EXPANDED SITE INSPECTION
FIELD SITE INVESTIGATION PLAN

For
Environmental Investigation at the Formerly Used Defense Site (FUDS)
at the Benicia Arsenal, Benicia, California

FUDS Site Number: J09CA075600

FINAL

Prepared for:

DEPARTMENT OF DEFENSE
UNITED STATES ARMY, SACRAMENTO DISTRICT
CORPS OF ENGINEERS
1325 J Street
Sacramento, California 95814-2922

Prepared by:
BROWN AND CALDWELL
2701 Prospect Park Drive
Rancho Cordova, California 95670

April 2004

Contract Number:
GS-23F-0067M

EXPANDED SITE INSPECTION
FIELD SITE INVESTIGATION PLAN
BENICIA ARSENAL, BENICIA, CALIFORNIA

Signatures of principal personnel responsible for development and execution of this Field Site Investigation Plan.

Approved:

Jim Smith
Quality Control Systems Manager

Wendy Linck, R.G. #6934
Project Manager

REGISTERED GEOLOGIST
WENDY LINCK
No. 6934
STATE OF CALIFORNIA

Rachel Goldberg
Technical Team Leader

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LIST OF ACRONYMS AND ABBREVIATIONS

AST	above ground storage tank
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, xylene
CDC	Center for Disease Control
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
COI	chemical of interest
CPT	direct-push cone penetrometer testing
DCE	dichloroethene
DoD	United States Department of Defense
EPA	United States Environmental Protection Agency
ESL	Environmental Screening Levels
ESL (SSHP)	End of Service Life
FA/BC	Forsgren Associates/Brown and Caldwell
FAR	further action recommended
FID	Flame Ionization Detector
FSIP	Field Site Investigation Plan
FUDS	Formerly Used Defense Site
GC	gas chromatography
GC/MS	gas spectroscopy
GSA	General Services Administration
IDW	investigation derived waste
IDLH	immediate dangerous to life and health
IP	ionization potential
IRR	imminent health risk requiring an immediate response
MCLs	maximum contaminant levels
MEK	methyl ethyl ketone
mg/dl	milligrams per deciliter
mg/kg	milligram per kilogram
mg/L	milligrams per liter
msl	mean sea level
MS	matrix spike
MSD	matrix spike duplicate
MTBE	methyl teriary-butyl ether

LIST OF ACRONYMS AND ABBREVIATIONS (continued)

NC	non-combustible
NDAI	no DoD action indicated
NE	not established
NF	non-flammable
ORP	Oxidation Reduction Potential
OVA	Organic Vapor Analyzer
PA	Preliminary Assessment
PAH	polyaromatic hydrocarbon
PEL	permissible exposure level
PID	photoionization detector
PPE	personal protective equipment
PQLs	practical quanitation limits
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
QCSR	Quality Control Summary Report
RCRA	Resource Conservation Recovery Act
RWQCB	California Regional Water Quality Control Board, San Francisco Bay Region
SI	Expanded Site Investigation
SSHP	Site Safety and Health Plan
TCE	trichloroethene
TDS	total dissolved solids
TEPH	total extractable petroleum hydrocarbons
TLV	threshold limit value
TPH	total petroleum hydrocarbons
TPHD	total petroleum hydrocarbons-diesel fuel
TPHG	total petroleum hydrocarbons-gasoline
TPHMO	total petroleum hydrocarbons-motor oil
TPPH	Total purgeable petroleum hydrocarbons
µg/L	micrograms per liter
USACE	United States Army Corps of Engineers
UST	underground storage tank
VOC	volatile organic compound

EXECUTIVE SUMMARY

The Expanded Site Inspection (SI) presented in this Field Site Investigation Plan (FSIP) is being conducted at the former Benicia Arsenal (Arsenal), a formerly used defense site (FUDS), located in Benicia, California.

The foundation of this FSIP is based on a Preliminary Assessment (PA) prepared to determine if past United States Department of Defense (DoD) activities warrant further environmental investigation (FA/BC, 2004). The PA addressed DoD uses of this facility prior to its closure and decommissioning in 1964. Supplemental research was performed after the final PA for an upcoming Fuel Storage Tank Removal Action Plan, that changed the recommendations of three sites from Further Action Recommended (FAR) to No DoD Action Indicated (NDAI). As a result, of the 389 sites evaluated in the PA, 327 are considered NDAI and 62 are categorized as FAR. This FSIP covers 53 of the 62 FAR sites. Of the remaining 9 FAR sites, the available records indicate the possibility of fuel storage tanks with the other sites recommended for risk evaluation in the remedial investigation phase. The fuel storage tank-related sites are not included in the scope of this FSIP due to DoD funding constraints.

The overall objectives to this Expanded SI include: 1) identifying DoD-related contamination based on the highest risk to human health and/or the environment, 2) determining if additional data is necessary to characterize any potential impact and 3) delineating the extent of contamination (if additional data is necessary). The Expanded SI will focus primarily on potential groundwater impacts at the former Arsenal. Soil samples will only be collected from selected locations. If data indicates only a post-Army impact (e.g. the occurrence of methyl-teriary-butyl ether [MTBE]), no further action will be conducted to investigate non-DoD-related contamination.

This FSIP was designed to accomplish all investigative work in the study area through a single field mobilization. A dynamic sampling strategy will be used to meet this goal. The strategy functions by collecting samples and quickly evaluating the resulting data to guide subsequent sample collection. The FSIP includes a decision chart that will help the project team acquire the necessary data for each study area. Contingencies are provided so that planned field activities can be modified quickly as the investigation proceeds.

At a minimum, an attempt will be made to collect the data necessary to determine impacts from DoD-related contaminants at all of the proposed inspection sites. If funds are still available after this step has been completed, each site will be evaluated to determine if contaminant delineation is necessary. If so, the sites will be ranked in order of highest risk to human health and/or the environment. Additional data will be collected at those sites based on these ranking and available funds. Any sites that are not fully characterized in this Expanded SI will be investigated at a later date when additional funds are available.

1.0 PROGRAM GOALS AND PROJECT ORGANIZATION

The Expanded Site Inspection (SI) presented in this Field Site Investigation Plan (FSIP) is being conducted at the former Benicia Arsenal (Arsenal), Benicia, California under General Services Administration Contract No. GS-23F-0067M, Task Order 9T3N176PG. The FSIP was prepared to comply with requirements of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and the Resource Conservation Recovery Act (RCRA), as appropriate. This section of the document describes the relationship between the Expanded SI and the Formerly Used Defense Sites (FUDS) program. It also identifies the personnel responsible for execution of the work described herein.

1.1 Project Overview

In accordance with FUDS program goals and U.S. Army Corps of Engineers (USACE) guidance documents, this Expanded SI is being conducted to determine the presence or absence of chemicals that may have impacted the environment from past Department of Defense (DoD) activities at the former Arsenal. FUDS program funding can only be used to assess and remediate DoD liability at eligible property, which is defined as real property formerly owned by, leased by, possessed by, or otherwise under the jurisdiction of the Secretary of Defense or elements of the U.S. military. Under the FUDS program, land that was previously utilized by DoD and that has no "beneficial use" history will be characterized and, if necessary, remediated to an appropriate standard. "Beneficial use" of former DoD land is defined as activity by subsequent landowners or lessors that would either mask contamination caused by DoD or continue contamination in the same manner.

As part of the FUDS process at the former Arsenal, a Preliminary Assessment (PA) was prepared to determine if past DoD activities warrant further environmental investigation (FA/BC, 2004). The PA addressed DoD uses of this facility prior to its closure and decommissioning in 1964. The specific goal of the PA was to develop sufficient information to categorize each site within the former Arsenal property as one of the following:

- No DoD action indicated (NDAI);
- Further Action Recommended (FAR); or
- Imminent health risk requiring an immediate response (IRR).

Of the 389 sites evaluated in the PA, 324 were considered NDAI and 65 were categorized as FAR (FA/BC, 2004). No IRR sites were identified. Since the submittal of the final version of the PA, more research was conducted as part of the upcoming Fuel Storage Tank Removal Action Plan where the recommendation of three sites changed from FAR to NDAI. Therefore, there are 327 NDAI sites and 62 FAR sites at the former Arsenal. This FSIP covers 53 of the 62 FAR sites. The remaining 9 FAR sites, the available records indicate the possibility of fuel storage tanks, with the other sites recommended for risk evaluation in the remedial investigation phase.

The fuel storage tank-related sites are not included in the scope of this FSIP due to DoD funding constraints. Two sites included in this FSIP may have underground storage tanks (USTs) (Building 31 and Building 161). As with the other sites with only a UST-related occurrence, the USTs at Building 31 and Building 161 will not be investigated. The Fuel Storage Tank Removal Action Plan is being developed for all fuel storage tank-related sites.

There are five sites (Building 26, Building 28, Building 53, Building 103 and Building 154) that underwent UST removal actions in 2002 (Geofon, 2003). Soil and groundwater samples were collected when the USTs were removed. Additional investigation was requested by the lead regulatory agency for further delineation of petroleum impacts at three sites (Buildings 53, 103 and 154). At all of these sites, the lead regulatory agency also requested sub-meter coordinates of the former tank locations. This additional investigative work is included as part of this FSIP.

1.2 Project Organization

Figure 1-1 presents the organization chart for this project and lists the specific responsibilities of key USACE staff, Brown and Caldwell staff, and subcontractors.

1.3 FSIP Organization

This FSIP is organized into ten sections. Section 1.0 presents general information pertinent to the overall project. Section 2.0 describes the problem to be addressed by this Expanded SI and provides background information for the project, including the physical setting, geology, hydrogeology, history, historical use, and chemical processes employed at the former Arsenal during its active life. Previous investigations are also summarized in Section 2.0. A summary project description and schedule are included in Section 3.0. Section 4.0 presents the project approach. Section 5.0 outlines the design and rationale of the investigative process in detail, including sampling objectives, sample types and matrices, sampling frequencies, and analytical methods. Decision criteria are presented for additional step-out/step-in soil borings. Sampling methods are listed in Section 6.0. A summary of analytical method requirements are included in Section 7.0. Section 8.0 describes the procedure for management of investigation derived waste (IDW). Section 9.0 presents quality control (QC) procedures. References are listed in Section 10.0.

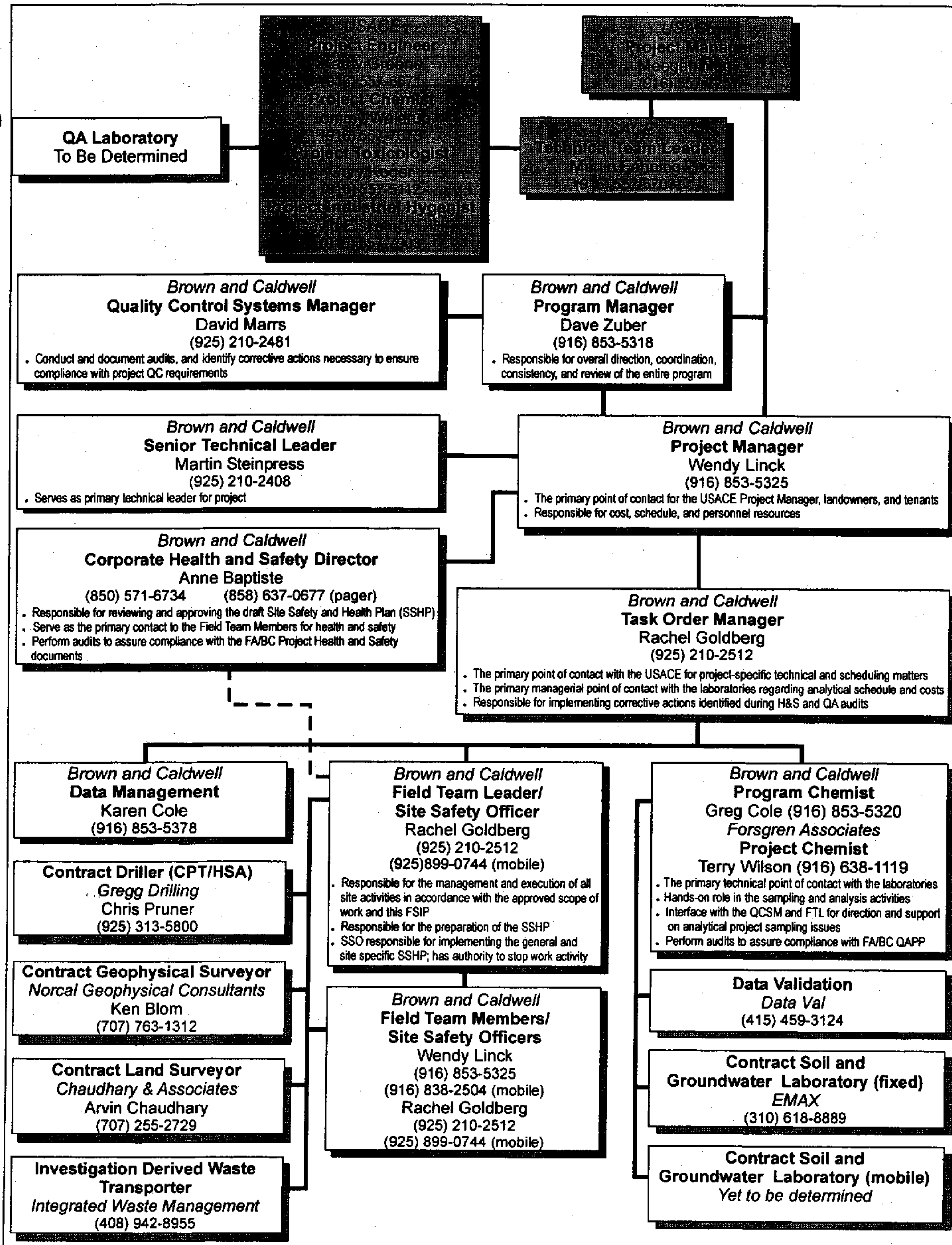


Figure 1-1
Organizational and Responsibility Chart
Expanded SI FSIP
Benicia Arsenal

2.0 PROBLEM DEFINITION AND PROJECT BACKGROUND

The sites selected for this Expanded SI were chosen based on previous investigations and the PA (FA/BC, 2004). There are a total of 62 FAR sites. As discussed in Section 1.0, there are 9 UST-related sites that will not be investigated at this time due to funding constraints. Also, there are several sites where risk assessments will be conducted in the remedial investigation phase. Therefore, a total of 53 FAR sites will be addressed in this investigation phase. Hereafter, these 53 FAR sites are referred to as the proposed inspection sites.

The overall objectives of this Expanded SI include: 1) identifying DoD-related contamination based on the highest risk to human health and/or the environment, 2) determining if additional data is necessary to characterize potential impacts and 3) delineating the extent of contamination (if additional data is necessary). If data indicates only a post-Army impact (e.g. the occurrence of methyl-tert-butyl ether [MTBE]), no further action will be conducted to investigate non-DoD-related contamination. Also, sites that have been identified in previous investigations as having another potentially responsible party will not be investigated.

This FSIP has been designed to accomplish all investigative work in the study area through a single field mobilization. A dynamic sampling strategy will be used to meet this goal. The strategy functions by collecting samples and quickly evaluating the resulting data to guide subsequent sample collection. The FSIP includes a decision chart that will help the project team acquire the necessary data for each study area. Contingencies will be provided so that planned field activities can be modified quickly as the investigation proceeds.

The Expanded SI will focus primarily on potential groundwater impacts at the former Arsenal. Soil samples will only be collected from selected locations. This strategy is based on the assumption that any significant surface or subsurface releases related to DoD activity would have impacted groundwater by this time, since groundwater is shallow (usually less than 8 feet below ground surface [bgs]) in the flatland areas adjacent to Suisun Bay and it has been at least 40 years since DoD activity ceased at the former Arsenal.

At a minimum, an attempt will be made to collect the data necessary to determine impacts from DoD-related contaminants at all of the proposed inspection sites. If funds are still available after this step has been completed, each site will be evaluated to determine if further contaminant delineation is necessary. If so, the sites will be ranked in order of highest risk to human health and/or the environment. Additional data will be collected at those sites based on these ranking and available funds. Sites that are not fully characterized in this Expanded SI will be investigated at a later date when additional funds are available.

2.1 Site Location and Description

The former Arsenal is located about 25 miles northeast of San Francisco in Benicia, California, on the north side of the Carquinez Strait (Figure 2-1). During its active life (1849-1964), this facility served the U.S. Army as a principal depot for ordnance and ordnance stores, as well as the issuance, manufacture and testing of small arms. The former Arsenal eventually grew by land acquisition to a total of 2,728 acres, of which 190 acres were located with the Carquinez Strait to the south and Suisun Bay to the northeast (Jacobs, 1999).

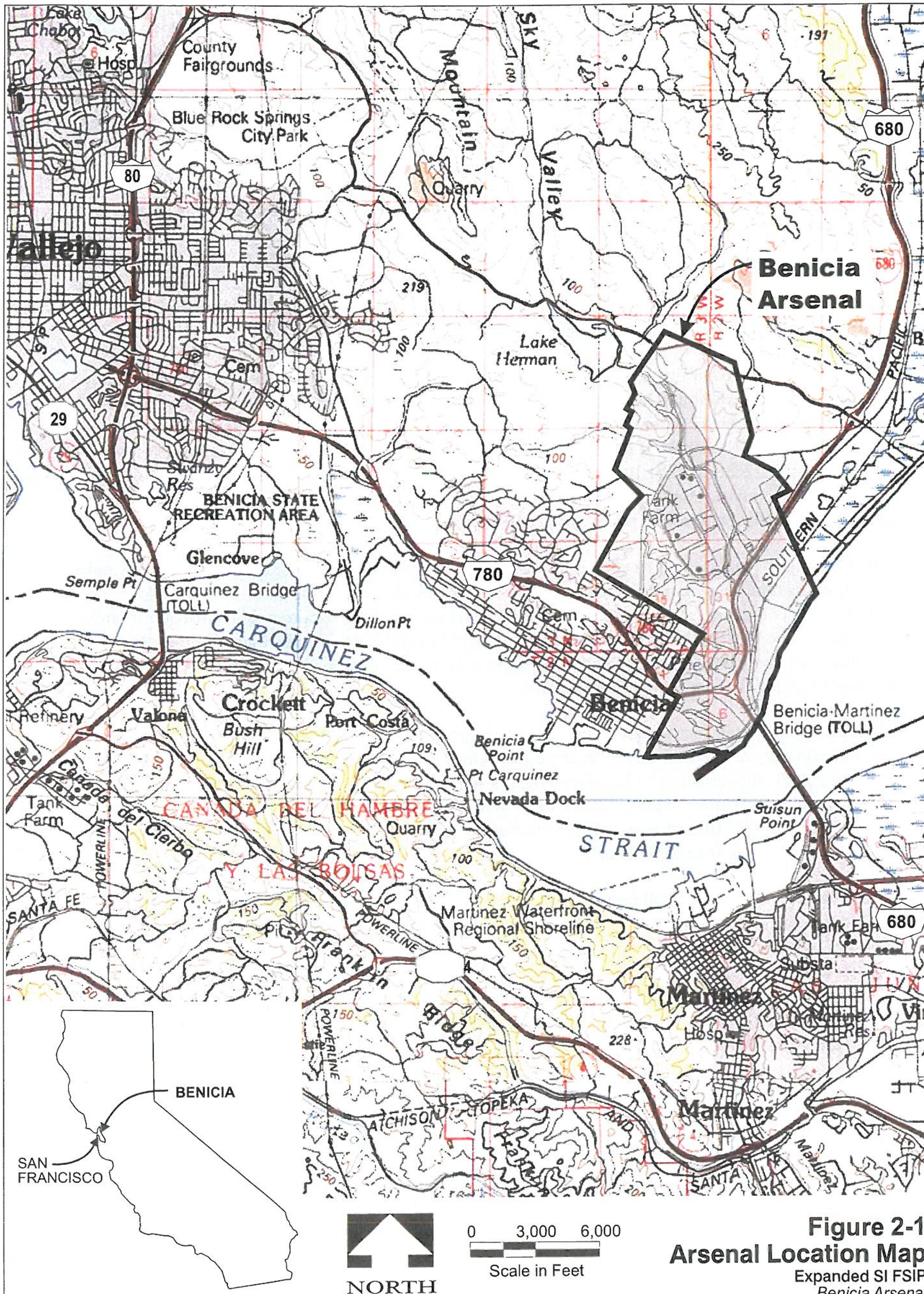


Figure 2-1
Arsenal Location Map
Expanded SI FSIP
Benicia Arsenal

The former Arsenal can be divided into five areas according to the primary DoD land uses shown on Figure 2-2. These areas are:

- Area W Warehouse Area
- Area I Industrial/Manufacturing Area
- Area R Revetment/Explosives Holding Area
- Area M Motor Pool and Historical Ordnance Storage Area
- Area S Magazine Storage Expansion Area

2.1.1 Physical Setting

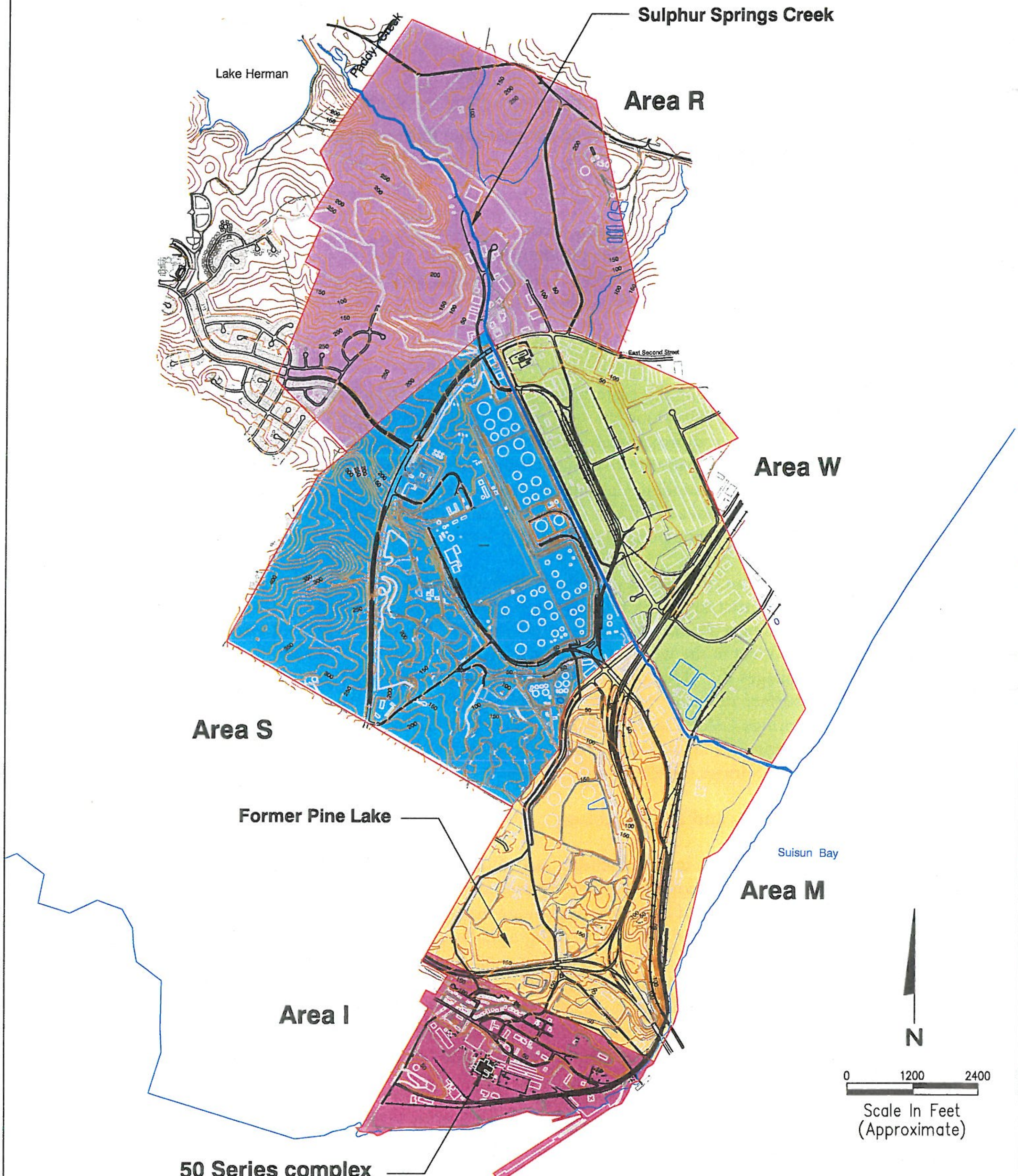
The Benicia area is located along the eastern margin of the Coast Range Geomorphic Province of California, in an area of low hills along the northern shore of the Carquinez Strait. North-northwest trending hills and valleys are approximately parallel to the San Andreas Fault system. The local topography controls the flow pattern of surface water, and to a large degree, the flow direction of groundwater. The east-west trending Carquinez Strait is a notable exception to the northwest trending valleys. The Carquinez Strait was created by erosion from the Sacramento River and San Joaquin River during Pleistocene periods of relatively low sea levels (Norris and Webb, 1990).

The southernmost portion of the former Arsenal (Industrial/Manufacturing Area) rises from sea level at the Carquinez Strait to an elevation of approximately 160 feet above mean sea level (msl) in the low-lying foothills near the former location of Pine Lake (Figure 2-2). The foothills rise to an elevation of over 400 feet in the western part of the former Arsenal. The foothills are cut by natural and man-made drainages that flow into the tidal flats and marshlands of the Carquinez Strait and Suisun Bay. The surface drainage in the northwestern part of the Arsenal area is toward the east into the Sulphur Springs Creek drainage channel. The northeastern corner of the former Arsenal is comprised of low-lying hills up to 250 feet in elevation, with surface drainage generally toward the west into the Sulphur Springs Creek drainage (Figure 2-2).

2.2 Arsenal Geology and Hydrogeology

The former Arsenal is located in the southern part of the northern Coast Range of California, where the geologic history has been complicated by stresses associated with the San Andreas strike-slip fault system. The complexity of the regional geology has resulted in some discrepancies between geologists concerning the names of various stratigraphic units (Dibblee, 1980; Sims et. al., 1973; and Graymer et al., 1999). However, published geologic interpretations generally agree on the relative ages and types of material for the stratigraphic units. For consistency, the names provided in the most recent geologic publication for the Benicia area (Graymer et al., 1999) are used throughout this report. A summary of the regional, local, and site-specific geologic and hydrogeologic setting is presented below, and lithologic data and groundwater quality parameters are also discussed for the former Arsenal.

Two faults were identified in the Benicia area by Graymer et. al. (1999): the Sky Valley Fault and the Lake Herman Fault (Figure 2-3). The Lake Herman Fault is a west-dipping thrust fault that is mostly equivalent to the West Sulphur Springs Valley thrust fault described by Weaver (1949). The Lake Herman Fault roughly follows the Sulphur Springs Creek drainage (Figure 2-3). The subparallel Sky Valley Fault is located in the hills about 2,000 feet to the east.



LEGEND

Topographic Contour, 25 Foot Interval

Former Arsenal Boundary

Source of Thickness of Bay Mud in Lowlands is Edward Schwafel Engineers, 1969

Figure 2-
Areas of Arsenal
Expanded SI FSIP
Benicia Arsenal

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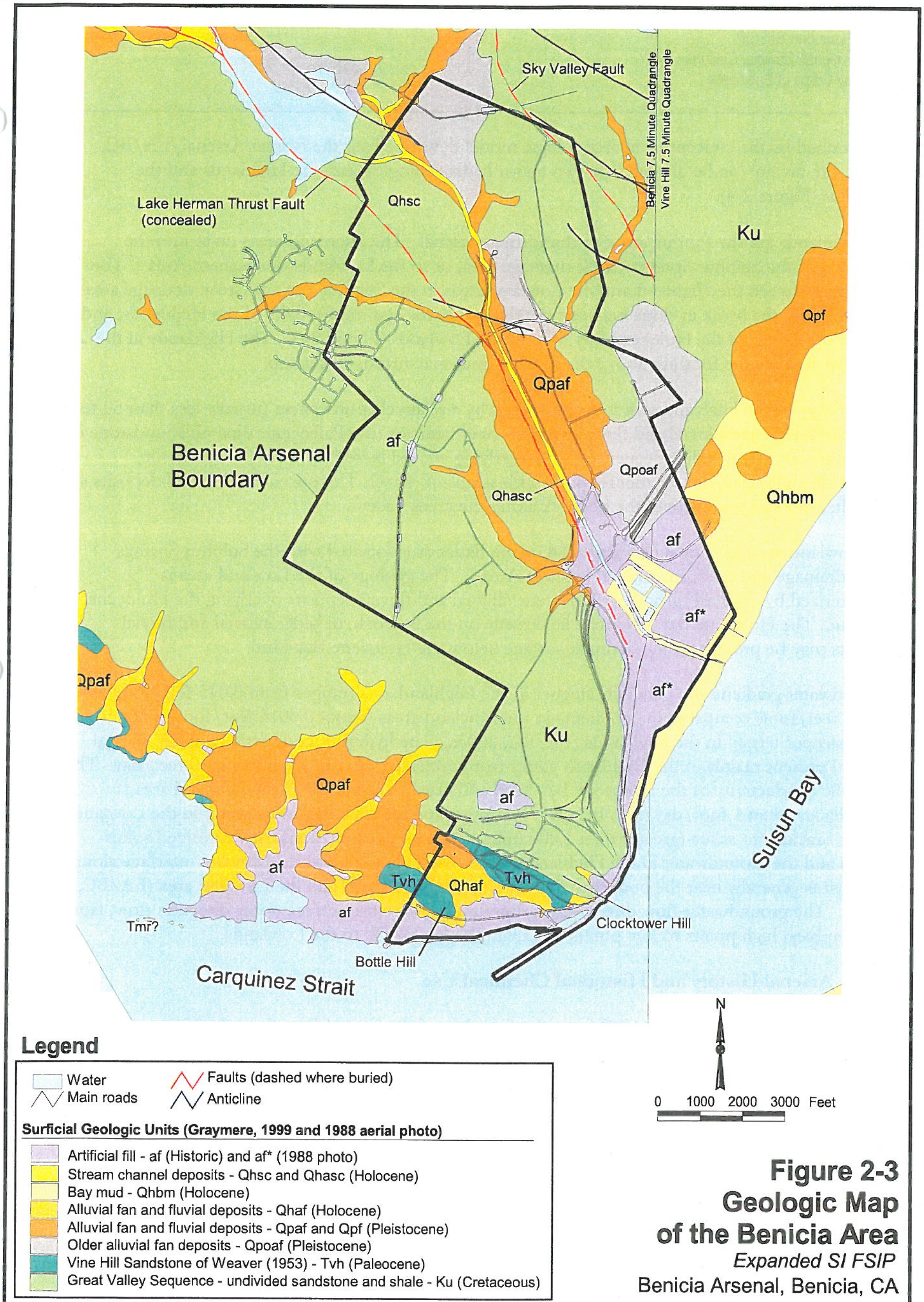

Figure 2-3
Geologic Map of the Benicia Area
Expanded SI FSIP
Benicia Arsenal, Benicia, CA

Forsgren Associates/Brown and Caldwell
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As described by the conceptual hydrogeologic model developed for the former Arsenal (FA/BC, 2003a), the facility can be divided into two major hydrogeologic areas: the Highlands and the Lowlands (Figure 2-4).

The Highlands are the foothill areas of the former Arsenal. The Highland areas drain into the Lowlands of the Sulphur Springs Creek drainage area, or to the Lowlands of southern Area I. The boundary between the Highland and the Lowland areas in the Sulphur Springs Creek drainage area is approximately the break in slope between the flat Lowlands and the foothills of the Highlands, and roughly the extent of the Holocene Bay Mud in the Lowlands (Figure 2-4). The Highlands in the industrial area are the foothills above the filled former marshlands or swamp.

The geology of the Highland area is characterized by a relatively thin veneer (usually less than 50 feet thick) of Pleistocene alluvial and fluvial deposits over bedrock (the Paleocene Vine Hill Sandstone or the Cretaceous Great Valley Sequence). The overlying alluvial material consists of sandy silt interbedded with clay, or as cemented sand with seams of gravel. Unconsolidated fluvial deposits of clay, silt, sand and gravel cover the bedrock along the creek valleys.

The Lowland area, as shown on Figure 2-4, is the flatlands associated with the Sulphur Springs Creek drainage and the former marshlands in Area I. The geology of the Lowland area is characterized by artificial fill and/or Holocene alluvial and fluvial deposits overlying the Holocene Bay Mud. The Holocene Bay Mud may lie directly on the bedrock, or older alluvial and fluvial deposits may be present on the bedrock surface below the Holocene Bay Mud.

Groundwater gradients are generally steeper in the Highland area (ranges from 0.045 feet/foot to 0.0053 feet/foot) compared the gradients in the Lowland areas (about 0.0016 feet/foot). This is due to the steeper terrain in the Highlands (FA/BC, 2003a). The hydraulic conductivity of the alluvial material present mainly in the Highlands varies from under 1 foot/day to just over 10 feet/day. The hydraulic conductivity of the Holocene Bay Mud and clayey fill material in the Lowland area is generally less than 1 foot/day (FA/BC, 2003a). In general the shallow groundwater in the Lowland areas is brackish to saline (greater than 1,000 milligrams per liter [mg/liter] total dissolved solids [TDS]) and the groundwater in the Highland areas is fresh. The freshwater-saltwater interface along the coast is generally near the boundary between the Highland area and the Lowland area (FA/BC, 2003a). The groundwater flow direction is generally similar to the surface water direction flow, from topographical high points to low points and from the Highlands to the Lowlands.

2.3 Arsenal History and Historical Chemical Use

Benicia Arsenal was created in 1849 from the founders of the City of Benicia to the U.S. government (Jacobs, 1999). Originally referred to as "the Post at Point near Benicia, California," the installation was later designated Benicia Barracks (Jacobs, 1999). In 1862, President Lincoln ordered that a plot of land at Benicia be segregated from the public lands for the purpose of a military reservation. Between 1849 and 1958, the United States acquired 1,790.48 fee acres, 351.12 public domain acres, 6.40 license acres, and 580.04 easement acres, for a total of 2,728.04 acres (Jacobs, 1999).

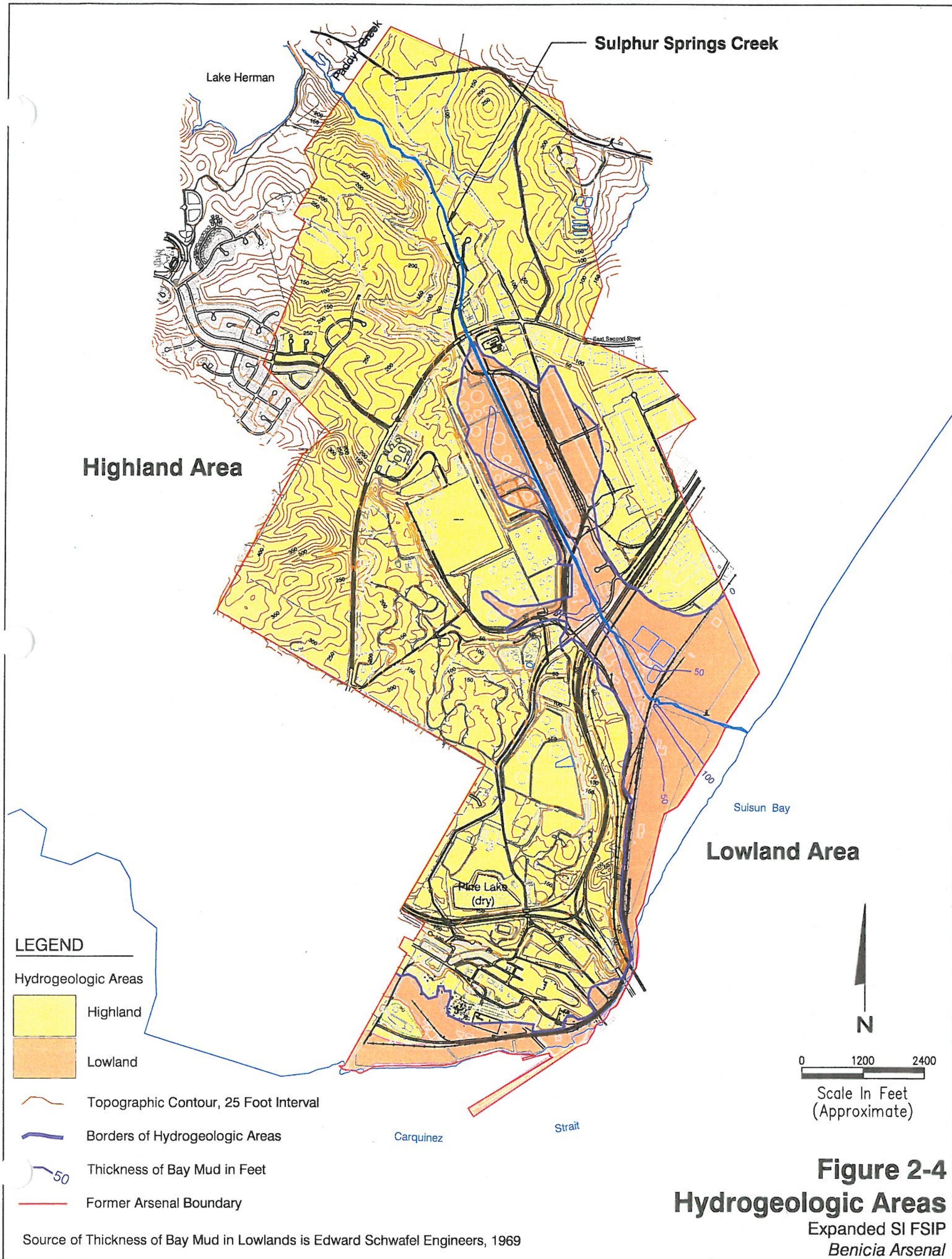

Figure 2-4
Hydrogeologic Areas
Expanded SI FSIP
Benicia Arsenal

The former Arsenal served as a principal depot for ordnance and ordnance stores, issuance of supplies, ammunition, small arms parts and accessories, the testing of small arms, mobile and seacoast artillery targets, and vehicle maintenance for the Division of the Pacific. A massive expansion of the former Arsenal took place during World War II. Physical expansion included the addition of 1,847 acres and over 200 structures. Another full-scale expansion took place just prior to and following the Korean Conflict, with the addition of approximately 40 to 50 structures. Many of these additions were warehouses for inert materials and transitory shelters. Throughout the former Arsenal's history, the functions of many buildings and operation areas changed, in response to changing government needs.

The former Arsenal was continuously occupied by the military from its establishment in 1849 to its closure in 1964. Benicia Arsenal was declared excess by the DoD and was reported to the General Services Administration (GSA) on 11 January 1963. Deactivation and closure of the former Arsenal was completed on 31 March 1964 (Jacobs, 1999).

Drilling efforts were undertaken in the late 1800s to increase water supply. However, the effort to find potable groundwater was unsuccessful. To counter the problem, cisterns were installed to store stormwater, and reservoirs were built to capture and store surface water.

Area I (Figure 2-2) served as the main industrial and manufacturing area throughout the 115-year history of the facility and was the center of activity at the former Arsenal. Several machine shops, manufacturing shops, and cleaning and painting shops were housed here, along with a blacksmith shop, a welding shop, numerous vehicle and artillery repair shops, and a small arms shop. The industrial area also housed the former Arsenal's administrative offices, most of the permanent housing facilities, photographic laboratories, a firehouse, and a hospital. Fuel storage and dispensing facilities, a locomotive house, boiler houses, storehouse and warehouse facilities, open storage facilities, landfills, and quarries were also located within this area. Approximately 64 percent (34 sites) of the 53 proposed inspection sites are located in Area I.

Several original structures (built between 1852 and 1857) are located north of the industrial area in Area M (Figure 2-2) on the low-lying hills. Area M was the location of the original Benicia Barracks, established in 1849 by two companies of the 2nd Infantry. This area housed officers and enlisted men, a hospital, the Adjutant's office, a storehouse, a carpenter shop, a blacksmith shop, and several buildings to house livestock (FA/BC, 2003a). The buildings were supplied with water from a series of six cisterns, two holding tanks, and four non-potable water wells. The cisterns had a total capacity of 212,000 gallons and were located near the hospital, the Commanding Officer's Quarters, the "north and south block" officers' quarters, the Adjutant's office, and the "band quarters." The two holding tanks had a total capacity of 24,500 gallons (Jacobs, 1999). For nearly 100 years, this area was primarily used to store ammunition, gunpowder, and ordnance. There are eleven sites in Area M to be investigated as part of the Expanded SI. They are mostly related to former DoD vehicle maintenance activities.

Area W (Figure 2-2) is occupied by structures that were erected during World War II and the early 1950s. Most of the construction in Area W was completed by 1942. Improvements in this area include a clip-link and belt plant (later converted to a Nike missile reconditioning shop), transitory shelters, materiel warehouses, open storage areas, storage igloos, small arms storage magazines, a rail yard, sewer and storm drainage systems, and a firehouse with accompanying support structures. This area was used mainly to receive and store small arms, ammunition, and related supplies throughout World War II. Area W includes four sites to be investigated during the Expanded SI.

The Army acquired Area S (Figure 2-2) in 1941 during the 1,800-acre expansion program (FA/BC, 2004). The structures within this area include a network of ammunition storage igloos built in 1942-1943. During the 1940s, these igloos were used largely to store artillery projectiles and aerial bombs (FA/BC, 2004). The mission of the Arsenal changed in the late 1940s and the igloos in this area were then used for general storage. There is one site in Area S to be investigated during the Expanded SI.

Area R (Figure 2-2) became part of the former Arsenal in 1944 to meet the need for a staging area for ammunition shipments during World War II. Land use in this area was mainly for temporary storage of explosives on flatbed railroad cars, artillery testing, demilitarization, and demolition of damaged and obsolete ammunition (FA/BC, 2004). The Army built very few permanent structures in this area between 1944 and the closure of the former Arsenal in 1964. Buildings in Area R were mainly used for demolition and demilitarization of damaged and obsolete ammunition and for weapons testing. Between the end of World War II and 1950, the former Arsenal received thousands of tons of ammunition from American military bases across the Pacific. The returned ammunition was inspected for obsolescence or damage, with the bulk of it taken to the northern portion of the former Arsenal and destroyed (FA/BC, 2004). Three proposed inspection sites in Area R are associated with demilitarization of damaged and obsolete ammunition.

2.3.1 Historical Chemical Use

The Army operated industrial and manufacturing shops, maintenance facilities, and fuel and waste storage areas. Potential sources of chemical releases from these activities include USTs, vapor degreasers, grease maintenance pits, degreasing tanks and waste disposal areas. Fuel-related petroleum hydrocarbons are expected at the former Arsenal due to known releases from former USTs and possibly from remaining USTs. The contents of these USTs included fuel oil, diesel fuel and gasoline. These petroleum products were used in vehicles, machinery and other equipment. In addition to fuel-related petroleum hydrocarbons, various chemicals were used in manufacturing processes that included coloring, cleaning, degreasing, and preserving.

The process of coloring, cleaning, and preserving metal parts was conducted primarily at the 50 Series Complex. These operations evolved from the Browning process of the early 1900s to the Parkerizing process that was used beginning in the 1940s. Building 31, Building 91 and Building 91A near the 50 Series Complex also performed some of these manufacturing operations. The overall approach to these processes included the removal of oil and grease from metal using boiling water, caustics or phosphoric acid. Some vapor degreasing was also performed. A vapor degreasing unit was added in the 1950s in Building 56A and Building 57. Records research indicates that trichloroethene (TCE) use at the 50 Series Complex was limited. The location and use of Stoddard solvent is not well understood, but this material was prescribed as a cleaner in the 1940s. Acid and caustic dip tanks were located in many buildings (Building 56, Building 56A, Building 57, Building 91, Building 91A, and Building 31) for degreasing small arms or vehicle parts. Preservation (primarily with light oil/wax oil) and coloring was performed in Building 56 and Building 57.

During the World War II era, Building 57A was built and named the "Parkerizing Room". Parkerizing (or Phosphating) is a metal finishing technique that gained in popularity during World War II, when the Army sought to replace the typical blued finish on most small arms with a rust resistant and anti-reflective coating that would be both durable and abrasion resistant and would also hold up in extreme climates. The Parkerizing technique is a phosphate etching process that produces a hard matte or dull finish. There are no solvents associated with the Parkerizing process, and therefore solvents are not associated with Building 57A.

Used materials may have been dumped into the former marshland area prior to placement of artificial fill around 1920 (FA/BC, 2004). Based on the processes occurring in the industrial area prior to 1920, it appears that any used material dumped into the former marshland would have been acids and possibly light oils.

It is not clear where the contents of the solvent-based materials in the degreaser tanks or other used materials were disposed. Storm drains and the sanitary sewer system were the most likely locations (Jacobs, 1999).

The above descriptions of manufacturing activities do not account for post-Army use. After closure of the Arsenal, several subsurface structures remained (e.g. the Parkerizing vat in Building 57A, the caustic tank in Building 56 and the storm drain/sewer system). Tenants and landowners used these structures for a variety of manufacturing, maintenance and repair activities. Prior to the 1970s, it was customary to discharge untreated waste into the sewer and/or storm drain system. Regulations were later enacted and enforced to prohibit these activities. The discharge of untreated wastes into the sewer system continued for five years after the Army left until 1969, when an upgrade to the sewer system was completed and untreated wastes were diverted from the Carquinez Strait into the City of Benicia Wastewater Treatment Plant. The storm drain system discharged directly into the Carquinez Strait for over a century.

Each proposed inspection site is listed in Table 2-1, with the DoD use, features and contaminants that are likely present based on its former DoD use. Further details and background information are provided in Appendix A. The locations of the proposed inspection sites are indicated on Figure 2-4A and subsequent figures in this report.

Table 2-1 shows that fuel-related contaminants such as diesel fuel, gasoline and motor oil have been associated with maintenance activities, USTs/above ground storage tanks (ASTs) for fueling systems. Volatile organic compounds (VOCs) and other solvents have been associated with cleaning, degreasing and maintenance activities. Oils were primarily used in preserving small arms and were commonly associated with the same sites where fuels were used. Metals and explosives are related to incineration, small arms disposal, and firing ranges.

Lead has also been associated with USTs due to the use of leaded gasoline. Tetraethyl lead was found to be a powerful anti-knock chemical for gasoline in 1921 (Pees, 2003). By 1923, tetraethyl lead was added to gasoline at refineries and was being distributed throughout the U.S. Tetraethyl lead and tetramethyl lead were added to gasoline up until the late 1970s (U.S. Department of Labor, 2003). The use of lead additives in gasoline were largely banned in the U.S. under the Clean Air Act of 1970.

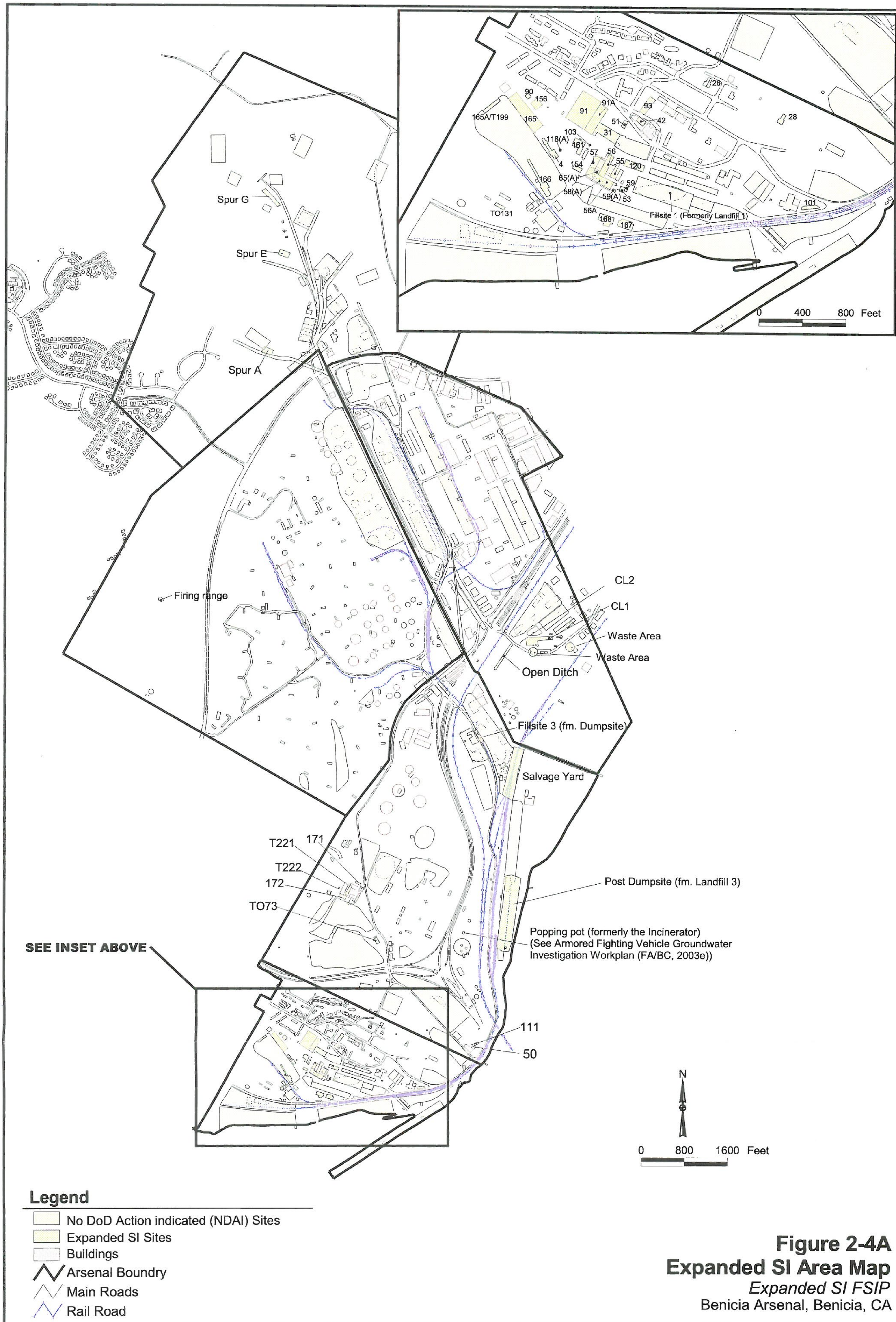

Figure 2-4A
Expanded SI Area Map
Expanded SI FSIP
Benicia Arsenal, Benicia, CA

Forsgren Associates/Brown and Caldwell
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Table 2-1. Proposed Inspection Sites

Proposed Inspection Site	DoD Use	DoD Activity	Expected Contaminant(s)
4	Sandblast Building/Paint Spray	Cleaning, painting	VOCs, metals
26	Lieutenant's quarters	UST (removed)	Fuels, metals, oils
28	Quarter's Commanding Officer	UST (removed)	Fuels, metals, oils
31	Store House/Engine Rebuild	Degreasing, UST*	Fuels, metals, oils, solvents
42	Garage/Repair Shop	Solvent washer, maintenance	Fuels, oils, solvents
50	Heavy Equipment Yard	Maintenance	Fuels, oils, lead
51	Stable/ Maintenance	Maintenance	Fuels, oils, metals
53	Dynamometer Shop (motors)/Engine Testing/Fuel Storage	Former UST	Fuels, lead
55	Blacksmith Shop/Machine/Welding Shops	Repair/ Maintenance	Fuels, oils
56	Leather & Canvas Shop/Welding Shop	Dip tanks	Oils
56A	Small Arms Shop/Leather Canvas Shop	Degreaser	Solvents
57	Small Arms Shop, Firing Range	Firing ranges, degreaser	Metals (firing range only)**, solvents
58(A)	Small Arms Repair and Retinning/ Boiler Room	Repair, former boiler UST?	Fuels, lead
59	Tool House/ Degreaser Pit	Cleaning, degreaser	Fuels, oils, solvents, lead
59(A)	Tool House	Storage	Fuels, oils, lead
65(A)	Boiler House	Former UST/AST?	Fuels, lead
90	Locomotive Building	Repair/ Maintenance	Fuels, oils, solvents
91	Machine Shop/Combat Vehicle and Artillery Repair	Cleaning, Degreasing	Fuels, oils, Solvents, metals
91A	Temporary Machine Shop/Engine Rebuild	Cleaning, Degreasing	Fuels, oils, Solvents, metals
93	Truck Storage Building/MMW Repair, Motor Vehicle Maintenance Building	Maintenance, grease tanks	Fuels, oils, solvents
101	Battery Charge Building	Steam cleaning battery cases	Metals, fuels
103	Service Station/Office Building	Former UST	Fuels, lead
111	Heavy Equipment Shop	Storage	Fuels, oils, solvents
118(A)	Diesel Fuel Tank, Fuel Oil Tank, Oil Storage Tank	Former ASTs	Fuels, oils
120	Quartermaster Storage/Shop/Electroplating	Dip tanks, degreaser	Solvents, metals
154	Motor Test Shed/Paint Spray/ Fuel storage	Former USTs	Fuels, oils, lead
156	Locomotive House	Maintenance	Fuels, oils, solvents, metals
161	Motor Cleaning Building/Steam Cleaning/Paint Spray/Fuel Storage	Maintenance Storage, UST*	Fuels, oils, solvents, metals
165	Reclamation Building/Transport Vehicle Shop	Degreaser	Solvents, oils, metals
165A	Steam Cleaning Building	Cleaning	Fuels, oils, solvents
166	Paint Shop	Grease rack	Oils

Table 2-1. Proposed Inspection Sites (continued)

Proposed Inspection Site	DoD Use	DoD Activity	Expected Contaminant(s)
167	Bar Stock Building/Storage/Vehicle Shop for Motor Pool	Maintenance	Fuels, oils, solvents
168	Bar Stock Building/Storage/Vehicle Shop for Motor Pool	Maintenance	Fuels, oils, solvents
171	Vehicle Shop	Maintenance	Fuels, oils, solvents
172	Vehicle Repair and Maintenance Shop	Maintenance	Fuels, oils, solvents
194	Former Septic Tank for CL1	Sewer	Solvents, metals
CL1	Clip-Link and Belt Plant (1942-1944); Guided Missile Shop/Nike Missile Assembly	Assembly area	Solvents, metals
CL2	Boiler House	Boiler house (former UST and AST)	Fuel, oils, metals
Fillsite 1 (Formerly Landfill 1)	Dump	Disposal	Fuels, oils, solvents
Fillsite 3 (formerly the Dumpsite)	Dump	Disposal	Fuels, oils, solvents
Firing range	Test Firing of .45 and .50 Caliber Weapons	Firing Range	Metals
Popping pot (formerly the Incinerator)	Incineration	Disposal	Metals, explosives, fuels, oils
Post Dumpsite (formerly Landfill 3)	Dump	Disposal	Metals
Salvage yard	Salvage Yard	Disposal	Fuels, oils
Spur A	Revetment and Burn Cage Area/Hydrazine Burn Area (1958/59)	Burn cage	Fuels, metals, explosives
Spur E	Revetment and Burn Cage Area	Burn cage	Fuels, metals, explosives
Spur G	Revetment and Burn Cage Area	Burn cage	Fuels, metals, explosives
T199	Maintenance Building, Body and Radiator Shop	Maintenance	Fuels, solvents
T221	Vehicle Maintenance	Maintenance	Fuels, oils, solvents
T222	Steam Cleaning	Cleaning	Solvents
TO73	Recreation and Storage Building/Photo Lab/Depot Facilities Shop	Cleaning	Solvents
TO131	Storehouse/Shop	Degreasing	Solvents
Waste Areas/Open Ditch	Waste Areas/Open Ditch for CL1	Disposal	Solvents
53 total sites			

*UST will not be investigated during this investigation.
** The firing ranges in the basement of Building 57 will be assessed for further action during the feasibility study/remedial action phase.

Chemicals associated with post-Army activities are not listed in Table 2-1. However, indicators of releases resulting from post-Army use will be reported during the investigation (i.e. sampling for fuel oxygenates such as MTBE).

2.4 Previous Investigations

The results of previous investigations at the former Arsenal are summarized below. Only those investigations that are relevant to this Expanded SI are discussed.

2.4.1 50 Series Complex

The 50 Series Complex is a collection of buildings within the central portion of Area I (Figure 2-2). The complex was originally constructed as three separate workshop buildings (Building 55, Building 56, and Building 57) between 1876 and 1884 (Photo B55-56-57). The remodeling of the original buildings occurred over many phases and included the addition of eight buildings and the removal and relocation of three buildings. Important features within the 50 Series Complex included a former smokestack/incinerator, degreasers, dip tanks, forges, firing ranges and USTs. Low-lying marshland areas to the west of the complex were filled in during site development.

Mr. Gordon Potter, the present owner of Building 57A, conducted an investigation in 1994 that was required for a bank loan. As part of this investigation, soil samples were collected from various depths and locations near the U-shaped gravel-filled vats for analysis. Test results from the field investigation indicated that TCE, trans-1,2-dichloroethene (trans-1,2-DCE), and methylene chloride were present in the soil beneath Building 57A (Meredith/Boli and Associates, 1994).

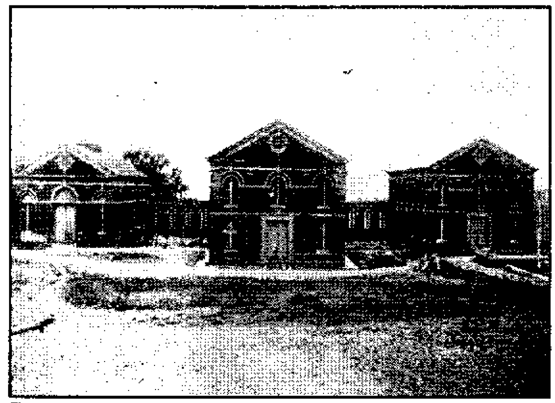


Photo B55-56-57. Looking southwest at Buildings 55, 56, and 57, from left to right. (Circa Early 1900s)

Mr. Potter's investigation at Building 57A generated only limited environmental data for metals and solvents in soil. These data do not indicate the maximum concentrations or extent of solvent or metals contamination at the 50 Series Complex. There is no other data indicating the use of other chemicals of interest (COIs) in the vicinity of Building 57A. In addition, the potential presence of underground cisterns, USTs, and associated piping was not positively determined. There is no information in the historical records regarding the disposition of the USTs and associated piping.

A site investigation was performed at the 50 Series Complex between 7 September 1999 and 28 September 1999 (FA/BC, 2003b). Identified COIs are attributed to historical DoD use at the complex. However, post-Arsenal use has also occurred in these buildings and evidence exists that some original structures (Parkerizing vats in Building 57A) had post-Army beneficial uses.

In general, solvents and fuel-related hydrocarbons were identified in several of the areas investigated at the 50 Series Complex. Detections of metals are expected in soil because these constituents generally occur naturally, but there were areas that indicated concentrations of various metals above typical ambient values. The predominant COIs in soil, soil gas and groundwater were chlorinated solvents. Fuel-related compounds and metals were also found in soil and groundwater. Some of the COIs detected were widespread and from multiple sources, while others may have been the result of an isolated source. The Expanded SI will focus on further delineation of solvents in groundwater in the area of the 50 Series Complex (see Figure 2-5, Figure 2-6 and Figure 2-7 for TCE, cis-1,2-DCE and vinyl chloride, respectively) and fuels (see Figure 2-8, Figure 2-9 and Figure 2-10 for gasoline, diesel fuel and motor oil, respectively).

MTBE, a fuel oxygenate used since the early 1970s (i.e., after Arsenal closure), was detected in three groundwater samples at concentrations of 0.59 micrograms per liter (μg/L), 0.52 μg/L, and 17 μg/L. These detections of MTBE indicate a post-Army gasoline release. MTBE was found in groundwater at Building 57A and southeast of Building 56A.

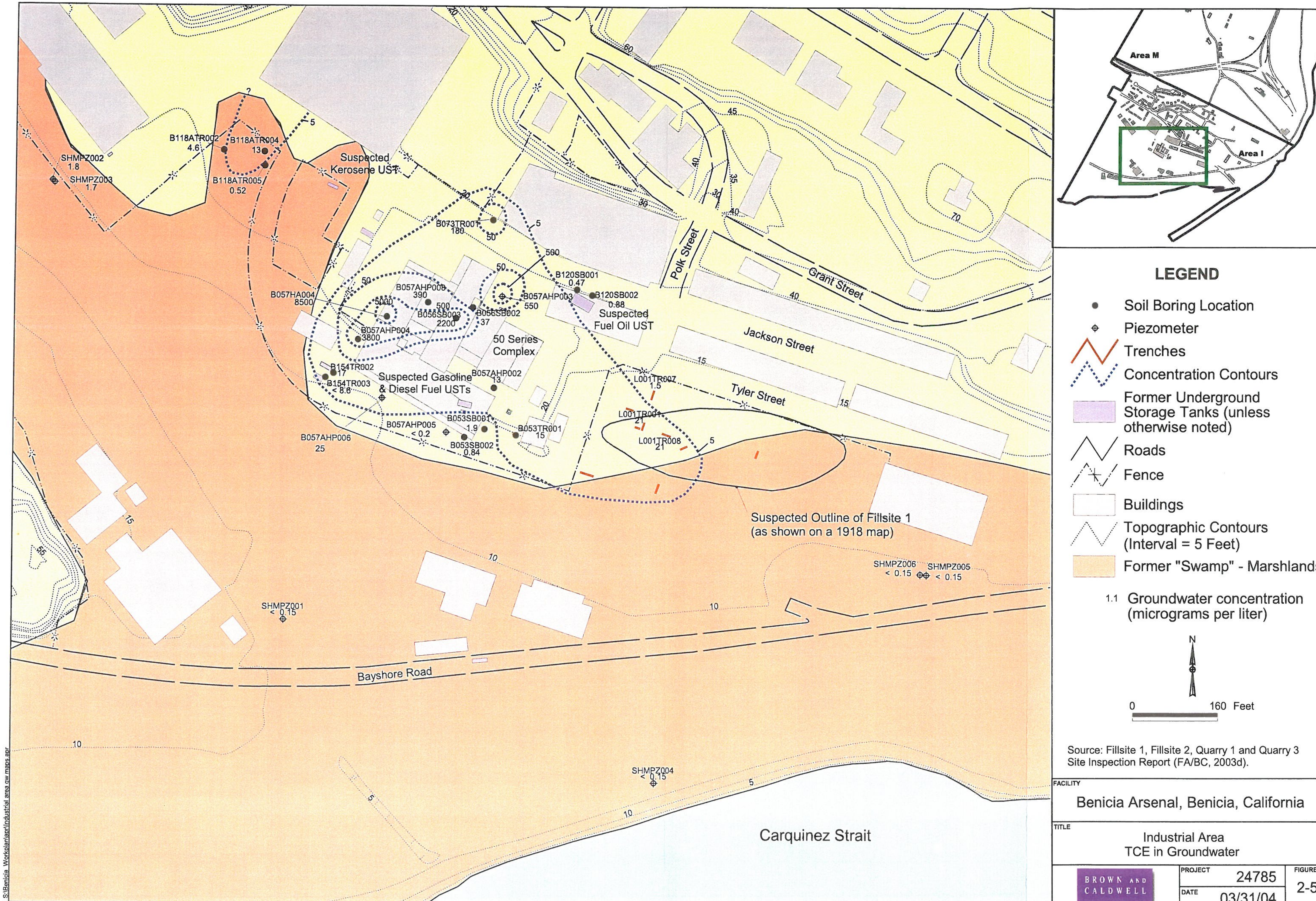
2.4.2 Area I Fuel Facilities

On behalf of and with oversight by the USACE, FA/BC conducted site investigations for the Area I Fuel Only Facilities in June 2000 (FA/BC. 2002a). Area I fuel facilities included Building 15, Building 25, Building 26, Building 27, Building 28, Building 45, Building 46(B), Building 53, Building 54, Building 73, Building 103, Building 118(A), Building 152, Building 154, and Building 178. Due to budget constraints, only the mostly likely sites with fuel storage tanks were investigated in 2000. Up to 13 fuel storage tanks were suspected at these locations. The FA/BC investigation focused on confirming the existence of the tanks and associated piping, and verifying whether past DoD activities caused environmental impacts to soil or groundwater by petroleum hydrocarbons and/or lead. Both surface geophysical methods and test pits were used to identify the location of suspected USTs and associated piping.

Six of the 13 suspected tanks, all USTs, were identified during this investigation (one 1,000-gallon UST at Building 53, one 15,000-gallon UST at Building 103, one 7,000-gallon and 10,000-gallon UST at Building 154, one 250-gallon UST at Building 26 and one 250-gallon UST at Building 28). In March 2002, Geofon, with guidance from the USACE, removed the six confirmed USTs (Geofon, 2003).

As shown on Figure 2-11 and Figure 2-12, Building 53, Building 103, Building 154, and Building 118(A) had reported total petroleum hydrocarbon (TPH), polynuclear aromatic hydrocarbon (PAH), and/or lead levels above soil or groundwater Environmental Screening Levels (ESLs) established by the California Regional Water Quality Control Board, San Francisco Bay Region (RWQCB). These findings are discussed below in further detail. The ESLs are published in *Screening For Environmental Concerns at Sites With Contaminated Soil and Groundwater (Interim final)* (RWQCB, 2003). Information on the remaining fuel facility buildings at the former Arsenal can be found in more detail in the following reports:

- Technical Memorandum for Area I Fuel Facilities (FA/BC, 2000)
- Technical Memorandum for Area I – Fuel Storage Facilities at Buildings 15, 25, 26, 27, 28, 45, 46(B), 54, 118(A), 152 and 178 for the Benicia Arsenal (FA/BC, 2002a).
- Revised Final Underground Storage Tank Removal Report (Geofon, 2003).



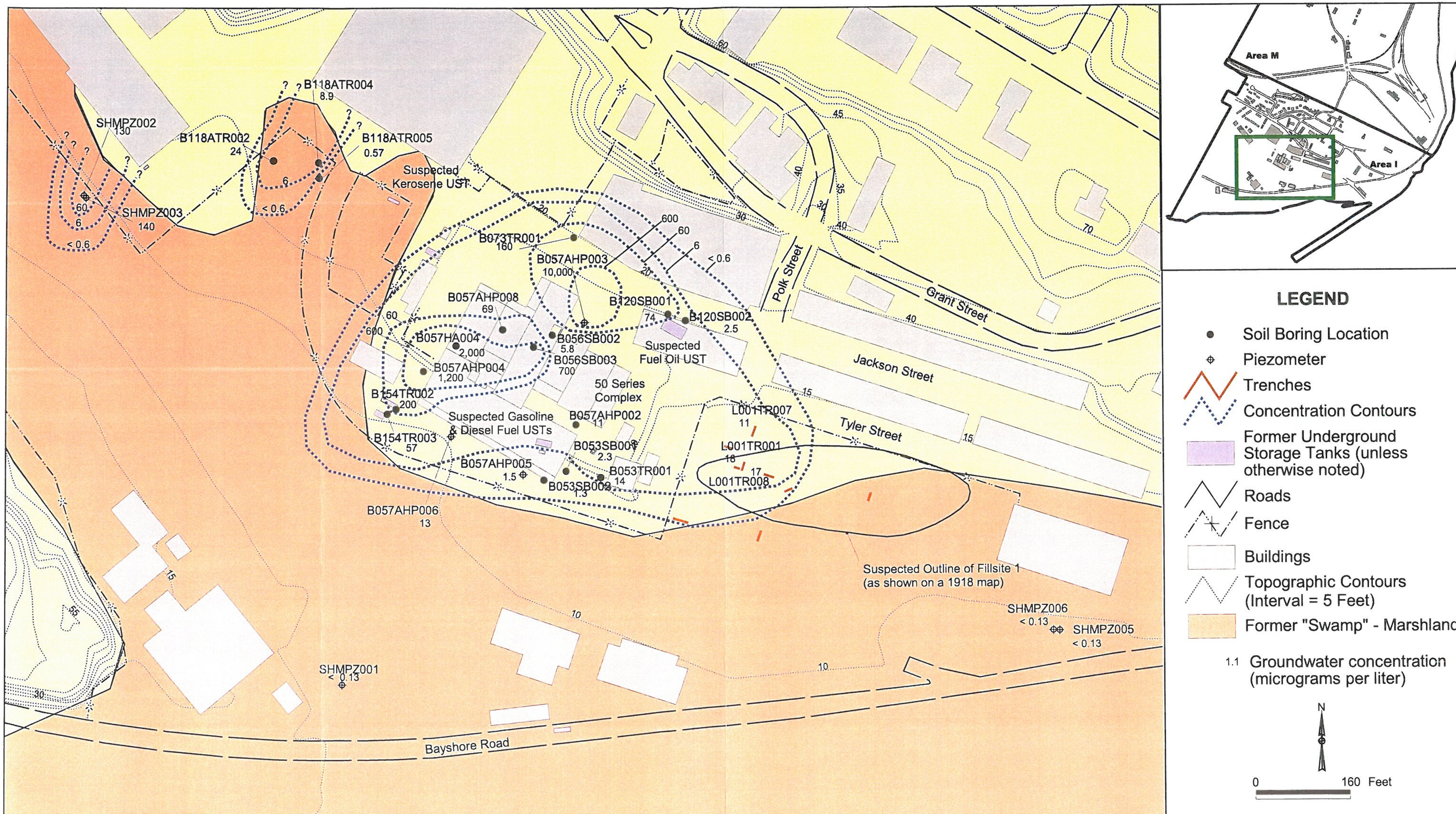
Source: Fillsite 1, Fillsite 2, Quarry 1 and Quarry 3 Site Inspection Report (FA/BC, 2003d).

FACILITY: Benicia Arsenal, Benicia, California

TITLE: Industrial Area TCE in Groundwater

BROWN AND CALDWELL

PROJECT 24785 | DATE 03/31/04 | FIGURE 2-5



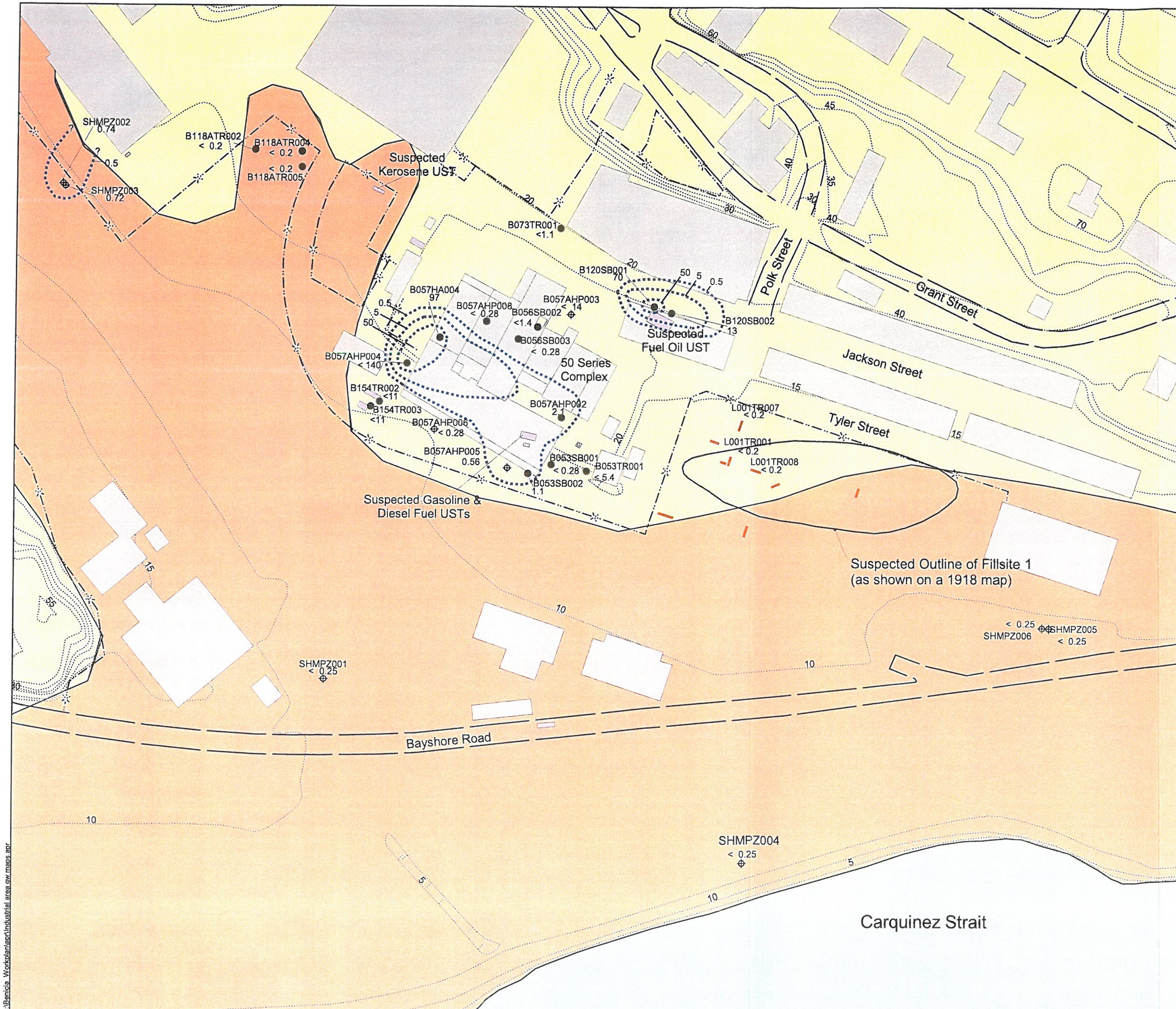
Source: Fillsite 1, Fillsite 2, Quarry 1 and Quarry 3 Site Inspection Report (FA/BC, 2003d).

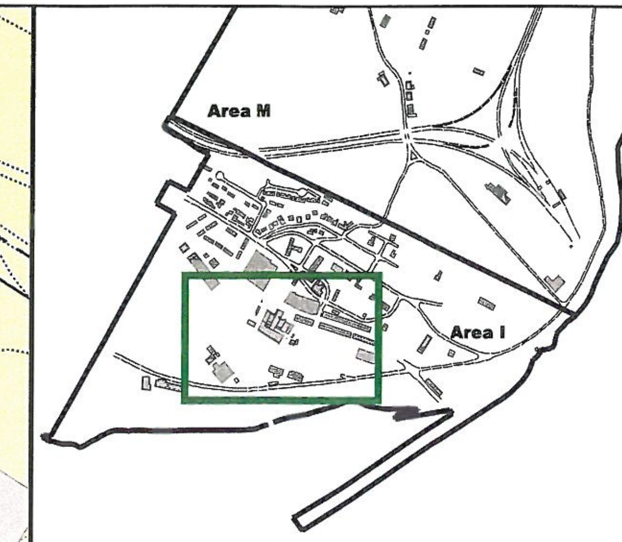
FACILITY
Benicia Arsenal, Benicia, California

TITLE
Industrial Area
cis-1,2-dichloroethene in Groundwater

BROWN AND CALDWELL

PROJECT	24785	FIGURE
DATE	03/31/04	2-6





LEGEND

- Soil Boring Location
- Piezometer
- Trenches
- Concentration Contours
- Former Underground Storage Tanks (unless otherwise noted)
- Roads
- Fence
- Buildings
- Topographic Contours (Interval = 5 Feet)
- Former "Swamp" - Marshlands

1.1 Groundwater concentration (micrograms per liter)

N

0 160 Feet

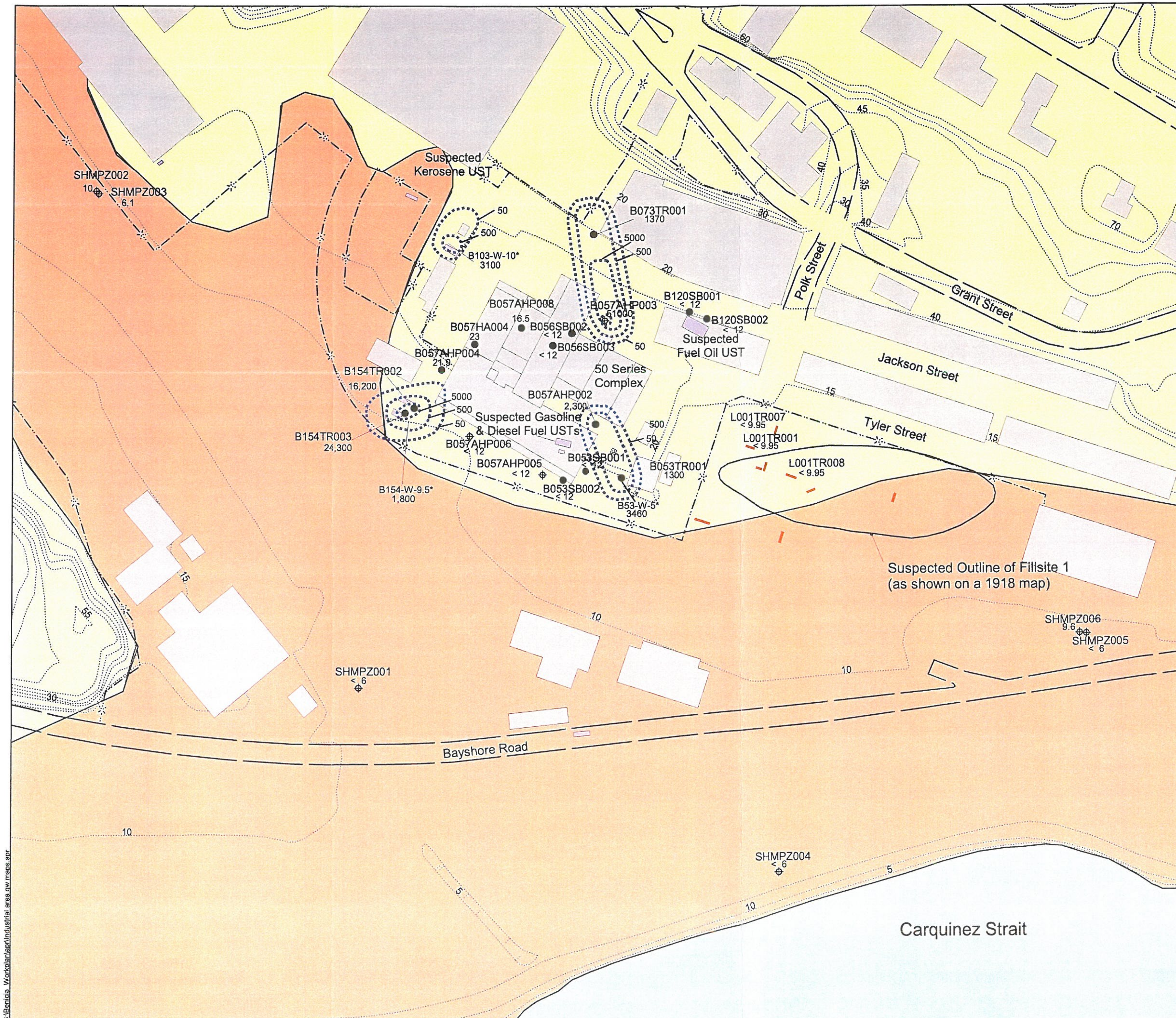
Source: Fillsite 1, Fillsite 2, Quarry 1 and Quarry 3 Site Inspection Report (FA/BC, 2003d).

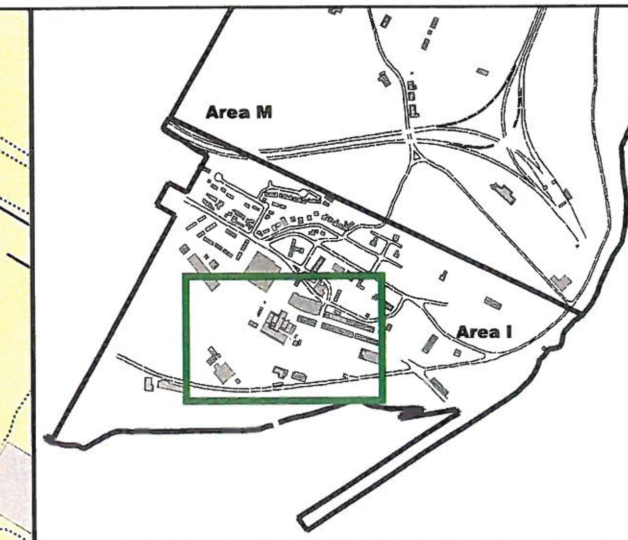
FACILITY
Benicia Arsenal, Benicia, California

TITLE
Industrial Area
Vinyl Chloride in Groundwater

BROWN AND CALDWELL

PROJECT 24785
DATE 03/31/04
FIGURE 2-7





LEGEND

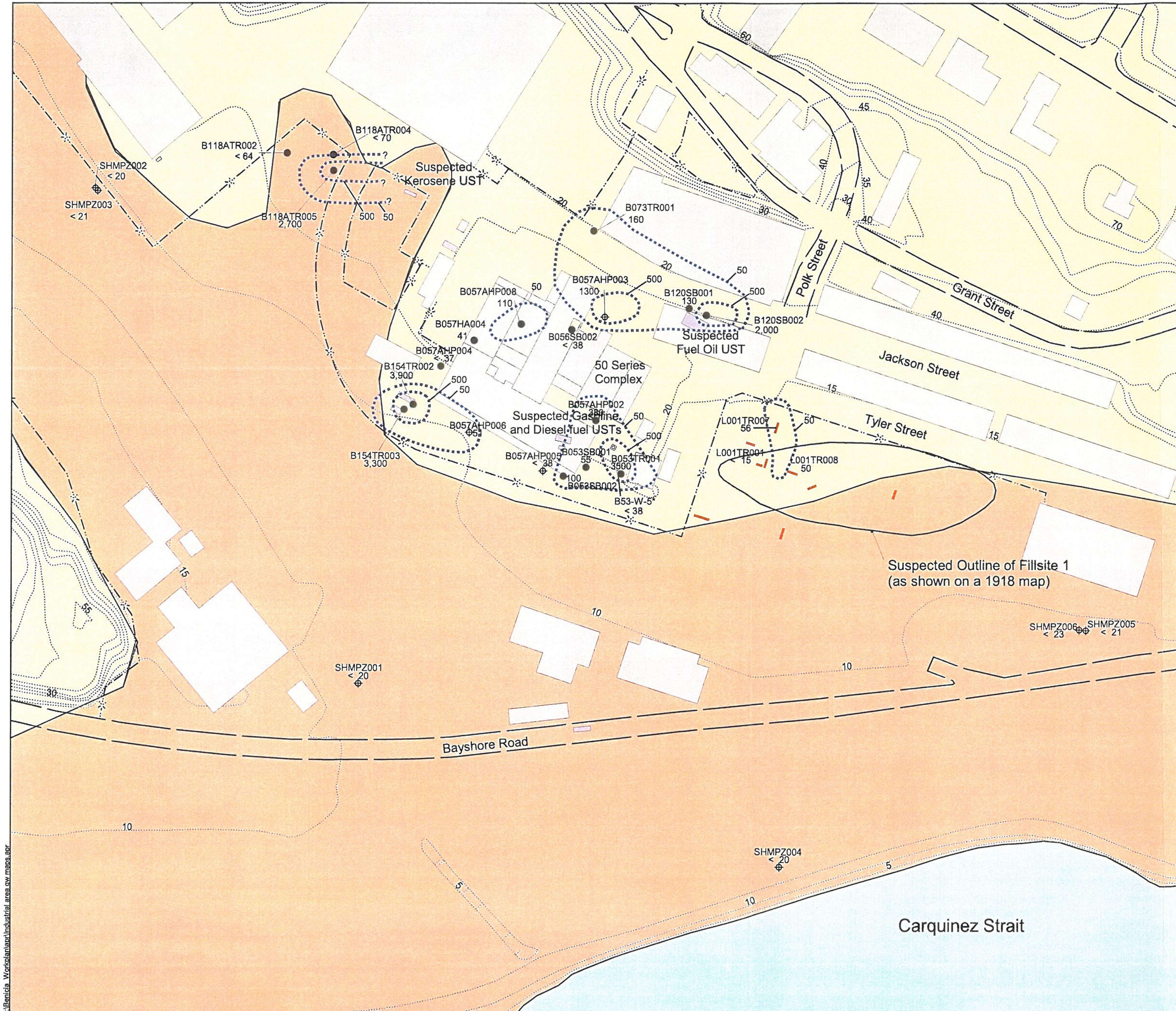
- Soil Boring Location
- Piezometer
- Trenches
- Concentration Contours
- Former Underground Storage Tanks (unless otherwise noted)
- Roads
- Fence
- Buildings
- Topographic Contours (Interval = 5 Feet)
- Former "Swamp" - Marshlands
- 1.1 Groundwater concentration (micrograms per liter)

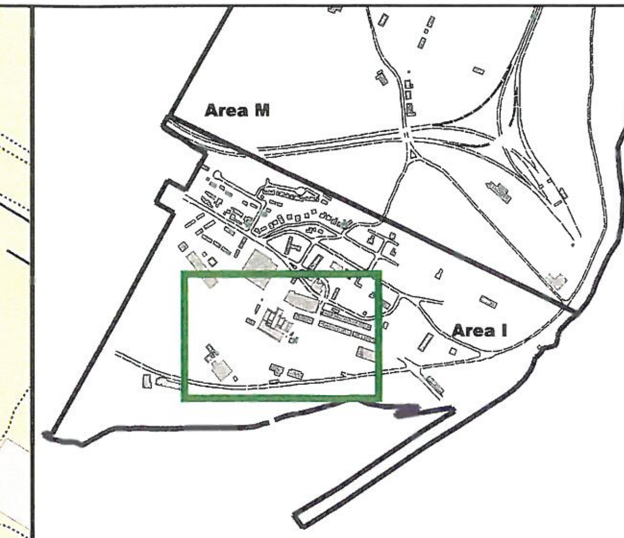
N

0 160 Feet

Source: Fillsite 1, Fillsite 2, Quarry 1 and Quarry 3 Site Inspection Report (FA/BC, 2003d) and Geofon (2003).

FACILITY	Benicia Arsenal, Benicia, California
TITLE	Industrial Area Gasoline in Groundwater
BROWN AND CALDWELL	PROJECT 24785 DATE 03/31/04
FIGURE	2-8





LEGEND

- Soil Boring Location
- Piezometer
- Trenches
- Concentration Contours
- Former Underground Storage Tanks (unless otherwise noted)
- Roads
- Fence
- Buildings
- Topographic Contours (Interval = 5 Feet)
- Former "Swamp" - Marshlands

1.1 Groundwater concentration (micrograms per liter)

N

0 160 Feet

Source: Fillsite 1, Fillsite 2, Quarry 1 and Quarry 3 Site Inspection Report (FA/BC, 2003d) and Geofon (2003).

FACILITY

Benicia Arsenal, Benicia, California

TITLE

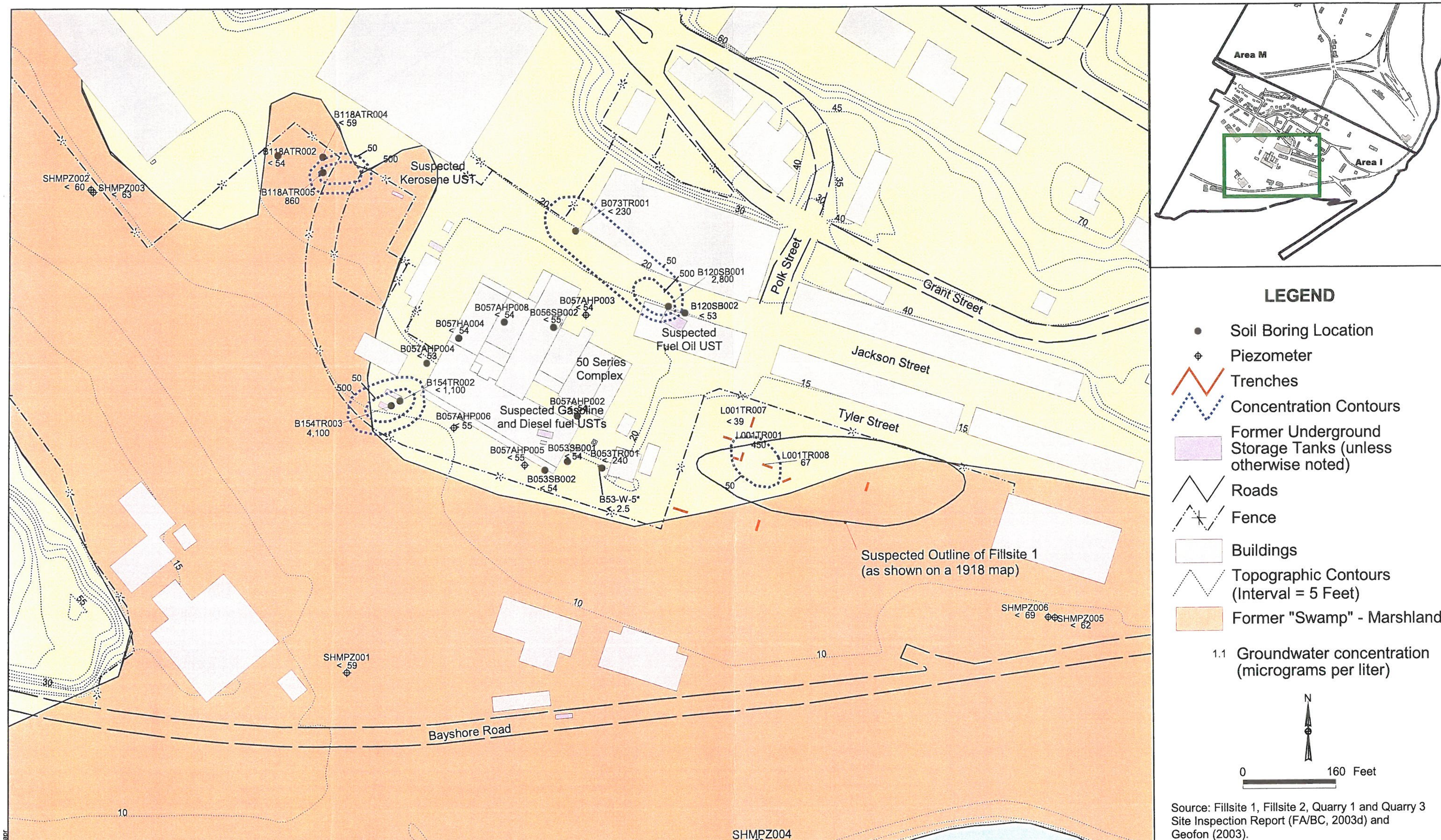
Industrial Area
Diesel Fuel in Groundwater

BROWN AND CALDWELL

PROJECT 24785

DATE 03/31/04

FIGURE 2-9



FACILITY

Benicia Arsenal, Benicia, California

TITLE

Industrial Area
Motor Oil in Groundwater

BROWN AND CALDWELL	PROJECT 24785	FIGURE 2-10
	DATE 03/31/04	

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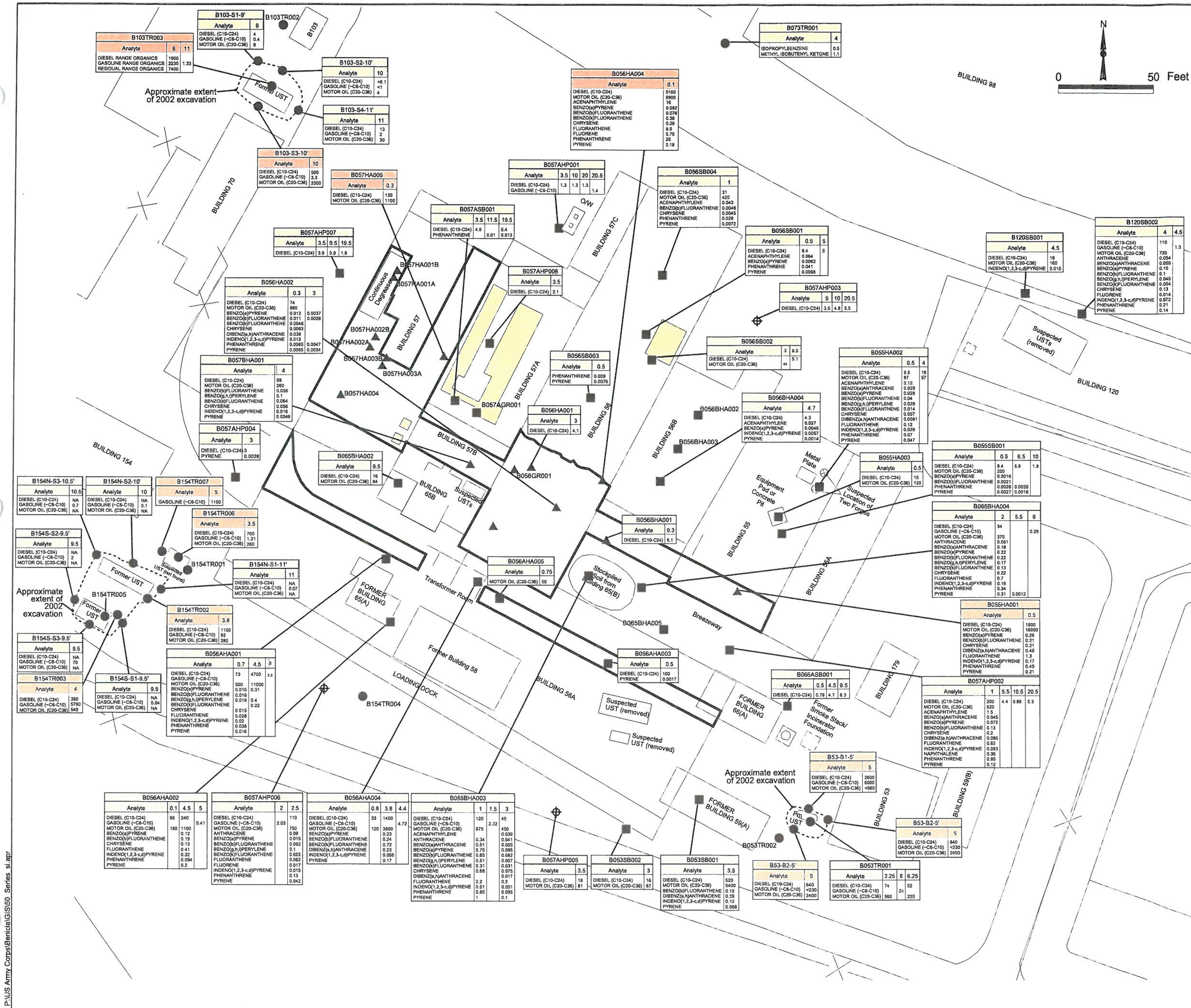

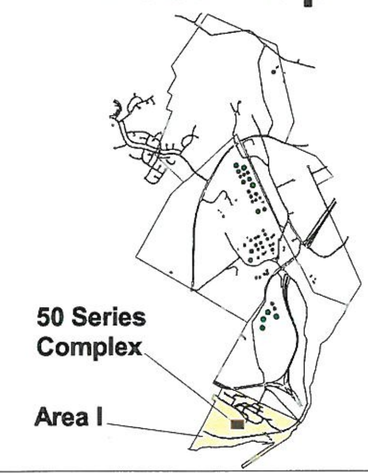

Legend

- Piezometers
- 50 Series Complex Basement Level Borings
- Historical Sample Points
- 50 Series Complex Ground Level Borings
- Former Parkerizing Vats
- Basement Level
- Buildings
- Fence
- Roads

Boring Location	
Analyte	Depth (ft)

Sample location with diesel fuel, gasoline or motor oil concentrations exceeding ESLs of 500 mg/kg, 400 mg/kg or 1000 mg/kg, respectively.

NOTES:

1) Only detected results above the method detection limits are shown.

2) Results are in mg/kg.

3) Environmental Screening Levels (ESLs) are established in "Screening For Environmental Concerns at Sites with Contaminated Soil and Groundwater (Interim final)" (RWQCB, 2003).

4) Analytical results are from samples collected in March 1999 (FA/BC, 2000), September 1999 (FA/BC, 2002), and in April 2002 (Geofon, 2003).

5) TPH concentrations at B057HA005, B055HA001 and B056HA004 exceed ESLs but will not be investigated as part of the Expanded SI. These locations are located in the 50 Series Complex basement (surface soils) and will be evaluated in the remedial action phase.

FACILITY

Benicia Arsenal, Benicia, California

TITLE

TPH and PAH Soil Results

BROWN AND CALDWELL

PROJECT 24785

DATE 03/31/04

FIGURE 2-11

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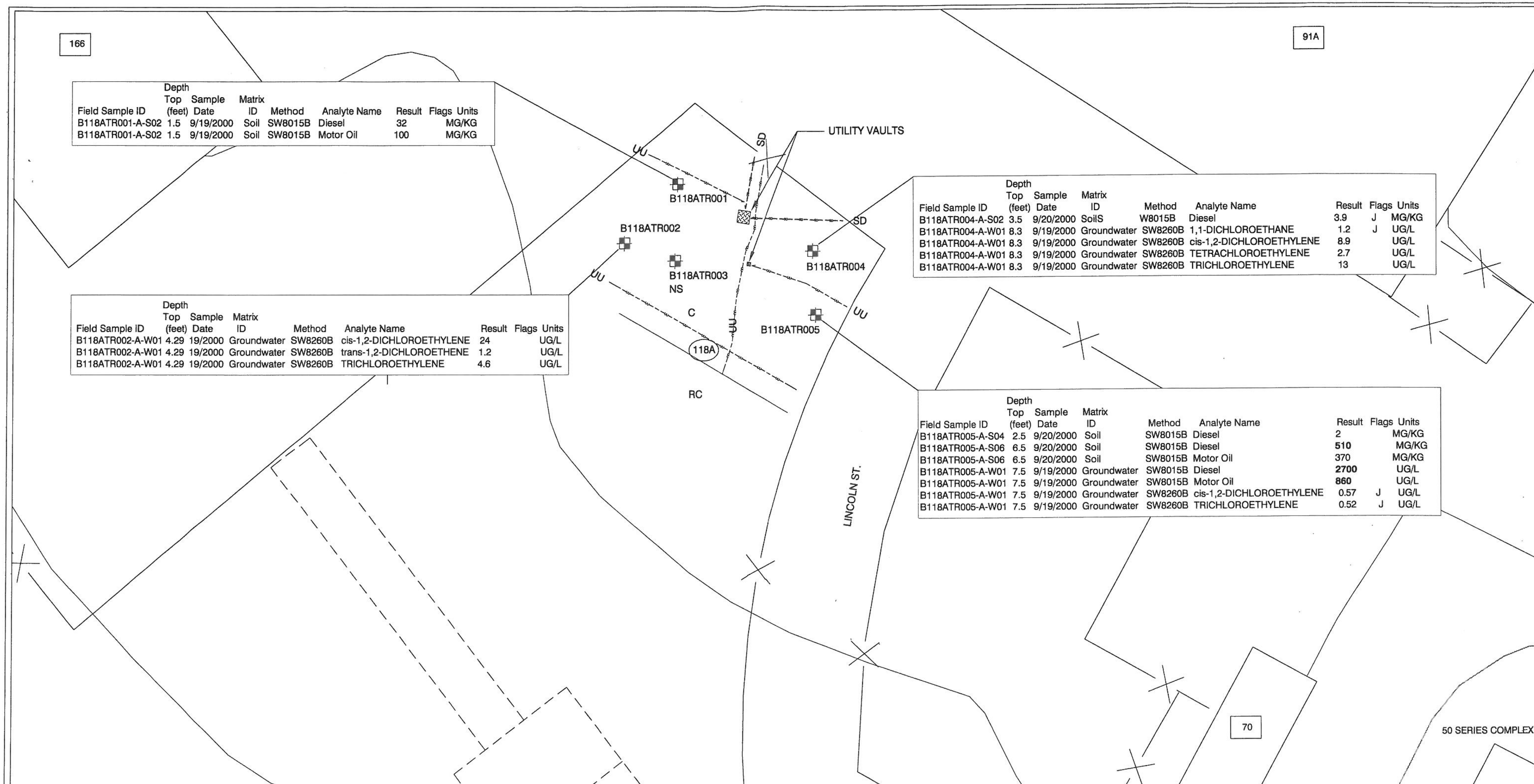


Field Sample ID	Depth Top (feet)	Sample Date	Matrix ID	Method	Analyte Name	Result	Flags	Units
B118ATR001-A-S02	1.5	9/19/2000	Soil	SW8015B	Diesel	32		MG/KG
B118ATR001-A-S02	1.5	9/19/2000	Soil	SW8015B	Motor Oil	100		MG/KG

Field Sample ID	Depth Top (feet)	Sample Date	Matrix ID	Method	Analyte Name	Result	Flags	Units
B118ATR002-A-W01	4.29	19/2000	Groundwater	SW8260B	cis-1,2-DICHLOROETHYLENE	24		UG/L
B118ATR002-A-W01	4.29	19/2000	Groundwater	SW8260B	trans-1,2-DICHLOROETHENE	1.2		UG/L
B118ATR002-A-W01	4.29	19/2000	Groundwater	SW8260B	TRICHLOROETHYLENE	4.6		UG/L

Field Sample ID	Depth Top (feet)	Sample Date	Matrix ID	Method	Analyte Name	Result	Flags	Units
B118ATR004-A-S02	3.5	9/20/2000	SoilS	W8015B	Diesel	3.9	J	MG/KG
B118ATR004-A-W01	8.3	9/19/2000	Groundwater	SW8260B	1,1-DICHLOROETHANE	1.2	J	UG/L
B118ATR004-A-W01	8.3	9/19/2000	Groundwater	SW8260B	cis-1,2-DICHLOROETHYLENE	8.9		UG/L
B118ATR004-A-W01	8.3	9/19/2000	Groundwater	SW8260B	TETRACHLOROETHYLENE	2.7		UG/L
B118ATR004-A-W01	8.3	9/19/2000	Groundwater	SW8260B	TRICHLOROETHYLENE	13		UG/L

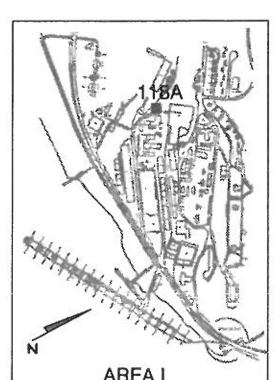
Field Sample ID	Depth Top (feet)	Sample Date	Matrix ID	Method	Analyte Name	Result	Flags	Units
B118ATR005-A-S04	2.5	9/20/2000	Soil	SW8015B	Diesel	2		MG/KG
B118ATR005-A-S06	6.5	9/20/2000	Soil	SW8015B	Diesel	**510**		MG/KG
B118ATR005-A-S06	6.5	9/20/2000	Soil	SW8015B	Motor Oil	370		MG/KG
B118ATR005-A-W01	7.5	9/19/2000	Groundwater	SW8015B	Diesel	**2700**		UG/L
B118ATR005-A-W01	7.5	9/19/2000	Groundwater	SW8015B	Motor Oil	**860**		UG/L
B118ATR005-A-W01	7.5	9/19/2000	Groundwater	SW8260B	cis-1,2-DICHLOROETHYLENE	0.57	J	UG/L
B118ATR005-A-W01	7.5	9/19/2000	Groundwater	SW8260B	TRICHLOROETHYLENE	0.52	J	UG/L

Note: Only positive results are shown. Bolded values exceed Environmental Screening Levels (ESLs) established in *Screening for Environmental Concerns at Sites With Contaminated Soil and Groundwater (Interim Final)* (RWQCB, 2003).

LEGEND

70	Building Location	C	Concrete
4	Former Location of Building	RC	Reinforced Concrete
118A	Suspected Tank Location Area	SD	Storm Drain
	Test Pit Location	UU	Undifferentiated Utility
NS	Not Sampled		

Note: All site features referenced in Records Research Report (Jacobs Engineering, 1999) documents or noted during site inspection are included on this figure.



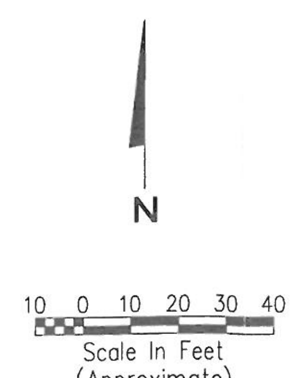


Figure 2-12
Detected Fuel and Solvent Concentrations Fuel Only Facility at Building 118A

Expanded SI FSIP
Benicia Arsenal

Building 53. In 2002, two soil samples were collected from the northern and southern sidewalls of the UST excavation at Building 53. Both samples were collected at 5 feet bgs at the soil/water interface. The northern soil sample reported TPH as diesel fuel (TPHD), TPH as gasoline (TPHG), toluene, ethylbenzene, xylenes and lead above ESLs. The southern sample reported TPHD, TPH as motor oil (TPHMO) and lead above ESLs at 5 feet bgs. These sampling locations are shown on Figure 2-11.

The UST at Building 53 was located within a hollowed-out sandstone cavity and groundwater at this location is shallow (approximately 4 feet bgs to 5 feet bgs). The vertical extent of impacted soil could not be delineated because of the presence of shallow groundwater. Because of the shallow groundwater, the soil sample was most likely saturated and the reported analytical results are likely due to contaminants in groundwater.

DCE isomers were detected in groundwater samples collected at this location. The presence of DCE is likely due to degradation of TCE that had been released in the past.

Geofon recommended further investigation at Building 53 based on the detection of hydrocarbons and lead above ESLs in groundwater and/or soil samples. Investigation of shallow surface soils was also recommended to determine the vertical and lateral extent of impacted soil (Geofon, 2003).

Building 103. TPHD and TPHMO were detected above ESLs in a soil sample collected along the southern sidewall of the UST excavation near the soil/water interface (Figure 2-11). The soil sample was collected at 10 feet bgs. Fuels and lead in three other samples collected from the northern and eastern excavation sidewalls were less than ESLs. A groundwater sample collected from the excavation also reported TPHG, toluene and xylenes above ESLs. TPHD was not evaluated in the water sample.

Geofon recommended further investigation at Building 103 based on the detection of hydrocarbons and lead above ESLs in groundwater and/or soil samples. Investigation of shallow surface soils was also recommended to determine the vertical and lateral extent of impacted soil (Geofon, 2003).

Building 154. Fuels and lead were not identified above ESLs in soil samples collected from the UST excavation at Building 154. However, groundwater was impacted with TPHG and lead above the ESLs (Figure 2-11). Isomers of DCE were detected in groundwater samples, likely the result TCE degradation.

Geofon recommended further investigation at Building 154 based on the detection of hydrocarbons and lead above ESLs detected in groundwater (Geofon, 2003).

Building 118(A). The FA/BC investigation included a geophysical survey and the excavation of five test pits. All soil and groundwater samples were collected from the test pits. TPHG and TPHMO did not exceed the ESLs for soil. However TPHD exceeded ESLs for soil and groundwater and TPHMO in groundwater (Figure 2-12).

Recommendations were made to collect additional samples in the area of trench (test pit) TR005 at former Building 118(A) to determine the extent of TPH and VOCs in soil and groundwater (FA/BC, 2002a).

2.4.3 Fillsite 1

On behalf of and with oversight by the USACE, FA/BC conducted an environmental site inspection at Fillsite 1, Fillsite 2, Quarry 1 and Quarry 3 between November 2000 and October 2002 (FA/BC, 2003c). These suspected fillsites and quarries were identified from historical information as possible repositories for industrial wastes from the shop area and other facilities at the former Arsenal. Of the two fillsites and two quarries investigated, only Fillsite 1 is located in an area covered by the Expanded SI. Therefore, only the results from the previous investigation at Fillsite 1 are discussed below.

Fillsite 1 (Figure 2-5 through Figure 2-10) is noted on the 1918 map included in "Benicia, Portrait of an Early California Town," (Jacobs, 1999). Identified on the 1918 map is a "dump" located slightly northeast of the former industrial shop buildings, at what appears to be the beginning of a swale leading northwest from the swamp area to Area I. The swamp area below the swale has since been filled. Building 71 was constructed over the filled swamp in 1920 and overlies the "dump". Compressible clays caused this building and others built on the former swamp to settle unevenly. The Army made several attempts to enhance the structural foundation of this building, including replacing wooden piling supports with concrete piling supports or buttresses. Building 71 was demolished in the 1980s by the current landowner. The site is now paved and used for temporary storage of new vehicles. The exact location and extent of this Fillsite 1 is unknown.

The types of materials managed at Fillsite 1 are unknown. This area is adjacent to the 50 Series Complex, which used a variety of fuels and solvents when the former Arsenal was operational. Thus, Fillsite 1 may have been a location for dumping of used fuels and solvents generated at the 50 Series Complex, and there is also a potential for acids, metal cleaning corrosives, petroleum, oils, lubricants, gasoline, foundry wastes, infectious wastes, and pesticides to be present. It should be noted that such unregulated dumping of waste materials was a common practice prior to the 1970s.

FA/BC conducted a geophysical evaluation of the Fillsite 1 area and collected soil and groundwater samples. These samples were analyzed for constituents related to materials that may have been commonly used at the 50 Series Complex and discarded at this location.

Geophysical techniques identified metallic and non-metallic anomalies at Fillsite 1, in locations where debris was found by trenching. The stratigraphy of Fillsite 1 was found to consist of artificial fill with underlying Bay Mud. Fill material included unconsolidated sandy silt with gravel and occasional wood, brick, and a discontinuous buried asphalt layer beneath the western third of the site.

No refuse was encountered in any trenches at Fillsite 1, although motor oil, diesel fuel and lead were detected in soil samples. All of these contaminants decreased with depth. Groundwater at Fillsite 1 was found to contain solvents, diesel fuel and motor oil (Figure 2-5 through Figure 2-10).

The source of the solvents in Fillsite 1 groundwater is not clearly understood, but is likely associated with a nearby source area (i.e., the 50 Series Complex or another unknown upgradient area). Widespread use of solvents in manufacturing began during World War II after the area was filled in and Building 71 was placed on top of the suspected "dump."

Fuels were used throughout the former Arsenal and could have been discarded at Fillsite 1. However, it is more likely that the hydrocarbons reported in soil and groundwater at this location result from decomposition of the buried asphalt layer. Additionally, low levels of MTBE were detected in groundwater samples from Fillsite 1. The discovery of MTBE in groundwater at this location demonstrates that fuels were released after the former Arsenal closed.

Based on the findings of FA/BC (2003c), soil and/or groundwater at Fillsite 1 appear to have been impacted to some extent by DoD activities. FA/BC recommended additional groundwater testing to assess the vertical and lateral extent of the solvents detected in groundwater at the Fillsite 1 area and identify the source area for these constituents.

3.0 PROJECT DESCRIPTION

Previous investigations at the former Arsenal have generated limited environmental data at some of the proposed inspection sites. There is no environmental data at other proposed inspection sites. The field work for the Expanded SI is therefore designed to determine the presence/absence of contamination at sites with no chemical data and delineate the extent of contamination at these locations with chemical data through the following sequence of activities:

- Performing direct-push cone penetrometer testing (CPT) to obtain lithologic data at the proposed inspection sites.
- After obtaining lithologic data, use CPT technology to collect soil and/or groundwater samples. Analyze these samples to determine the presence or absence of DoD-related contamination at the proposed inspection sites.
- If contamination is discovered at the initial proposed inspection site location above project criteria, collect additional CPT groundwater samples to delineate the DoD-related VOC/TPH contamination.
- After the DoD-related VOC/TPH contamination is delineated, assess the location and need for groundwater monitoring wells.
- If deemed necessary, install up to 13 groundwater monitoring wells.
- Purge, sample, and analyze samples from the new wells and up to four other existing wells (piezometers or wells from the existing non-DoD monitoring wells).
- Collect three rounds of water-level data within a period of six months after installation of the new wells. The water-level measurements will be collected from the new wells, up to 10 existing non-DoD monitoring wells, and 20 existing wells within the former Arsenal's groundwater monitoring network.

The samples collected by CPT will be analyzed at a mobile laboratory located on site to obtain rapid results, which will be used to determine the need for additional sampling locations as the field work progresses. These decisions will be made while the field team is mobilized. Regulatory agencies will be updated as delineation of the contaminants progresses and when key decisions are needed. Details of the decision making process are presented in Section 5.0.

3.1 Project Schedule

The activities described in this FSIP will begin approximately three weeks after this document is finalized. Once field activities begin, the former Arsenal-wide groundwater investigation will be conducted in a sequence that enables project personnel (in consultation with USACE and the regulatory agencies) to refine the sampling location as new data are collected. Field activities are expected to take four weeks.

4.0 PROJECT APPROACH

The general technical approach to be used during the Expanded SI is listed below:

- Use initial CPT lithologic results with previous lithologic data collected from other investigations (if present) to determine cross-sectionally the presence of low permeability zones (e.g. clay) and higher permeability zones (e.g. sand).
- Correlate CPT lithologic results and analytical results to determine the location and transport of contamination through subsurface soil and groundwater.
- Use initial analytical results to determine the presence or absence of key indicators of groundwater contamination at the proposed inspection sites.
- If any of the key indicators are present:
  - determine the source of the contamination, if not already known (e.g., grease rack).
  - determine the owner (source) of the contamination (e.g., DoD or post-DoD).
- If key indicators are not present and sampling locations were placed at the best locations based on professional judgment, then no further sampling is required. Request concurrence from regulatory agencies.
- If key indicators are present, then contamination may be related to DoD activities and further delineation needs to be assessed.
- Rank sites that need further delineation based on known current exposure routes. The ranking will be as follows (in descending priority):
  1. Sites with possible human exposure by direct contact (e.g., exposed soil)
  2. Sites with impacted subsurface soil that have no cap (i.e., no concrete or asphalt cover)
  3. Sites with groundwater impacted by VOCs
  4. Sites with groundwater impacted by TPH
  5. Sites with impacted subsurface covered by impermeable material (e.g., concrete or asphalt)

As noted above, the decision-making process will be based on several key indicators of groundwater contamination. Data collected from USACE investigations at the former Arsenal were reviewed to develop the indicator list. The previous investigations evaluated a wide variety of analytes, including metals, TPH, VOCs, PAHs, and various semi-volatile organic compounds. Other than metals and general water quality parameters (e.g. TDS, pH, anions), the most frequently detected analytes were VOCs and TPH. This finding supports the hypothesis that groundwater at the former Arsenal has been impacted by chemicals consistent with historical and present uses. The six contaminant species that were detected most often are listed in the top-right table.

As a result of this evaluation, the analytes listed in the bottom-right table will be used as key indicators of groundwater contamination in this Expanded SI. With the exception of trans-1,2-DCE, the key indicators include the contaminants that have been detected most frequently in previous studies. Since trans-1,2-DCE is a degradation product of TCE, and cis-1,2-DCE (the primary TCE breakdown product) was found to be more widespread with the higher concentrations, it is not necessary to have trans-1,2-DCE as a key indicator if cis-1,2-DCE is already a key indicator. Benzene was added as a key groundwater indicator because of its relatively high risk to human health and the environment.

Six Most Frequently Detected Groundwater Contaminants at Benicia Arsenal

Analyte Name	Analytical Method
Cis-1,2-dichloroethylene	SW8260B
Trichloroethylene	SW8260B
Diesel-range organics	SW8015B
Trans-1,2-dichloroethene	SW8260B
Gasoline-range organics	SW8015B
Vinyl chloride	SW8260B

Key Groundwater Indicators for Expanded SI

Analyte Name	Analytical Method
Cis-1,2-dichloroethylene	SW8260B
Trichloroethylene	SW8260B
Diesel-range organics	SW8015B
Benzene	SW8260B
Gasoline-range organics	SW8260B
Vinyl chloride	SW8260B

5.0 SAMPLE PROCESS DESIGN

This section presents the rationale and design of the investigative procedures for the former Arsenal-wide groundwater investigation. Data collection and sampling, sample types and matrices, and sampling frequencies are discussed. As stated above, the goal of the Expanded SI is to determine if former DoD activities have resulted in soil or groundwater contamination and to delineate DoD-related contaminant plumes.

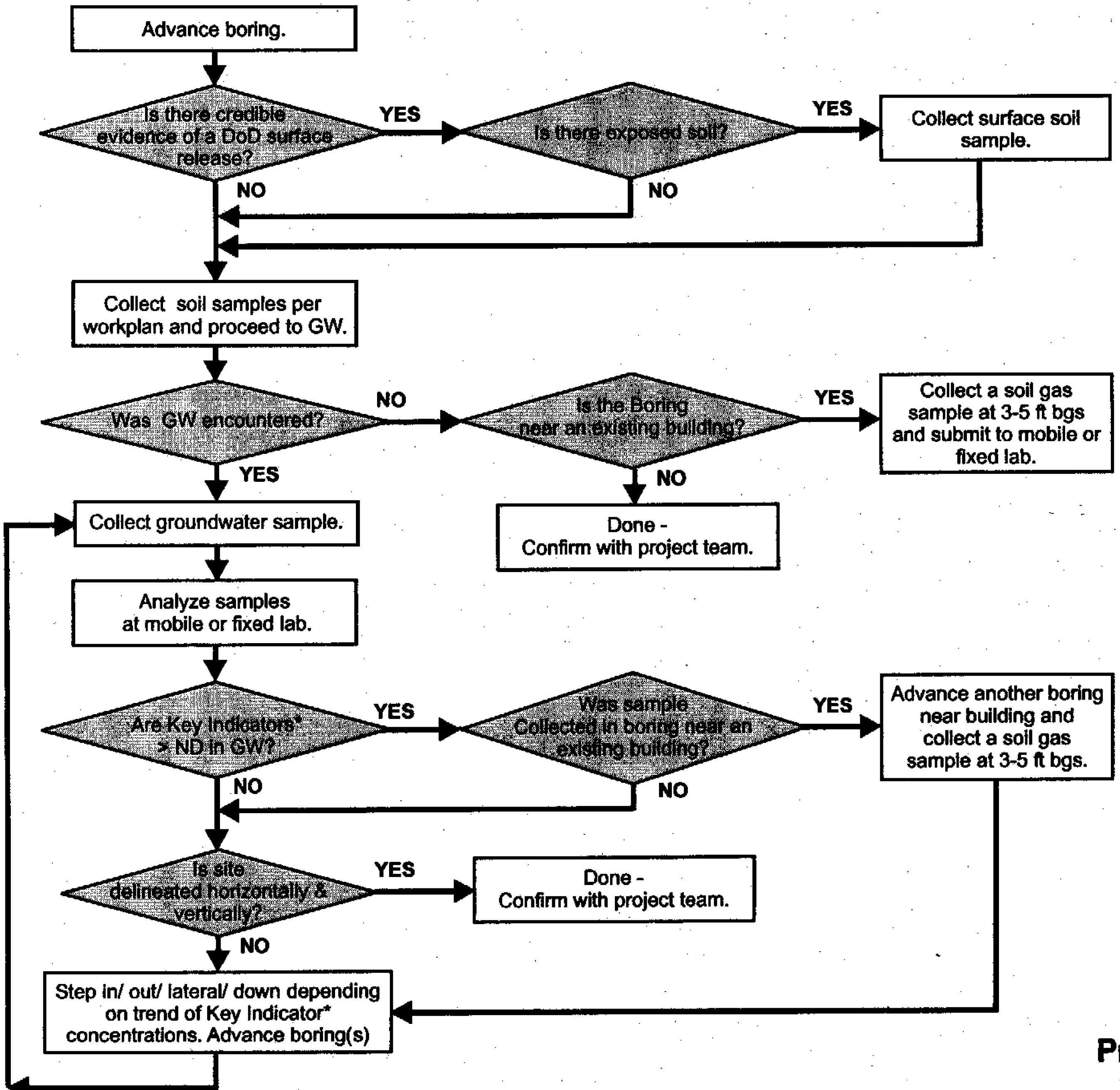
5.1 Subsurface Investigation

Table 5-1 is a matrix that lists the sample locations, the media to be sampled, and the analytical methods to be used at each proposed inspection site. The purpose of these activities is to first determine the presence or absence of contamination and then assess the extent of potential impacts resulting from DoD uses. As discussed in Section 4, the boring locations and chemical parameters were selected based on site-specific historical records and information obtained during previous investigations. A decision diagram (Diagram 5-1) will be used to determine if additional step-out/step-in borings are needed.

A slide hammer will be used for surface and subsurface sampling (less than 10 feet bgs) in areas that cannot be accessed by vehicles. In all other areas, CPT will be used to evaluate lithology, collect depth-discrete soil samples, and collect Hydropunch® groundwater samples. CPT technology is also capable of pushing a probe for collection of a depth-discrete soil gas sample.

A Site Safety Health Plan (SSHP) for this field investigation is included in Appendix B.

Based on the "dynamic" and "real-time" aspects of this investigation, the CPT borings will be surveyed quickly for interpolation of lithologic data with the analytical results from the mobile lab. Therefore, a mobile survey station will be employed during the investigation that will have less accuracy than a licensed surveyor but adequate for the purposes of this investigation. This mobile field station will measure elevation and location to an accuracy of 1 foot horizontally and 3-feet vertically.



*** Key Indicators**
Cis-1,2-dichloroethene
Trichloroethene
Vinyl Chloride
Benzene
Gasoline
Diesel Fuel

Sites will be delineated in the following order based on highest risk to human health and the environment:
1. Sites with possible exposure by direct contact (e.g. exposed soil)
2. Sites with impacted subsurface soil with no cap
3. Sites with impacted groundwater by VOCs
4. Sites with impacted groundwater with TPH
5. Sites with impacted subsurface soil with a cap

"Near" defined as any boring placed for investigating a building suspected to have a DoD related source.

Diagram 5-1
Process Flow and Decision Diagram
Expanded SI FSIP
Benicia Arsenal

Table 5-1. Sampling Objective and Analytical Matrix

Proposed Inspection Site	Proposed Boring Name	Existing Piezometer to be sampled	Location and Objective of Proposed Borings	Matrix (SG/S/GW) and Sampling Depths	Mobile Lab Analyses (EPA Method #)	Fixed Lab Analyses (EPA Method #)	Figure No.
4	B004HP001, B004HP002, B154HP001		Downgradient of the building groundwater will be sampled to determine the presence/absence of lead-based and/or solvent-based paints.	GW	VOCs (8260B)	Metals	Plate 1
31	B031HP001 B031HP002		Spaced along south side of building in the downgradient direction to determine the presence/absence of a possible release from former DoD engine rebuild activities in the building and a possible underground storage tank.	GW/~8 ft bgs	TPHD/MO (8015M) TPHG/VOCs (8260B)	Metals	Plate 1
42	B042HP001 B042HP002		Spaced along the south side of building in the downgradient direction to determine the presence/absence of a possible release from former DoD repair activities in the building.	GW/? (if encountered)	TPHD/MO (8015M) TPHG/VOCs (8260B)		Plate 1
50	B050HP001		On the southeast side of the former building in the downgradient direction to determine the presence/absence of a possible release from former road oil and stove oil ASTs.		TPHD/MO (8015M) VOCs (8260B)	Lead (6010B)	5-2
51	B051HP001 (Hand Auger)		On the south side of the building in the downgradient direction to determine the presence/absence of a possible release from former DoD maintenance activities in the building and in the location of the former drum storage area.	S (see Note 7 for sampling depths)	TPHD/MO (8015M) TPHG/VOCs (8260B)	PAHs (8310), SVOCs (8270C), Metals	Plate 1
				GW/? (if encountered)	TPHD/MO (8015M) TPHG/VOCs (8260B)		

Table 5-1. Sampling Objective and Analytical Matrix (continued)

Proposed Inspection Site	Proposed Boring Name	Existing Piezometer to be sampled	Location and Objective of Proposed Borings	Matrix (SG/S/GW) and Sampling Depths	Mobile Lab Analyses (EPA Method #)	Fixed Lab Analyses (EPA Method #)	Figure No.
53	B053SB003		B053SB003 will be placed approximately 25 feet south of the southern sidewall of the former UST excavation to delineate the lateral extent of fuels and lead in soil for B53 and lateral extent of PAHs for former Building 59(A) (see Site B59(A)).	S/4-5 feet bgs	TPHD/MO (8015M) TPHG (8260B)	Lead (6010B), PAHs (8310)	Plate 1
	B053HP001		On the south side of the building in the downgradient direction to delineate a suspected release from a former UST.	GW/~5 ft bgs	TPHD/MO (8015M) TPHG/VOCs (8260B)	Lead (6010B)	
55	See B120HP003 at Site 120	B057AHP003	On the northeast and northwest sides of the building in the downgradient direction to delineate a suspected release from former DoD maintenance and repair activities (fuels and oils) in the building.	GW/existing piezometer	TPHD/MO (8015M) TPHG/VOCs (8260B)		Plate 1
56	B056HP001	B057AHP003	On the northeast and east sides of the building in the downgradient direction to delineate a suspected release from former DoD activities (preserving small arms with oils) in the building.	GW/~8 ft bgs and a existing piezometer	TPHD/MO (8015M) TPHG/VOCs (8260B)		Plate 1
56A	B056AHP001	B057AHP005 B057AHP006	On the south side of the building in the downgradient direction to delineate a suspected release from former DoD cleaning and degreasing activities in the building.	GW/~5 ft bgs and two existing piezometers	TPHD/MO (8015M) TPHG/VOCs (8260B)		Plate 1
57	See B161HP002 at Site 161 See B031HP002 at Site 31 See B103SB001 at Site 103	B057AHP006	On the east, north, and south sides in the downgradient direction to delineate a suspected release from former DoD degreasing activities in the building.	GW/~5 ft bgs and a existing piezometer	TPHD/MO (8015M) TPHG/VOCs (8260B)		Plate 1

Table 5-1. Sampling Objective and Analytical Matrix (continued)

Proposed Inspection Site	Proposed Boring Name	Existing Piezometer to be sampled	Location and Objective of Proposed Borings	Matrix (SG/S/GW) and Sampling Depths	Mobile Lab Analyses (EPA Method #)	Fixed Lab Analyses (EPA Method #)	Figure No.
58(A)	B058ASB001		South of the former boiler house on the southern perimeter of the 50 Series Complex to delineate a suspected release to soil from the former boiler house.	S/4-5 feet bgs	TPHD/MO (8015M) TPHG/VOCs (8260B)	Lead (6010B), PAHs (8310)	Plate 1
	B056AHP001	B057AHP005 B057AHP006	South side of the 50 Series Complex in the downgradient direction to delineate a suspected fuel release from a former boiler house.	GW/~5 ft bgs and two existing piezometers	TPHD/MO (8015M) TPHG/VOCs (8260B)		
59	B053HP001 B059HP001		On the south and east sides of the building in the downgradient direction to delineate a suspected release from former DoD cleaning and degreasing activities in the building.	GW/~5 ft bgs	TPHD/MO (8015M) TPHG/VOCs (8260B)	Lead (6010B) (B053HP001 only)	Plate 1
59(A)	B059(A)HP001		On the south side of the former building in the downgradient direction to delineate a suspected fuel release from a former storage building. Site 53 boring B035SB001 will be used to delineate the eastern extent.	S/4-5 feet bgs	TPHD/MO (8015M) TPHG/VOCs (8260B)	Lead (6010B), PAHs (8310)	Plate 1
				GW/~5 ft bgs	TPHD/MO (8015M) TPHG/VOCs (8260B)		
65(A)	B065ASB001		South of the former boiler house on the southern perimeter of the 50 Series Complex to delineate a suspected release to soil from the former boiler house.	S/4-5 feet bgs	TPHD/MO (8015M) TPHG/VOCs (8260B)	Lead (6010B), PAHs (8310)	Plate 1
		B057AHP006	South of the former boiler house on the in the downgradient direction to delineate a suspected release to groundwater from the former boiler house.	GW/ existing piezometer	TPHD/MO (8015M) TPHG/VOCs (8260B)		
90	B090HP001		On the southwest side of the building in the downgradient direction to determine the presence/absence of a suspected release from former DoD degreasing and cleaning activities in the building.	GW/~8 ft bgs	TPHD/MO (8015M) TPHG/VOCs (8260B)		Plate 1

Table 5-1. Sampling Objective and Analytical Matrix (continued)

Proposed Inspection Site	Proposed Boring Name	Existing Piezometer to be sampled	Location and Objective of Proposed Borings	Matrix (SG/S/GW) and Sampling Depths	Mobile Lab Analyses (EPA Method #)	Fixed Lab Analyses (EPA Method #)	Figure No.
91	B091HP001		On the southwest side of the building in the downgradient direction to determine the presence/absence of a suspected release from former DoD degreasing and cleaning activities in the building.	GW/~8 ft bgs	TPHD/MO (8015M) TPHG/VOCs (8260B)	Metals	Plate 1
91A	B091AHP001		On the south side of the building in the downgradient direction to determine the presence/absence of a suspected release from former DoD degreasing and cleaning activities in the building.	GW/~8 ft bgs	TPHD/MO (8015M) TPHG/VOCs (8260B)	Metals	Plate 1
93	B093HP001 B093HP002		On the southeast side of the building downgradient to determine the presence/absence of a suspected release from a former DoD hoist and steam cleaning room in the building.	GW/? (if encountered)	TPHD/MO (8015M) TPHG/VOCs (8260B)		Plate 1
101	B101HP001 B101HP002		On the south side of the former building downgradient to determine the presence/absence of a suspected release from a former DoD steam cleaning of battery cases in the building.	GW/~4 ft bgs	TPHD/MO (8015M)	Metals	Plate 1
103	B103SB001		Approximately 10 feet south of the southern limits of the UST excavation to delineate the lateral extent of fuels in soil from a suspected release from a former UST.	S/9 feet bgs	TPHD/MO (8015M) TPHG/VOCs (8260B)		Plate 1
			To determine the presence/absence of a possible diesel fuel release to groundwater from a former UST.	GW/~10 ft bgs			
111	B111HP001		On the southeast side of the former building in the downgradient direction to determine the presence/absence of a possible release from former DoD cleaning and fueling activities at the building.		TPHD/MO (8015M) TPHG/VOCs (8260B)		5-2

Table 5-1. Sampling Objective and Analytical Matrix (continued)

Proposed Inspection Site	Proposed Boring Name	Existing Piezometer to be sampled	Location and Objective of Proposed Borings	Matrix (SG/S/GW) and Sampling Depths	Mobile Lab Analyses (EPA Method #)	Fixed Lab Analyses (EPA Method #)	Figure No.
118(A)	B004HP002		South and downgradient of the former ASTs to delineate a suspected fuel release to groundwater.	GW/~8 ft bgs	TPHD/MO (8015M) (soil and groundwater) TPHG/VOCs (8260B) (groundwater only)		Plate 1
	B118AHP001		South of test pit B118ATR005 to delineate a suspected fuel release to soil and groundwater.	S/7 ft bgs GW/~8 ft bgs			
	B118AHP002		East of test pit B118ATR005 to delineate a suspected fuel release to soil and groundwater.	S/7 ft bgs GW/~8 ft bgs			
120	B120HP001 B120HP002 B120HP003 B120HP004		North of the building and in the downgradient to delineate a suspected release from former DoD degreasing activities in the building and an unknown source of fuels in groundwater.	S/3 ft		Cadmium, Nickel, Copper, Chromium (6010B), Cyanide (SW9014) @B120HP002 Only	Plate 1
				GW/~6 ft bgs	TPHD/MO (8015M) TPHG/VOCs (8260B)	Cadmium, Nickel, Copper, Chromium (6010B), Cyanide (SW9014) @B120HP002 Only	
154	B154HP001 B154HP002		South and east of the former USTs in the downgradient direction to delineate the lateral extent of fuels and lead in groundwater due to a release from the former USTs.	GW/~5 ft bgs	TPHD/MO (8015M) TPHG/VOCs (8260B)	Lead (6010B)	Plate 1
156	B156HP001 B156HP002		South and east of the building in the downgradient direction to determine the presence/absence of a suspected release from a former DoD cleaning and fueling activities in the building.	GW/~8 ft bgs	TPHD/MO (8015M) TPHG/VOCs (8260B)	Metals	Plate 1

Table 5-1. Sampling Objective and Analytical Matrix (continued)

Proposed Inspection Site	Proposed Boring Name	Existing Piezometer to be sampled	Location and Objective of Proposed Borings	Matrix (SG/S/GW) and Sampling Depths	Mobile Lab Analyses (EPA Method #)	Fixed Lab Analyses (EPA Method #)	Figure No.
161	B161HP001 B161HP002		Spaced south of the former building in the downgradient direction to determine the presence/absence of a suspected release from former DoD maintenance and cleaning activities in the building.	GW/~6 ft bgs	TPHD/MO (8015M) TPHG/VOCs (8260B)	Metals	Plate 1
165	B165HP001 B165HP002 B165HP003		Spaced on the south and southeast sides of the building in the downgradient direction to determine the presence/absence of a suspected release from former DoD maintenance and cleaning activities in the building.	GW/~6 ft bgs	TPHD/MO (8015M) TPHG/VOCs (8260B)	Metals	Plate 1
165A/T199	B165AHP001 B165AHP002		Spaced on the southeast sides of the former building in the downgradient direction to determine the presence/absence of a suspected release from former DoD cleaning activities in the building.	GW/~5 ft bgs	TPHD/MO (8015M) TPHG/VOCs (8260B)		Plate 1
166	SWAMPAHP00 3		Southeast of the former building in the downgradient direction to determine the presence/absence of a suspected release from former DoD maintenance (grease rack) activities in the building.	GW/~4 ft bgs	TPHD/MO (8015M) TPHG/VOCs (8260B		Plate 1
167	B167HP001 B167HP002		Spaced along south side of building in the downgradient direction to determine the presence/absence of a suspected release from former DoD maintenance activities in the building.	GW/~4 ft bgs	TPHD/MO (8015M) TPHG/VOCs (8260B)		Plate 1
168	B168HP001 B168HP002		Spaced along south side of building in the downgradient direction to determine the presence/absence of a suspected release from former DoD maintenance activities in the building.	GW/~4 ft bgs	TPHD/MO (8015M) TPHG/VOCs (8260B)		Plate 1

Table 5-1. Sampling Objective and Analytical Matrix (continued)

Proposed Inspection Site	Proposed Boring Name	Existing Piezometer to be sampled	Location and Objective of Proposed Borings	Matrix (SG/S/GW) and Sampling Depths	Mobile Lab Analyses (EPA Method #)	Fixed Lab Analyses (EPA Method #)	Figure No.
171	B171HP001		Southeast side of the former building in the downgradient direction to determine the presence/absence of a suspected release from former DoD maintenance activities in the building.	GW/~10 ft bgs	TPHD/MO (8015M) TPHG/VOCs (8260B)		5-4
172	B172HP001		Southeast side of the former building in the downgradient direction to determine the presence/absence of a suspected release from former DoD maintenance activities in the building.	GW/~10 ft bgs	TPHD/MO (8015M) TPHG/VOCs (8260B)		5-4
194	B194Hp001		South side of former septic tank to determine the presence /absence of a suspected discharge from former DoD activities at CL1.	GW/~10 ft bgs	TPHD /MO (8015M VOCs (8260B)		5-7
CL1	CL1HP001 CL1HP002		Spaced along south side of building in the downgradient direction to determine the presence/absence of a suspected release from former DoD activities in the building.	GW/~8 ft bgs	VOCs (8260B)		5-7
CL2	CL2HP001		South side of former building in the downgradient direction to determine the presence/absence of a suspected release from former fuel oil UST and AST in the building.	GW/~8 ft bgs	TPHD/MO (8015M) VOCs (8260B)	Metals	5-7
Fillsite 1 (Formerly Landfill 1)	FS001HP001 FS001HP002 FS001HP003 FS001HP004 FS001HP005 FS001HP006 FS001HP007 FS001HP008		Evenly spaced along the south side of the suspected fillsite in the downgradient direction to delineate a suspected release of an unknown source and in the upgradient direction to determine the source.	GW/~5 ft bgs	TPHD/MO (8015M) TPHG/VOCs (8260B)		Plate 1

Table 5-1. Sampling Objective and Analytical Matrix (continued)

Proposed Inspection Site	Proposed Boring Name	Existing Piezometer to be sampled	Location and Objective of Proposed Borings	Matrix (SG/S/GW) and Sampling Depths	Mobile Lab Analyses (EPA Method #)	Fixed Lab Analyses (EPA Method #)	Figure No.
Fillsite 3 (formerly the Dumpsite)	FS003HP001 FS003HP002		Evenly spaced along the east side of the suspected fillsite in the downgradient direction to determine the presence/absence of a suspected release from former DoD waste disposal activities.	GW/~10 ft bgs	TPHD/MO (8015M) TPHG/VOCs (8260B)		5-6
Firing Range	FR01CS001 (grab composite sample)		Target Berm - A composite of 5 soil samples per 50 yards	S/within 6 inches of the surface (sieve bullets and bullet fragments)		Antimony, Copper, Lead, Zinc (6010B), Arsenic (7060A)	5-8
	FR01HP001 (hand auger)		On the east side of the target berm in the downgradient direction to determine the presence/absence of a suspected release from the target berm into native soil and groundwater (if encountered).	GW/within 10 feet of grade		Antimony, Copper, Lead, Zinc (6010B), Arsenic (7060A)	
Post Dumpsite (Formerly Landfill 3)	PD001HP001 PD001HP002 PD001HP003 PD001HP004 PD001HP005 PD001HP006		Evenly spaced along the eastern side of the former dumpsite to determine a suspected release of metal cleaning corrosives.	GW/~2ft bgs		Metals	5-5
Popping pot (formerly the Incinerator)	See the "Armored Fighting Vehicle Work Plan" (FA/BC, 2003c)						
Salvage yard	OS29HP001		Evenly spaced along the east side of the suspected salvage yard in the downgradient direction to determine the presence/absence of a suspected release from former DoD waste disposal activities.	GW/~8 ft bgs	TPHD/MO (8015M) TPHG/VOCs (8260B)		5-5

Table 5-1. Sampling Objective and Analytical Matrix (continued)

Proposed Inspection Site	Proposed Boring Name	Existing Piezometer to be sampled	Location and Objective of Proposed Borings	Matrix (SG/S/GW) and Sampling Depths	Mobile Lab Analyses (EPA Method #)	Fixed Lab Analyses (EPA Method #)	Figure No.
Spur A	SPURACS001 SPURACS002		If results from the samples collected at Spur E can be associated with former burning at the cage and exceed background concentrations then sampling will occur at Spur A. If so, samples will be collected on the upwind and downwind side of the former burn cage to determine the presence/absence of metals from former burning of ammunition in a burn cage.	Surface soil/5pt-composite		Metals Explosives (8330)	5-9
	SPURAHP001 SPURAHP002		If results from the samples collected at Spur E indicate the presence of key indicators (TPHD or TPHMO) in groundwater then sampling will occur at Spur A. Sampling locations will be on the east side and in the downgradient direction to determine the presence/absence of a suspected release of fuels from former burning of ammunition in a burn cage	GW/~8 ft bgs	TPHD/MO (8015M)	Metals Explosives (8330)	5-9
Spur E	SPURECS001S PURECS002		On the upwind and downwind side of the former burn cage to determine the presence/absence of metals from former burning of ammunition in a burn cage.	Surface soil/5pt-composite (upwind and downwind based heaviest fallout seen in photo)		Metals Explosives (8330)	5-10
	SPUREHP001		On the south side and in the downgradient direction to determine the presence/absence of a suspected release of fuels from former burning of ammunition in a burn cage	GW/10 ft bgs	TPHD/MO (8015M)	Metals Explosives (8330)	5-10

Table 5-1. Sampling Objective and Analytical Matrix (continued)

Proposed Inspection Site	Proposed Boring Name	Existing Piezometer to be sampled	Location and Objective of Proposed Borings	Matrix (SG/S/GW) and Sampling Depths	Mobile Lab Analyses (EPA Method #)	Fixed Lab Analyses (EPA Method #)	Figure No.
Spur G	SPURGCS001 SPURGSC002		If results from the samples collected at Spur E can be associated with former burning at the cage and exceed background concentrations then sampling will occur at Spur G. If so, samples will be collected on the upwind and downwind side of the former burn cage to determine the presence/absence of metals from former burning of ammunition in a burn cage.	Surface soil/5pt-composite		Metals Explosives (8330)	5-10
	SPURGHP001		If results from the samples collected at Spur E indicate the presence of key indicators (TPHD or TPHMO) in groundwater then sampling will occur at Spur G. A sampling location will be on the south side and in the downgradient direction to determine the presence/absence of a suspected release of fuels from former burning of ammunition in a burn cage	GW	TPHD/MO (8015M)	Metals Explosives (8330)	5-10
T221		PZ-20	PZ-20 is downgradient of T221	GW/ existing piezometer	TPHD/MO (8015M) TPHG/VOCs (8260B)		5-4
T222	T222HP001		Southeast side of the former building in the downgradient direction to determine the presence/absence of a suspected release from former DoD cleaning activities in the building.	GW/~10 ft bgs	TPHD/MO (8015M) TPHG/VOCs (8260B)		5-4
TO73	TO73HP001		Northeast side of the former building in the downgradient direction to determine the presence/absence of a suspected release from former DoD cleaning activities in the building.	GW/~10 ft bgs	VOCs (8260B)		5-3
TO131	TO131HP001		In the center of the former building's foundation to determine the presence/absence of a suspected release from former DoD degreasing activities in the building.	SG/3-5 feet	VOCs		Plate 1

Table 5-1. Sampling Objective and Analytical Matrix (continued)

Proposed Inspection Site	Proposed Boring Name	Existing Piezometer to be sampled	Location and Objective of Proposed Borings	Matrix (SG/S/GW) and Sampling Depths	Mobile Lab Analyses (EPA Method #)	Fixed Lab Analyses (EPA Method #)	Figure No.
Swamp	SWAMPAHP001 SWAMPAHP002 SWAMPAHP003 SWAMPAHP004 SWAMPAHP005 SWAMPBHP001 SWAMPBHP002 SWAMPBHP003 SWAMPBHP004 SWAMPBHP005 SWAMPBHP006		Swamp A line begins south of Building 56A and continues in a southwest direction (downgradient) past Building 166. Swamp B line runs east to west beginning east and downgradient of Building 71 and continuing past Buildings 167 and 168. The objective of these borings is to determine the presence/absence of a suspected release from former DoD waste discharge into swamp via storm drain or sewer lines that transect through this area.	GW/~3-50 ft bgs	TPHD/MO (8015M) TPHG/VOCs (8260B)		Plate 1
Waste Areas/Open Ditch	WA001HP001 OD01HP001 OD01HP002 OD01HP002	Valero Well #117	In the center of the former ditches and waste areas to determine the presence/absence of a suspected discharge from former DoD activities at CL1. A groundwater sample will be collected from an existing well located within a former waste area.	GW/~10 ft bgs	TPHD/MO (8015M) TPHG/VOCs (8260B)		5-7

Notes:
1. Sampling points, locations, depths and analytical methods to be determined in the field.
2. Unless otherwise noted for soil, metals consists of antimony, barium, beryllium, total chromium, cobalt, copper, manganese, molybdenum, nickel, silver, tin, vanadium and zinc by 6010B, cadmium and lead by 6010B ICP trace, arsenic by 7060A, selenium by 7740, thallium by 7841 and mercury by 7471A.
3. At the firing range, only copper, lead, arsenic, antimony and zinc will be analyzed. The bullets and bullet fragments will be sieved from the soil with a No. 10 sieve.
4. Field QC samples, including trip blanks, equipment rinsate blanks, filter blanks, source water blanks, splits and field duplicates, will be taken at the minimum frequency specified in the QAPP.
5. Procedures to be used for proper collection, characterization, storage, containerization, transport and disposal of the former Arsenal's IDW will be in accordance with the IDW Plan in the former Arsenal-Wide Investigation Workplan (FA/BC, 1999b).
6. All borings will be advanced using a cone penetrometer (CPT), unless noted otherwise.
7. Soil samples proposed at locations with a possible surface release will be collected at 0.5 and 5 feet below subgrade materials (non-asphalted areas) or 2 and 5 feet below subgrade materials (asphalted areas).
8. Up to ten (10) of the highest results for TPHD or TPHMO in GW that also exceed the delineation limit (640 ug/L) will be submitted for PAH analysis by EPA Method 8310.

AST = aboveground storage tank
bgs = below ground surface
GW = groundwater
S = soil
SG = soil gas
ft = feet
TPHD = total petroleum hydrocarbons as diesel fuel
TPHG = total petroleum hydrocarbons as gasoline
TPHMO = total petroleum hydrocarbons as motor oil
UST = undeground storage tank
VOCs = volatile organic compounds

5.1.1 Soil Sampling

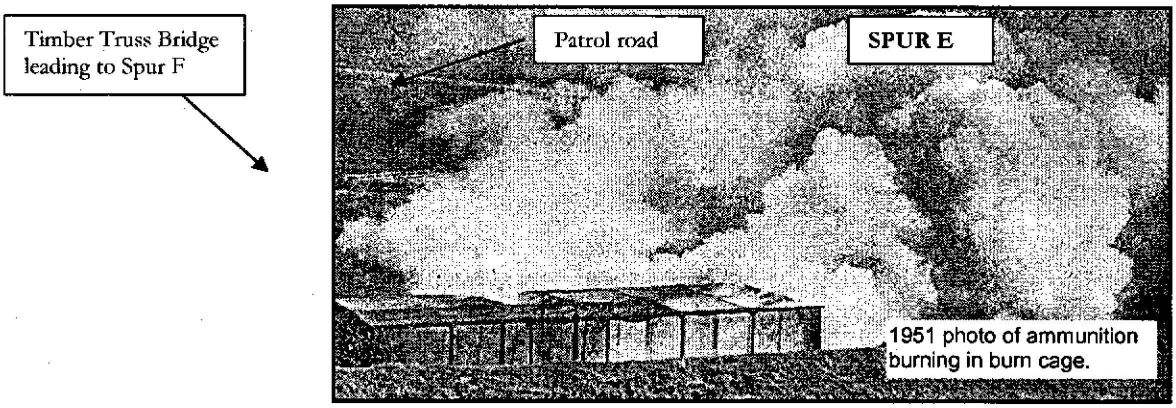
The borings listed in Table 5-1 will be advanced to bedrock. The maximum depth to bedrock is estimated to be 65 feet bgs within the former marshland in Area I. The depth for collection of soil, soil gas, or groundwater Hydropunch® samples will be determined from each boring log.

With two exceptions, all borings will be advanced with a CPT rig to collect lithologic data. Because of vehicle access issues, a hand auger will be advanced to the desired depth and a slide hammer will be used to collect soil samples from the Firing Range and near Building 51. The Firing Range is covered in heavy vegetation, the terrain is hilly, and there is no paved access. At the former drum storage area at Building 51, the proposed boring location is blocked by equipment. The hand-augured borings at these two locations will be advanced to no more than 10 feet bgs or to groundwater, whichever is encountered first. If groundwater is encountered, a grab groundwater sample will be collected.

At the Firing Range, several additional steps will be taken before any samples are collected. The first step will be to remove the brush and determine if a small berm in this area was used as a target or backstop for .45 and .50 caliber rounds. If there is sufficient evidence that the berm was so used, soil samples will be collected from the berm and from underlying native soil. A composite of five soil samples will be collected every 50 yards along the berm. Bullet and bullet fragments will be removed from the sample using a No. 10 sieve (0.0787-inch opening).

For areas of a possible surface release (marked in Table 5-1), soil samples will be collected at various depths depending upon surface conditions (e.g. asphalt paved versus non-asphalt paved surfaces). For asphalt-paved surfaces, soil samples will be collected at 2 and 5 feet below subgrade materials (e.g. aggregate, base rock) in order to minimize the possible impact from the asphalt in the near surface soil. At non-asphalt paved surfaces, soil samples will be shallower and will be collected at 0.5 foot and 5 feet below subgrade materials.

Two composite surface soil samples (less than 0.5 foot bgs) will be collected near Spur E. One composite sample will be collected in the upwind direction of the former Spur E and one composite sample will be collected in the downwind direction (using the photo shown below), approximate sampling locations are shown on Figure 5-10. These surface soil samples will be collected from native soil or just below any aggregate or paving materials. Each sample will be composed of five soil samples composited into one soil sample. The downwind soil sample will be used to determine if there is an impact to surface soil from particulates produced during burning which were blown downwind of the former burn cage. While the upwind sample, collected in the same manner as the downwind sample, will determine the ambient concentrations of the area. See Table 5-1 for proposed analyses. If results of these composite soil samples can be associated with the former burning at this burn cage and indicate an impact, then the other burn cages (Burn Cage A and Burn Cage G) will be evaluated for the same sampling.



1951 photo of ammunition burning in burn cage.

Additional soil sampling will be conducted as recommended in a previous investigation for the former UST sites at Building 53, Building 103, and Building 154 (Geofon, 2003). The objectives are to delineate the vertical and lateral extent of fuel and lead-impacted soil and/or groundwater at these sites at concentrations above the ESLs established by the RWQCB (2003).

5.1.2 Soil Gas Sampling

The purpose of soil gas sampling is to evaluate areas where VOCs below buildings have potential to impact current indoor air quality. The Decision Diagram (Diagram 5-1) will be used to determine the soil gas sampling locations. In addition, a soil gas sample will be collected adjacent to Building TO-131 since this building is located on a bedrock high and any boring advanced will likely not encounter groundwater.

Soil gas samples collected during this project will be collected from the CPT borings that meet either of the following criteria:

- No groundwater was encountered, but the sampling location is near an existing building, with the exception of Building TO131.
- Groundwater was encountered, key indicator chemicals were present at detectable concentrations, and the location is near an existing building.

5.1.3 Groundwater Sampling

The Hydropunch® technique will be used to collect groundwater samples from most locations after lithologic data is collected from the CPT rig. The purpose of the Hydropunch® is to collect a one-time sample to obtain information on groundwater impacts from previous facility use and aid in determining the location of permanent monitoring wells.

In order to determine the possible impact on groundwater from PAHs, up to ten (10) of the highest results for TPHD or TPHMO in groundwater that also exceed the delineation limit of 640 ug/L will be submitted for PAH analysis by EPA Method 8310.

5.1.4 Groundwater Monitoring Wells

Up to 13 monitoring wells will be installed at the former Arsenal during the Expanded SI. Well locations will be determined from lithologic logs and results from soil/groundwater samples collected with the CPT. The purpose of these wells is to obtain water-level elevations and groundwater samples. Concurrence from the project team, including the regulatory agencies, will be requested before well installation. The rationale for the placement of each well will be provided at that time.

The wells will be installed in 8-inch diameter boreholes and constructed of 2-inch diameter screened and blank PVC casing. Screen intervals will typically be installed 5 feet below and 5 feet above the water table. Screen size and filter pack material will be determined based on soil materials observed in the CPT logs according to procedures referenced in Section 6 of this FSIP. If there is no CPT boring within close proximity of the planned well 44approximately 50 feet) then a CPT boring will be installed at the well location to obtain lithologic data. Otherwise, there will be sufficient information about the lithology in the area of the planned well from CPT log(s), the boring for the well will not be evaluated for lithology.

PARAMETERS FOR SCREENING IN SITU BIODEGRADATION OF CHLORINATED VOCs

- oxygen (dissolved)*
- nitrate *
- iron II *
- sulfate*
- sulfide *
- methane*
- oxidation reduction potential (ORP) *
- pH *
- TOC (Total Organic Carbon)
- Temperature *
- Carbon dioxide
- alkalinity
- chloride *
- hydrogen
- volatile fatty acids
- BTEX concentrations *
- TCE, DCE, vinyl chloride concentrations *
- ethene/ethane concentrations

*required analysis

Once installed, each newly constructed monitoring well will be purged and sampled once. Up to four existing monitoring wells will also be sampled. Each monitoring well will be sampled for VOCs by U.S. Environmental Protection Agency (USEPA) Method SW8260B, TDS by EPA Method 160.3, anions (nitrate, chloride, sulfate) by EPA Method 300.0, alkalinity by SM2320, and cations (calcium, magnesium, sodium and potassium) by SW6010B.

The elevations of the top of the well casings will be surveyed vertically to an accuracy of 0.01 foot. Horizontal locations will be established to an accuracy of 0.1 foot. The surveys will be referenced to mean sea level and all horizontal coordinates will be tied to the California stateplane coordinate system (North American Datum 1927, Zone 2).

Three rounds of water level measurements will be completed within a 6-month period. These measurements will occur at existing 20 piezometers, the 13 new monitoring wells, and up to 10 other existing monitoring wells. Water level measurements will be measured before the wells are sampled.

Existing data beneath and around the 50 Series Complex indicates that chlorinated solvents may be attenuating naturally. Natural attenuation in the subsurface is the net result of several processes, including biodegradation, dilution, and adsorption of contaminants onto the aquifer matrix. For most chlorinated solvents, biodegradation in the environment occurs through a process known as reductive dechlorination (USEPA, 1998). Additonal data will be collected during the Expanded SI to determine whether subsurface biodegradtion of chlorinated solvents is significant fate pathway at the former Arsenal. According to USEPA, there are a number of required chemical and geochemical parameters that can be used as indicators of biologically-mediated reductive dechlorination. The EPA (USEPA, 1998) protocol suggests a screening process involving the parameters listed in the text box above.

EPA (USEPA, 1998) recommends that a screening-level evaluation of chlorinated solvent biodegradation is to collect data to represent the following areas:

1. the most contaminated portion of the aquifer, generally referred as the "source area";
2. downgradient from the source area but still in the dissolved contaminant plume;
3. downgradient from the dissolved contaminant plume; and
4. upgradient and lateral locations that are not impacted by the plume.

Previous investigations have obtained data on benzene, toluene, ethylbenzene, and xylene (BTEX), TCE, DCE, vinyl chloride, chloride, sulfate, dissolved oxygen, oxidation/reduction potential (ORP), and temperature in the piezometers at the former Arsenal but not necessarily in the location recommended by USEPA. During the Expanded SI, in addition to the proposed chemical analyses for TCE, DCE, vinyl chloride and BTEX by SW8260B, up to seven groundwater samples will be collected from existing or new groundwater monitoring wells located in locations as suggested above for required analyses of parameters and Manganese IV (Table 5-2).

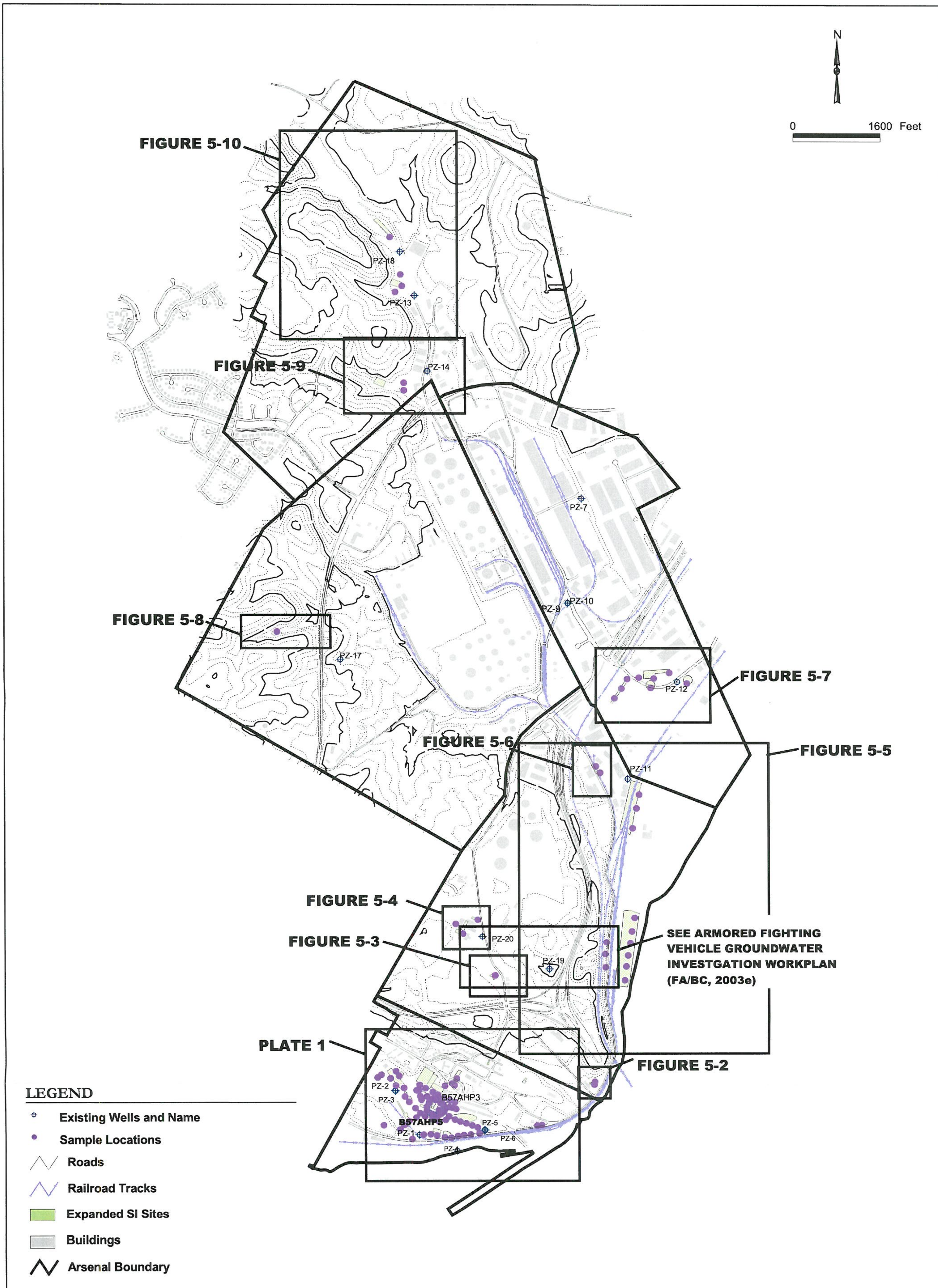
Table 5-2. Parameters for Chlorinated Solvent Biodegradation Assessment

Parameter	Method	Interpretation
Dissolved oxygen	Field meter with flow thru cell	value will indicate if reductive pathway is suppressed by oxidizing conditions
Nitrate	E300	at high concentrations may compete with reductive pathway
Iron II	SM 3500	indicates a possible reductive pathway
Sulfate	E300	At high concentrations may compete with reductive pathway.
Sulfide	E376.3	indicates a possible reductive pathway
Methane	RSK175	indicates whether vinyl chloride will accumulate or oxidize
ORP	Field meter	indicates a possible reductive pathway
pH	Field meter	indicates whether aquifer provides an optimal environment for reductive dechlorination
Temperature	Field Meter	At >72°C biochemical process is accelerated.
Chloride	E300	Indicates final product of chlorinated solvent reduction.
ethane/ethene	RSK175	indicates presence of a daughter product of vinyl chloride/ethene biodegradation
Manganese IV	Field Test Kit or EPA 200.7	indicates whether anaerobic biological activity is solubilizing manganese from the aquifer matrix material

Manganese IV was added as an indicator to determine if Manganese is solubilizing from the aquifer matrix in an anaerobic environment. In these environments, the geochemical conditions and processes that lead to biodegradation of chlorinated solvents and petroleum hydrocarbons may also chemically transform naturally occurring Manganese to more mobile and/or toxic forms of the metal.

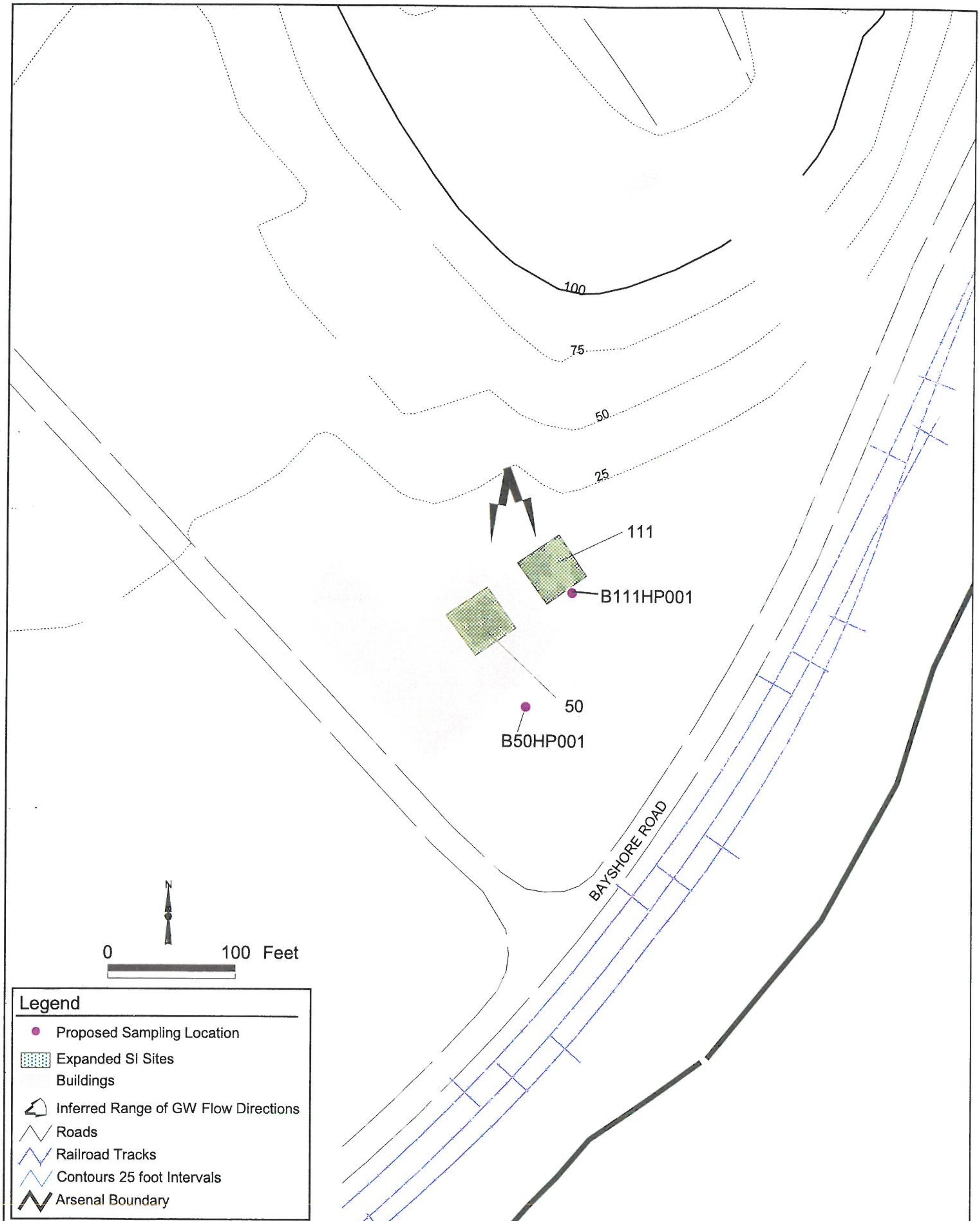
5.2 Sampling Locations

Figure 5-1 shows the site-wide sample locations for the Expanded SI. More details on the proposed sampling location are shown in Figure 5-2 through Figure 5-10). Details for Area I, where the majority of the sampling will take place, are presented on Plate 1 at the end of this document.



DATE 03/29/04	PROJECT NO. 24785-004	SITE Former Benicia Arsenal, Benicia, California	Figure 5-1
BROWN AND CALDWELL	2701 Propsect Park Drive Rancho Cordova, CA 95670 (916) 444-0123 (916) 635-8805 fax	TITLE **Expanded SI Location Map**	

Brown and Caldwell
S:\Benicia_workplan\apr\workplan.apr



DATE 03/29/04

PROJECT NO. 24785-004

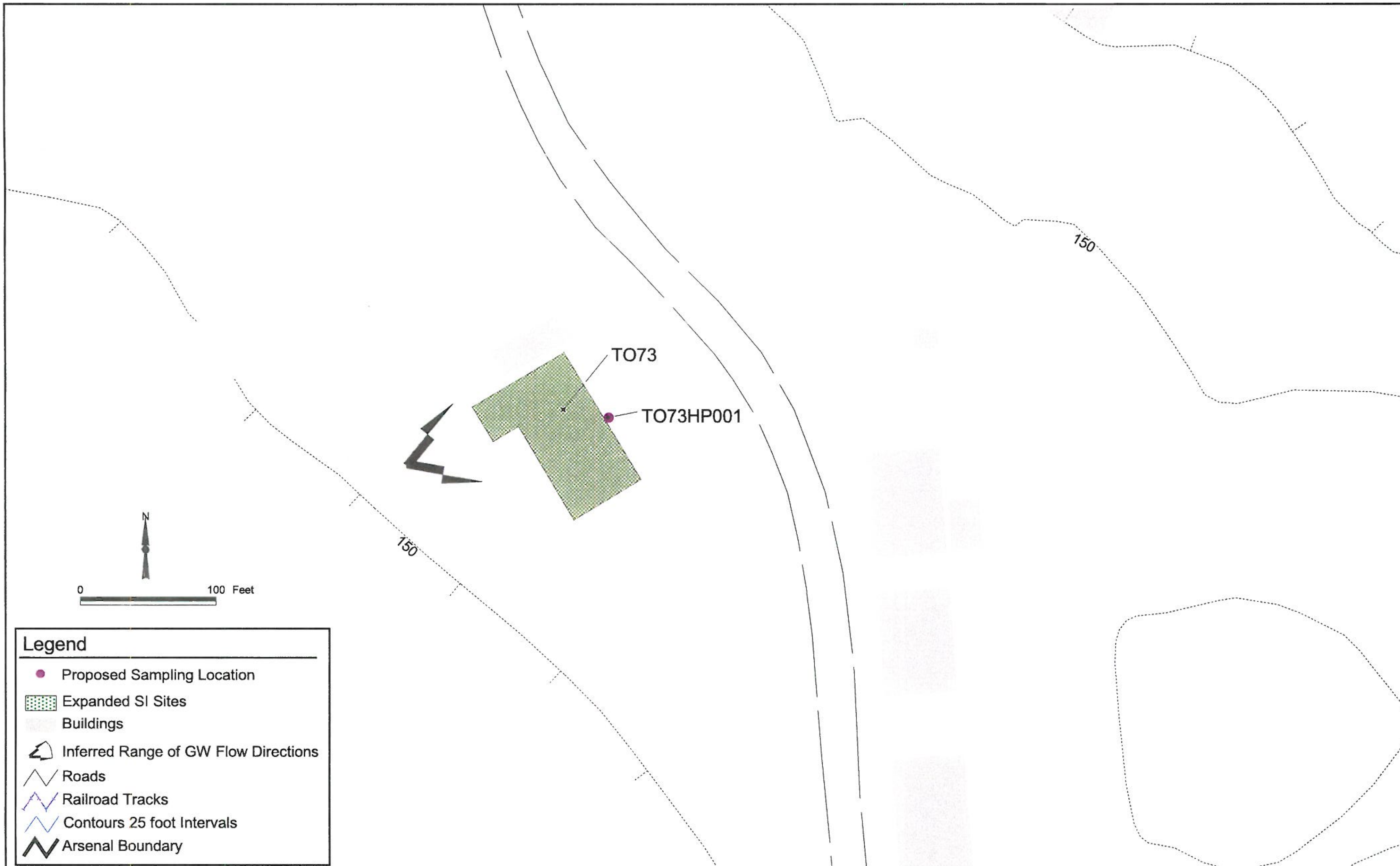
SITE Benicia Arsenal, Benicia, California

BROWN AND CALDWELL

2701 Propsect Park Drive
Rancho Cordova, CA 95670
(916) 444-0123
(916) 635-8805 fax

TITLE **Proposed Sampling Locations at the Former Building 50 and Building 111**

Figure 5-2



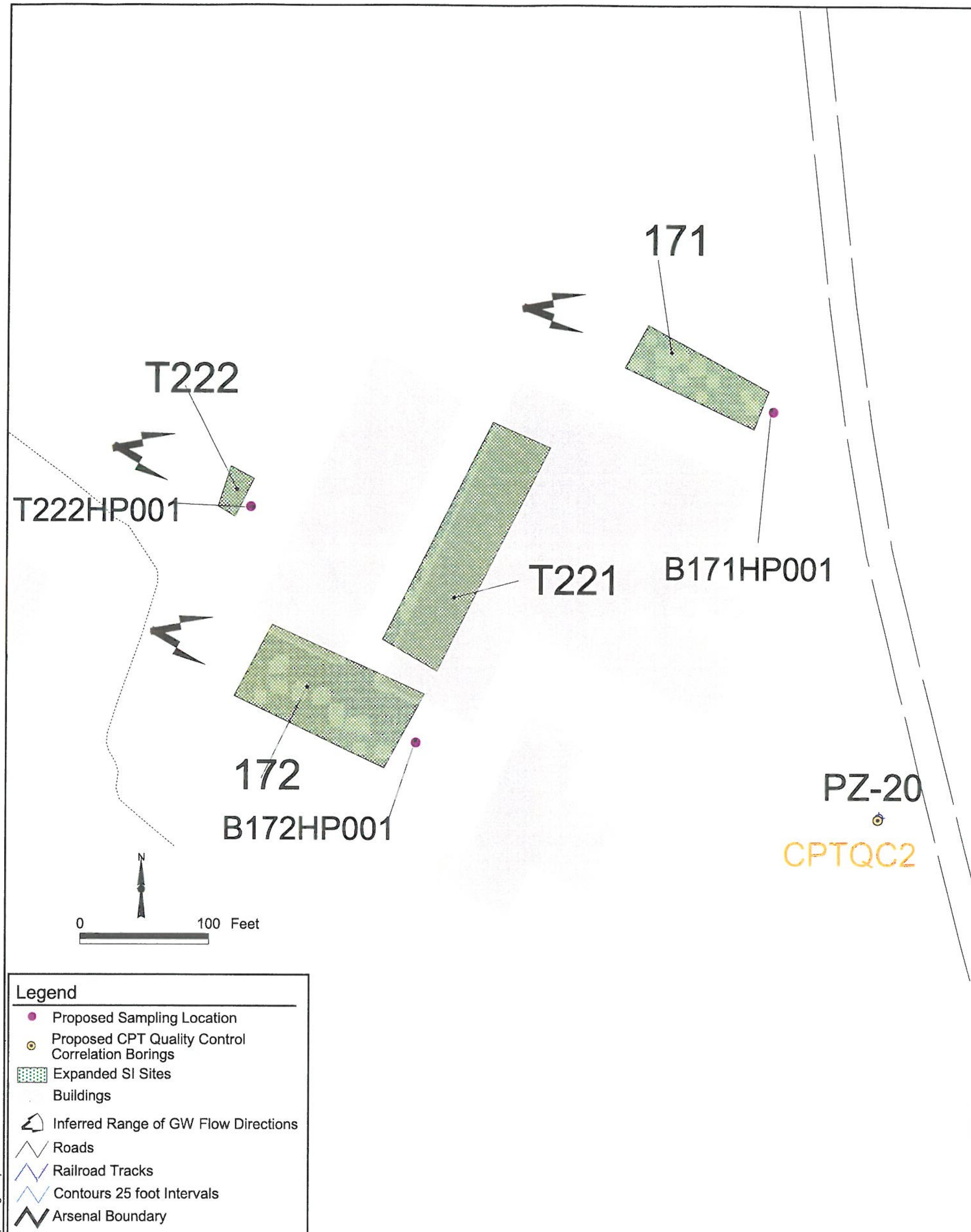
DATE	PROJECT NO.	SITE
04/02/04	24785-004	Former Benicia Arsenal, Benicia, California

2701 Propsect Park Drive
Rancho Cordova, CA 95670
(916) 444-0123
(916) 635-8805 fax

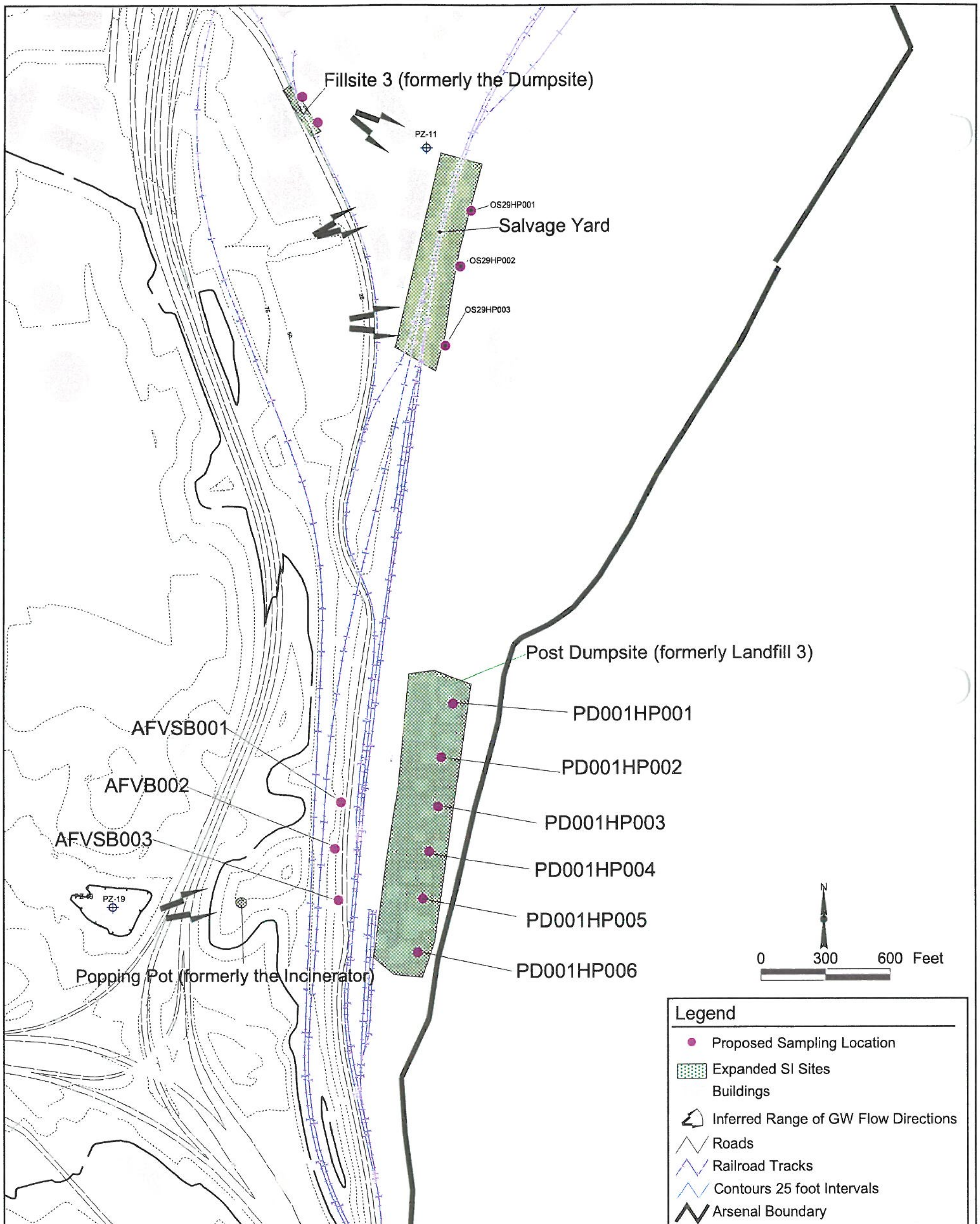
TITLE

Propose[illegible]ampling Locations at Former Building TO73

Figure
5-3



DATE	PROJECT NO.	SITE	
03/10/04	24785-004	Former Benicia Arsenal, Benicia, California	Figure 5-4
BROWN AND CALDWELL	2701 Propsect Park Drive Rancho Cordova, CA 95670 (916) 444-0123 (916) 635-8805 fax	TITLE **Proposed Sampling Locations at Former Buildings T221, T222 , 171 and 172**	



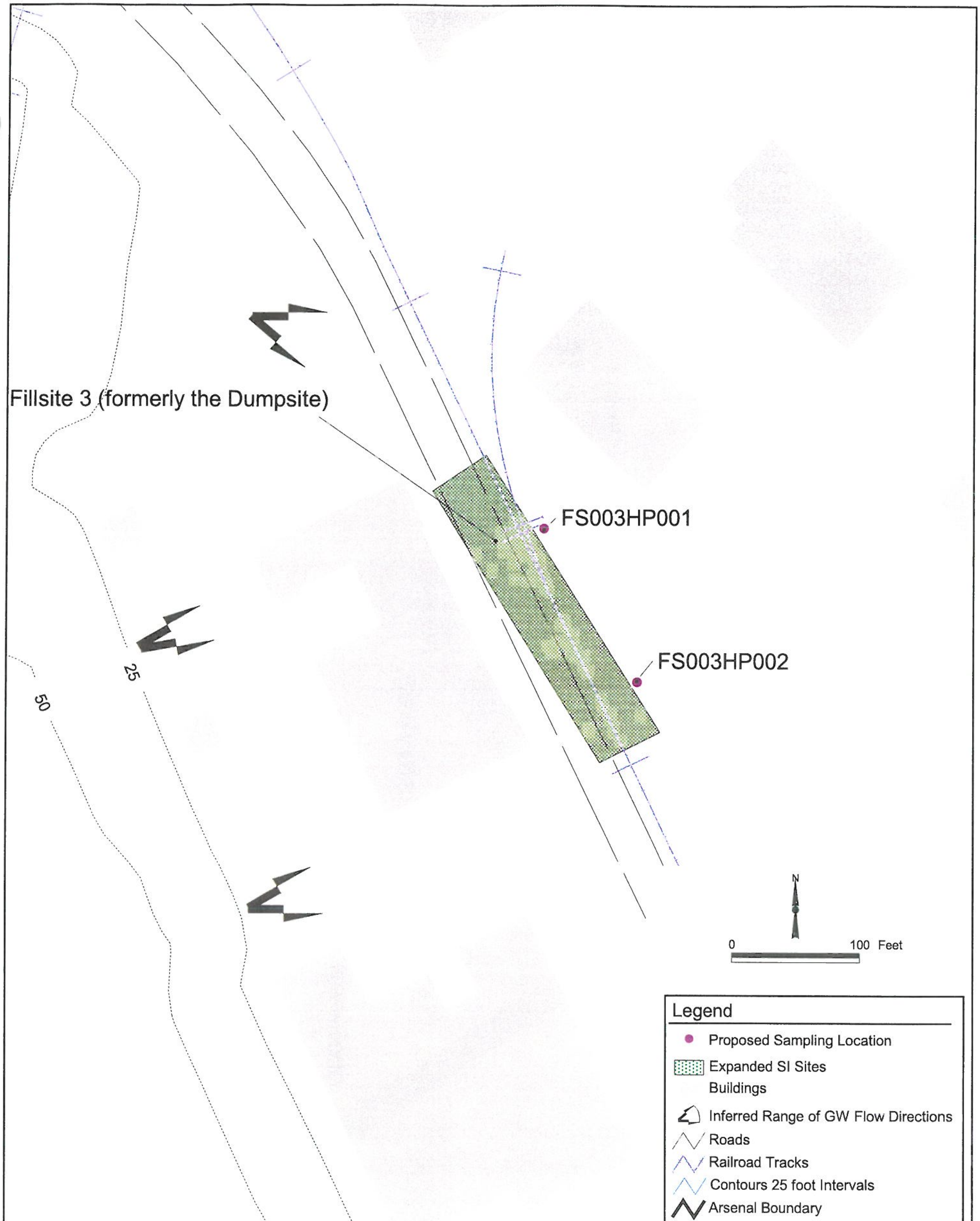
DATE	PROJECT NO.	SITE	
03/10/04	24785-004	Former Benicia Arsenal, Benicia, California	Figure 5-5

BROWN AND CALDWELL

2701 Propsect Park Drive
Rancho Cordova, CA 95670
(916) 444-0123
(916) 635-8805 fax

TITLE

Proposed Sampling Locations at the Post Dumpsite (formerly Landfill 3)



DATE	PROJECT NO.	SITE	
03/10/04	24785-004	Former Benicia Arsenal, Benicia, California	Figure 5-6
BROWN AND CALDWELL	2701 Propsect Park Drive Rancho Cordova, CA 95670 (916) 444-0123 (916) 635-8805 fax	TITLE **Proposed Sampling Locations at Former Fillsite 3**	

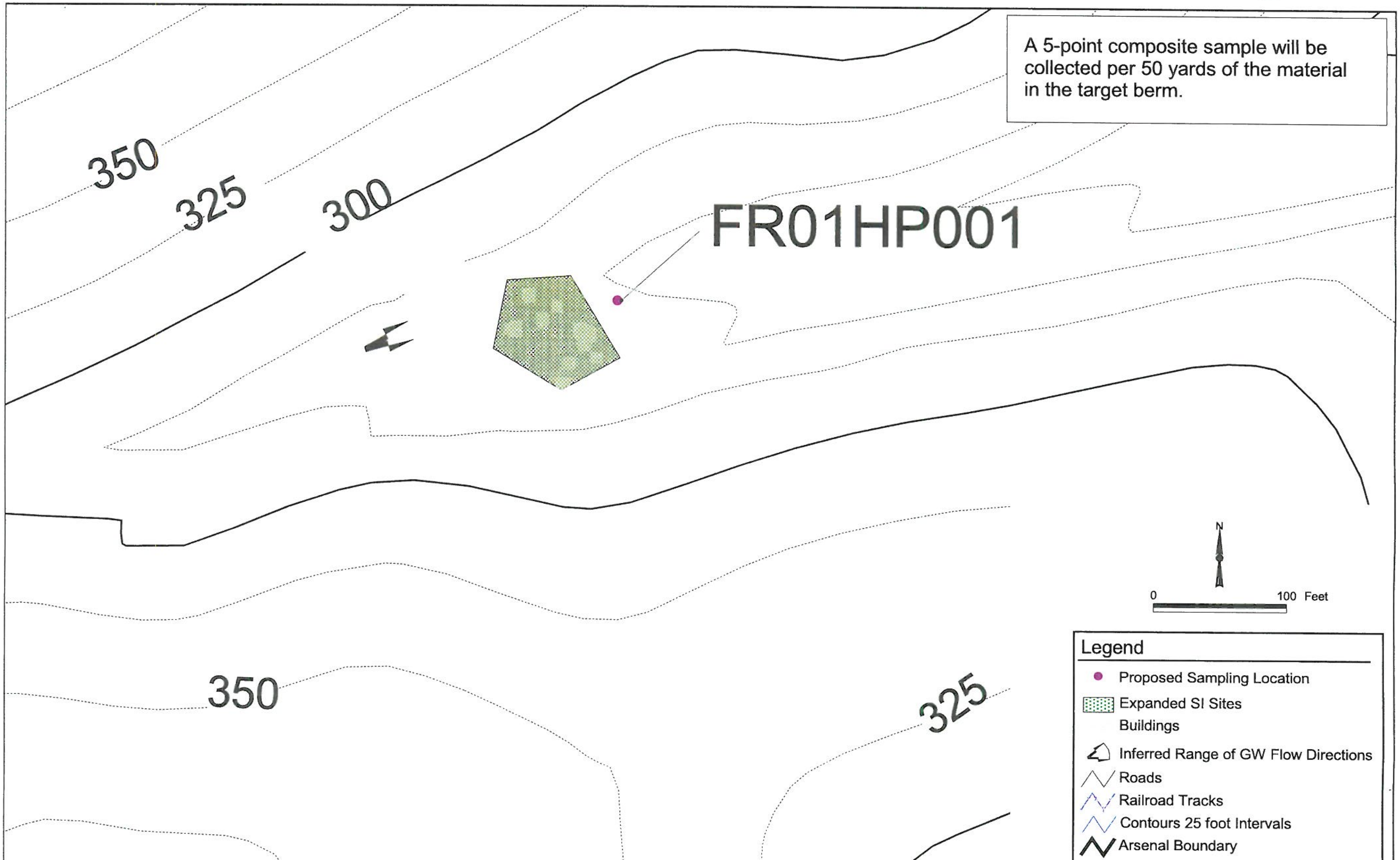
DATE	PROJECT NO.	SITE
03/29/04	24785-004	Former Benicia Arsenal, Benicia, California

2701 Propsect Park Drive
Rancho Cordova, CA 95670
(916) 444-0123
(916) 635-8805 fax

TITLE

Proposed Sampling Locations at CL1, CL2, the Former Waste Areas, en Ditches, and the Abandoned Septic Tank 194

Figure 5-7



DATE	PROJECT NO.	SITE
03/29/04	24785-004	Former Benicia Arsenal, Benicia, California

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2701 Propsect Park Drive
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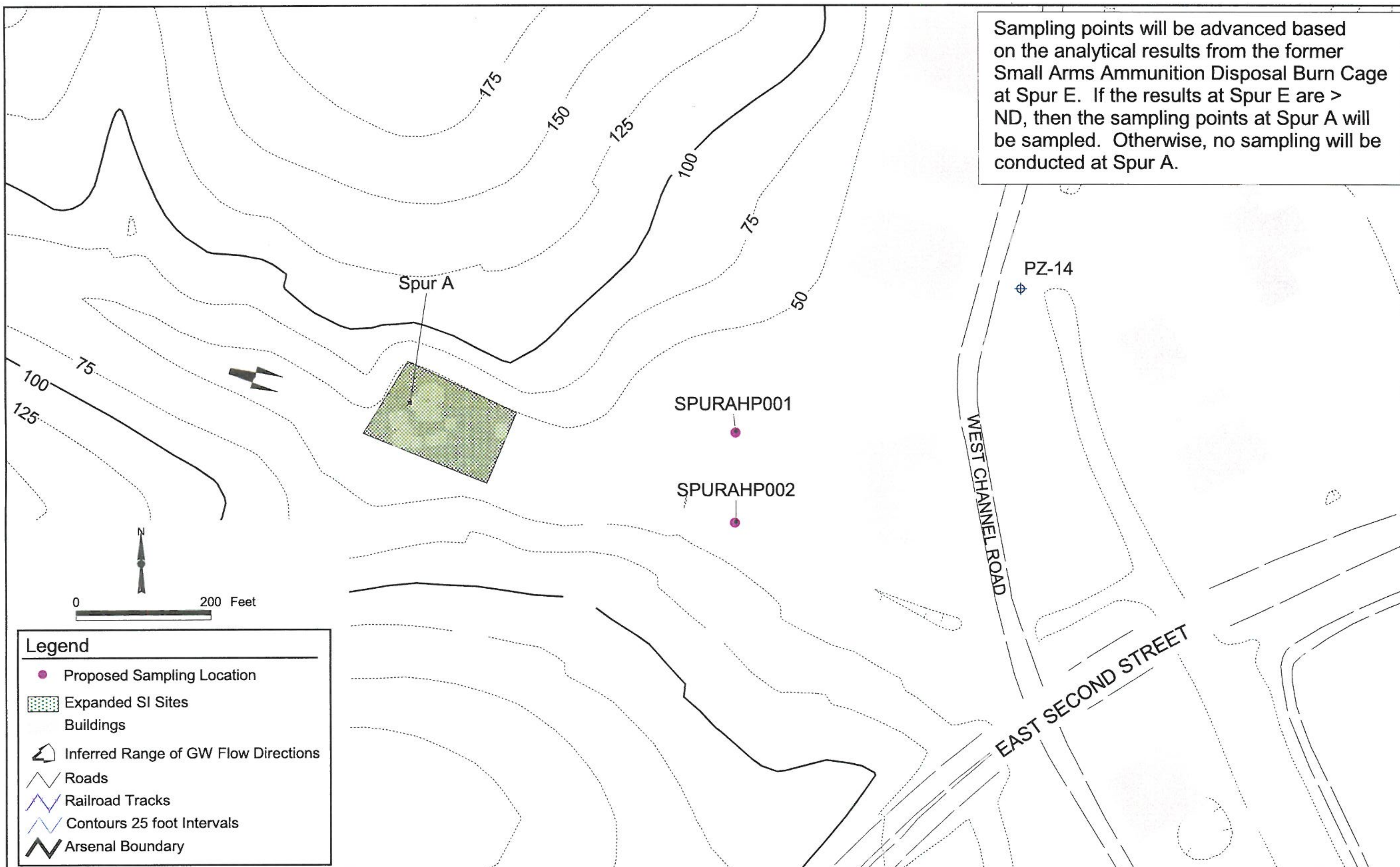
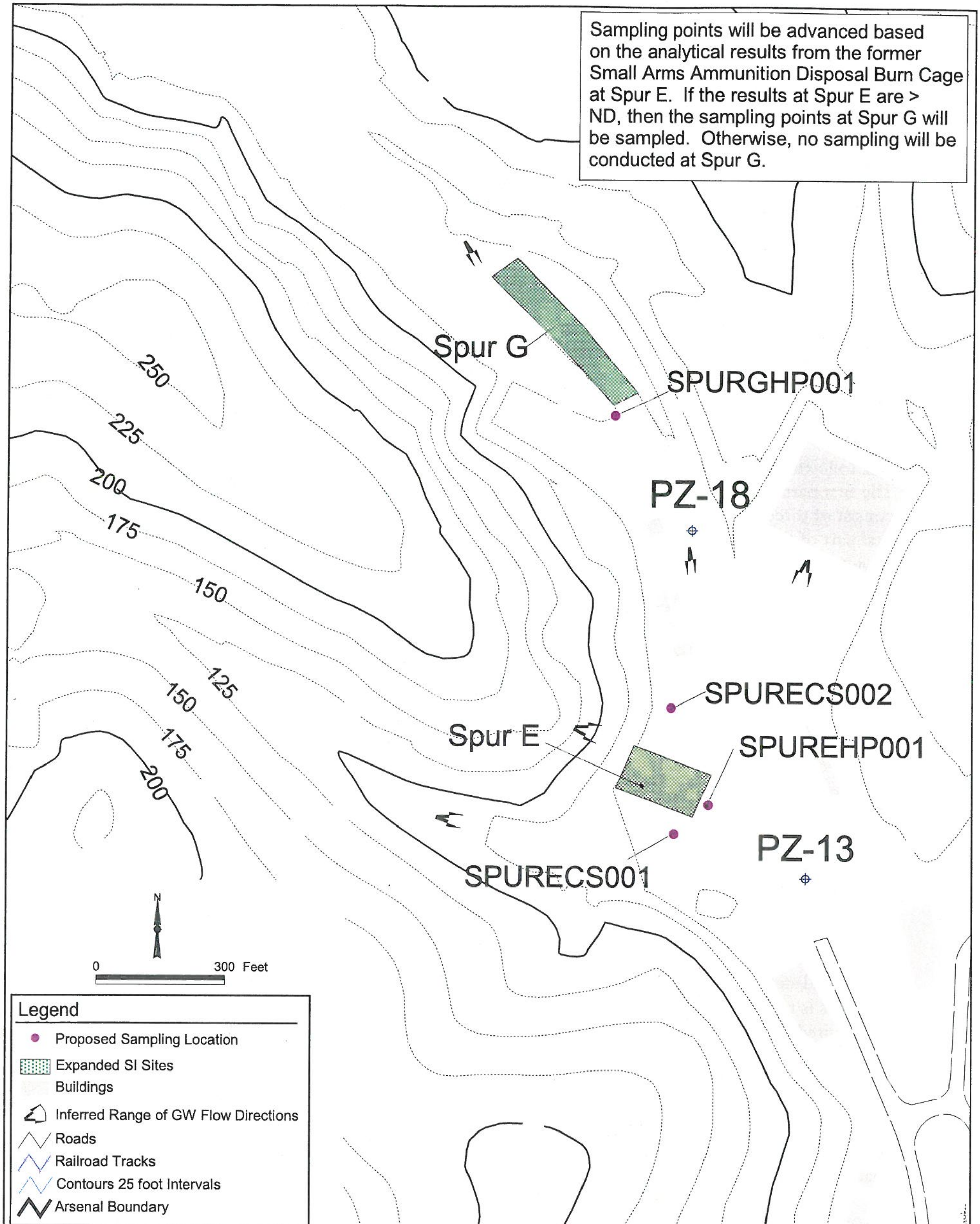
(916) 444-0123
(916) 635-8805 fax

TITLE
Proposed Sampling Locations at the Former Firing Range

Figure 5-8



DATE 03/29/04	PROJECT NO. 24785-004	SITE Former Benicia Arsenal, Benicia, California	Figure 5-9
BROWN AND CALDWE	2701 Propsect Park Drive Rancho Cordova, CA 95670 (916) 444-0123 (916) 635-8805 fax	TITLE **Proposed Sampling Locations at the Former Small Arms Ammunition Disposal Burn Cage at Spur A**	



DATE	PROJECT NO.	SITE	
03/29/04	24785-004	Former Benicia Arsenal, Benicia, California	Figure 5-10
BROWN AND CALDWELL	2701 Propsect Park Drive Rancho Cordova, CA 95670 (916) 444-0123 (916) 635-8805 fax	TITLE **Proposed Sampling Locations at the Former Small Arms Ammunition Disposal Burn Cage at Spur E and Spur G**	

Hydropunch® and soil boring locations were selected based on the location of activities where suspected contamination originated or at the nearest downgradient location. Soil gas samples were chosen if the sample location is located near an existing building. This data will be used for future risk screening.

Groundwater in the vicinity of the 50 Series Complex is impacted with fuels and solvents. Because the mobile laboratory to be used for this investigation provides capability for rapid analysis of fuels and solvents, a baseline suite of groundwater analyses is planned for borings and existing piezometers that would not necessarily be dictated by former DoD activities in this area. In other words, all groundwater samples collected in the vicinity of the 50 Series Complex will be analyzed for fuels and solvents. This will give the project team a "picture" of the presence and current extent of the fuel and solvent plumes in this area.

The following numbering system will be used to identify samples collected during this investigation. The first part of the sample identification will be the location where the sample is collected and will consist of three to six characters. For example, for a sample collected adjacent to Building 31, the first part of the identification would read, "B031". The second part of the sample identification will designate the sample point descriptor as follows:

- "HP" - Groundwater collected or planned with a Hydropunch® and at locations where soil and groundwater will be collected.
- "SB" - Only soil collected or at locations where both soil and soil gas are collected.
- "CS" - Composite soil samples.
- "SG" - Only soil gas collected.

5.3 Step-In/Step-Out Decision Criteria

Selection of the initial sampling locations was based on previous sampling results and the FAR sites identified in the PA. These initial locations, described in the previous section, will be sampled to establish the presence or absence of contamination related to DoD activities. Immediately after sample collection, a mobile laboratory stationed near the 50 Series Complex will complete the initial set of analyses.

After obtaining results from the initial samples, the field team will use the Decision Diagram (Diagram 5-1) to determine the next step of investigation for each proposed inspection site. Additional step-in or step-out borings may be required if contamination related to former DoD activities is reported. According to the Decision Diagram, repeated step-in or step-out borings may be required to fully delineate DoD-related contamination.

Step-in/step-out borings will be advanced with a CPT rig to collect lithologic data. These borings may be advanced to bedrock if data gaps remain in mapping the bedrock surface. The soil, soil gas, or Hydropunch® sampling depth will be determined from the boring logs. After the initial borings to bedrock are pushed, additional borings advanced to delineate contamination may extend deeper than originally planned based on the lithology encountered or the depth to groundwater.

As outlined in Section 4, sites will be prioritized for further delineation (if necessary) based on the potential risk posed to human health and/or the environment. The purpose of site ranking is to expend available funds on sampling activities that address the greatest concerns remaining at the former Arsenal. For example, the Firing Range/Demolition Area has exposed soil and may have metal contamination. If any impact to soil is found during the initial sampling, this site would be considered to present the highest human health or environmental risk and would be given first priority for further delineation. The ranking scheme provided in Section 4 will be used to establish subsequent priorities for site delineation. Delineation of contaminant extent will continue until available funds are exhausted. Any proposed inspection sites that are not fully characterized during this Expanded SI will be investigated when additional funds are available.

Delineation limits are based on the mobile laboratory's capabilities and are shown on Table 5-3 through Table 5-5. For water, all of the delineation limits are at least as stringent as the maximum contaminant levels (MCLs) established by EPA and the State of California for drinking water. For those analytes where a MCL has not been established (TPHD), the Environmental Screening Level (ESL) established by the RWQCB San Francisco Region is used (RWQCB, 2003). The delineation of any DoD related contaminant plume would be controlled by the six key indicators discussed in Section 4 and listed on the Decision Diagram (Diagram 5-1). Delineation limits for metals are based on the Benicia Screening Levels (BSLs) which are described in the Final Soil Assessment Criteria for the Former Benicia Arsenal, Benicia, California (FA/BC, 2002b).

Table 5-3. Estimated Reporting Limits and Delineation Limits
Field Analysis for GC/MS Volatiles by SW846-8260B

Volatile Organics	Mobile Lab Reporting Limits*			Delineation Limits			MCL**
	Air µg/m^3	Water µg/L	Soil mg/kg	Air µg/m^3	Water µg/L	Soil mg/kg	µg/L
Benzene	100	[illegible]	[illegible]	NA	[illegible]	[illegible]	1
Bromobenzene	100	1	0.5	NA	1	0.5	NE
Bromochloromethane	100	1	0.5	NA	1	0.5	NE
Bromodichloromethane	100	1	0.5	NA	1	0.5	NE
Bromoform	100	1	0.5	NA	1	0.5	NE
Bromomethane	100	1	1	NA	1	1	10
n-Butylbenzene	100	1	0.5	NA	1	0.5	NE
sec-Butylbenzene	100	1	0.5	NA	1	0.5	NE
tert-Butylbenzene	100	1	0.5	NA	1	0.5	NE
Carbon Tetrachloride	100	1	0.5	NA	1	0.5	0.5
Chlorobenzene	100	1	0.5	NA	1	0.5	NE
Chlorodibromomethane	100	1	0.5	NA	1	0.5	NE
Chloroethane	100	1	1	NA	1	1	NE
Chloroform	100	1	0.5	NA	1	0.5	NE
Chloromethane	100	1	1	NA	1	1	NE
2-Chlorotoluene	100	1	0.5	NA	1	0.5	NE
4-Chlorotoluene	100	1	0.5	NA	1	0.5	NE
1,2-Dibromo-3-chloropropane	100	1	0.5	NA	1	0.5	NE
1,2-Dibromomethane	100	1	0.5	NA	1	0.5	NE

Table 5-3. Estimated Reporting Limits and Delineation Limits Field Analysis for GC/MS Volatiles by SW846-8260B (continued)

	Mobile Lab Reporting Limits*			Delineation Limits			
Volatile Organics	Air µg/m³	Water µg/L	Soil mg/kg	Air µg/m³	Water µg/L	Soil mg/kg	MCL** µg/L
Dibromomethane	100	1	0.5	NA	1	0.5	NE
1,2-Dichlorobenzene	100	1	0.5	NA	1	0.5	600
1,3-Dichlorobenzene	100	1	0.5	NA	1	0.5	NE
1,4-Dichlorobenzene	100	1	0.5	NA	1	0.5	5
Dichlorodifluoromethane	100	1	0.5	NA	1	0.5	NE
1,1-Dichloroethane	100	1	0.5	NA	1	0.5	5
1,2-Dichloroethane	100	1	0.5	NA	1	0.5	0.5
1,1-Dichloroethene	100	1	0.5	NA	1	0.5	6
cis-1,2-Dichloroethene	100	1	0.5	NA	1	0.5	6
trans-1,2-Dichloroethene	100	1	0.5	NA	1	0.5	10
1,2-Dichloropropane	100	1	0.5	NA	1	0.5	5
1,3-Dichloropropane	100	1	0.5	NA	1	0.5	NE
2,2-Dichloropropane	100	1	0.5	NA	1	0.5	NE
Ethylbenzene	100	1	0.5	NA	1	0.5	300
Hexachlorobutadiene	100	1	0.5	NA	1	0.5	NE
Isopropylbenzene	100	1	0.5	NA	1	0.5	NE
p-Isopropyltoluene	100	1	0.5	NA	1	0.5	NE
Methyl-tert-butyl ether	100	1	0.5	NA	NA	NA	13
Methylene Chloride	100	1	0.5	NA	1	0.5	NE
Naphthalene	100	1	0.5	NA	1	0.5	NE
n-Propylbenzene	100	1	0.5	NA	1	0.5	NE
Styrene	100	1	0.5	NA	1	0.5	100
1,1,1,2-Tetrachloroethane	100	1	0.5	NA	1	0.5	NE
1,1,2,2-Tetrachloroethane	100	1	0.5	NA	1	0.5	1
Tetrachloroethene	100	1	0.5	NA	1	0.5	5
Toluene	100	1	0.5	NA	1	0.5	150
1,2,3-Trichlorobenzene	100	1	0.5	NA	1	0.5	NE
1,2,4-Trichlorobenzene	100	1	0.5	NA	1	0.5	5
1,1,1-Trichloroethane	100	1	0.5	NA	1	0.5	200
1,1,2-Trichloroethane	100	1	0.5	NA	1	0.5	5
Trichloroethene	100	1	0.5	NA	1	0.5	5
Trichlorofluoromethane	100	1	0.5	NA	1	0.5	150
1,2,3-Trichloropropane	100	1	0.5	NA	1	0.5	NE
1,2,4-Trimethylbenzene	100	1	0.5	NA	1	0.5	NE
1,3,5-Trimethylbenzene	100	1	0.5	NA	1	0.5	NE

Table 5-3. Estimated Reporting Limits and Delineation Limits Field Analysis for GC/MS Volatiles by SW846-8260B (continued)

Volatile Organics	Mobile Lab Reporting Limits*			Delineation Limits			MCL**
	Air µg/m³	Water µg/L	Soil mg/kg	Air µg/m³	Water µg/L	Soil mg/kg	µg/L
[illegible]	100	[illegible]	[illegible]	NA	[illegible]	[illegible]	0.5
o-Xylene	100	1	0.5	NA	1	0.5	1750
m-Xylene	100	1	0.5	NA	1	0.5	
p-Xylene	100	1	0.5	NA	1	0.5	
[illegible]	NA	[illegible]	[illegible]	NA	[illegible]	[illegible]	NE

Notes:

*Quantitation limits listed for soil/sediment are based on wet weight. The quantitation limits calculated by the laboratory for soil/sediment, calculated on dry weight basis as required by the contract, will be higher.

** Maximum Contaminant Levels for Organic Chemicals - Title 22, California Code of Regulations, Division 4. Environmental Health. Chapter 15. Domestic Water Quality and Monitoring, Article 5.5. Primary Standards—Organic Chemicals, Section 64444. General Requirements, Table 64444-A. September 12, 2003.

***Environmental Screening Levels (ESLs) were established in *Screening For Environmental Concerns at Sites With Contaminated Soil and Groundwater (Interim final)* (RWQCB, 2003). Values are based on Table B - Shallow soils (</= 3 m bgs), Groundwater is NOT a Current or Potential Source of Drinking Water for Commercial/Industrial Use. Shallow soils are soils, less than 3 meters (approx 10 ft), where the maximum depth that impacted soil could be excavated and left exposed at the surface. Typically, groundwater is less than 10 feet below ground surface at the former Arsenal. Therefore, any impacted soil would be expected at depths less than 10 feet.

****All concentrations will be reported down to Method Detection Limits, which can be up to 3 times lower than the reporting limit. Therefore, the delineation limit will be met for this compound but the result will be estimated.

NA = not applicable
NE = not established
Key Indicators are shaded
µg/m³ = microgram per cubic meter
µg/L = microgram per liter
mg/kg = milligrams per kilogram

Table 5-4. Estimated Reporting Limits and Delineation Limits Field Analysis for GC/MS Method 8015M TEPH (Extractable)

	Mobile Lab Reporting Limits*			Delineation Limits		
	Air µg/m³	Water µg/L	Soil mg/kg	Air ug/m³	Water µg/L	Soil mg/kg
[illegible]	NA	[illegible]	[illegible]	NA	[illegible]	[illegible]
[illegible]	NA	[illegible]	[illegible]	NA	[illegible]	[illegible]

Notes:

*Quantitation limits listed for soil/sediment are based on wet weight. The quantitation limits calculated by the laboratory for soil/sediment, calculated on dry weight basis as required by the contract, will be higher.

**Environmental Screening Levels (ESLs) were established in *Screening For Environmental Concerns at Sites With Contaminated Soil and Groundwater (Interim final)* (RWQCB, 2003). Values are based on Table B - Shallow soils (</= 3 m bgs), Groundwater is NOT a Current or Potential Source of Drinking Water for Commercial/Industrial Use. Shallow soils are soils, less than 3 meters (approx 10 ft), where the maximum depth that impacted soil could be excavated and left exposed at the surface. Typically, groundwater is less than 10 feet below ground surface at the former Arsenal. Therefore, any impacted soil would be expected at depths less than 10 feet.

NA = not applicable
Key indicators are shaded
µg/m³ = microgram per cubic meter
µg/L = microgram per liter
mg/kg = milligrams per kilogram

Table 5-5. Quantitation Limits, Ambient Concentrations, Benicia Screening Levels and Delineation Limits for Metals

Chemical of Interest	Fixed Lab Quantitation Limits* (mg/kg)	Ambient Concentration (mg/kg)	Benicia Screening Levels (BSLs)										Delineation Limits
			Commercial/Industrial Workers		Construction/Utility Workers		Residents			Open Space Visitors			
			Carcinogens (mg/kg)	Noncarcinogens (mg/kg)	Carcinogens (mg/kg)	Noncarcinogens (mg/kg)	Carcinogens[1] (mg/kg)	Adult Noncarcinogens (mg/kg)	Child Noncarcinogens (mg/kg)	Carcinogens 1 (mg/kg)	Adult Noncarcinogens (mg/kg)	Child Noncarcinogens (mg/kg)	mg/kg
Aluminum	5.00E+01	2.83E+04	NC	1.68E+06	NC	1.23E+05	NC	6.59E+05	7.61E+04	NC	1.18E+08	2.52E+07	1.68E+06
Antimony	2.00E+01	8.52E+00	NC	8.18E+02	NC	1.06E+03	NC	2.92E+02	3.13E+01	NC	NA	NA	8.18E+02
Arsenic	4.00E-01	1.69E+01	2.73E+00	4.39E+02	1.20E+01	6.74E+02	3.89E-01	1.96E+02	2.16E+01	5.35E+04	NA	NA	4.39E+02
Barium	1.00E+00	2.24E+02	NC	1.24E+05	NC	1.20E+04	NC	4.75E+04	5.37E+03	NC	1.18E+07	2.52E+06	1.24E+05
Beryllium	1.00E-01	8.29E-01	2.24E+03	3.69E+03	1.10E+02	4.77E+02	1.05E+03	1.39E+03	1.54E+02	9.55E+04	4.79E+05	1.03E+05	3.69E+03
Cadmium	1.00E+00	8.66E-01	2.99E+03	1.01E+03	1.46E+02	1.32E+03	1.40E+03	3.64E+02	3.90E+01	1.27E+05	NA	NA	1.01E+03
Chromium, Total	2.00E+00	7.53E+01	4.48E+02	C	2.19E+01	C	2.11E+02	C	C	1.91E+04	C	C	4.48E+02
Cobalt	2.00E+00	1.33E+01	NC	1.23E+05	NC	1.60E+05	NC	4.38E+04	4.69E+03	NC	NA	NA	1.23E+05
Copper	3.00E+00	4.05E+01	NC	7.58E+04	NC	9.87E+04	NC	2.71E+04	2.90E+03	NC	NA	NA	7.58E+04
Iron	1.50E+01	5.26E+04	NC	6.13E+05	NC	7.98E+05	NC	2.19E+05	2.35E+04	NC	NA	NA	6.13E+05
Lead[2]	5.00E+00	2.01E+01	NC	7.50E+02	NC	NA	NC	NA	4.00E+02	NA	NA	NA	7.50E+02
Manganese	5.00E-01	1.07E+03	NC	3.23E+04	NC	1.26E+03	NC	1.39E+04	1.76E+03	NC	1.18E+06	2.52E+05	3.23E+04
Mercury	1.00E-01	2.87E-01	NC	6.13E+02	NC	7.98E+02	NC	2.19E+02	2.35E+01	NC	NA	NA	6.13E+02
Molybdenum	1.50E+01	2.51E+00	NC	1.02E+04	NC	1.33E+04	NC	3.65E+03	3.91E+02	NC	NA	NA	1.02E+04
Nickel	1.50E+01	3.83E+01	NC	4.09E+04	NC	5.32E+04	NC	1.46E+04	1.56E+03	NC	NA	NA	4.09E+04
Selenium	1.00E+00	6.05E-01	NC	1.02E+04	NC	1.33E+04	NC	3.65E+03	3.91E+02	NC	NA	NA	1.02E+04
Silver	5.00E+00	1.67E+00	NC	1.02E+04	NC	1.33E+04	NC	3.65E+03	3.91E+02	NC	NA	NA	1.02E+04
Thallium	4.00E+00	8.50E-01	NC	1.35E+02	NC	1.76E+02	NC	4.82E+01	5.16E+00	NC	NA	NA	1.35E+02
Tin	1.00E+01	1.90E+01	NC	1.23E+06	NC	1.60E+06	NC	4.38E+05	4.69E+04	NC	NA	NA	1.23E+06
Vanadium	1.00E+01	9.22E+01	NC	1.43E+04	NC	1.86E+04	NC	5.11E+03	5.48E+02	NC	NA	NA	1.43E+04
Zinc	1.00E+01	1.26E+02	NC	6.13E+05	NC	7.98E+05	NC	2.19E+05	2.35E+04	NC	NA	NA	6.13E+05

Notes:
BSLs are based on ingestion of soil, dermal contact with soil, and inhalation of dust particles and vapors.
1 Age-adjustment for carcinogenic chemicals takes into account both child and adult soil exposures per USEPA (1991b) guidance.
2 BSLs for lead are based on the USEPA's Integrated Exposure Uptake Biokinetic Model and recommendations of USEPA's Technical Review Workgroup.
C = Chemical is a carcinogen. No BSL developed for noncancer endpoint.
NC = Chemical is a noncarcinogen. No BSL developed for cancer endpoint.
ND = Not Detected
NA = Not available.
*Analysis of antimony, barium, beryllium, total chromium, cobalt, copper, manganese, molybdenum, nickel, silver, tin, vanadium and zinc by 6010B, cadmium and lead by 6010B ICP trace, arsenic by 7060A, selenium by 7740, thallium by 7841 and mercury by 7471A.

6.0 SAMPLING METHOD REQUIREMENTS

The Standard Operating Procedures (SOPs) to be implemented during this project are listed in Table 6-1. These SOPs are located in Appendix F of the Quality Assurance Project Plan (QAPP) for environmental investigations at the former Arsenal (FA/BC, 2001). Requirements for sample containers, preservation methods and analytical holding times are also included in the QAPP.

Table 6-1. Applicable SOPs for Expanded SI

SOP No.	SOP Title	Applicable	Not Applicable	Specific Aspects of SOP to be Implemented for this FSIP
1.0	Field Logbook	✓		All
2.0	Boring Log Development	✓		All
3.0	Field Classification and Description of Soils	✓		All
4.0	Sample Management	✓		All
5.0	Field Measurement of Organic Vapors	✓		1. A photoionization detector (PID) Model 580B OVM or equivalent will be used instead of a flame ionization detector (FID). 2. Direct reading colorimetric indicator tubes TCE (VOC related sites) will be used as prescribed in the SSHP
6.0	Utility Clearance	✓		All except, no lock-out/tag-out procedures necessary for this FSIP
7.0	Collection of Soil Samples	✓		1. Surface, subsurface, and depth-discrete soil samples will be collected using scoop/trowels, thin-walled tubes, and ring-lined samplers, as appropriate. 2. Surface soil samples will be collected within the first 6 inches below base rock and/or asphalt and concrete. 3. A #10 sieve will be used to remove bullets/bullet fragments from soil samples collected from the Firing Range/Demolition Area.
8.0	XRF Soil Analysis		✓	
9.0	Packing and Shipping of Environmental Samples	✓		All
10.0	Sample Preservation and Analysis Methods	✓		Subcontracting laboratories will provide preserved sample containers. Preserved groundwater samples from previous investigations have been checked for proper pH. These results indicate that correct pH aliquots are provided in the sample containers. Therefore, only periodic pH checks will be conducted. Preservatives are available at the site and will be added, if necessary.

Table 6-1. Applicable SOPs for Extended SI (continued)

SOP No.	SOP Title	Applicable	Not Applicable	Specific Aspects of SOP to be Implemented for this FSIP
11.0	Sampling Equipment Decontamination	✓		All
12.0	Immunoassay		✓	
13.0	*In Situ* Groundwater Sampling	✓		Hydropunch® samples will be collected as part of this investigation.
14.0	Borehole Abandonment	✓		Boreholes will be "plugged" according to this SOP.
15.0	Well Development	✓		Development of static water level measuring points shall be performed using the procedures for Microwell/Monitoring Wells .
16.0	Surface Water Sampling		✓	
17.0	Groundwater Purging and Sampling	✓		Disposable bailers attached to industrial-type twine will be used to collect groundwater samples from wells.
18.0	Geophysical Testing	✓		For this investigation, ground penetrating radar and electromagnetic line locating methods will be used for utility clearance.
19.0	Soil Gas Sampling	✓		Drive probes will be used to collect soil gas samples as part of this FSIP.
20.0	Sludges and Sediments		✓	
21.0	Well and Piezometer Installation	✓		All
22.0	Field Measurement of pH	✓		A digital or analog pH meter will be used.
23.0	Field Measurement of Temperature	✓		All
24.0	Field Measurement of Specific Conductance	✓		All
25.0	Field Measurement of Water Levels	✓		All
26.0	Photographic/Video Documentation	✓		All
27.0	Drilling	✓		Hollow stem auger drilling will be implemented for this investigation. Direct push hollow-stem auger drilling will be used to install monitoring wells.
28.0	Cone Penetrometer Drilling and Sampling Procedures	✓		CPT methods will be use to collect lithologic data and groundwater samples.
29.0	Trenching		✓	
30.0	Methanol Preservation for Volatile Organic Compounds in Soils		✓	
31.0	Field Classification and Description of Rocks	✓		All
32.0	Field Sampling with EnCore™	✓		All

XRF = X-Ray Fluorescence

7.0 ANALYTICAL METHODS SUMMARY

The chemical analyses to be conducted on each groundwater sample are listed on Table 5-1. Detailed descriptions analytical methods, practical quantitation limits (PQLs) and analyte lists are presented in the QAPP (FA/BC, 2001). Quality assurance/quality control (QA/QC) protocols are described in the QAPP and in Section 9 of this FSIP.

To facilitate this investigation's dynamic approach, samples will be analyzed at a mobile laboratory stationed near the 50 Series Complex. However, for metals analyses, those samples will be sent to an off-site laboratory (EMAX Laboratories) on a 48-hour to 72-hour turnaround. The turnaround time for any off-site analysis will depend on the status of the field effort at the time a sample is collected. It is possible that at the end of the investigation shorter turnaround times may be necessary (12-hour to 24-hour) in order to make final decisions. Results from other analytes (well sample analyses), not necessary for making time critical decisions will be sent to EMAX Laboratories on a standard turnaround (approximately 14 days).

Sample analytical results will be reported in electronic and hardcopy deliverables. Specifications for laboratory reporting are included in the QAPP. Reporting for 10 percent of the analytical data will be in Level IV–equivalent packages for full third-party validation. All Level III and Level IV data reviews will be completed within 30 days of receipt of last laboratory data package for the field event.

7.1 QAPP Addendum Overview

The activities described in this FSIP will be conducted in accordance with guidance set forth in the QAPP and the QAPP Addendum included in Appendix C. The QAPP details field and laboratory parameters, specific QA/QC activities, and reporting requirements. The QAPP Addendum, which has been prepared specifically for use during the Expanded SI field work, is an integral part of this FSIP. It provides information on the additional laboratory analyses required in this investigation that are not covered currently in the QAPP. The QAPP Addendum additions are presented in text and tables corresponding with the existing sections of the QAPP.

The mobile laboratory will provide rapid analysis of soil, groundwater, and soil gas to determine the presence of solvents and/or fuel-related VOCs and petroleum hydrocarbons. The mobile lab will perform the following analytical methods:

- Analysis for VOCs by gas chromatography/mass spectroscopy (GC/MS) following EPA Method SW8260B. This method will detect total purgeable petroluem hydrocarbons (TPPH) as gasoline.
- Analysis for total extractable petroleum hydrocarbons (TEPH) as diesel fuel and motor oil by gas chromatography (GC) following EPA Method SW8015M.

Appendix C includes the project specific analyte lists, corresponding reporting limits, and the SOPs to be used by the mobile laboratory during this Expanded SI.

8.0 INVESTIGATION DERIVED WASTE

The purpose of this section is to describe the specific procedures to be used for collection, characterization, storage, containerization, transport and disposal of IDW. The Arsenal-wide IDW Plan is described in detail in Section 4.5 of the Investigation Workplan (FA/BC, 1999b).

The IDW generated by this Expanded SI will include soil from drilling, decontamination rinsate from drilling equipment, and disposable protective clothing and ground covers. Soil and groundwater will be contained in the containers specified in the QAPP (FA/BC, 2001).

The soil and groundwater containers will be placed at a temporary staging area in Area I. This area is a secure site. Heavy equipment will be decontaminated near the staging area, according to procedures described in the QAPP (FA/BC, 2001). Decontamination of sampling equipment during groundwater purging and drum sampling activities will be staged at the Brown and Caldwell Benicia Arsenal Field Office at 942 Tyler Street, Benicia, California.

Excess disposable wastes derived from sampling, such as personal protective equipment (PPE), gloves and bailers, will be disposed by the local garbage service for the area.

Soil samples will be collected for the purpose of IDW characterization. Additional analytical work may be required based on requirements of the disposal facility. Soil derived from drilling and sampling activity will be segregated, if possible, based on visual and instrument readings from a photoionization detector (PID) and by the potential contaminant. For example, wastes with potential solvent impacts will be segregated from potential fuel-only impacts.

9.0 QUALITY CONTROL

Field QC activities will include collection and analysis of QC samples, implementation of the three-phase QC program described below, and validation and verification of analytical data. In accordance with the QAPP, field QC activities, including variances from this FSIP, will be documented in field logbooks and the quality control summary report (QCSR). These activities are described in the QAPP and are summarized below.

9.1 Quality Control Samples

Eight types of QC samples will be used to quantitatively assess the quality of data generated during the field investigation. These samples include matrix spike/matrix spike duplicate (MS/MSD) samples, field duplicates, split samples, trip blanks, equipment rinsate blanks, filter blanks, source water blanks and field ambient blanks. The QA/QC sampling protocol is also described in the QAPP. QA/QC samples (sample duplicates, MS/MSD and QA split samples) will be collected at the frequencies required in the QAPP (FA/BC, 2001).

The list of analyses evaluated during previous investigations at the former Arsenal includes all the analytes planned for this investigation. The contract analytical laboratory procedures and services will be in accordance with the QAPP.

CPT lithologic data QC measures will involve calibration of the probe by advancing CPT borings adjacent to previous borings where soil samples were physically collected and logged under the supervision of a geologist registered in the State of California. Two confirmation CPT borings will be advanced near existing PZ-3 (Plate 1) and PZ-20 (Figure 5-4). CPTQC1 and CPTQC2 will be advanced to match the total depth of PZ-3 and PZ-20, respectively. PZ-3 is located within the Lowlands and the capped marshland. The lithology encountered at this location will include Holocene Bay Mud to a depth of 63 feet bgs, where sandstone was encountered. PZ-20 is located in the Highlands where silty to sandy alluvial material with some gravel was encountered to 34.5 feet bgs. QC measures for these borings will involve confirming that material from PZ-3 and PZ-20 does not represent sluff from above and that depth measurements are accurate and properly documented.

9.2 Three-Phase Quality Control Program

A three-phase QC program will include preparatory phase, initial phase and follow-up phase activities.

9.2.1 Preparatory Phase – Laboratory

At least one week prior to beginning field work, the project team will conduct a laboratory kick-off meeting to review items outlined in the QAPP and FSIP with the Task Order Manager, the Project Chemist and the contract laboratories. The results of this meeting will be documented in minutes signed by all participants and distributed to the project team.

9.2.2 Preparatory Phase – Field

The Task Order Manager, Field Team Leader and Project Chemist will conduct a readiness review meeting approximately one week prior to beginning field work. The USACE Technical Leader will also be invited to attend. The purpose of this meeting will be to review and document preparation for the field investigation. All items discussed in the readiness review meeting must be completed prior to the start of field work. The Field Team Leader will complete a checklist during the readiness review meeting to ensure that adequate documentation and equipment is available. This checklist may be modified, as necessary, during preparation activities.

9.2.3 Initial Phase – Laboratory

As a part of the previous field activities, USACE conducted an audit of EMAX Laboratories in May 1999 under the direction of the Project Chemist and again in June 1999 in conjunction with Jacobs Engineering. The audit results and labbratory responses to the audit findings are maintained in the project files. All issues identified during this audit have been resolved. Because the analyses planned for this Expanded SI were covered in the two previous audits, no additional audits are proposed for this phase of work. EMAX Laboratories underwent USACE Missouri River Division re-validation in May 2000 and is certified by the State of California for the required analyses.

If Level III data review or Level IV data validation indicates potential fraud, significant systematic errors, or laboratory contract compliance below 80 percent, corrective action (potentially including auditing the laboratory) could be initiated. The Project Chemist will work in conjunction with USACE, the Program Chemist and the QCSM to determine the appropriate corrective action.

9.2.4 Initial Phase-Field

To ensure compliance with the QAPP and this FSIP, field QC activities will be evaluated during the first week of the field effort through the initial phase inspection conducted by the Task Order Manager. The initial phase inspection will be documented in a meeting. Meeting minutes will be signed by all participants and attached to the daily QC report. QC activities to be evaluated during the initial phase inspection include those described in the QAPP.

9.2.5 Follow-up Phase

QC will be performed as needed throughout the Expanded SI to resolve deficiencies identified during the preparatory and initial inspections or other issues noted during field activities by the Task Order Manager, Field Team Leader, or Project Chemist. Follow-up QC activities will be performed to assure continuing compliance with contract, QAPP, and FSIP requirements until completion of all field and laboratory work. Final follow-up checks will be conducted and all deficiencies corrected prior to the start of additional field work.

The QC Systems Manager will participate in the QC program as described in this FSIP and the QAPP. Additional QC phases and/or review of subcontractors may be added during the execution of work as deemed necessary by project staff and the QC Systems Manager.

9.2.6 Data Validation

All laboratory data will be verified according to guidelines presented in the QAPP. Data generated for 100 percent of the field samples analyzed using definitive methods will be verified. Ten percent of the data will be provided in EPA Level IV-equivalent data packages as described in the QAPP. The remaining 90 percent of the data will be verified to EPA Level III requirements. Ten percent of the data will be independently validated using procedures consistent with those specified in *Contract Laboratory Program National Functional Guidelines for Organic/Inorganic Data Review* (EPA, CLP Organic/Inorganic, 1994a, b) the appropriate EPA reference methods, and the QAPP.

10.0 REFERENCES

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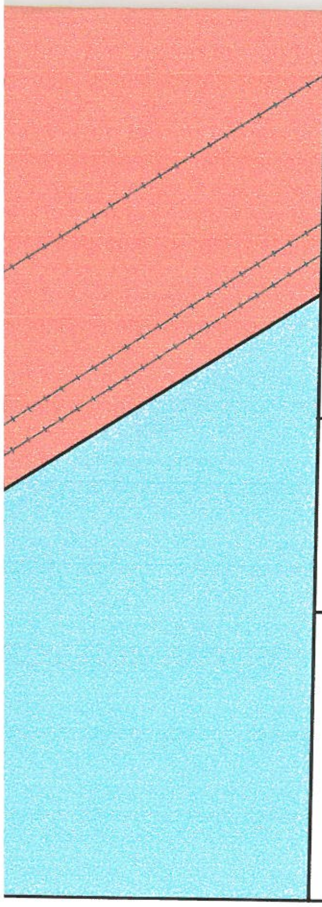

locations are primary locations. Additional CPT locations (not shown) will be based on a step-in/step-out decision logic based on the results of the groundwater samples.

SITE

Benicia Arsenal, Benicia, California

TITLE

Area I - Proposed Sampling Locations Expanded SI

BROWN AND CALDWELL

DATE 03/31/04

PROJECT NO. 24785

Plate 1