equipped with sensors that can determine physical and chemical characteristics of the soil as the penetrometer tip is forced through the soil. The SCAPS includes sensors that can determine the strength and spectral properties, in this case the fluorescence, of petroleum hydrocarbon residues on soils. All sensors read out in real time, and a computer-based data collection and analysis system permits a display and partial interpretation of data in the instrument compartment on the penetrometer truck. The data analysis system also allows processing of various types of surface geophysical and mapping data collected on site, and integration of data into a unified data base. The SCAPS is also equipped to seal each penetrometer hole with grout as the investigation proceeds across a site. SCAPS is designed to save time and costs and to minimize exposure of the crew while sensor data or samples are collected. Penetrometer units available commercially do not have this combination of capabilities.

4.2 SITE MAPPING METHODS

The location of penetrometer push points will initially be determined using conventional surveying techniques. It is anticipated that during FY 1994 the SCAPS will be upgraded to include access to the

Global Positioning System (GPS) for real-time determination of push locations. For the purposes of determining the push locations at NAS Alameda, site maps provided by WESTDIV will be used to locate the positions of previous borings, subsurface structures, and currently estimated location of vadose zone and LNAPL (light, non-aqueous phase liquid) hydrocarbons.

4.3 GEOPHYSICAL INVESTIGATIONS

Geophysical site surveys are undertaken primarily to determine if there is metallic material in the area where the penetrometer unit will be operating. The geophysical techniques available for use in conjunction with the SCAPS truck are magnetometry and electromagnetic induction.

The magnetic surveys are performed utilizing a proton precession magnetometer. The proton precession magnetometer (EDA OMNI IV or Scintrex SG3) measures the absolute value of the total magnetic field intensity with an accuracy of 1 gamma (or 1 nano tesla, nT), in the earth's field of approximately 50,000 gammas. The total magnetic field intensity is a scalar measurement of the magnitude of the earth's field vector independent of its direction. The total field is a vector sum of the earth's main field and any local anomalous field component in the direction of the main earth's field. A magnetic anomaly represents a local disturbance in the earth's magnetic field which arises from a localized change in magnetization, or magnetization contrast. The observed anomaly expresses the net effect of the induced and remanent magnetization and the earth's field which usually have different directions and intensities of magnetization.

The electromagnetic induction devices are used to measure the earth's apparent ground conductivity. The responses are directly proportional to conductivity and inversely proportional to resistivity. The basic operation utilizes a transmitter coil (Tx) energized with an alternating current at an audio frequency and a receiver coil (Rx) located a short distance away. The time varying magnetic field arising from the alternating current in the transmitter coil induces currents in the earth. These currents generate a secondary magnetic field which is sensed, together with the primary field, by the receiver coil. In general, this secondary magnetic field is a complicated function of the intercoil spacing, the operating frequency, and the ground conductivity. Under certain constraints, called the low induction condition, the secondary magnetic field is a very simple function of these variables. Under these constraints, the ratio of the secondary to the primary field is linearly proportional to the terrain conductivity. The apparent conductivity indicated by the instruments depends on measurement of the secondary to primary field ratio and assumes low induction conditions. The units of conductivity are the mho (Siemen) per meter or, more conveniently, the millimho per meter.

There are two components of the induced magnetic field measured by the instrument. The first is the quadrature-phase component which gives the ground conductivity measurement. The second is the inphase component, which is used primarily for calibration purposes; however, the inphase component is significantly more sensitive to large metallic objects and hence very useful when looking for buried metal containers.

In situations where the locations of subsurface utilities are fairly well known and/or documented, NCCOSC utilizes a Schonstedt MAC-51B Magnetic and Cable Locator to field screen potential SCAPS push locations. The MAC-51B is a light-weight, dual-mode instrument designed for detecting buried iron and steel objects and tracing underground cables and pipes. The system consists of two major units, a transmitter and a dual-function receiver. When used in the cable locator mode, the transmitter generates a distinctive alternating current (AC) signal which is applied to the cable or pipe. The receiver is used to detect and trace the signal as it travels along the cable or pipe. A siren-like tone from the receiver is identified as the tracing signal. In magnetic mode, the receiver is the only unit required for operation. The MAC-51B receiver responds when the magnetic field strength at the two sensors, which are 20 inches apart, is different. This response consists of a change in the idling frequency of the signal emitted from the speaker. Switching from cable locator mode to magnetic locator mode while tracing a cable or pipe is the method for unscrambling ground clutter.

4.4 GROUTING METHODS

The SCAPS unit is equipped to backfill and destroy the penetrometer holes in accordance with applicable California regulations. NCCOSC has developed two methods to accomplish SCAPS push hole grouting. The method for grouting holes that have penetrated groundwater is known as the rod/tube injection method which involves pumping a dilute Portland cement/bentonite mixture through a plastic tube within sections of the standard push rod. To accomplish this, a standard data collection SCAPS push is advanced and then extracted from the hole. Upon extraction of the standard SCAPS probe and rod, the injection nozzle assembly with a sacrificial aluminum tip and plastic tube lined rod is advanced down the same hole. As the cement/bentonite mixture is being prepared, the injection nozzle assembly is advanced to the former maximum depth in the hole. This allows the slightly larger diameter sacrificial tip to settle in the push hole, aiding in its capture. The cement/bentonite mixture is then pumped through the plastic tube within the rod and the rod extraction process is begun as the grout mixture is pumped into the hole with an air driven double diaphragm pump from the bottom of the hole upward, ensuring the entire hole is backfilled and destroyed. In cases where groundwater will not be penetrated, and push holes remain open following probe retraction, the penetrometer cavities will be sealed using a conventional cement/bentonite grout mixer and a low-pressure progressive cavity pump for tremmie grouting of penetrometer cavities.

4.5 CELLULAR PHONES

NCCOSC has installed portable cellular phones in both the SCAPS vehicle and the auxiliary support vehicle. The cellular phones are used periodically during field operations to maintain communication between the field crew and NCCOSC, and in the event problems arise in the field that require immediate attention. The SCAPS field crew should be notified prior to initiation of field activities if there are concerns over the use of cellular phones at specific areas of the facility to avoid conflicts with official naval activities and to prepare contingency plans.

5.0 SITE CHARACTERIZATION METHODS

The major component of the SCAPS is a 20-ton, all-wheel-drive penetrometer truck that was designed specifically for operations at hazardous waste sites. The truck carries a hydraulic power unit and controls to operate the push apparatus, separated push and data acquisition work spaces, and other personnel protection features. A specially designed auxiliary vehicle is used to carry the grouting pumps, water tank, tools, spare parts, tremmie pipe, traffic cones, and other miscellaneous equipment.

The electronics package includes NCCOSC-designed and built signal-conditioning hardware and test equipment capable of providing on-site calibrations of contaminant detectors and load cells used to make penetration resistance measurements. Data acquisition and initial data processing are carried out with an on-board computer with a matching computer used for data management and file integration.

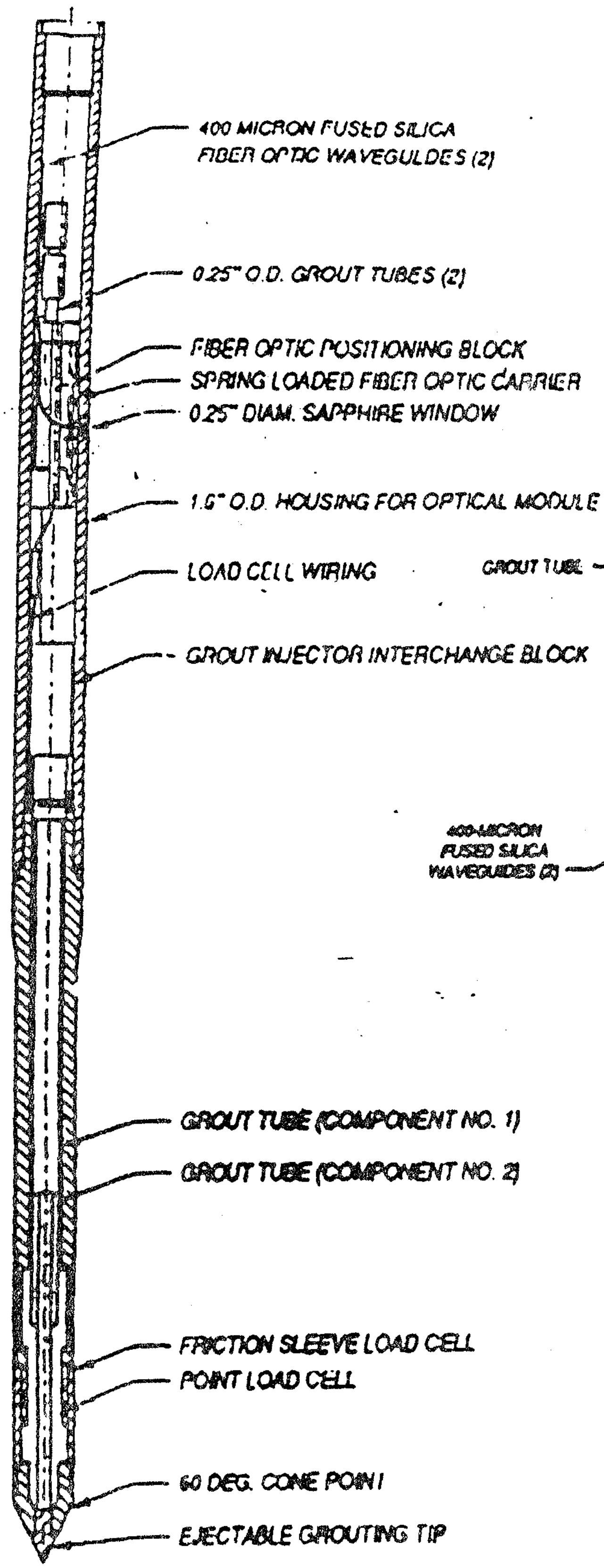
5.1 SOIL TYPE AND STRENGTH DETERMINATION

The point load cell is loaded in compression as the cone tip is advanced. The friction sleeve load cell is in the form of a hollow cylinder which is split along its cylindrical axis and strain gauged on the inside surface of the cylinder. The cell surrounds the tip load cell and is also loaded in compression when soil friction acts on the friction sleeve which jackets the front of the probe. The design employed in this soil strength unit allows the tip penetration resistance and sleeve friction to be made independently and continuously.

Techniques for using the soil strength measurements (cone tip and sleeve friction) made with the cone penetrometer to determine soil type have been well-documented (Olsen and Farr, 1986; Olsen, 1988). The classification scheme used by the SCAPS was devised by Robertson and Campanella (1989) to identify the types of soils encountered by the CPT probe. The cone resistance measurement, q_c, is recorded with a full Whetstone bridge strain gauge in terms of voltage and converted to bearing pressure typically expressed as tons/ft^2 (tsf). The cone resistance is a measure of the grain-to-grain skeleton strength for sands and silts. The sleeve friction resistance, f_s is the resistance of the soil as it slides past the friction sleeve.

5.2 SOIL FLUORESCENCE MEASUREMENT

The in-situ fluorometer is described in detail in Lieberman, et al, (1991). A schematic of the system is presented in Figure 3. Polynuclear aromatic hydrocarbons present in petroleum hydrocarbons are detected by their fluorescent response (emission) to excitation by ultra violet light. In making a measurement, the excitation radiation is produced by firing a pulsed nitrogen laser emitting at 337 nanometers (nm). The laser light is coupled into two optical fibers, a timing circuit fiber and the downhole sample irradiation fiber. The light in the timing circuit fiber is used to set the timing for the detector. The major part of the laser pulse is directed into a 400-micron fiber that passes down the center of the penetrometer rod. The fiber ends at a 6.35 millimeter diameter sapphire window that passes the light onto the soil surface adjacent to the window. The light at 337 nm causes electrons in the polynuclear aromatic hydrocarbons to move into more energetic states. Upon removal of the light source, the electrons will return to their original state and simultaneously fluoresce. The fluorescent signal is collected by a second fiber and is carried back up through the



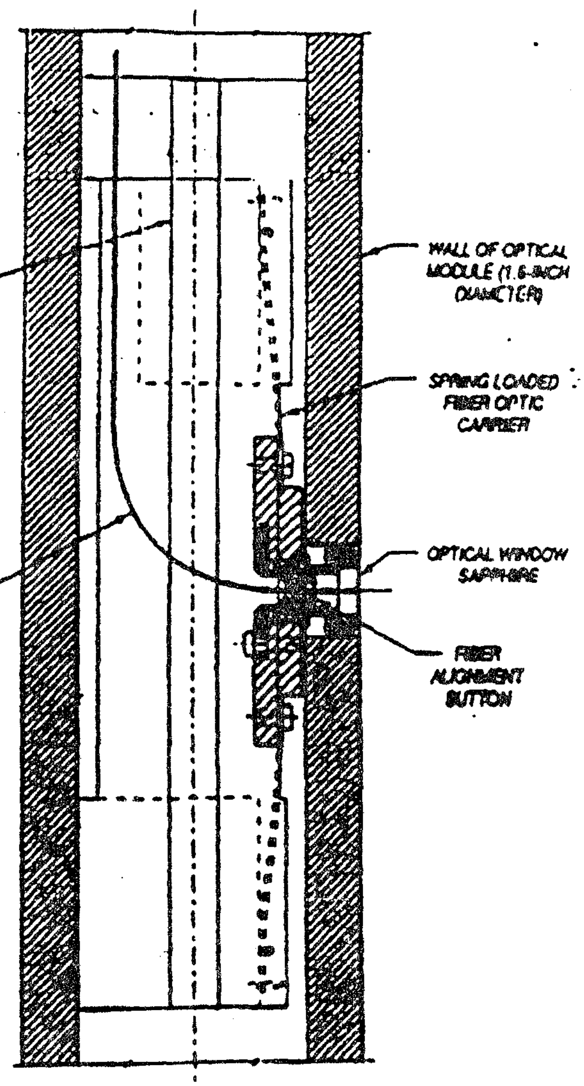


FIGURE 3

SCHEMATIC OF
SCAPS PROBE

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penetrometer rod to the polychromator. In the polychromator the fluorescent signal is spectrally dispersed and the energy distribution at the wavelengths of interest is measured using a linear photodiode array. Readout of an entire emission spectrum requires only 15 milliseconds. The response of the fluorometer is directly related to the concentration of polynuclear aromatic compounds in the soil.

Each fluorescence spectrum consists of photon counts measured at 1,024 points (over a wavelength range of 300 to 800 nm) for every 2-centimeters (0.8-inch) layer of soil investigated. The present data processing system records all spectral intensity measurements and makes corrections for instrument drift during measurement. On board software generates real-time vertical profiles of fluorescence intensity, wavelength of the maximum peak intensity and soil type. A file containing the single equivalent normalized counts, the map coordinates, and the depth below a surveyed datum is prepared from the spectral data.

5.3 DATA ACQUISITION

The data acquisition system and the post processing system each have a separate control computer. The two computers are linked by a network to provide backup and so that data can be exchanged after the penetration testing. During the penetration test the data acquisition computer controls all systems and stores the data on a hard disk. The major block of data is generated by the soil fluorometer system in the optical multichannel analyzer (OMA). The OMA is a separate computer that is controlled by the data acquisition computer through a general purpose interface bus. The data acquisition is also interfaced directly with the amplifier/filter components for the measurement of strain on the cone tip and sleeve, and a variable potentiometer that reads out the position of the hydraulic rams (data used to calculate the depth of the penetrometer tip), and the computer network.

6.0 SCOPE OF WORK

The scope of work anticipated to be performed at the NAS Alameda Site 13, former oil refinery, utilizing the SCAPS is described below. Because the petroleum hydrocarbon at Site 13 are not completely delineated, certain portions of the scope may be modified during the field activities. However, it is anticipated that the primary goals of the work, improving the understanding of the horizontal and lateral extent of petroleum hydrocarbons and obtaining a data set for analysis and data manipulation at Site 13 will be met.

6.1 WORK PLAN DEVELOPMENT

This work plan has been developed, at the request of NAS Alameda and WESTDIV, for review by WESTDIV, NAS Alameda, and applicable regulatory agencies. As previously mentioned, the SCAPS is a new technology which provides real-time, in situ characterization of subsurface conditions at sites impacted with petroleum hydrocarbons. Specifically, the polynuclear aromatic hydrocarbon components of petroleum hydrocarbons are induced to fluoresce by excitation with a laser source at 337 nanometers. The laser light is carried to the soil through the penetrometer rods within a fiber optic cable which terminates at an optical window in the penetrometer tip. Polynuclear aromatic hydrocarbons are induced to fluoresce and this signal is carried back to the surface through a second optical fiber. The signal is quantified spectrally by a linear photodiode array spectrophotometer and recorded via computer and "quantified" against a standard curve to provide a fluorescent response measurement.

Due to the presence of structures which may cover portions of Site 13 and time constraints, it is possible that complete site characterization will not be completed within the scope described herein. However, it is anticipated that a substantial quantity of data will be generated to both increase the understanding of the extent of hydrocarbon impacts at Site 13 and to continue in the validation of this method for rapid field screening.

6.2 UTILITY AND SUBSURFACE SCREENING

Geophysical surveys will be conducted to minimize the potential that the cone penetrometer will not be damaged during probes, and to prevent the puncture of pipes, drums, etc. during pushes. These surveys are generally site specific and depend upon the area being investigated in determining the quality of data obtained. Since the techniques utilize some form of electric or magnetic pulses, they are greatly hindered by objects such as metal buildings, overhead power lines, and construction equipment. A determination will be made at the site as to whether the tests will be valuable or not. If the tests are not feasible for the area, site maps and site knowledge are used to prevent damaging the cone or puncturing underground objects. The surveys are generally carried out only at the individual spots selected for making a push with the cone. Data can be collected and saved, however, after a site has been cleared for pushing, the data are no longer maintained.

6.3 SYSTEM CALIBRATION AND SYSTEM CHECKS

The SCAPS has been engineered to allow for system calibration by comparison to a standard curve comprising of site specific soil and standard additions of known quantities of specific hydrocarbons. System checks are performed before and after each individual push. Each of these calibration methods is described below.

Prior to initiation of field activities, a sample of non-hydrocarbon impacted, on site soil will be collected and homogenized. The soil sample will then be split into separate aliquots of known weight and these aliquots will be separately "inoculated" with known masses of the petroleum hydrocarbons of concern at the site. These standard samples will be homogenized and repetitively analyzed to obtain a standard curve. This standard curve will be entered into the data acquisition system in order to facilitate the conversion of fluorescent response to concentration in the subsurface soils. Standard curves will be generated for both the refinery waste and diesel fuel marine. The fluorescent signature of the petroleum product will determine which standard curve is used to quantify observed fluorescent signal. In cases where multiple fuel products are observed or suspected (such as both gasoline and diesel commingled plumes), the present technology available allows for post-processing to estimate the fraction of which each product is present.

System checks are performed prior to and after each penetrometer push. This check consists of the excitation and measured response of a known fluorescent compound, such as rhodamine or quinine solution. The comparison of the fluorescent response between pushes is designed to confirm system operation and stability.

6.4 PERMITTING

Pursuant to conversations with Lieutenant Mike Petouhoff (USN), of the NAS Alameda Environmental Office, boring/well permits will not be required for the SCAPS deployment at NAS

Alameda. However NCCOSC will adhere to guidelines set forth in the state of California Department of Water Resources Bulletin 74-90 in general agreement with permit requirements of the city and county of Alameda. NCCOSC will provide NAS Alameda and the appropriate regulatory agency with amended permit applications and reports of subsurface investigation which will be signed by a California registered geologist.

6.5 PUSH LOCATIONS

The exact number of probes planned for the site is not practicable to determine. The truck and crew will be onsite for approximately one to two weeks (5 to 9 days of field work). It is anticipated that push points will be advanced in grid pattern across Site 13 to aid in overall site delineation. The site conditions control how many probes can be completed. Due to the nature of the soils at the site, predominantly silts and sands, and the depth to the top of groundwater, it is anticipated that up to eight 15 foot deep pushes can be completed per day utilizing the SCAPS. Additionally, based upon review of data to be supplied by WESTDIV, selected SCAPS pushes will be advanced adjacent to planned soil borings that will have typical soil samples collected and analyzed by state of California certified analytical laboratories for comparison. It is anticipated that approximately 30 to 40 pushes to between 10 and 15 feet below ground surface will be advanced at Site 13.

6.6 DATA COLLECTION AND REDUCTION

The data to be collected will consist of probe location (northing, easting, elevation), tip resistance, sleeve friction, soil fluorescence, and depth. All of these data will be collected for each probe approximately every 4 centimeters from the ground surface to a depth of approximately two to five feet below the potentiometric surface or refusal. The tip resistance and sleeve friction data will be used to produce soil classification information. The soil fluorometry data will be used to produce a number, termed counts, that will be converted to equivalent concentrations of fuel product in milligrams per kilogram (mg/kg). This conversion is based on comparison of fluorescent response during pushes to the fluorescent response of the site specific soil inoculated with petroleum hydrocarbons.

As the system is presently designed, a limited amount of data processing occurs in the field. After each probe a plot is produced containing all information relevant to that probe. More refined processing is required and can be performed in the field or at the NCCOSC before producing finalized plots. However, the field plots are used to display results on a near real time basis.

6.7 GROUTING

As previously described, the voids formed by the advancement of the penetrometer will be backfilled with a Portland cement/bentonite mixture. The cavities will be filled by either the tremmie method following probe removal or by utilizing the injection nozzle assembly and sacrificial tip with a second grout push.

6.8 INVESTIGATION DERIVED WASTE

The SCAPS does not bring significant quantities of soil to the surface as do conventional drilling methods. However, investigation derived waste (IDW) will be generated during the steam cleaning of the rods and probe following retraction. Steam cleaning waste will be placed in 55-gallon drums, labeled, and stored on site. Lieutenant Mike Petouhoff of the NAS Alameda Environmental Office has indicated that the station will be responsible for appropriate waste water disposal.

6.9 SCHEDULE AND REPORT PREPARATION

A final report, to include a description of the methods used, the results of the investigation, final versions of plots, three dimensional volumetric representations, and full discussion will be incorporated into a final published technical report.

The exact dates of additional site visits and field work are not finalized. However, tentative plans are to mobilize to NAS Alameda from NCCOSC in March 1994. Preliminary data interpretation will be ready approximately four weeks after completion of the field work and return of the push truck to NCCOSC. A final draft report will be ready approximately three months from completion of work.

7.0 REFERENCES

Angel, S.M., Daley, P.F. and Kulp, T.J. 1987. "Optical Sensors for Environmental Monitoring." Proceedings of the Symposium on Chemical Sensors, Vol. 87, Electrochemical Society, Pennington, N.J., pp. 484-489.

Atwater, B.F., Hedel C.W., and Helley E.J., 1977. "Late Quarterly Depositional History, Holocene Sea-level Changes, and Vertical Crustal Movement, Southern San Francisco Bay, California." U.S. Geological Survey (USGS) Professional Paper 1014.

Barrows, L. and Rocchio, J. E., 1990. "Magnetic Surveying for Buried Metallic Objects, Ground Water Monitoring Review, Vol. 10, No. 3, pp. 204-211.

Bavan, B. W., 1983. "Electromagnetics for Mapping Buried Earth Features," Journal of Field Archaeology, Vol. 10.

Canonie, 1990. Feasibility Study Plan, Remedial Investigation/Feasibility Study (RI/FS), Naval Air Station (NAS) Alameda, California, Vol. 8. Prepared for NAVY-WESTDIV, January 31, 1990.

Chudyk, W. A., Carrabba, M.M. and Kenny, J.E. 1985. "Remote Detection of Groundwater Contaminants Using Far-Ultraviolet, Laser-Induced Fluorescence," Anal. Chem., Vol 57, pp. 1237-1242.

Comes, G.P., Malone, P. G. and Cooper, S.S. 1991. "Hazardous Waste Site Investigation/Characterization using a Cone Penetrometer System," Presented at the Society of American Military Engineers First Technology Transfer Conference on Environmental Cleanup, Nov. 13-15.

Cooper, S. S., Malone, P.G., Lurk, P. W. and Lieberman, S.H., 1989. "Development of Innovative Penetrometer Technology for the Detection and Delineation of Contaminated Soils," Proceedings of the 14th Annual Army Environmental R&D Symposium. pp. 577-588, Report No. CETHA-TE-TR-90055, U. S. army Toxic and Hazardous Materials Agency, Aberdeen Proving Ground, MD.

Cooper, S.S., Malone, P. G. and Lieberman, S.H. 1990. "Tracking Simulated Contaminant Plumes Using a Cone Penetrometer," Presented at the 1990 Annual Meeting of the Association of Engineering Geologists.

Cooper, S. S. and others 1988. "Development of a Computerized Penetrometer System for Hazardous Waste Site Soils Investigation," Rept. No. AMXTH-TR-TE-882452, U. S. Army Toxic and Hazardous Materials Agency, Aberdeen Proving Ground, MD.

Cooper, S.S. and others 1988. "Use of an Instrumented Cone Penetrometer in Monitoring Land Disposal Sites," Proceedings of the 5th National Conference on Hazardous Wastes and Hazardous Materials. pp. 424-427, Hazardous Materials Control Research Institute, Silver Springs, MD.

Inman, S.M., Thibado, P.M., Theriault, G. and Lieberman, S.H. "Laser-Induced, Pulsed Time-Resolved Fluorometry over Fiber Optic Cables: Characterization of Polycyclic Aromatic Hydrocarbons in Seawater." (submitted to Anal. Chem Acta).

Lieberman, S. H., Inman, S.M. and Stromvall, E.J. 1987. "Fiber Optic-Fluorescence Sensors for Remote Detection of Chemical Species in Seawater." In: Proceedings of the Symposium on Chemical Sensors. Vol. 87, Electrochemical Society, Pennington, N.J., pp. 464-473.

Lieberman, S.H., Inman, S.M. and Theriault, G.A. 1990. "In-Situ, Remote Measurement of Laser-Induced Fluorescence Emission Spectra of Aromatic Hydrocarbons in Seawater using Fiber Optic Cables." EOS, Vol. 71, pp. 133.

Lieberman, S.H., Inman, S.M. and Theriault, G.A. 1989. "Use of Time-Resolved Fluorometry for Improving Specificity of Fiber Optic Based Chemical Sensors." In: Chemical, Biochemical and Environmental Fiber Sensors, Proceedings SPIE, Vol. 1172, Bellingham, WA, pp. 94-98.

Lieberman, S.H., Theriault, G.A., Cooper, S.S., Malone, P.G., Olsen, R.S., and Lurk, P.W. 1991. "Rapid, Subsurface, In Situ Field Screening of Petroleum Hydrocarbon Contamination Using Laser Induced Fluorescence Over Optical Fibers." Symposium Proceedings, Second International Symposium - Field Screening Methods for Hazardous Wastes and Toxic Chemicals. Las Vegas, NV.

Long, J.R., Gregoriou, V.G., and Gemperline, P.J. 1990. "Spectroscopic Calibration and Quantitation using Artificial Neural Networks." Anal. Chem. 62: 1791-1797.

Lurk, P. W. and others. 1990. "Development of Innovative Penetrometer Systems for the Detection and Delineation of Contaminated Groundwater and Soil." Superfund 90: Proceedings of the HMCRI 11th Annual National Conference, pp. 297-306, Hazardous Materials Control Research Institute, Silver Spring, MD.

McNeil, J.D. 1980. "Electromagnetic Terrain Conductivity Measurements at Low Induction Numbers," Technical Note TN-6, Geonics Limited, Mississauga, Ontario, Canada.

Olhoeft, G.R. 1984. "Applications and Limitations of Ground Penetrating Radar," 54th Annual International Mtg., Soc. Explor. Geoph., Expanded Abstracts, pp. 147-148.

Olsen, R.S. and Farr, J.V. 1986. "Site Characterization Using the Cone Penetrometer Test." Proceedings of the ASCE Conference on Use of In-Situ Testing in Geotechnical Engineering. Amer. Soc. of Civil Eng., New York, NY.

Radbruch, D. H., 1957. "Areal and Engineering Geology of the Oakland West Quadrangle, California." Miscellaneous Geologic Investigations MAP I-239. U.S. Geological Survey (USGS).

Robertson, P.K. and Campanella, R.G. 1989. "Guidelines for Geotechnical Design Using the Cone Penetrometer Test and CPT with Pore Pressure Measurement." Hogentogler & Co., Inc., Columbia, MD.

Rogers, J.D., and Figuers, S.H., 1991. "Engineering Geologic Site Characterization of the Greater Oakland-Alameda Area, Alameda and San Francisco Counties, California," Final Report to National Science Foundation, Grant No. BCS-9003785.

Schlager, Kenneth, 1990. "Fiber Fluorometry (Spectrometry) for On-line Chemical Analysis of Nutrient Solutions," Final Report to National Aeronautics and Space Administration, NASA Contract No. NAS10-11656, pp. 65.

Seitz, W.R. 1984. "Chemical Sensors Based on Fiber Optics." Anal. Chem., Vol. 56, 16A-34A.

Trask, P.D., and Rolston J.W., 1951. "Engineering Geology of San Francisco Bay, California," Geological Society of America Bulletin, Vol. 62, No. 9, pp. 1079-1110.

Wythoff, B.J., Levine, S.P. and Tomellini, S.A. 1990. "Spectral Peak Verification using a Multilayered Neural Network." Anal. Chem., 62: 2702-2709.