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Naval Facilities Engineering Command
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RE: Contract N62470-96-D-5901, Delivery Order No. 0050
Draft Final Work Plan for Semiannual Groundwater Monitoring and Quality Assurance Project Plan (QAPP)
Atlantic Fleet Weapons Training Facility (AFWTF) Vieques, Naval Station Roosevelt Roads, Puerto Rico

Sir:

EnSafe is pleased to submit one copy of the referenced documents. These documents may also be viewed on EnSafe's web page at http://www.ensafe.com. On the left side of the web page, select **project EXTRANETS**, then on the next screen enter **obod** for User ID and **vieques** (both lower case) for Password and click on the **LOGIN** button. The files will be in pdf format.

If you have questions, please call James N. Speakman, Senior Vice President, or me at 901/372-7962.

Very truly ours,
EnSafe, Inc.

Michael R. Banker

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Senior Project Manager

Enclosure
cc: Wilfredo Rivera, Naval Station Roosevelt Roads

DRAFT FINAL
GROUNDWATER MONITORING WORK PLAN
OPEN BURNING/OPEN DETONATION UNITS

for

ATLANTIC FLEET WEAPONS TRAINING FACILITY
VIEQUES ISLAND, PUERTO RICO

Prepared for:

ATLANTIC DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
NORFOLK, VIRGINIA

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ACRONYM LIST

AFWTF	Atlantic Fleet Weapons Training Facility
ATSDR	Agency for Toxic Substances and Disease Registry
COPC	chemical of potential concern
EOD	Explosive Ordnance Disposal
EMA	Eastern Maneuver Area
GMR	groundwater monitoring report
GWMP	groundwater monitoring plan
HASP	health and safety plan
HMX	cyclotetramethylene tetranitramine
IDW	investigation-derived waste
LDR	land disposal restriction
LIA	Live Impact Area
mg/L	milligrams per liter
NASD	Naval Ammunition Support Detachment
NEW	net explosive weight
NPDES	National Pollutant Discharge Elimination System
OB/OD	open burning/open detonation
PETN	pentaerythritol tetranitrate
PHA	Public Health Assessments
PRASA	Puerto Rico Aqueduct and Sewer Authority
QAPP	quality assurance project plan
RCRA	Resource Conservation and Recovery Act
RDX	cyclo-1,3,5-trimethylene-2,4,6-trinitramine
SIA	Surface Impact Area
TNT	2,4,6-trinitrotoluene

UCL	upper confidence limit
USEPA	United States Environmental Protection Agency
UXO	Unexploded Ordnance

1.0 INTRODUCTION

EnSafe Inc. has prepared this groundwater monitoring work plan (GMWP) for the Atlantic Division, Naval Facilities Engineering Command (U.S. Navy). It presents and describes the objectives, rationale, procedures, and methodology to be followed during ongoing groundwater monitoring by the U.S. Navy along the western border of U.S. Navy property on Vieques, Puerto Rico, pending closure of the open burning/open detonation (OB/OD) units at the Naval Station Roosevelt Roads Atlantic Fleet Weapons Training Facility (AFWTF) in Vieques. The development and implementation of this work plan was based on previous U.S. Navy investigations.

This work plan is in response to United States Environmental Protection Agency's (USEPA's) request that the Resource Conservation and Recovery Act (RCRA) Section 3008 Consent Order (RCRA-02-2000-7301) be modified to include the following requirements:

- A groundwater baseline investigation in an area within relative close proximity of the OB/OD units (either just outside the Live Impact Area [LIA] of the AFWTF or inside the LIA) at or near the shorelines to assess groundwater impacts to surface water.

- An ongoing groundwater monitoring program along the western boundary of the Navy's property to verify that no unacceptable threats to human health or the environment result from the unclosed but not operating OB/OD units.

- Prompt cleanup and closure of the OB/OD area when the Navy stops using of the LIA in which the OB/OD units are located.

USEPA made this request in response to the Navy's request to withdrawal its June 1993 RCRA Part B Hazardous Waste Facility Operations Subpart X Permit Application for the

Naval Station Roosevelt Roads OB/OD units in Vieques. (The facility has been operating under interim status since approximately 1980.)

USEPA has requested a groundwater baseline investigation in an area within relative close proximity of the OB/OD units. The purpose of this investigation would be to ensure that the delay of closure of the OB/OD does not result in an unacceptable risk to human health or the environment. As an alternative to the suggested groundwater investigation, the Navy proposes utilizing the pertinent complete and pending assessments of the Vieques range, conducted by the Agency for Toxic Substances and Disease Registry (ATSDR) and the Navy. These assessments provide a more detailed account of conditions on the active range, of which OB/OD activity was a minor subset. Also, by utilizing these existing and pending assessments, additional intrusive work on or around the active range may be avoided. Unexploded ordnance (UXO) hazards exist both on the LIA, as well as on the adjacent Surface Impact Area (SIA), and the Navy believes subsurface activity will present an unacceptable risk to personnel.

ATSDR has published both a final groundwater pathway and a draft soil pathway Public Health Assessment (PHA), both of which indicated current and former Navy range activities (of which OB/OD was a minor subset) do not result in an unacceptable risk to the public. Pending ATSDR work will address both the air and marine food chain pathways. The Navy will continue to monitor ATSDR's work and will address any noted impacts, should they be discovered. The current ATSDR studies are summarized in section 1.3.

The Navy has monitored water quality as required by it's National Pollutant Discharge Elimination System (NPDES) permit. It has also conducted other studies comparing the water quality adjacent to the LIA to other locations around the isle of Vieques and to other locations around the Caribbean. The monitoring and studies show no significant difference between water quality adjacent to the LIA and these other locations. The Navy

believes these studies significantly add to the body of work indicating that Navy range operations, including OB/OD, do not adversely impact the off-range environment.

Given the aforementioned studies and assessments, the Navy will focus on the semi-annual groundwater monitoring along the Navy's western boundary, as presented in this work plan.

Project Objectives

The specific project objectives of this groundwater monitoring program include the following:

- Establish a network of monitoring wells along the western boundary of Navy property that allows long-term determination of groundwater flow and the collection of groundwater samples.

- Sample the monitoring well network at a prescribed frequency that meets the specified USEPA requirements and reflects actual site conditions.

- Use current, recognized methods and procedures to ensure the collection of representative groundwater samples.

- Analyze all samples at a sufficient level of data quality and quality assurance to allow for a statistical comparison with baseline groundwater results collected along the western boundary of Navy property in 1999 (CH2MHill and Baker Environmental, 1999a).

Section 2.0 further discusses the guidance, design, and development of this groundwater monitoring program and these objectives.

1.1 Site Location

Vieques Island, approximately seven miles southeast of U.S. Naval Station Roosevelt Roads, Puerto Rico, is 20 miles long east to west and 3 to 4 miles long north to south. It has a total surface area of roughly 33,000 acres. The former Naval Ammunition Support Detachment (NASD), an 8,000-acre property in the island's westernmost tip, was transferred to the Commonwealth of Puerto Rico and others on May 1, 2001. Approximately 14,700 acres are now owned by the U.S. Navy.

U.S. Navy Property

- Approximately 100 acres in the former NASD used for the operation of the Relocatable Over The Horizon Radar and Monte Pirata sites.

- The Eastern Maneuver Area (EMA), 11,000 acres in the island's east-central portion.

- The AFWTF, 3,600 acres on the island's eastern portion.

Together, the EMA and AFWTF are known as the "Inner Range," which extends 3 miles offshore. A portion of the AFWTF, the Live Impact Area or LIA, was used primarily for aerial bombing and ordnance delivery training. Figure 1-1 shows Vieques relative to Puerto Rico and other nearby islands, while Figure 1-2 shows the AFWTF's location on the island.

Several small towns and villages are scattered throughout the west-central portion of the island. Outside the towns and villages, cattle grazing, is the primary land use. Local ranchers also graze their cattle on leased portions of the EMA.

FIGURE 1-1
VICINITY MAP

ATLANTIC DIVISION
NAVAL FACILITIES
ENGINEERING COMMAND
VIEQUES PUERTO RICO

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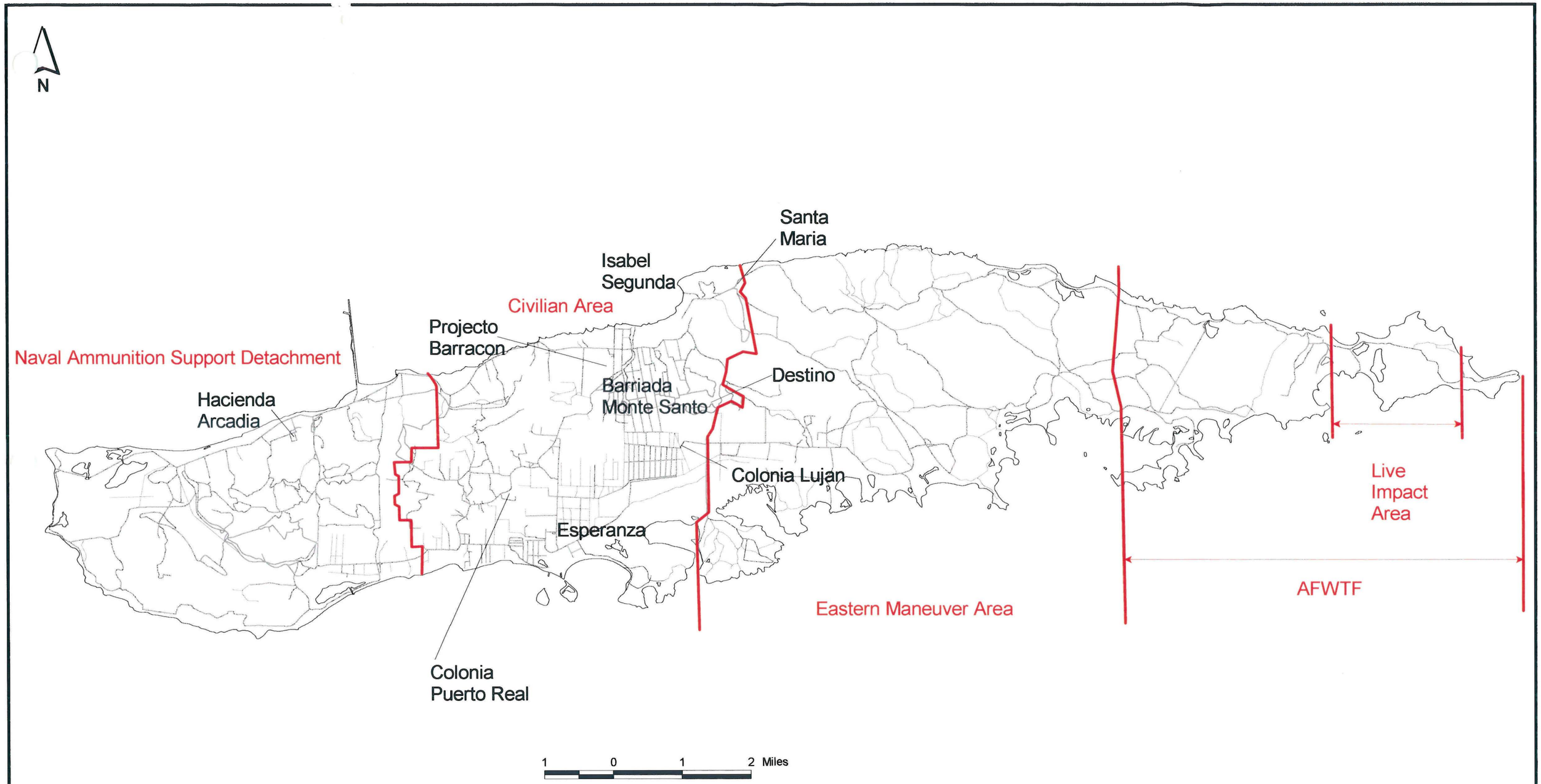

ATLANTIC DIVISION
NAVAL FACILITIES
ENGINEERING COMMAND
VIEQUES PUERTO RICO

Figure 1-2
Island of Vieques
Location Map

Source: Digitized USGS Quadrangle - Isla de Vieques

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1.2 Description of Site Operations

The AFWTF functions under the consolidated command of Commander in Chief Atlantic Fleet and Commander Navy Region Southeast. It provides facilities to train Atlantic Fleet and NATO ships, air wings, and smaller air units from other allied nations and the Puerto Rican National Guard in naval gunfire support and air-to-ground ordnance delivery. The Atlantic Fleet's ships, aircraft, and marine forces also conduct training in all aspects of air-to-surface mine delivery, amphibious landings, small arms, artillery and tank fire, and combat engineering within the Inner Range.

Within the AFWTF's LIA, two separate locations were designated for treatment of retrograde (unserviceable) ordnance through open burning and open detonation. In the open detonation area, retrograde munitions were detonated with high explosives in excavated earthen pits; a separate area had been designated for open burning of waste propellants and pyrotechnics. However, open burning has never occurred. Prior to approximately 1995, open detonation was limited to 10,000 pounds net explosive weight (NEW) per year. After that date, open detonation was limited to 3,000 pounds NEW per event (50,000 pounds NEW per year). Actual annual OD quantities have been much less than the annual 50,000 NEW limit. The military munitions that have been treated onsite are listed below. The chemical constituents of these munitions that will be analyzed are discussed in Section 2.3.3 of this work plan.

Munitions Treated Onsite

- black powder
- TNT (trinitrotoluene)
- explosive D (ammonium picrate)
- PETN (pentaerythritol tetranitrate)
- tetryl (N-tetranitro-N-methylaniline)

- RDX compositions (cyclotrimethylene trinitramine with other explosives and materials)
- cyclotols (RDX/TNT mixtures)
- HMX (cyclotetramethylene tetranitromine)
- octols (HMX/TNT mixtures)
- HBXs (RDX/TNT/aluminum mixtures)
- H6 (RDX/TNT/aluminum mixtures)
- tritonal (TNT/aluminum mixture)
- DBX (TNT/RDX/ammonium nitrate/aluminum mixture)
- Torpex (RDX/TNT/aluminum mixture)
- Comp D-2 (desensitizing wax mixture)
- PBX (explosives/plastics mixture)
- lead azide
- lead styphnate
- mercury fulminate
- tetracene
- DDNP (diazodinitrophenol)
- smokeless powder
- solid propellant (including perchlorate)
- pyrotechnics
- picric acid

The OB/OD units are within the LIA range, which the Navy used for training with live military ordnance. Semi-annually, the Navy Explosive Ordnance Disposal (EOD) team clears safe paths to the target area so the targets can be repaired. While clearing the paths, they locate UXO detected at various locations on the range, then detonate the ordnance in-place. From January 31, 2000, until present, Navy training has been limited to the use of non-explosive ordnance, which may include spotting devices.

Each unit (OB and OD) is approximately 100-feet x 100-feet. The OB unit has never been used. Inside the OD unit, a circular earthen pit, approximately 30 to 60 feet in radius and 6 to 8 feet deep, has been used for no more than one detonation per day. Cover materials were not used because response would be complicated in the event of a misfire. The pit had no specific location because training with live munitions obliterated it between treatment events. However, all OD occurred within the 100 feet x 100 feet unit, the location of which was determined with a global positioning system.

Waste retrograde ordnance was transported from the NASD to the Inner Range via water. Within the range, waste ordnance was transported via motor vehicle to the OD unit, where high explosives were placed in direct contact with the waste ordnance to maintain explosive continuity. Although high explosives were used to supplement open detonation, they are not technically a fuel, but an initiating mechanism. No supplemental fuels were used for detonation.

Following each detonation, EOD personnel carefully searched the surrounding grounds for unexploded ammunition or explosives. Explosives or unfused ammunition were collected and prepared for the next detonation. Fused ammunition or items with potentially damaged internal components were generally detonated in-place.

As a security precaution, the LIA, in which the OB/OD units are located, is visually monitored 24 hours a day. During range operations, all roads entering the area are guarded. Warning signs are posted at all LIA access roads.

1.3 Previous Studies and Investigations

Previous studies of geology and groundwater occurrence have been conducted on Vieques by the United States Geological Survey (Learned et al., 1973; Torres-Gonzalez, 1989; Cherry and

Ramos, 1995) to document natural conditions and groundwater use and occurrence and establish a hydrogeologic framework. The U.S. Navy (Department of the Navy, 1990; CH2MHill and Baker Environmental, 1999) and others (Hoffsommer and Glover, 1978; Lai, 1978; Young, 1978: Marsh, 1992; Garcia et al., 2000) have conducted environmental soil, surface water and groundwater investigations and studies on Navy property and other areas of Vieques These environmental investigations addressed effects on human health and the environment from U.S. Navy activities.

The following sections briefly summarize the most recent environmental efforts by the ATSDR and the U.S. Navy to assess threats to human health and the environment and characterize groundwater occurrence and quality along the western boundary of U.S. Navy property.

1.3.1 ATSDR Focused Public Health Assessments for Vieques Drinking Water Supplies and Groundwater and Soil Pathway Evaluations

The ATSDR published two focused Public Health Assessments (PHAs) conducted at Vieques in 2001. The first (October 16, 2001) presents the findings of the PHA for Vieques drinking water supplies and groundwater pathway evaluation. Its goal was to determine whether U.S. Navy activities at the AFWTF LIA and OB/OD expose Vieques residents to unhealthy contaminant concentrations in public drinking water or groundwater. The PHA studied Vieques geology and hydrology and reviewed existing analytical data for sampling of drinking water and groundwater. The available data set was determined by the ATSDR to be adequate to conduct the PHA, which concluded that the public drinking water (supplied to Vieques by a pipeline from Puerto Rico) is "safe to drink." Groundwater from sampled wells is "safe to drink," except for one private well thought to have agriculturally derived nitrate-nitrite contamination. The only detections of explosives-related analytes were from well water samples analyzed in 1978, and the validity of this data is suspect. However, even assuming the 1978 data is valid, the detected concentrations of

explosives-related compounds were well below concentrations considered harmful to human health. Further study by the ATSDR will evaluate drinking water derived from collected rainwater.

An equally significant PHA finding was that there is no groundwater pathway from the LIA area of Vieques to the civilian areas of the central and west portions of the island. The PHAs states that "... the geology and topography of the island prevents groundwater from moving in that direction" and "... groundwater cannot move uphill from the LIA westward — there is no connection between groundwater at the LIA and groundwater of the central portion of the island. Neither the Esperanza aquifer, nor the shallow groundwater around Isabel Segunda and other populated areas of the island is directly impacted by groundwater beneath the LIA or the OB/OD area."

The second focused PHA (published in draft form for public comment October 23, 2001) was a soil pathway evaluation to determine whether island residents were being exposed via ingestion or dermal contact to harmful soil contaminant concentrations resulting from Navy activities at the AFWTF LIA and OD/OD. The PHA studied the soils and geology of Vieques and reviewed available soil sampling data. The available data set was judged by ATSDR as adequate to conduct the PHA. The PHA concluded that there is no evidence that Navy training activities have resulted in elevated concentrations of metals or other chemicals in Vieques' soils or that residents are being exposed to harmful contaminant concentrations. No evidence noted in the report indicated contaminant migration from the LIA area to civilian areas to the west or further contamination of the LIA during the last 28 years. Full use of the LIA began in the mid-1970s. Soil samples analyzed in 1972 were compared with recent analytical results.

The ATSDR plans additional PHAs to evaluate drinking water derived from collected rainwater, the airborne soil particle/explosives residue pathway, and the locally collected fish and shellfish ingestion pathway.

The findings of the two PHAs discussed above have significant relevance regarding the Navy's request to delay final RCRA closure of the now-unused OB/OD units within the LIA. The Navy made this request because it is not feasible to close these units while the LIA is being used for essential Navy training. Such closure is not feasible because explosives residue from past OD activities (burning of waste at the OB has not occurred) are essentially the same as those generated by detonating munitions in training activities. The Navy believes that the ATSDR PHA reports support the conclusion that no risk to human health or the environment will exist as a result of delaying final RCRA closure of the OB/OD areas until the Navy closes the range. Also, the PHAs conclude that no groundwater pathway or connection exists between the LIA area (in the extreme eastern portion of Vieques) and areas west of the LIA, in particular the civilian property in central and western Vieques. Therefore, groundwater on non-Navy property cannot be adversely impacted by groundwater from previous OB/OD activities.

1.3.2 U.S. Navy Studies

The U.S. Navy retained CH2MHill and Baker Environmental in 1999 to develop and conduct hydrogeologic investigations, and complete ecological screening and a baseline human health risk assessment for soil and groundwater pathways along the western boundary of the U.S. Navy property (i.e., along the western EMA boundary with non-Navy civilian property). The investigation planning and results are available in reports by CH2MHill and Baker Environmental (1999a and 1999b). During the investigation, 32 shallow surface soil samples were collected and analyzed. Eleven groundwater monitoring wells and nine piezometers were installed; samples were collected from wells

completed in the first encountered groundwater in both the alluvial and underlying bedrock aquifers. Both soil and groundwater samples were analyzed for the primary chemical constituents and elements in explosives disposed of at the AFWTF. No explosive-related compounds or elements were detected in either soil or groundwater. Laboratory detection limits for the target compounds were below the most conservative risk screening values; consequently, no chemicals of potential concern (COPCs) were designated. Therefore, a conclusion of no unacceptable risk to human health or the environment from area soil or groundwater was supported. Based on the surveyed wells and piezometers, groundwater flows north and the south in the bedrock aquifer from a central groundwater divide. In the alluvial aquifer, groundwater flows to the southeast.

In addition to these studies, at ATSDR's request, the Navy's collected and analyzed 37 surface soil samples within the LIA and within the conservation zones immediately adjacent to the LIA in June 2000 (CH2MHill, 2000). The samples were analyzed for metals and explosive compounds. The results of this investigation were used in the ATSDR soil study discussed in Section 1.3.1.

1.4 Environmental Setting

This section of this work plan was developed from the available U.S. Geological Survey information and data, as well as U.S. Navy site-specific environmental and hydrogeologic studies conducted in 1999 by CH2MHill and Baker Environmental. The investigations conducted under this work plan rely upon this information, and will serve to improve the database of environmental and specific hydrogeologic site information.

1.4.1 Topography

Vieques' topography is characterized by low hills and small valleys. The highest elevations, which are generally along the east-west longitudinal axis, exhibit a more angular block structure than the adjacent lower hills lying north and south of the main axis.

The hills on the island's western end generally differ in form and character from those on the eastern end. The western hills are gentler, more rolling, and have a deeper soil profile than the angular and rugged eastern hills, which have a greater amount of exposed rock surface. The highest point on the western end of the island, Monte Pirata, has an elevation of 1,000 feet, more than twice the highest point on the eastern end, Cerro Matias, which has an elevation of 420 feet.

The hilly central portion of the island contrasts sharply with the low-lying coastal zones. The three largest of these coastal zones are in the island's northwest corner, in the island's eastern portion just north of Bahia Salina del Sur, and in the island's southern valley between Esperanza and Bahia Tapon. These generally level areas are covered with extensive lagoons and mangrove swamps.

Topography along the western boundary of the U.S. Navy property is dominated by a northwest to southeast trending group of central ridge system as shown in Figure 1-3. The ridge slopes on the north towards the Atlantic Ocean and on the south toward the Caribbean Sea. Flat terraces line the shore along southern boundary of the Caribbean Sea on the south. The central ridge is incised and provides numerous drainage paths for surface water. The ridge acts as a surface water divide, directing rainfall runoff and subsurface rainfall percolation (if any) toward the north or the south.

1.4.2 Geology

Vieques geology is characterized by unconsolidated sedimentary deposits in the lowlands and three major rock types in the upland areas: Upper Cretaceous volcanic rocks, Upper Cretaceous, or Lower Tertiary intrusive rocks, and Upper Tertiary and Quaternary sedimentary rocks. The Quaternary age consolidated sedimentary deposits consist of alluvial deposits, beach and dune deposits, and swamp and marsh deposits. Vieques' larger valleys are blanketed and filled by Quaternary-age stream-laid,

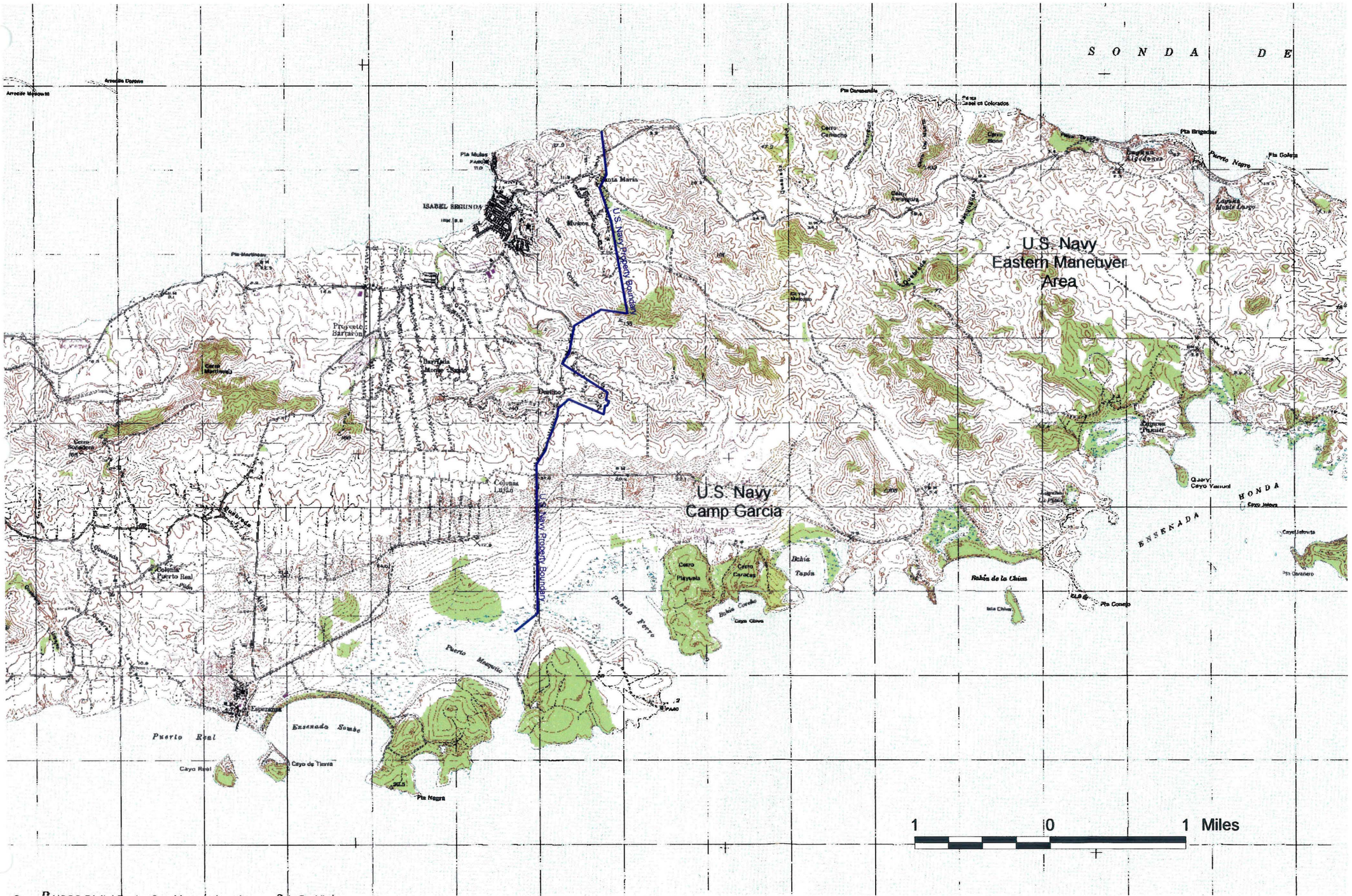


FIGURE 1-3
Topography and Property Boundary

ATLANTIC DIVISION
NAVAL FACILITIES
ENGINEERING COMMAND
VIEQUES PUERTO RICO

Source: USGS Digital Raster Graphics quadrangle map - Isle De Vieques

gissafe/projects/puerto_rico/data2.apr/new fig. 1-3

alluvial deposits of clay, silt, sand, and gravel derived from the parent volcanic or intrusive rock. The larger valleys include Valle de Resolucion on the northwest side of the island and the large valley stretching from Esperanza to Camp Garcia on the south coast. Although the alluvial deposits in these valleys vary in thickness, they are generally thicker than 40 feet. In addition to the major soil areas mentioned above, the areas along the shoreline are covered with beach, alluvial, and windblown sand deposits and lagoon and salt marsh muds.

The oldest exposed rocks are presumed to be from the Upper Cretaceous age and are mostly andesites, tuffs, and conglomerates. These rocks are though to have been deposited in a marine environment, and to be similar to rocks of this age found on Puerto Rico and the Virgin Islands. The deposit's bedding thickness is thought to vary across the island; total thickness is difficult to determine because of the rocks' metamorphism and generally poor surface exposure. These volcanic rocks are most common on the eastern end of the island.

During the Upper Cretaceous or Lower Tertiary period, a quartz diorite complex pluton deformed and metamorphosed the Cretaceous volcanic rocks. The quartz diorite plutonic rocks outcrop over a large percentage of the island, particularly in the western and central portions. The pluton is divided into two major bodies by a narrow belt of metamorphosed andesites and andesite tuffs running from Isabel Segunda to Bahia de la Chiva. The western pluton is generally coarse-grained and equiangular in texture, while the eastern pluton is generally finer-grained with a microgranitic texture.

There are also well distributed, local occurrences of mafic intrusives throughout the island. Dark, fine-grained dike rocks outcrop at various locations throughout the island, while coarse-grained rocks of varying color and texture outcrop at its western end in the quartz diorite complex.

Upper Tertiary-age limestones outcrop at three major areas on the island. Limestone headlands are on the south coast and on the extreme eastern tip of Vieques. A third limestone outcrop, approximately 50 feet thick, covers two acres of Punta Caballo on the north coast. Limestone was once a widespread deposit around the coast of Vieques, but has since been eroded. The limestone, which is locally known as the Puerto Ferro limestone and is of Tertiary-Miocene age, ranges from 125 to 140 feet thick on the south coast and 160 to 175 feet on the eastern tip of the island. On the south coast, the limestone rests on granodiorite basement rock.

Quaternary deposits include beach, swamp, and alluvial deposits. Quaternary-age alluvial deposits blanket most of the valleys of Vieques, including areas on the south coast: the area from Esperanza to Camp Garcia, the area around Ensenada Honda, and the area around Laguna Playa Grande. On the north coast, they include the Valle de Resolucion and Hacienda Arcadia areas. Alluvial deposits are stream-laid silt, clay, and gravel derived from the disintegration of diorite or volcanic rock. Fringing the Vieques shoreline are assorted deposits of Pleistocene to Holocene-age beach and windblown sand and lagoon and salt marsh muds.

Two major types of sand deposits are on Vieques. The first is an alluvial deposit found in valleys filled with the material formed from the weathering of the quartz diorite intrusive. These deposits, which are found primarily on the western end of the island, consist of coarse siliceous sand. The second type is a marine-deposited calcareous sand located on the fringe beaches.

As determined from wells installed during 1999, the geology along the western boundary of U.S. Navy property consists of unconsolidated alluvial deposits overlying a massive igneous granite/granodiorite rock complex. The unconsolidated alluvium consists of

gravel, sand, silt and clay distributed in various percentages throughout the alluvial layer. The unconsolidated alluvial layer is 5 to 50 feet thick. In general, the alluvium thickness increases as elevation decreases away from the central ridge toward the Caribbean Sea and the Atlantic Ocean.

1.4.3 Soil

A layer of residual soil covers portions of the rock and alluvium surfaces on Vieques. Because of the tropical wet and dry type climate and the relatively impermeable intact volcanic rock, soil development has been severely limited on the eastern portion of the island, resulting in a very shallow soil profile. Generally, the soils on the eastern end of the island are fine-grained with a high clay content. The soil profiles on the western end of the island, which are somewhat better developed, have been formed by the weathering of the underlying granitodiorite intrusive rocks. These solids are primarily coarse-grained and contain primarily arkosic material with subordinate amounts of clay.

Because of its small size and relatively uniform climate, the island has a limited range of soil series. Most common are the Descalabrado soils, which cover more than 30% of the total land area. Those moderately steep to steep (5% to 60%), shallow, well-drained soils, which are found above consolidated volcanic rocks, were formed in a medium to fine-textured residuum derived from this same rock. The surface layer is typically very dark brown to dark grayish-brown, 3 to 7 inches thick, and topped with grasses and shrubs. On Vieques, all types or phases of this soil series are severely limited in both agricultural and non-agricultural land uses due to low rainfall, steep slopes, shallow areas, and in some cases, the presence of rocks. All these soils are easily eroded, and virtually all are restricted to grazing, woodland, or wildlife.

The Vieques series is found on another 26% of the island's total land area. Vieques soils occur on moderate to steep slopes (5% to 40%) in the dry uplands. They are formed from partially weathered granitic rocks. They are shallow, and in a typical profile, the dark brown surface layer is 4 to 8 inches thick. Drainage is good, runoff medium, and permeability moderate. Texture ranges from loam to clay loam. Associated series are the Descalabrado, Coamo, and Guayama, which all also form significant portions of the island's surface area.

The Coamo soils, which constitute almost another 16% of the island's total land area, are gently sloped, deep, and fairly rich. Characteristically, they are deep and well-drained, occurring over deep layers of stratified coarse-textured materials. They formed in sediments derived from volcanic and limestone rocks. Usually, the surface layer is very dark brown, and slightly acidic to neutral. Subsoils are mildly to moderately alkaline. Typical natural vegetation consists of xerophytic (requires small amounts of water) trees and brush. This soil series is considered good for agriculture.

At least 8% of Vieques' surface is covered by a land type called simply *rock land*, where rock outcrops cover 50% to 70% of the surface area, or where loose stones and boulders are common. The shallow soil between the rocks and around them is insufficient to be classified by soil series. The slope grades from 60% to 70%. Natural vegetative cover is usually brush and wild grasses, though some of the higher undisturbed peaks are still forested on Vieques. There are two subcategories of the rock land type on Vieques: volcanic rock land and limestone rock land. The remaining 15% of the island's area is distributed in 11 additional series of varying quality: Ametia, Cartgena, Catano, Coastal Beaches, Descalabrado, Fraternidad, Jacana, Pandura, Paso Seco, Pancena, and Pozo Blanco.

A wide variety of the soil types mentioned are present along the western boundary of the U.S. Navy property. Rock land is also present along portions of the boundary. Exact soil types present vary with topography and the underlying parent material

1.4.4 Surface Water

From the island's high points, small, normally dry streambeds or *quebradas* flow either north or south toward the sea, resulting in many small drainage basins. Most are less than a mile long, drain only a fraction of a square mile, and have no well-defined drainage channel.

Vieques has no perennial surface drainage. Rainfall on the island ranges from 25 to 45 inches annually, with 36 inches considered the average annual precipitation for the entire island. Based on figures for the U.S. Virgin Islands, the amount of water that evaporates and is transpired back into the atmosphere is about 90% of the rainfall. An additional 5% infiltrates the surface and recharges groundwater aquifers, leaving only 5% as runoff. Equivalent data for the island of Vieques does not exist; therefore, the Virgin Islands data was used based on the size of Vieques. In the rainy season, channels in many valleys contain runoff; however, in dry months, the streams tend to pond or dry up entirely. Groundwater discharge sustains several springs in the quebradas during the dry season. One or two streams are said to have flowed continuously at some time in the past, probably before well fields lowered the water table.

1.4.5 Groundwater

Vieques has two major aquifers: the Valle de Resolucion aquifer which is beneath the western portion of the island within the former NASD, and the Valle de Esperanza aquifer within a 4-square-mile area between the village of Esperanza and Camp Garcia on the southern central portion of the island. Of these, the Valle de Esperanza is more productive. Prior to the installation of the water line from the main island of Puerto Rico in 1978, the Valle de Esperanza aquifer supplied most of the potable water for the island.

To supply the island with potable water before the water pipeline was installed, the Puerto Rico Autoridad de Acueductos y Alcantarillados (Aqueduct and Sewer Authority, or PRASA) maintained a network of 16 wells which collectively pumped 450,000 gallons per day. The PRASA well field, which is located in Esperanza, is currently not in regular use although it might be available in emergencies.

In 1985, the U.S. Geological Survey completed a two-year study of groundwater resources in Vieques, focusing on the Valle de Resolucion and Valle de Esperanza. The study showed rainfall to be the primary source of local groundwater, recharging aquifers through infiltration and stream incisement.

Analyses of samples from wells near Esperanza showed that groundwater is a sodium-bicarbonate type generally characterized as hard, but suitable for uses other than irrigation. Because of high sodium levels, untreated groundwater used for irrigation on a long-term basis would result in salt accumulating in the soils. The relatively high concentrations of chloride recorded in 1977 in groundwater from the Valle de Espernaza aquifer have been attributed to seawater encroachment as a result of excessive groundwater withdrawals and the accumulation of salts from infiltration of sea spray, a condition typical of islands with low rainfall. Because withdrawals from the PRASA wells have been discontinued, chloride concentrations in the groundwater have decreased substantially, from 205 milligrams per liter (mg/L) to 94 mg/L.

The 11 groundwater monitoring wells and nine piezometers installed along the western boundary of U.S. Navy property in 1999 encountered groundwater in the fractured bedrock aquifer at the higher ground elevations, and groundwater in the alluvium at lower elevations near the coast. Groundwater flows directions were determined from two separate gauging events. Groundwater flow in the bedrock aquifer along

secondary porosity features such as fractures and joints to the south and north, away from a pronounced groundwater high and divide along the central ridge. Groundwater flows southeast in the alluvial aquifer along the southern coast. No explosive compounds were detected in groundwater samples from either aquifer. Several groundwater "divides" separate the units from the primary aquifers, making hydraulic connection unlikely. Groundwater is no longer used as a drinking water supply for the civilian or military population of Vieques Island; water is piped from Puerto Rico for this purpose.

1.4.6 Marine Water Quality

The coastal waters of Vieques are subject to the Puerto Rico Water Quality Standards and classified in accordance with them. For the most part, the island's marine waters are of acceptable quality and are classified as suitable for direct human contact and for use in the propagation or preservation of desirable marine species. The only offshore waters classified as limited to indirect human contact or for use in propagation and maintenance of desirable species are those near Isabel Segunda and Puerto Real between Cayo de Tierra and Cayo Real. In accordance with the provisions of a USEPA NPDES permit issued in November 1984, the Navy has extensively analyzed the quality of the coastal waters off the LIA. These studies indicate that activities in the LIA on Vieques Island have not impacted the surrounding oceanic surface waters (Department of the Navy, 1990).

1.4.7 Climate

Vieques' climate is tropical-marine, with minimal fluctuations in temperature. Year-round easterly trade winds moderate the tropical heat considerably.

The U.S. Department of Commerce, National Oceanic and Atmospheric Administration, established two weather stations on Vieques since 1982; one is near the main gate at Camp Garcia and the other is in the main area of the camp. However, data from these stations

have been erratic, with only one station (the one near the main gate) reporting sufficient daily values to warrant publication. This station records only precipitation and temperature.

The mean annual temperature on Vieques is approximately 79°F to 80°F, with little variation in mean monthly temperatures. Historical data show August as the warmest month, at 81.8°F, and February the coldest, at 76.0°F. The minimal variation in monthly temperature ranges is attributable to two factors. First, the island is surrounded by water whose temperature changes little from the warmest to the coolest season; second, the island is near the equator, which accounts for the relatively small differences in energy received from the sun from season to season. Monthly extreme temperatures at Esperanza ranged from 98°F to 60°F for a 14-year period of record. The mean daily temperature range (the difference between the daytime maximum and the nighttime minimum) is estimated to be between 15°F and 25°F.

Little information is available on rainfall patterns on Vieques. The island's rainy season is typically characterized as August to November, although rain showers occur frequently throughout the year. For the most part, these showers are short, usually less than 30 minutes. The island's dry season extends from December to April.

The outstanding feature with regard to wind patterns around Vieques is the steadiness of the trade winds, which almost always have a major easterly component. The trade winds move inland, where they are lifted over the terrain or pushed aside by the hills and form micro-circulation patterns. Wind speeds tend to change from calmer night winds to stronger day winds at daybreak and change back again at approximately 4 p.m. The day winds generally peak in late morning or early afternoon. Tropical cyclones (hurricanes and tropical storms) are most likely to occur during the summer and early fall.

2.0 PROJECT DESIGN AND SCHEDULE

The activities presented in this GMWP have been designed and developed to meet the particular requirements for effective long-term groundwater monitoring. The project design incorporates direct requirements for the facility as specified by the USEPA in recent correspondence as well as recent groundwater monitoring guidance in *Handbook of Groundwater Protection and Cleanup Policies for RCRA Corrective Action* (USEPA, 2001). This section details the goals and assumptions that direct the project tasks and presents the specific project tasks and a schedule.

2.1 Project Goals

As discussed in a USEPA directive letter, the U.S. Navy is required to conduct "an ongoing program of groundwater monitoring, on a semi-annual basis, either along the western boundary of the Navy's property or elsewhere on Navy property, subject to EPA's approval, to verify that no unacceptable threats to human health and the environment result from the unclosed but not operating OB/OD units ..." Complying with this directive is the goal of the current work plan. Based on recent USEPA groundwater guidance, long-term monitoring serves as a critical short-term goal to help ensure protection of human health and the environment. Both compliance-point location and sampling frequency have been considered to ensure effective monitoring.

2.2 Sampling Locations and Frequency

The critical compliance-point location for groundwater monitoring has been designated as the western boundary of U.S. Navy property. The ATSDR and Navy groundwater investigations have established that this designated compliance point is beyond the boundary of any possible COPC groundwater plume. This serves to establish a short-term goal recognized by the USEPA as "throughout-the-plume/unit boundary" point of compliance. Upon further

examination, the specified compliance point location also adequately satisfies or is consistent with the following four established criteria and considerations:

- Proximity of sources.
- Vulnerability of groundwater and users.
- Exposure and likelihood of exposure.
- Technical impractability of achieving cleanup goals.

Sampling frequency has been specified by the USEPA as semi-annual (every six months). Upon review, the specified frequency has been found to be adequate to meet the following six facility-specific conditions and criteria:

- Current and future land and water use.
- Type, source, and extent of contamination.
- Hydrogeologic characteristics.
- Reliability of exposure controls.
- Financial resources.
- Community preferences.

The U.S. Navy reserves the right to periodically evaluate site conditions, and with USEPA approval, adjust the sampling frequency as changing site conditions require.

2.3 Survey and Sampling Activities

This section summarizes the specific survey and sampling activities designed to achieve the project goals. These tasks include the initial evaluation of the boundary monitoring well system currently in place, the installation of additional wells if necessary, and long-term groundwater monitoring and reporting (i.e., until closure of the OB/OD units).

2.3.1 Monitoring Well System Evaluation

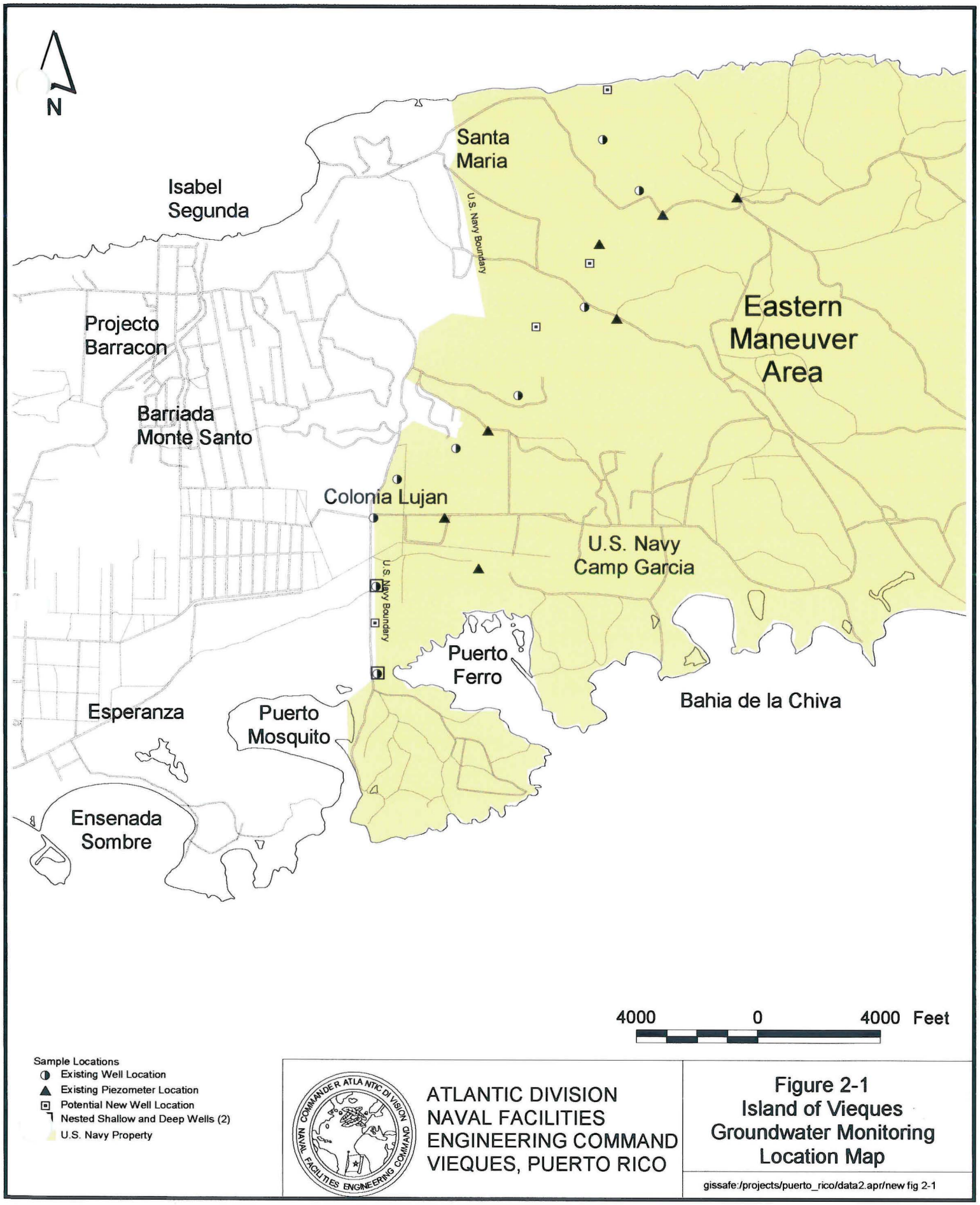
The existing monitoring wells along the western boundary of the U.S. Navy property (Figure 2-1) constitute an effective groundwater monitoring system. They will be evaluated to completely ensure system effectiveness for long-term monitoring under all seasonal conditions and variations. The evaluation will include a determination of major groundwater flow paths along the U.S. Navy property boundary. Identification and confirmation of the trend of these flow paths will allow the U.S. Navy to determine if additional wells should be added to supplement the existing wells for long-term monitoring.

As learned in 1999 studies conducted by CH2MHill and Baker Environmental, groundwater along much of the western boundary of U.S. Navy property occurs and moves in an anisotropic aquifer in the granodiorite bedrock. Groundwater in this aquifer moves along preferential flow paths such as joints and fractures, features that are the targets for additional monitoring wells. The presence and trend of the primary groundwater-bearing joint and fracture systems can frequently be determined through the use of simple remote sensing and field surface investigation methods. Three techniques that may be employed during this initial evaluation period are a mapping study, a field survey, and surface geophysics.

These evaluation techniques and methods are detailed further in Section 3.1 of this work plan.

2.3.2 Groundwater Monitoring Well Installation

Additional groundwater monitoring wells may be installed to supplement the existing well system. As shown in Figure 2-1, the installation of four additional wells is suggested based on the current knowledge of conditions and the present coverage and density of the existing wells along U.S. Navy property. The additional wells will be completed in the first encountered groundwater using installation and completion procedures described in Section 3.2 of this work plan.



ATLANTIC DIVISION
NAVAL FACILITIES
ENGINEERING COMMAND
VIEQUES, PUERTO RICO

Figure 2-1
Island of Vieques
Groundwater Monitoring
Location Map

gissafe:/projects/puerto_rico/data2.apr/new fig 2-1

2.3.3 Groundwater Sampling and Analysis

Groundwater sample collection will begin following the completion and development of the new wells and the redevelopment of the current wells. Groundwater samples for long-term monitoring will be collected, where possible, using low-flow sampling techniques. Based on this GMWP, 15 primary groundwater samples will be collected during the first sampling and each subsequent event. This number of samples assumes that groundwater is present in all wells.

Groundwater samples will be analyzed for cyclotetramethylene tetranitramine (HMX), cyclo-1,3,5-trimethylene-2,4,6-trinitramine (RDX), and 2,4,6-trinitrotoluene (TNT). The Navy believes that these three target analytes will serve as appropriate markers, indicating the potential presence and/or migration of range/OB/OD residues. Samples will be analyzed by a qualified contract analytical laboratory.

Pertinent data will be recorded for wells each time groundwater samples are collected. Examples are static water levels and measurements of groundwater physical parameters such as pH, conductivity, and turbidity. Specific sampling techniques, methods, and analysis are detailed in Section 3.3 of this work plan.

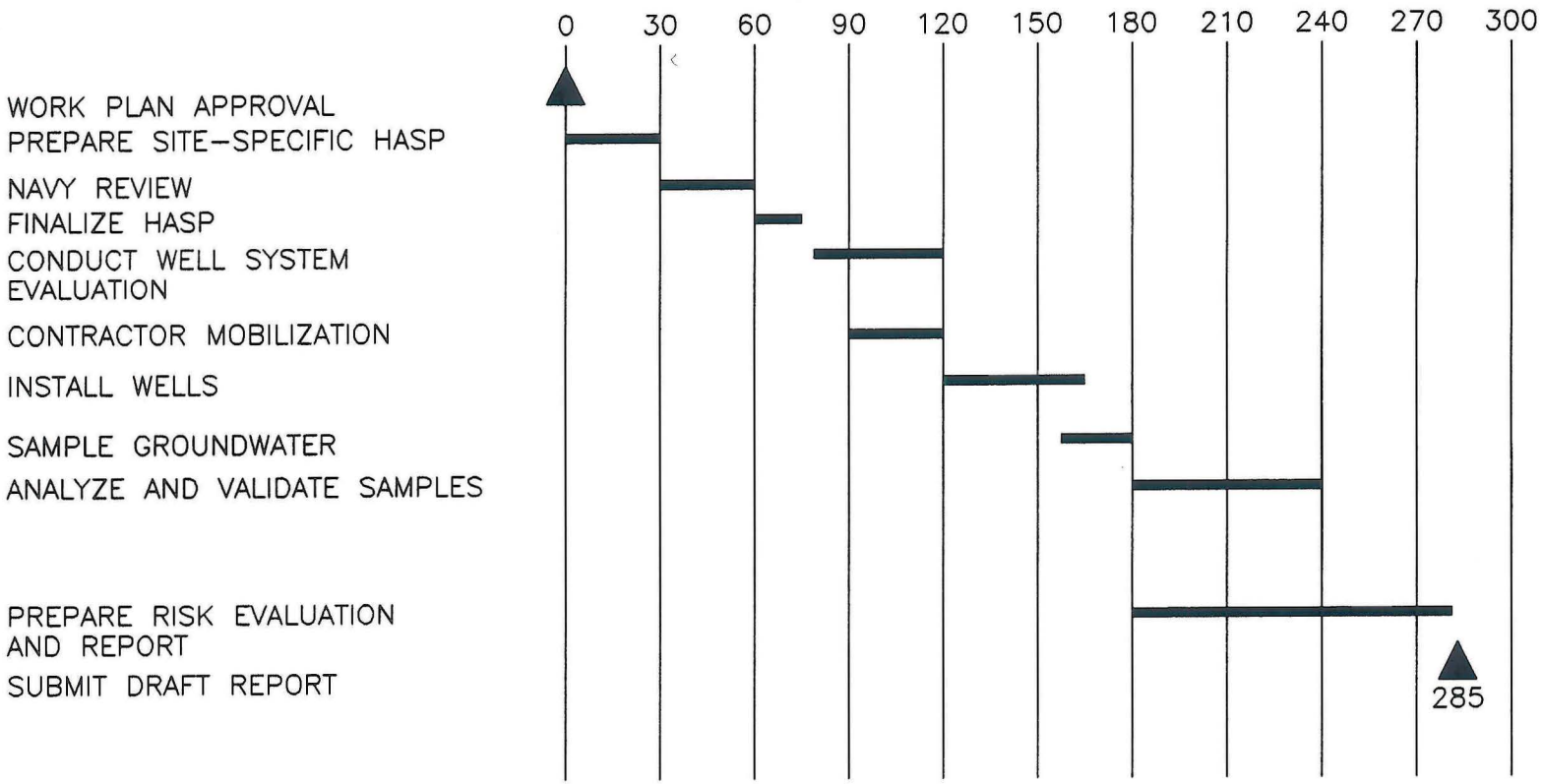
2.3.4 Reporting

A report will be written after each monitoring event is complete and samples have been analyzed and validated. The monitoring report will present the sample results and groundwater flow direction. The first round sampling report will also document well evaluation results and the installation of new wells, if necessary. Section 4 of this work plan outlines statistical data evaluation methods. Section 3.6 of this work plan further details reporting requirements.

2.4 Project Schedule

A summary of actions and a tentative time schedule for completing the work plan activities have been established. The established schedule (Figure 2-2) does not reflect delays associated with influences such as weather, site use, or access. Figure 2-2 does not include specific dates for milestones because start dates for the tasks are not currently known. The well evaluation, installation, and sampling specified here cannot begin until the final work plan has been approved and the contractor has free, safe access to Navy property.

SCHEDULE
DAYS AFTER WORK PLAN APPROVAL



SUBSEQUENT GROUNDWATER MONITORING AND REPORT EVENT BEGINS 180 DAYS AFTER DAY 285, WITH ADDITIONAL SAMPLING EVENTS FOLLOWING AT THAT INTERVAL.

ATLANTIC DIVISION
NAVAL FACILITIES
ENGINEERING COMMAND
VIEQUES PUERTO RICO

FIGURE 2-2
AFTWF, VIEQUES, PR
SCHEDULE

DWG DATE: 01/10/02 | NAME: 5901050G001

3.0 GROUNDWATER MONITORING ACTIVITIES AND METHODS

The groundwater monitoring and the well evaluation and installation to support it are detailed in this section. This discussion is based on the complete quality assurance project plan (QAPP), attached as an appendix to this work plan.

3.1 Well Evaluation

The existing Navy wells and the U.S. Navy boundary property will be evaluated to assess the need for supplemental monitoring wells and the adequacy of the existing wells for long-term monitoring. Map review, field survey, and surface geophysics are techniques frequently used during studies of fractured rock aquifers (Pohll, et al., 1999; Dahan et al., 2000; and Lachassagne et al., 2000). Evaluation methods and activities are presented in the following sections.

3.1.1 Mapping Study

The mapping study will begin with the in-depth analysis of all boring logs and groundwater elevation data. Incorporating information from the logs, elevation mapping, and desk-top fracture trace analysis will be completed using available topographic maps and infrared and aerial photography. Groundwater-bearing lineaments, fractures, and joint systems can frequently be identified and traced through the photographic evaluation of landforms and vegetation on large-scale maps. The final information from this effort will be summarized on site maps suitable for use in the field.

3.1.2 Field Survey

A field survey will be completed, directed, and focused by the information developed during the mapping study. The field survey will involve surface orientation and mapping of geologic features in selected areas along the western U.S. Navy property boundary. The field survey will provide field confirmation of the trend and orientation of any lineaments or joint or fractures systems that have been identified through surface expression or

trace analysis. The survey will also allow the identification of any other surface features or surface connections to groundwater such as seeps or springs that help identify and confirm the trace of subsurface groundwater flow paths.

3.1.3 Surface Geophysics

During the field survey, surface geophysics will be further evaluated to determine if it can be used to provide subsurface detection of preferential flow paths. Several techniques are available, but an evaluation of the site hydrogeology and surface conditions initially suggests that three methods might likely be most appropriate: reflection seismic, spontaneous potential, and source audio-frequency magneto tellurics.

One or more techniques may be conducted across selected areas if it has been determined that they are needed to supplement the other studies and can be applied effectively based on existing site conditions.

3.2 Monitoring Well Installation and Completion

Additional monitoring wells, if deemed required, will be installed and completed in accordance with Section B.2.2.2 of the QAPP. Boreholes for the wells will be advanced and logged using hollow stem augers, air or mud rotary, or rotasonic drilling. Drilling techniques will be chosen after drilling sites are selected during the well evaluation. The drilling technique will be selected based on site access, the proposed completion depth, and anticipated weather conditions.

Wells will be constructed of 2-inch polyvinyl chloride riser and 0.010-inch slotted well screen. Screen lengths will be sufficient to monitor the aquifer during seasonal changes in groundwater levels caused by temporal variations in recharge and aquifer replenishment.

Wells will be completed with silica sand packs and bentonite seals, followed by grouting the annular space to ground surface. At surface, wells will be topped with a stick-up completion.

Wells will be developed by hand bailing or pumping to reduce turbidity and improve the sample quality. Groundwater physical field parameters (pH, conductivity, turbidity, etc.), will be monitored during development. The complete list of field parameters to be measured is identified in Table A.1 of the QAPP.

Completed wells will be surveyed using global positioning system methods to determine horizontal locations to the nearest 0.1-foot and vertical elevations to the nearest 0.01-foot. The surveys will be conducted by a registered land surveyor and tied to a designated benchmark point.

3.3 Groundwater Sampling and Analysis

Groundwater samples will be collected and analyzed following procedures and methods specified in Sections B.2 and B.4 of the QAPP, and consistent with guidance specified by the USEPA Region 2 (USEPA, 1995). Low-flow pump sampling will be used where possible to reduce turbidity and ensure collection of representative samples. This method of sampling is especially appropriate in hard-rock terraines where well performance can be poor, and only slow production rates can be attained during sample collection.

The primary groundwater samples and the associated field blanks will be identified, labeled, packed and shipped under strict chain-of-custody procedures as detailed in the QAPP in Section B.3. The estimated number of samples is provided in Table A-1 of the QAPP. The remote nature of this site will require special coordination of sample preservation and shipment to the analytical laboratory.

Once received, samples will be analyzed according to the analytical methods and protocols in Section B.4 of the QAPP for HMX, RDX, and TNT. The specific analytical methods, sample containers, preservation methods, and holding times are detailed in Table B-2 of the QAPP.

3.4 Supporting Data

Supporting data will be collected with portable field devices and meters. For groundwater development and sampling, the data will include static water level measurements, water volumes, and the groundwater field parameters identified in Table A-1 of the QAPP. Groundwater representativeness for sampling will be assessed by the stability of the groundwater field parameters. Air quality field screening will be conducted in the breathing zone during selected activities for health and safety protection of site workers. For field meters, calibration procedures and goals from the QAPP and equipment manufacturers' standards will be followed.

3.5 Decontamination and Waste Management

Decontamination and waste management procedures will be followed as outlined in the QAPP, with amendments for certain site-specific considerations. Decontamination will occur in a central decontamination unit where possible. However, certain soil and groundwater equipment may require decontamination at remote sampling sites. In this event, decontamination cleaning procedures from the QAPP will be followed, and all waste rinse solutions will be containerized as investigation-derived waste (IDW). Depending on the volume generated, the waste will either be held onsite or transported back to a central staging point.

IDW will be handled and sampled for profiling as described in the QAPP. Due to the distances between drilling and sampling sites, containerized IDW will be held onsite, where appropriate, during the profiling process. The results of the analytical sampling of

IDW, as described in the QAPP, will be used to characterize decontamination solutions and soil/rock debris generated during well installation and sampling. Groundwater generated during well development and purging will be profiled using the analytical results generated from the groundwater sample analysis.

As discussed in the QAPP, IDW will be managed and disposed of according to all applicable local, state, and federal regulations. Where protective of human health and the environment, consideration will be given to the disposal of IDW at the site of generation based on the results of profiling. Recent USEPA guidance has clarified waste management issues for corrective actions in *Management of Remediation Waste Under RCRA* (EPA, 1998). This guidance states that contaminated environmental media do not contain hazardous waste when concentrations of hazardous constituents from listed hazardous wastes are below health-based levels. In this instance, these wastes are not subject to RCRA requirements, but may be subject to Land Disposal Restrictions (LDRs).

In certain site-specific cases, risk-based LDR treatment variances may be given for contaminated soils. Under certain circumstances, this would allow a site-specific, risk-based determination to supersede LDR treatment standards. With these considerations, onsite disposal of IDW may be appropriate when the IDW contains contaminant levels below health-based risk levels, or when no contaminants are detected. Following profiling, no onsite disposal will be allowed until an understanding has been reached between the U.S. Navy, the USEPA, and any other agencies.

3.6 Data Management and Reporting

All field, office, and laboratory data will be managed in accordance with guidance specified in the QAPP in Section B.10. This guidance covers the generation, contents, handling, and storage of all project data including the following:

- Field documentation.
- Sample documentation.
- Laboratory reporting.
- Data logs.
- Maps.
- Photographs.
- Other related data, communications and notes.

Data will managed and handled consistently in both field and office settings.

A Groundwater Monitoring Report (GMR) will be written after well evaluation, installation, and sampling. Similar reports will follow each subsequent sampling event during the long-term sampling process. Each GMR will describe site activities, locations sampled, analytical results and field data, statistical evaluations, and conclusions with recommendations. A Draft GMR will be produced by the contractor, reviewed by the U.S. Navy, corrected as necessary based on comments, then submitted to the USEPA for review and approval. A Final GMR will be issued that incorporates all changes made based on USEPA comments to the Draft Report.

4.0 DATA EVALUATION

Site-specific data collected during long-term groundwater monitoring will indicate whether explosive compounds are present in groundwater under a variety of temporal and aquifer conditions over time. Groundwater quality in the fractured rock aquifer changes over time, primarily due to variations in the volume of surface water supplying groundwater, and resultant changes in concentrations and migration rates of potential contaminants. A long-term monitoring program will provide sufficient data to identify trends in these variations, and determine the significance of changes in groundwater quality.

Baseline sampling by CH2MHill and Baker in 1999 indicated that explosive compounds were not present in the aquifer at the time of sampling. However, explosive compounds may be detected in subsequent sampling because groundwater is not a static medium. If detected, there may be significant variations between concentrations for the same compounds from one event to another. These potential detections and variations require evaluation through an established statistical process.

Statistical evaluation provides an organized way to establish a data set of results from the aquifer under similar conditions. Currently 11 wells have been completed in the first groundwater aquifer along the western Navy property boundary. A data set of 11 quantitative variables (one sample from each well) is large enough for statistical evaluation. The proposed possible addition of four wells to this network increases the population significance. As more data are gathered from these wells during successive events, results can be tested for normality and compared to determine if they are from the same distribution or population. As successive data sets are evaluated, they can be combined where statistical testing indicates they are from the same population. Consequently, one large data set can be developed over time. If successive results are from the same distribution, the lack of statistically significant variations might indicate that aquifer conditions are remaining stable.

Alternatively, an abundance of outliers (results outside the distribution in a future data set) might indicate a change in aquifer conditions. The change in conditions might signal a need for more frequent monitoring, or the installation of additional wells.

The following discusses the elements and methods of the statistical process that will be applied to the data. It is based on guidance provided in the following USEPA documents:

- *Statistical Analysis of Groundwater Monitoring Data, Interim Final Guidance* (1989)
- *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Addendum to Interim Final Guidance* (1992a)
- *Statistical Training Course for Groundwater Monitoring Data Analyses* (1992b)

The general steps in the evaluation process are listed below.

Steps in Statistical Evaluation:

Step 1 — Data organization and screening

Step 2 — Consideration of nondetect data

Step 3 — Normality testing

Step 4 — Calculation of upper confidence levels (UCLs)

Step 5 — Comparison and combination of data sets

This process leads to determination of normality for each data set, calculation of UCLs, identification of outliers, and comparison and possible consolidation of data sets from multiple sampling events.

4.1 Step 1 — Data Organization and Screening

Sampling data will be entered into a spreadsheet and screened for detections. The data from each sampling event represent a discrete data set. Nondetect data are considered before the data set is statistically evaluated for normality and the UCL calculated.

4.2 Step 2 — Consideration of Nondetect Data

The precise methods of statistical analysis will be established after reviewing the number of nondetect values for each detected analyte in the data set. The percentage of nondetects (data with "U" or "UJ" qualifiers) is calculated for each analyte. The rejected values (those with "R" or "UR" qualifiers) are excluded from all calculations. The procedures for handling nondetects and proceeding with UCL calculation are as follows:

- If less than 50 percent of all samples of an explosive compound in a data set are nondetect, each nondetect will be replaced by half its reported detection limit (i.e., half of the U-qualified value, which represents the sample quantitation limit). The statistical distribution of the data will then examined for normality.

- If the percentage of nondetects is equal to or greater than 50 percent and less than 90 percent, a nonparametric UCL (i.e., a confidence limit not based on a normal distribution) will be assigned. For this monitoring effort, the second-highest observed value in the data will used as the nonparametric UCL.

- If the percentage of nondetects is greater than 90 percent, the second-highest observed value will be used as the UCL. If only one detection value is available, it will be used. When there are no detection, a value of zero is used. When one concentration is detected multiple times, that value will be used as the UCL if it represents the highest overall value.

4.3 Step 3 — Normality Testing

Both normal and lognormal histograms, probability plots, and the Shapiro-Wilk test will be used to determine normality and distribution. The histograms and probability plots are used to visually examine the data for normality and detect outliers. The histograms and probability plots present the number of samples, mean, variance, standard deviation, coefficient of variation, skewness, kurtosis, minimum, and maximum values. The Shapiro-Wilk test is a more powerful and rigorous test of normality. It works well for data sets with 50 or fewer samples, and operates by testing the null hypothesis (assumption of normality). This test evaluates the sets of original and transformed data values for normality as outlined below:

- Analysis begins by calculating the *W*-statistic from the Shapiro-Wilk test, skewness, and the probability plot correlation coefficient *r*.

- For each analyte, the data set is checked for outliers, concentrations very different than the majority of the other values in the data set. Outliers are identified by performing the outlier test as specified in the *Statistical Training Course for Ground-Water Monitoring Data Analysis*, in conjunction with a review of the histogram and probability plots for each analyte. After removal of the outliers, the *W*-statistic from the Shapiro-Wilk test, skewness, and *r* value are calculated for the data sets. It is important to remember that while an outlier may be an extreme measurement, it may also be legitimate and related to cross-contamination, inconsistencies in analysis, or data entry errors. Consequently the quality assurance aspects of these samples should be evaluated before a final determination is made.

- Test results are compared for original and transformed data sets, with and without the outliers removed. The data set with the best combination of *W*-statistic from the

Shapiro-Wilk test, low skewness, and high *r* value is considered the best approximation of the true distribution of the data, despite the inclusion of outliers.

4.4 Step 4 — Calculation of UCLs

After the best transformation of the data is established and the data set is determined to be normally distributed, a parametric UCL can be calculated for each analyte. A confidence interval is established from the groundwater data as a basis of comparison for future data to determine if there is statistically significant evidence of change in the aquifer quality. The confidence interval establishes a concentration range for a specific proportion of the population with a specific confidence factor. The specific proportion of the population is referred to as the "coverage", and the probability that the confidence interval includes the specified proportion of the population is referred to as the "confidence factor." Because contamination in samples from another data set is indicated when its concentration exceeds the upper limit of the tolerance interval, only the upper limit or UCL of a one-sided tolerance interval will be calculated instead of an entire two-sided interval. The UCLs calculated for the data evaluation in this project will represent one-sided UCLs with 95% coverage and 95% confidence. A one-sided UCL with 95% coverage and 95% confidence allows the user to assume that there is a 95% certainty that a given value is higher than 95% of the possible sample values from the population. UCLs can be parametric, based on the assumed data distribution of the sample population, or nonparametric, based on the distribution of specific samples.

If the best data set is determined to be normally distributed, the parametric UCL is calculated. Antilog or square conversions will be performed as necessary to obtain the UCL in terms of the original data values. As explained previously, it is possible to calculate a parametric UCL if less than half of all samples of an analyte in a data set are nondetects. After replacing each

nondetect by half its reported detection limit, the most representative distribution of the data can be determined.

A parametric UCL will be calculated by using the following equation:

$$UTL = x + Ks$$

where:

x = the mean of the data
K = the one-sided normal tolerance factor
s = the standard deviation.

The tolerance intervals are constructed assuming the data are normally distributed. Therefore, the appropriate data transformation indicated by the normality tests are used for the calculation. A nonparametric UCL cannot be based on an assumed data distribution because no population distribution is identified. Instead, it is based on the actual distribution of the values in the data set.

4.5 Step 5 — Comparison and Combination of Data sets

A statistical comparison between data sets from successive sampling events can be conducted following data organization. The comparison can be conducted to determine if all samples with detections of a particular analyte from separate data sets can be considered to have originated from the same population, and if a combined data set is more representative of the true population compared to the two separate sampling event sets.

For data set comparison, the Kruskal-Wallis test will be performed to determine the level of significance that the events could be assigned based on the assumption that they were derived

from the same population. Analytes having more than 90% nondetects in at least one event or more than 50% nondetects in both events will not be compared using the Kruskal-Wallis test. Despite test results, data sets may be combined where enough similarities exist between site and aquifer conditions, including groundwater physical parameters and water levels, during separate sampling events.

5.0 HEALTH AND SAFETY PLAN

Before beginning any field activities, the contractor performing the work described in this work plan must produce and submit a site-specific Health and Safety Plan (HASP) for review, comment, and approval by the appropriate U.S. Navy personnel at Naval Station Roosevelt Roads. The HASP must be administered by a qualified health and safety professional and comply with applicable federal, state, and local health and safety requirements. Work must be performed in accordance with the accepted plan. It is assumed that monitoring wells, existing or planned, are or will be in areas free of unexploded ordnance, other hazards, and known or suspected contamination. Locations will be cleared by the appropriate Navy authorities prior to field activities.

5.1 Applicability

The HASP provisions are mandatory for contractors involved in corrective action field activities who will be, or could be, exposed to onsite hazardous substances and physical hazards. Site personnel will operate in accordance with the most current requirements of Title 29 CFR 1910.120, *Standards for Hazardous Waste Operations and Emergency Response*, 29 CFR 1926, *Construction Standards*, and the *U. S. Army Corps of Engineers Safety and Health Requirements Manual*. These regulations include the following provisions for employees exposed to hazardous substances, health hazards, or safety hazards: training as described in §120(e), medical surveillance as described in §120(f), and personal protective equipment as described in §120(g).

Site work will be suspended and the area evacuated if the contractor does not take adequate safety precautions, or if the contractor may be exposed to an immediate health hazard.

Health and safety training certificates will be maintained onsite for all contractor employees who may be exposed to onsite hazardous substances. Current Occupational Safety and Health Administration training or refresher training certificates will be included for employees involved in field activities.

5.2 Site Activities and Considerations

Given the nature of site conditions, caution and adherence to approved safety procedures are mandatory when conducting the field work described in this work plan. Well installation and sampling may be conducted on sites with somewhat rugged terrain, heavy foliage, and in a warm climate. Consequently, the HASP should address slip, trip, and fall hazards, biological hazards (insects and poisonous plants), temperature-induced stress, and other weather-related hazards. Site security and restriction of non-authorized personnel is also an important issue to be addressed in the HASP.

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A.1
Quality Assurance Project Plan
for the
Groundwater Monitoring Work Plan
AFWTF Vieques, Puerto Rico

Prepared by:

EnSafe Inc.
5724 Summer Trees Drive
Memphis, Tennessee 38134

February 11, 2002

LANTNAVFACENGCOM Engineer-in-Charge	**Date**
Contractor Project Manager	**Date**
Contractor QA Manager	**Date**
USEPA Project Manager	**Date**

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A PROJECT MANAGEMENT

A.3 Distribution List

Roberto P. Pagtalunan, LANTNAVFACENGCOM (Engineer-in-Charge)
Wilfredo Rivera, Naval Station Roosevelt Roads, (Public Works Department)
Carl A. Soderberg, USEPA Caribbean Division, (Project Manager)
Carmelo Vasquez Director, Puerto Rico Environmental Quality Board,
(Land Pollution Regulation)
Contractor, (Project Manager, Quality Assurance Manager, Site Supervisor)

A.4 Project/Task Organization

The individuals directly involved with the groundwater monitoring program along the western perimeter of Navy property on the island of Vieques, Puerto Rico, for the Atlantic Fleet Weapons Training Facility (AFWTF) and their specific responsibilities are outlined below. Figure A-1 is an organization chart showing lines of responsibility and reporting responsibilities.

Roberto P. Pagtalunan, LANTNAVFACENGCOM Engineer-in-Charge: Overall coordination of the project and decision maker. Review and approve Quality Assurance Project Plan (QAPP) and subsequent revisions in terms of project scope and objectives.

Carl A. Soderberg, USEPA Caribbean Division Project Manager: Review and approval of QAPP and subsequent revisions. Conduct regulatory assessments of field activities, if necessary.

Contractor Project Manager: Overall coordination of field work. Oversee preparation of QAPP. Implement final, approved version of QAPP.

Contractor Quality Assurance Manager: Review and approval of QAPP. Conduct in-house audits of field operations, when needed.

Contractor Site Supervisor: Direct the sampling operations according to the QAPP.

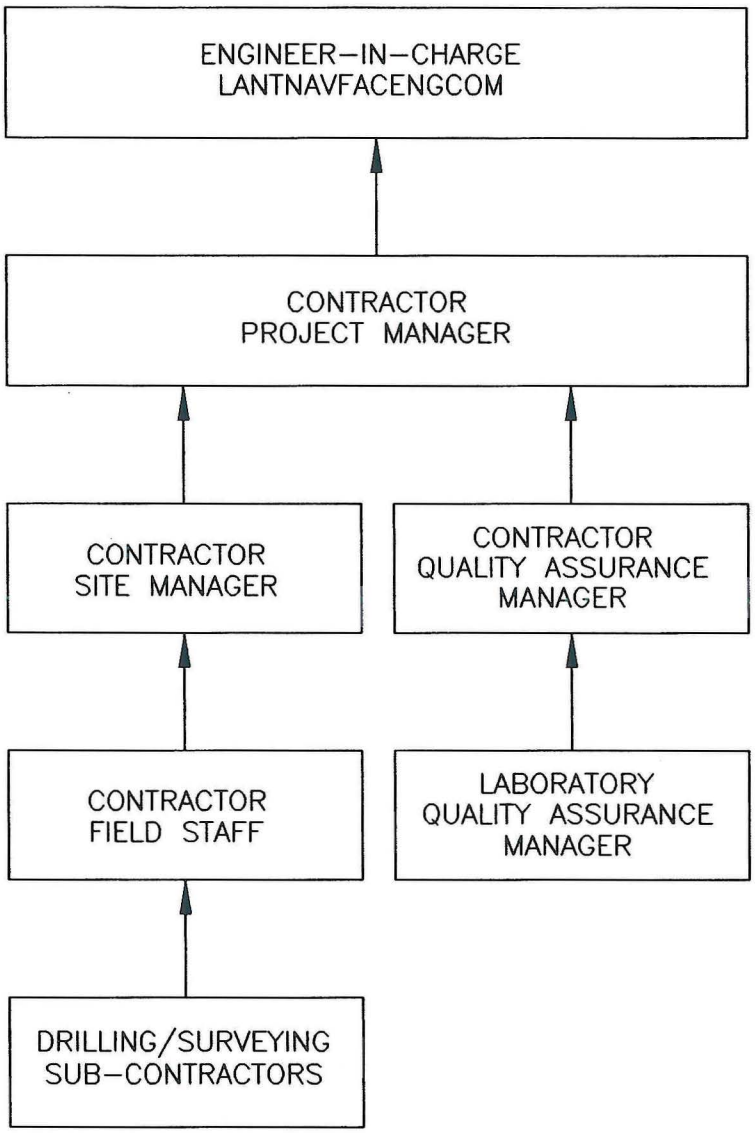

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FIGURE A–1
AFTWF, VIEQUES, PR
PROJECT ORGANIZATION CHART

DWG DATE: 01/09/02 | DWG NAME: 5901G044

A.5 Problem Definition/Background

A.5.1 Purpose/Background

A detailed discussion of the site background, facility location, and history may be found in Section 1 of the Groundwater Monitoring Work Plan.

A.5.2 Problem Statement and Background

A detailed discussion of the problem statement and objectives may be found in Section 1 of the Groundwater Monitoring Work Plan.

A.6 Project/Task Description and Schedule

A detailed description of the sampling activities may be found in Sections 2 and 3 of the Groundwater Monitoring Work Plan. A project schedule is also provided in Section 2. Table A-1 of this QAPP summarizes the sampling program.

A.7 Quality Objectives and Criteria for Measurement Data

The project data quality objective is to provide valid data of known and documented quality to determine the concentrations of contaminants in groundwater. Definitive data, as established in Guidance for the Data Quality Objective Process, EPA/600/R-96/055 (September 1994), will be collected for use in evaluating groundwater contaminant concentrations. Sampling, analytical, and data validation procedures will conducted in accordance with USEPA Region 2's CERCLA Quality Assurance Manual (1989).

Precision, accuracy, representativeness, comparability, and completeness will be addressed by collecting, analyzing, and reporting the data as described in this document. The completeness goal for this project is 95% for analytical data. Field measurements will have a completeness goal of 90%. To acquire definitive data to meet the project QA objectives, the laboratory will supply QC information so the accuracy and precision of the data may be assessed.

Table A-1
Summary Table of Sampling and Analysis Program

Location	Sample Matrix	Field Parameters	Laboratory Parameters	Number of Samples	Duplicates	Trip Blanks	Field Blanks	Equipment Rinsate Blanks	MS/MSD	Total Samples
Western Perimeter Groundwater Monitoring	Groundwater	Water level, total dissolved solids, pH, specific conductivity, turbidity, dissolved oxygen, and salinity	HMX, RDX, TNT	15 (semi-annually)	2	2	2*	1*	1	23

Notes:

*	=	more blank samples may be required depending upon the duration of the investigation (weekly frequency).
Field Blanks	=	one sample per water source — potable ad reagent grade.
HMX	=	cyclotetramethylene tetranitramine
RDX	=	cyclo-1,3,5-trimethylene-2,4,6-trinitramine
TNT	=	2,4,6-Trinitrotoluene

Detection Limits

Detection limits are described in many different terms depending on the analysis being performed and the capabilities of the instrument. The following terms are important for this project in describing detection limits:

- SW-846 Practical Quantitation Limit (PQL) or Method Quantitation Limit (MQL) is used to determine the extent of contaminants in media. The organic PQL/MQL is the lowest non-zero standard concentration in the laboratory's initial calibration curve.

- Organic Method Detection Limit (MDL) is defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from the analysis of a sample in a given matrix type containing the analyte. It is the lowest concentration of an analyte a method can reliably detect taking into consideration the reagents and preparation steps applied to a sample.

- Sample Quantitation Limit (SQL) is the PQL/MQL adjusted for sample characteristics, sample preparation, dilutions, and/or laboratory adjustment. All undetected results will be reported at the SQL.

For this project all organic values observed below the SQL, but above the MDL will be reported as estimated values (flagged "J") by the laboratory.

Since the Navy has not yet selected a laboratory to perform the analyses described in this work plan, specific MDLs and similar issues cannot be presented in the work plan. However, the selected laboratory will be required to meet the following performance standard prior to being selected to perform analysis:

When possible, the detection limit (PQL) concentration for an analyte shall be less than or equal to the corresponding human health or ecological screening level concentrations for that analyte. In cases where the detection limit (PQL) for the analysis of a particular analyte is greater than the analyte's screening level concentration, the laboratory shall certify and demonstrate with appropriate documentation that the concentration of its MDL for the analyte is less than the analyte's screening level concentration. In cases where either of the proceeding performance standards can be met for an analyte, the laboratory must provide documentation clearly establishing the reason(s) that normally available analytical methods cannot attain the analyte's screening level concentrations.

Failure to meet the above performance standard will result in a laboratory not being selected to perform this analytical work.

A.8 Special Training Requirements/Certification

The 40-hour HAZWOPER class and annual refreshers are required for all field personnel.

A.9 Documentation and Records

All individuals and organizations on the distribution list (A.3) will receive a copy of the approved QAPP and all subsequent revisions. The Contractor's Project Manager will be responsible for distribution of the QAPP and associated updates/revisions.

A9.1 Maintenance of Documentation and Records

The following documentation and records will be maintained by the Contractor during the investigation:

- **Sample Collection Records:** (sample tracking, soil borings, well installation, etc.): Records showing that the proper sampling protocol was performed, including the names of persons conducting the activity, sample number, sample collection points,

maps and diagrams, and equipment/methods used. General field records will also be maintained in bound field logbooks to record the procedures used in the field to collect data and outline potential areas of difficulty in collecting data.

- **Chain-of-Custody Records:** records that document the progression of sample custody.

- **Quality Control (QC) Sample Records:** records that document the generation of QC samples, including field blanks, trip blanks, equipment rinsate blanks, and duplicate samples. QC records also include laboratory quality control records.

- **Laboratory Records:** Sample data, sample management records, test methods, and quality assurance/quality control (QA/QC) reports.

- **Additional Records:** Records to be maintained in the field including the site activity log daily master, individual activity field logs, soil sampling log, groundwater sampling log, well installation log, sampling log daily master, and internal field audits.

A.9.2 Data Reporting Format

All analytical data reporting packages will be generated according to the procedures and formats described in *Test Methods for Evaluation of Solid Waste Physical/Chemical Methods*, (SW-846), Third Edition, USEPA, Office of Solid Waste and Emergency Response (OSWER), Update III, December 1996, and as detailed in Sections B, C, and D of the QAPP. The requested laboratory turnaround time is 28 days. Data will be delivered on hard copy and electronically.

Analytical data deliverables for this project will include the information in Table A-2.

Table A-2
Hardcopy Data Deliverables for SW-846 Explosives

Non-CLP Deliverable Requirements — Explosives	CLP Equivalents
Case Narrative should contain: laboratory name; sample delivery group (SDG) number; sample identifications in the SDG including differentiations between initial analyses and re-analyses; analyses performed for each sample; and detailed documentation of all quality control, sample shipment and/or analytical problems encountered in processing the samples reported in the data package. The narrative must also include any problems encountered or deviations from the requested analytical method, both technical and administrative, corrective actions taken, and resolution and explanation for all laboratory flags. In addition, the narrative must contain a signed certification statement.	Case Narrative
Sample, method blank and matrix spike/matrix spike duplicate (MS/MSD) results to be tabulated or reported on spreadsheet. Results greater than the MDL and less than the quantitation limit will be reported as estimated.	Form I
Surrogate recoveries for all samples including QA/QC samples. One surrogate standard is added to each sample.	Form II
Matrix Spike/Spike duplicate (1 spike and 1 spike duplicate per 20 samples of similar matrix). Spike sample and spike duplicate results will be tabulated. Percent recoveries and relative percent differences (RPDs) will be tabulated and summarized.	Form III
Method Blank spikes with results and control charts. Run with each batch of samples processed. Analyzed per matrix/concentration.	Form IV
Instrument Blank results. Instrument blanks analyzed every 12 hours.	Report Results
SW-846: A 5-point initial calibration is to be analyzed. Report the following: Initial calibration factors and %RSDs.	Form VI
A mid-concentration standard will be analyzed after each group of 10 samples in the analysis sequence.	Form VII — 1 and 2
Analytical Sequence (including analysis dates and times) reported for each column and for all samples including QA/QC samples.	Form VIII
Cleanup Efficiency recoveries reported for silica gel or GPC.	Form IX — 1 Form IX — 2
All explosives identified in all samples. Percent differences (%D) between columns are to be reported and those results with %D great than 25% are to be flagged "P."	Form X

Note:
In addition to all summary forms identified above, deliverables may include all sample chromatograms, data printouts, and mass spectra for all samples including QA/QC (blanks, MS/MSD, samples, calibrations).

A.9.3 Data Reporting, Archiving, and Retrieval

All records, which constitute evidence relevant to sampling and analysis activities as described in this QAPP will be maintained by the Navy or its designee. Records will be maintained for a minimum of 7 years after the final report for this investigation is submitted. The final evidence file will be held in a central repository. It will include all relevant records, reports, logs, field books, pictures, subcontractor reports, correspondence, and data reviews. The location will be secured, with limited access.

B MEASUREMENT/DATA ACQUISITION

B.1 Sampling Process Design

Details of the data collection design process for this investigation may be found in Sections 2 and 3 of the Groundwater Monitoring Work Plan. Analytical samples are critical for evaluating potential groundwater contamination. Field measurements are needed to provide background information but are considered non-critical.

B.2 Sampling Methods Requirements

B.2.1 Purpose/Background

See the Groundwater Monitoring Work Plan for a detailed discussion of site background and sampling objectives.

B.2.2 Sample Collection, Preparation, and Decontamination Procedures

B.2.2.1 Soil Investigation

Subsurface samples for lithologic logging may be collected using power devices such as drill rigs equipped with steel split-barrel samplers.

Soil Description

A qualified geologist will describe samples on a soil boring log using the Unified Soil Classification System (USCS). Descriptions will include color, texture, grain size, staining, and odor in accordance with the American Society for Testing and Materials (ASTM) standards for Description and Identification of Soils using the USCS Visual-Manual Procedure (ASTM D2488). Figure B-1 contains a sample boring log.

Subsurface Sample Collection by Drill Rig

Subsurface sample collection will be completed in accordance with the Navy-approved safety plan (see Section 5). Subsurface soil borings may be advanced by a drill rig using hollow-stem augers, which will be advanced without a center plug to facilitate

FIGURE B-1 SAMPLE BORING LOG

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JOB NO.	CLIENT	LOCATION

DRILLING METHOD:

BORING NO.

SHEET OF

SAMPLING METHOD:

LOCATION OF BORING

DRILLING

					START	FINISH
WATER LEVEL					TIME	TIME
TIME						
DATE					DATE	DATE
CASING DEPTH						

DATUM ELEVATION

DRILLING CONTR _____

BY _____ CHK BY _____

DATE _____

SAMPLER TYPE	INCHES DRIVEN / INCHES RECOVERED	DEPTH OF CASING	SAMPLE NO. / SAMPLE DEPTH	BLOWS/FT SAMPLER	VAPOR CONCENTRATIONS (PPM)	DEPTH IN FEET	SOIL GRAPH	SURFACE CONDITIONS:
						0		
						1		
						2		
						3		
						4		
						5		
						6		
						7		
						8		
						9		
						0		
						1		
						2		
						3		
						4		
						5		
						6		
						7		
						8		
						9		
						0		

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split-barrel sample collection. An attempt will be made to complete all borings using hollow-stem auger drilling techniques. If geologic conditions (such as bedrock) are encountered that prevent the use of hollow-stem augers, alternate drilling methods such as rotasonic techniques and mud rotary or air rotary drilling will be employed.

After soil samples are obtained to the proper depth, the borings will be completed as monitoring wells. Specific sampling procedures are provided below.

Split-Barrel Sampling

Before Split-Barrel Sampling:

1. Don personal protective clothing and equipment as specified in the site-specific health and safety plan (see Section 5).

2. Stake the location(s) to be sampled.

3. Clear vegetation and debris from the surface.

4. Prepare the site by placing plastic sheeting around the borehole and over the sampling table.

5. Align the derrick of the drill rig at the sampling location.

6. Set up a decontamination area for sampling equipment.

During Sampling:

1. Install a decontaminated steel split-barrel sampler on the center rod(s) and insert it into the hollow-stem auger. Connect the hammer assembly and lightly tap the rods to seat the drive shoe at the ground surface.

2. Push the sampler down into the soil using the drill rig's hydraulics. Cease pushing when the full length of the sampler has been driven or upon sampler refusal. Perform a standard penetration test (ASTM-1586) each time a split-spoon sample is collected and record the results on the boring log.

3. Pull the sampler free with upswings of the hammer, or use the drill rig's winch. Pull out the center rod and sampler.

4. Unscrew the split-barrel assembly from the center rod and place it on a sampling table.

5. Remove the drive shoe and head assembly. If necessary, tap the split-barrel sampler assembly with a decontaminated hammer to loosen threaded couplings.

6. With the drive shoe and head assembly off, split the sampler and expose the contents to log samples.

7. Decontaminate sampling equipment as needed in accordance with Section B.2.2.3 of this plan.

8. Attach the hollow-stem auger with the cutting head and center rod(s).

9. Proceed to the next sampling depth.

10. Slightly raise the auger flight(s) to disengage the cutting head and rotate without advancement to clean cuttings from the bottom of the hole.

11. Describe sample lithology on soil boring logs (see Figure B-1) based on observations of the auger cuttings, the bottom end of the sample in the liner, or the sample inside the split-barrel sampler.

B.2.2.2 Groundwater Investigation

The following sections outline the methods for installing groundwater monitoring wells and collecting groundwater samples.

Monitoring Well Construction

Boreholes will be advanced and sampled using hollow-stem augers, rotasonic drilling, mud rotary, or air rotary methods where site conditions prevent the use of hollow stem augers. A qualified geologist or hydrogeologist will log and describe all drilling, well installation, well development, and well testing operations. A protective well cover will be used while sampling activities are ongoing. Refer to Figures B-2 and B-3 for a typical monitoring well construction diagram and a monitoring well construction log.

TYPICAL ILLUSTRATION OF MINIMUM SPECIFACTIONS
FOR MONITORING WELL CONSTRUCTION

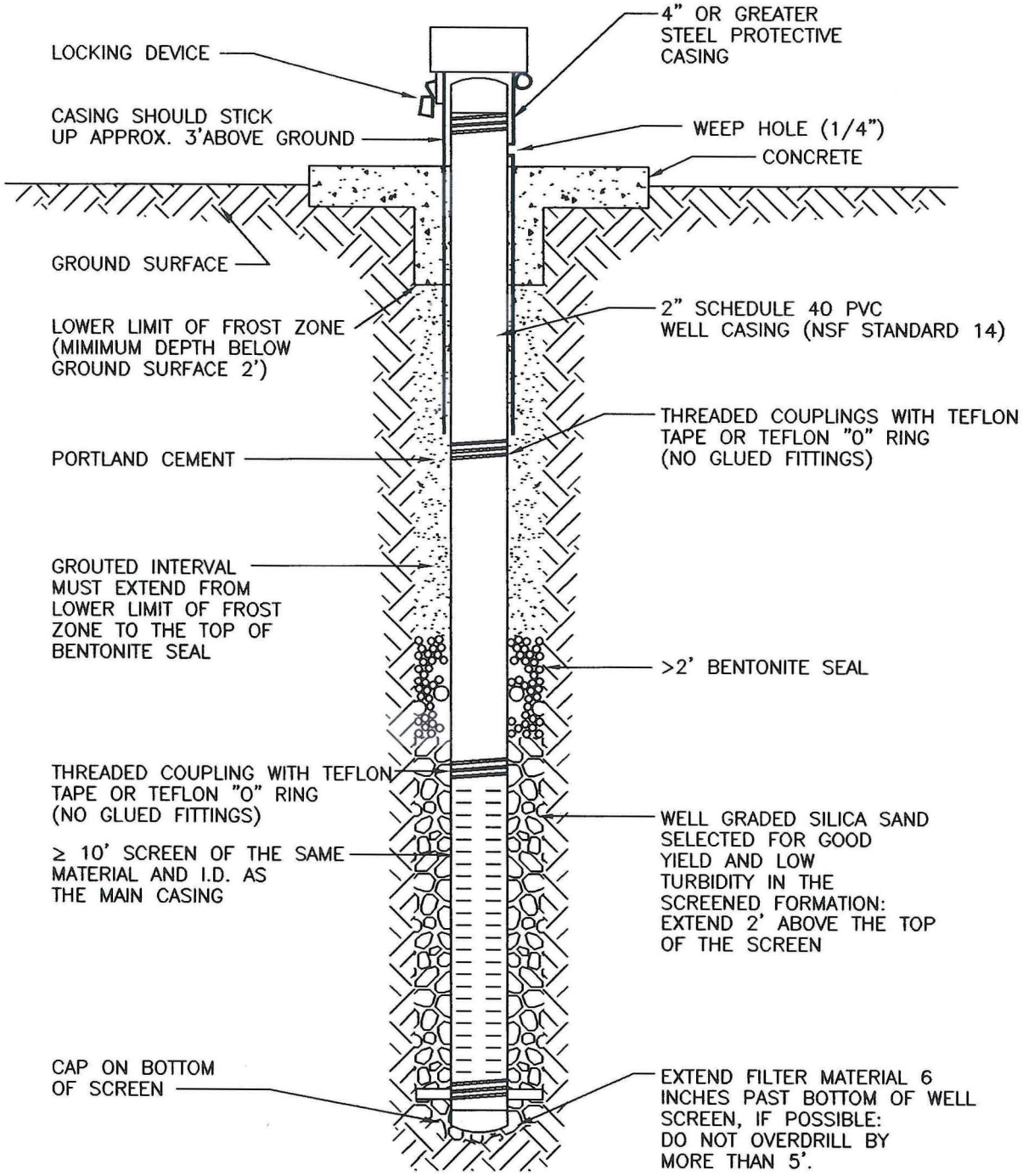

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FIGURE B-2
AFTWF, VIEQUES, PR
PIEZOMETER/TYPICAL MONITORING WELL

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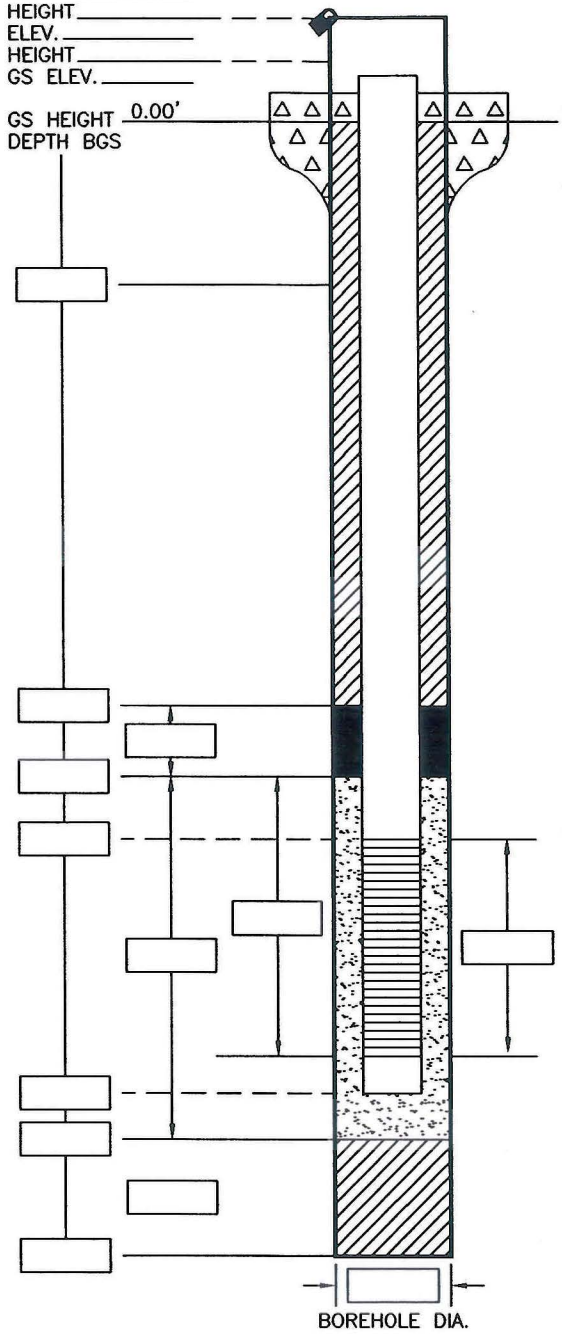
MONITORING WELL CONSTRUCTION LOG – STANDARD		
WELL NO.:	INSTALLATION:	SITE:
PROJECT NO.:	CLIENT/PROJECT:	
CLEAN CONTRACTOR:	DRIG. CONTRACTOR:	
COMP. START: (____m)	COMP. END: (____m)	
BUILT BY:	WELL COORD.:	



PROTECTIVE CASING
MATERIAL/TYPE _____
DIAMETER _____
DEPTH BGS _____ WEEP HOLE(Y/N) _____

GUARD POSTS (Y/N)
NO. _____ TYPE _____

SURFACE PAD
COMPOSITION & SIZE _____

RISER PIPE
TYPE _____
DIAMETER _____
TOTAL LENGTH(TOC to TOS) _____
VENTILATED CAP (Y/N)

GROUT
COMPOSITION & PROPORTIONS _____
TREMIED (Y/N)
INTERVAL BGS _____

CENTRALIZERS (Y/N)
DEPTH(s) _____

SEAL
TYPE _____
SOURCE _____
SETUP/HYDRATION TIME _____
VOL. FLUID ADDED _____
TREMIED (Y/N) _____

FILTER PACK
TYPE _____
AMT. USED _____
TREMIED (Y/N)
SOURCE _____
GR. SIZE DIST. _____

SCREEN
TYPE _____
DIAMETER _____
SLOT SIZE & TYPE _____
INTERVAL BGS _____

SUMP (Y/N)
INTERVAL BGS _____ LENGTH _____
BOTTOM CAP (Y/N)

BACKFILL PLUG
MATERIAL _____
SETUP/HYDRATION TIME _____
TREMIED (Y/N)

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FIGURE B-3
AFTWF, VIEQUES, PR
MONITORING WELL CONSTRUCTION LOG

DWG DATE: 01/09/02 | DWG NAME: 5901G047

The monitoring wells will consist of 2-inch inside diameter, schedule 40 polyvinyl chloride (PVC) well screen and riser pipe with flush joint threaded connections. Well screens will be 10 feet long or longer with continuous 0.10-inch slots and will be set with the top of the screen 2 feet above the water table. Enough 20 to 40 filter sand will be used to ensure the placement of a continuous filter pack around the well screen. The filter pack will extend at least 2 feet above the screen. A 2- to 3-foot minimum bentonite plug will be installed after placement of the filter pack. The plug will consist of 3/8-inch diameter bentonite pellets, hydrated for at least one hour. A grout seal will be placed from the top of the bentonite seal to the ground surface through a tremie pipe. The grout seal will consist of portland cement powder (ASTM C-150, Type I or II) and bentonite at a 95/5 ratio. Hydrate mixture according to manufacturer's instructions. Depending on well depth, bentonite chips may be used to fill the annular space. The chips will be hydrated as they are emplaced. Specific monitoring well installation procedures are outlined below.

Monitoring Well Installation

Subsurface sample collection will be completed in accordance with the Navy-approved safety plan (see Section 5).

1. Clear vegetation and debris from monitoring well site.

2. Place plastic sheeting on the ground near the area to hold decontaminated equipment. Stake the location(s) to be sampled.

3. For monitoring well boreholes requiring lithologic sampling, advance the boring and conduct sampling in accordance with Section B.2.2.1. If the boreholes don't require soil sampling, advance the borehole to the required depth using a bit or auger flight with plug. The borehole should be at least 4 inches larger in diameter than the well casing. Drill the hole slightly deeper — approximately 6 inches more than required for the combined length of casing and screen. Sound the final completion depth with a decontaminated, weighted tape before continuing.

4. Condition the borehole by circulating drilling fluids (mud, water, or air) that are free of contamination, or by rotating augers without advancing them until the hole is cleaned of cuttings. Remove cuttings from the area around the auger. Record the type and quantity of drilling fluid used and the amount recovered on the boring log.

5. Prepare the casing and screen for installation. Decontaminate both in accordance with Section B.2.2.3. *Do not* clean the casing and screen with hot water or solvent rinse.

6. Withdraw the drill rods. Check the hole's depth with a weighted surveyor's tape. It is not necessary to remove the drill string at this point because the well will be constructed through the center of either the augers or the casing.

7. Hang the casing string, screen down, over or in the borehole top. Lower the casing string down to the bottom of the well.

8. Prepare the dry sand or sand slurry for the filter pack to set the well casing.

9. When the casing string is set to the desired depth, hang the centered casing in place. Leave 2 to 3 feet of stickup once the well has been lowered to its final position.

10. If the well is deeper than 20 feet, install the filter pack through the tremie pipe. Six inches or more of filter pack material must be spotted at the bottom of the hole, under the screen. Withdraw the augers slowly so the filter pack is placed evenly around the screen without bridging. Conditions permitting, install the filter pack to a depth of approximately 2 feet above the top of the screened interval.

11. Check the depth to the top of the filter pack with a weighted tape.

12. To install the bentonite seal, tremie bentonite pellets on top of the filter pack if well is deeper than 20 feet. Slowly withdraw the auger as the bentonite is added to ensure even placement of the seal around the annulus. Check the depth with a weighted tape. If possible, leave at least 2 feet of bentonite above the screen.

13. Hydrate according to manufacturer's specifications or eight hours, whichever is greater.

14. To grout the annular space, mix high solids bentonite and water to make a pumpable slurry. Use a cement/bentonite ratio of 95%/5% in preparing the bentonite slurry. When chips are used to fill all the annular space, hydrate according to manufacturers' specifications.

15. If well is deeper than 20 feet, tremie the grout into the annulus using a side-discharge tremie pipe. Slowly withdraw the auger as the annulus fills. Grout the well to within 2 to 4 feet of the surface. Note the amount of grout used in the field logbook.

16. After installing grout, dismantle and decontaminate equipment. Allow adequate cure time (24 hours) for the grout before developing the well.

17. Record construction information on the monitoring well construction log, an example of which is provided in Figure B-3.

Rotasonic Drilling Method

Rotasonic drilling will not be used in areas of suspected unexploded munitions. Rotasonic drilling combines rotational and high frequency vibrational forces to advance the drill bit and drill pipe in the borehole. The primary design difference between rotasonic drilling and other types of rotary systems is the incorporation of an oscillator in the drill head to produce vibrational energy. The vibrational frequency generated by the oscillator can be adjusted for different drilling conditions. Rapid drilling rates, result from matching the drill pipe's vibrational frequency with the resonant frequency of each 10-foot core barrel or drill pipe section. The resulting high amplitude waves within the core barrel or drill pipe are transmitted to the drill bit. This vibrational energy, combined with the rotational energy, allows effective operation in both unconsolidated and consolidated material.

Basic equipment associated with a rotasonic drill rig includes the vibratory/oscillatory top-mounted drill head, mast, elevated drill platform, motor, hydraulic pump and lines, drill center, drill pipe, and core barrels. A support truck for holding drill pipe, core barrels, and other drilling materials is located at the rear of the drilling platform. Using a second vehicle to hold drill pipe allows off-location decontamination of these materials without moving the drill rig itself. The drill rig also has the capability to carry 1,000 gallons of potable drilling water.

The rotasonic drill rig can be operated by one driller and a driller's helper. The drill head is lowered down the mast to a working height above the drill platform and mechanically rotated from a vertical to a horizontal orientation. Hydraulic mechanical vises rapidly connect drill pipe or core barrel sections to the drill head, which is then raised and rotated to a vertical orientation prior to drilling.

The borehole is drilled by advancing two lines of drill pipe. A studded drill bit is attached to the base of the core barrel, which has a 4-inch inner diameter (ID) and 4.5-inch outer diameter (OD). The core barrel, which is 10 feet long, is connected to the 4.5-inch drill pipe and is advanced to the desired depth by using high frequency vibration and rotation, forcing an undisturbed, continuous core into the core barrel. When the core barrel reaches the desired depth, a larger outer drill pipe with a 5.875-inch OD is advanced along the outside of the core barrel to the same depth. The larger drill pipe is left in place to hold the borehole open while the inner drill pipe, core barrel, and sample are retrieved. This assembly is removed from the borehole and rotated to a 45-degree orientation relative to the drill mast. The core sample is extruded sonically into a plastic sleeve, which is placed on a core table for lithologic description. The core barrel is removed, replaced with a decontaminated barrel, and returned to the borehole. The process is then repeated, with the core barrel always driven ahead of the outer drill pipe to ensure representative sampling. Successive 4-inch-diameter cores are laid end-to-end for lithologic description and sampling. In this manner, a complete lithologic core from ground surface to the desired depth can be obtained.

Before Rotasonic Sampling:

1. Don personal protective clothing and equipment as specified in the site-specific health and safety plan (see Section 5).

2. Stake the location(s) to be sampled. Clear vegetation and debris from the monitoring well site.

3. Place plastic sheeting on ground near the area to hold decontaminated equipment.

4. Prepare the site by placing plastic sheeting over the sampling location and a sampling table.

5. Set up the decontaminated drill rig at the sampling location. Decontaminate it in accordance with Section B.2.2.3.

6. Set up a drilling fluid containment system over the borehole location. Create a water-tight seal between the ground surface and the bottom of the containment tank using a pure bentonite powder.

During Rotasonic Sampling:

1. Advance the inner drill pipe and core barrel to the desired interval. Disconnect the drill head from the inner drill pipe and rotate the drill head to a horizontal orientation. Attach a length of outer drill pipe casing to the drill head and raise the drill head while rotating the drill head back to the vertical orientation.

2. Advance the outer drill pipe casing to the same depth as the inner drill pipe and core barrel.

3. Retrieve the inner drill pipe, core barrel, and sample.

4. Remove the sample core from the inner barrel sonically and placed it directly into a sample sleeve. Lithology can be determined through the plastic sleeve. Record this information on the boring log.

5. Change out the lead inner core barrel with a decontaminated barrel. Advance the core barrel 10 feet past the outer drill pipe. Disconnect the drill head and rotate the head to a horizontal orientation. Connect another section of outer drill pipe casing. Rotate the drill head back to a vertical orientation and make up the outer drill pipe casing joint.

6. Disconnect the drill head from the outer drill pipe casing and raise the drill head 1 to 2 inches for venting.

7. Pump potable water through the drill head to fill the annulus between the inner and outer drill pipe for lubrication. When water shows at the vent space, reconnect the drill head to the outer drill pipe casing and advance the outer drill pipe casing to the elevation of the lead core barrel.

8. Repeat steps 4 to 6 until the desired depth is reached.

After Rotasonic Sampling:

1. Pump any drilling fluid, which has accumulated in the containment system into a clearly marked drum for disposal.

2. Backfill the borehole with neat cement grout, or install a monitoring well according to the methods discussed in this section. A tremie pipe is not needed for wells deeper than 20 feet, which are completed within the annulus of the outer drill pipe casing. As the casing is pulled back, the sand pack is sonically vibrated into place against a smooth borehole wall eliminating the threat of bridging. The bentonite seal should be emplaced in the same manner.

3. Remove the drill rig to the decontamination area.

4. Place used plastic sheeting and other disposable sampling equipment in a clearly marked drum for disposal.

5. Record all relevant information in the field logbook before leaving the site (see Section B.10.1).

Developing Monitoring Wells

Monitoring wells will be developed after the bentonite grout in its annular space has cured at least 24 hours. Development restores the normal hydrologic conditions of the geologic formation near the borehole. Monitoring wells can be developed using various techniques such as bailing, surging and bailing, or surging and pumping. Wells with low aquifer recovery will be developed by bailing, or a combination of surging and bailing. Wells with high aquifer recovery will be developed by a combination of surging and pumping. *Before development* and *after development* procedures apply to surging, bailing, and pumping. All monitoring wells must be developed until temperature, specific conductivity and turbidity measurements stabilize and the well produces clear, sediment-free water. A log of these measurements will be maintained during development and submitted with the "as-built" well construction details.

Before Development:

1. Don personal protective clothing and equipment.

2. Cover the surface around the well with clean plastic sheeting to contain any spilled development water.

3. Open the well cover and check the wellhead condition.

4. Measure the depth to static water level with an electronic water-level indicator.

5. Prepare the necessary equipment for well development.

During Development:

Wells may be developed by bailing, surging and bailing, or surging and pumping. These techniques are discussed separately but may be used either separately or in combination. Various pumps that may be used during well development include:

- Brainard Kilman hand pump
- Centrifugal pump
- Peristaltic pump
- Bladder pump
- Grundfos pump

Bailing:

1. Assemble and lower the decontaminated bailer into the monitoring well and begin bailing.

2. Develop the monitoring well until the water column is as free of visible turbidity as possible given the subsurface conditions (between 10 and 30 nepholemetric turbidity units [NTUs]), and until the pH, temperature, and specific conductivity have stabilized to satisfy the following criteria:

Temperature:	within ± 1.0°C
pH:	within ± 0.5 standard unit
Conductivity:	within ± 10% of the duplicate
Turbidity:	relatively stable

Surging:

1. Attach rope or PVC rod to a surge block.

2. Lower the surge block into the monitoring well with rope or rods.

3. Raise and lower the surge block so groundwater will be surged in and out of the monitoring well screen. Continue for approximately 10 to 15 minutes.

4. Remove the surge block from the well for decontamination.

Pumping:

1. Prepare the decontaminated pump and tubing, and lower them into the well.

2. Begin pumping the well.

3. If the well's productivity is low, pump it, then leave it idle to recover. The onsite geologist will determine when development is complete based on normal development criteria.

4. Develop the monitoring well until the water column is as free of visible turbidity as possible, given the subsurface conditions (between 10 and 30 NTUs), and until the pH, temperature, and specific conductivity have stabilized to satisfy the following criteria:

Temperature:	within ± 1.0°C
pH:	within ± 0.5 standard unit
Conductivity:	within ± 10 % of the duplicate
Turbidity:	relatively stable

After Development:

1. Place groundwater withdrawn from the monitoring wells during development in 55-gallon drums for disposal in accordance with Section B.2.2.4 of this plan.

2. Remove development equipment from the monitoring well and decontaminate in accordance with Section B.2.2.3 of this plan.

3. Record all well development data in the field logbook.

Groundwater Sampling

All purging and sampling of monitoring wells will be conducted with a peristaltic, bladder, or Grundfos-type (helical rotor submersible) pump with Teflon vacuum container, depending on the depth of the well. Peristaltic pumps may be used in wells where the depth to groundwater is less than 30 feet. Groundwater depths greater than 30 feet will require either electric (Grundfos type) or bladder pumps. The limitations of these two pumps are not depth-related but rather that an electrical source and a nitrogen supply source are needed, respectively. All pump tubing will be constructed of a Tygon- or Teflon-lined material. If a pump is ineffective or impractical for successful purging and/or sampling, a Teflon bailer with a stainless-steel leader will be used.

Purging Static Water

Field personnel will purge monitoring wells before collecting samples to remove stagnant water from the casing and surrounding borehole space. General purging techniques to remove three to five well casing volumes or micropurge for low-flow sampling will be used. If possible, a pumping flow rate of 0.05 to 0.25 gallons per minute (gpm) will be maintained during purging and sampling.

General Purging Procedures:

- Purge monitoring wells with a decontaminated pump.

- Purge three to five well casing volumes. In addition, turbidity should be 10 NTUs or less. Measure the indicator parameters temperature, turbidity, specific conductivity, and pH in a groundwater sample prior to purging and after removal of each well casing volume. If these parameters have stabilized after removal of three well casing volumes, sample the well. If not, continue until five well casing volumes have been removed from the well. Even if the indicator parameters have not stabilized after removal of the fifth, proceed with sampling. Contained purge water in a dedicated drum.

- Record well purging data in the field logbook and/or the groundwater sampling form (Figure B-4).

- When purging is complete, allow monitoring wells to recharge before beginning sampling. Wells evacuated while purging will be sampled when sufficient volume has re-entered the well. For this project, low recharge monitoring wells are defined as those with recharge rates not allowing sample collection within 12 hours of initial purging. These wells will be documented as *dry*. Specific procedures for monitoring well purging are provided below.

Before Purging:

1. Don personal protective clothing and equipment in accordance with the site-specific health and safety plan (see Section 5).

2. Cover the surface around the well with clean plastic sheeting to contain any water spilled during purging or sampling.

Figure B-4
Groundwater Sampling Form

Groundwater Sampling

Sample ID:

PROJECT NAME: _____ JOB NO: _____ DATE: _____

WELL NO.: _____ LOCATION:

WEATHER CONDITIONS: _____ AMBIENT TEMP:

REVIEWED BY: PERSONNEL:

PURGING DEVICE	SAMPLING DEVICE
Type device?	Type device?
How was the device decontaminated? How was the line decontaminated?	How was the device decontaminated?
Which well was previously purged?	How was the line decontaminated?
	Which well was previously sampled?

INITIAL WELL VOLUME	PURGING
Well diameter (in.)	Time started _____ Finished
Stickup (ft.)	Volume purged
Depth to bottom of well from TOC (ft.)	Comments on Well Recovery
Depth to water surface from TOC (ft.)	Depth to water (ft.)
Length of water (ft.)	Completion
Volume of water (ft.)	Additional Comments
(gal.)	Sample Collected: Start
Amount of sediment at bottom of well (ft.)	Finish
3 Volumes of water (gal.)	

IN-SITU TESTING Time:

	1	2	3	4	5	6	7
Well Volume Purged (gal.)							
Turbidity							
Odor							
pH (units)							
Conductivity (mho)							
Water Temperature (C)							
Depth to water (ft.)							

Notes: 1 ft. length of 4" = 0.087 ft^3 or 0.65 gal. 1 ft. length 2" = 0.022 ft^3 or 0.16 gal.
Turbidity choices: clear, turbid, opaque Revision Date: 8/5/92

3. Measure static the total depth of the well and the water level to the nearest 0.01 foot using an electronic water-level indicator. Record the measurement in the field logbook.

4. Calculate static volume using one of the following formulas:

$$V = 0.041\ d^2h$$

where:

V	=	volume of water in gallons
d	=	diameter of well in inches
h	=	depth of water in feet (total well depth — static water level)

The static volume may also be calculated using this formula:

$$V = hr^2(0.163)$$

where:

V	=	volume of water in gallons
h	=	depth of water in feet (total well depth — static water level)
r	=	radius of well in inches

During Purging:

1. Lower the decontaminated pump into the casing.

2. Begin purging the well; purge at least three volumes of water (water column).

3. Withdraw groundwater until temperature, pH, turbidity, and conductivity have stabilized. A monitoring well is considered stabilized when three readings each of temperature, pH, turbidity, and specific conductivity have stabilized to satisfy the following criteria:

Temperature:	within ± 1.0°C
pH:	within ± 0.5 standard unit
Conductivity:	within ± 10 % of the duplicate
Turbidity:	relatively stable

4. Purge upgradient and background wells before downgradient wells to reduce the cross-contamination risk.

After Purging:

1. Record purging data in the field logbook.

2. If well is purged dry, allow it to recharge before sampling. However, make every effort to avoid purging the monitoring well dry.

3. Document the well as *dry* if it does not recharge within 12 hours of initial purging.

4. Drum all investigation-derived waste produced while purging for disposal in accordance with Section B.2.2.4.

Micropurging/Low-Flow Sampling

The following groundwater sampling procedure combines low-flow-rate micropurging and groundwater sampling into one process. The low flow rate micro-purging process eliminates the need for the typical three to five borehole volume purge and thereby generates significantly less purge water IDW. To ensure representative groundwater samples, a controlled low-flow pumping rate is maintained at each well until water level and field parameter stabilization occurs. Well purging and groundwater sample collection will be performed according to the following procedures.

Before Well Purging:

1. Don protective clothing and equipment as specified in the site-specific health and safety plan (see Section 5).

2. Prepare the site by covering the ground surface around the wellhead with plastic sheeting and arrange the required sampling equipment so it is easy to use.

3. Open the well cover and immediately insert a photoionization device into the wellhead to measure ionizable organic vapors for approximately one minute. If vapors are detected, use an oil-interface probe to verify the presence of an immiscible layer.

4. Measure static water level and total depth of the monitoring well to the nearest 0.01 foot using an electronic water-level indicator. Record the measurement in the field logbook. Calculate the static water volume in the well.

5. Connect the dedicated nitrogen line from the pump to the controller. Direct the dedicated discharge tubing to containerize all IDW.

6. Begin purging the well at approximately 0.05 to 0.25 gpm.

During well purging:

1. Closely monitor the purge rate and water level.

2. Adjust the purge rate until the water level stabilizes, and then monitor temperature, pH, specific conductivity, and turbidity.

3. Record the measurements.

4. Continue purging at the controlled rate until temperature, pH, conductivity, and turbidity have stabilized to satisfy the following criteria:

Temperature:	within $\pm$ 1.0°C
pH:	within $\pm$ 0.5 standard unit
Conductivity:	within $\pm$ 10 % of the duplicate
Turbidity:	relatively stable

5. Once stabilization has been obtained, allow the pump to continue running and prepare for sample collection. However, if field parameter stabilization cannot be achieved or the well's yield is insufficient to reach a stabilized water level, purge three to five borehole volumes.

6. If the well pumps dry before the required purge volume has been obtained or field parameters have stabilized, turn off the pump and allow it to recharge to within 75% of its initial water level before sampling.

7. Arrange the sample containers in the order of sample collection, organics first followed by inorganics.

Groundwater Sample Collection:

1. While the pump is still running, collect the groundwater sample immediately after the purging stabilization (or when water level for wells purged dry recovers 75%) using the same pump to fill all sample containers at the same low controlled flow rate (approximately 0.05 to 0.25 gpm). Allow the water to flow gently down the inside wall of the sample vial to avoid volatilization. Cap the vial, maintaining zero headspace.

2. Turn off the pump when sufficient volume is collected to fill all containers.

3. Disconnect the air line from the controller and remove it from the monitoring well.

4. Add preservative (if needed), cap, seal, and properly label all containers. Place the filled containers in the cooler(s) with ice to begin cooling them to 4°C.

5. Record sample identifications, types and amounts collected, as well as the time, date of collection, and analyses in the field logbook and/or on the groundwater sampling form.

6. Decontaminate or properly dispose of sampling equipment if it is not dedicated to the monitoring well.

General Groundwater Sampling

Monitoring wells will be sampled with either a decontaminated pump or Teflon bailer. To sample monitoring wells, a peristaltic pump, or another similar type of pump which will not chemically or physically alter groundwater samples, must be used.

- Allow newly installed wells to recover for two weeks before sampling them.

- Use peristaltic pumps instead of bailers for purging and sampling when turbidity exceeds 10 NTU.

- Collect samples using a decontaminated pump with a Teflon vacuum container so that groundwater does not touch the pump. If a pump is ineffective or cannot successfully sample the monitoring well, a Teflon bailer may be used.

- Measure temperature, pH, and specific conductance for each sample collected and record these measurements in the field logbook.

- Chemically preserve samples as required (see Section B.4). After chemical preservation and labeling, chill the samples to 4°C.

- Record weather at the time of sample collection in the field logbook. Refer to the specific procedures for groundwater sampling below.

Before Groundwater Sampling:

1. Don protective clothing and equipment.

2. Prepare the site by covering the surface around the wellhead with plastic sheeting and arrange the required equipment to make it easy to use.

3. Purge the well according to the procedures outlined above. If bailing, allow the water level to recover enough to completely submerge the bailer without touching the well bottom.

4. If bailing, securely attach the bailer to decontaminated Teflon-coated stainless-steel leader.

5. Arrange the sample containers in the order of sample collection.

During Groundwater Sampling:

1. Slowly lower the pump hose or bailer into the water to prevent aeration.

2. Start pump or retrieve full bailer to the surface. If bailing, do not allow the line to touch the ground.

3. Unless using the same pump or bailer for both purging and sampling, allow initial pump water to discharge into a drum. If using a bailer, use the first bailer of water to rinse out the bailer; then discard the water.

4. If using a bailer, repeat Steps 2 and 3.

5. Fill all sample containers to capacity. Add preservative (if needed), cap, seal, and properly label all containers. Place the filled containers in the cooler(s) immediately and preserve them to 4°C.

After Groundwater Sampling:

1. Record sample identifications, types, amounts collected, analyses, as well as the time and date of sample collection in the field logbook. Prepare chain-of-custody forms and analytical request documents.

2. Decontaminate sampling equipment if it is not dedicated to the monitoring well.

3. Clean up the area and place disposable materials (plastic sheeting, gloves, and rope) in the drum designated for disposal.

Water Level Measurements

A measuring point will be established at the top of each well casing. A point will be marked and the elevation established (to the nearest 0.01 foot) with respect to a permanent benchmark. Static groundwater levels will be measured in each monitoring well 24 hours following development. All wells will be gauged on the same day as quickly as possible. The measurements will be made to an accuracy of 0.01 foot. The well depth will be measured using a decontaminated, electronic water level indicator with an accuracy of at least 0.01 foot. All readings will be made at a clearly marked reference point at the top of each well casing. The barometric pressure, date, and time will be recorded in the field logbook at the time of measurement.

B.2.2.3 Decontamination Procedures

Decontamination will be performed in accordance with USEPA Region 2's CERCLA Quality Assurance Manual (1989), with the following exceptions. When available, hot water will be used for field decontamination. A stainless-steel bowl, sink, or bucket will be used to contain the clean water wash solution. PVC well construction materials will not be solvent-rinsed or washed with hot water. The steam cleaner and/or high-pressure hot water washer will be

capable of generating adequate pressure and producing hot water and/or steam. All wastes generated during decontamination will be containerized in designated drums or tanks for disposal in accordance with Section B.2.2.4.

Decontamination Area Setup

Decontamination generally occurs at a designated area downgradient and downwind of the clean equipment storage area. Liquids contained within the decontamination area will be pumped regularly into designated drums or tanks. All large equipment (i.e., augers, rods) will be cleaned on saw horses or auger racks above the ground surface. Smaller equipment (i.e., spoons, bowls, etc.), will be cleaned on plastic sheeting to contain any spills and to prevent cross contamination. If field cleaning is necessary, place plastic sheeting on the ground designated as the decontamination area to contain any spills. To prevent cross-contamination of samples, all equipment will be thoroughly cleaned both before and after sampling.

Cross-Contamination Prevention Procedures

1. Don a new pair of disposable outer gloves before handling sampling equipment.

2. Use only Teflon, glass, or plastic spray bottles/pressurized containers to apply decontamination rinsates. Keep each solution in a separate container.

3. Transport all necessary decontaminated field equipment to each designated location to minimize the need for field cleaning.

Sampling Equipment

Sampling equipment will be decontaminated according to the following procedures:

1. Don protective gloves before decontaminating equipment.

2. Wash and scrub small, hand-held equipment with laboratory-grade detergent and clean-water wash solution. Decontaminate large equipment with high-pressure steam.

3. Rinse with clean tap water.

4. Rinse with clean, tap water.

5. Rinse with ASTM Type III water.

6. Air dry.

7. If equipment is visibly contaminated, return to Step 2.

8. Wrap in aluminum foil or plastic for storage if the equipment will be stored or transported.

Rinses with 10% HNO_3 and/or acetone, methanol, and hexane may be necessary, but only if equipment is heavily soiled and stained by grease or oils. The use of solvents has been shown to produce false "positive" during analytical testing of samples. Consequently, solvents should only be used sparingly, if at all.

Pump Decontamination

Pump decontamination differs from decontaminating most sampling equipment. The pump exterior and interior both require decontamination. The procedures for decontaminating the interior and exterior of the pump are outlined below:

1. Don protective gloves before decontaminating the equipment.

2. Immerse the pump head in a detergent solution with the effluent hose prepared to discharge into a liquid IDW drum. A stainless-steel bucket or closed 4-inch pipe can be used to contain the pump head and pump solutions. All pump effluent will be containerized as IDW.

3. Using a brush, scrub the exterior of the pump and hose with the detergent solution. Rinse the exterior of the hose with a clean water rinse solution followed by a ASTM Type III water rinse. Roll the hose back onto the spool.

4. Each decontamination fluid will be pumped through submersible sampling pumps.

5. Rinse the outside of the pump housing and hose with ASTM Type III water.

6. Wrap the pump in plastic sheeting for transport to the field or for storage to prevent cross-contamination.

B.2.2.4 Investigation-Derived Waste

IDW from the investigation will likely include soil cuttings from boring installation, disposable personal protective equipment, sampling utensils, and decontamination fluids from the cleaning of PPE, sampling equipment, and drilling equipment, and purge water from groundwater sampling. These wastes will be containerized, as appropriate, in U.S. DOT-approved drums or other collection receptacles, and labeled with the site, date of generation, and waste category. After IDW is characterized, the waste will be managed in a manner consistent with all applicable local, state, and federal regulations and laws. Table B-1 presents the minimum sampling requirements for IDW. One composite soil sample and decontamination/purge water sample will be collected from the sampling area. Other analysis may be required depending upon the disposal options selected.

Table B-1
Quantity of Composite IDW Samples

Analysis	Western Perimeter
Soil	
HMT, RDX, TNT by Method 8330	1
Water	
HMT, RDX, TNT by Method 8330	1

Note:
All methods are from SW-846.

B.2.3 Support Facilities

When the contractor has been selected, all support offices will be identified.

B.2.4 Sampling Measurement System Failure Response and Corrective Action Process

The contractor's Site Manager and Quality Assurance Manager will oversee the implementation of the QAPP, address problems identified by field personnel, and implement corrective measures, as needed. Field change request forms (see Section B.10.3) will be submitted when any deviation from the work plan is required. Generally, these include changes that will (1) harm data quality, (2) change the cost of field activities, (3) alter the scope of field activities, or (4) significantly delay the schedule.

Specific changes include:

- Number of wells.
- Number of sampling points.
- Decontamination procedures.
- Drilling method or well construction design.
- Sampling methodology.

Information should include the nature of the change, appropriate rationale, and date it will be implemented. These forms will be submitted to all parties on the QAPP distribution list.

B.2.5 Sampling Equipment, Preservation, and Holding Time Requirements

Requirements to prevent sampling contamination are discussed in B.2.2.3. The physical volume of the material to be collected and preservation and holding time requirements are discussed in Section B.4.

B.3 Sampling Handling and Custody Requirements

B.3.1 Sample Identification and Labeling

Labels will be affixed to each sample container that identify the site, sample number, collection time, and date, method of preservation, signatures of persons collecting samples,

and analyses requested. A sample label is shown in Figure B-5. The selected contractor must use a form that meets these minimum requirements.

Sample Numbering

Assign the sample identification number according to the following format and guidelines:

Format: — *1 2 3 4 5 6 7 8 9 0*

1 2 3 — The first three digits designate that the sample is from the western Navy boundary.

4 — This digit will represent the sample matrix. To keep the data consistent and facilitate data management, use the following:

S — soil
C — soil duplicate sample
G — groundwater sample
H — groundwater duplicate sample

5 6 7 8 — These four digits designate the sampling location.

9 0 — The final two digits represent the sample-specific identification, the serial number for water samples.

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Ensafe, Inc.

SITE NAME	DATE
ANALYSIS	TIME
	PRESERVATIVE
SAMPLE IDENTIFICATION	
PROJECT NUMBER	

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FIGURE B-5
AFTWF, VIEQUES, PR
ENSAFE SAMPLE LABEL

DWG DATE: 01/09/02 | DWG NAME: 5901G048

Quality Control Samples:

1 2 3 — The first three digits designate that the sample is from the western Navy boundary.

4 — This digit will represent the type of QC sample. To keep the data consistent and facilitate data management, the master list of abbreviations below will be used for commonly collected QC samples when applicable:

T — trip blank
E — equipment rinsate blank
D — deionized water system blank
P — potable water blank
F — field blank
L — filter blank
2 — cement blank
3 — drilling mud
4 — grout blank
5 — bentonite blank
6 — sand blank

5 6 7 8 — These four digits correlate the QC sample with its associated field samples. A simple method is to use the location of the sample collected on the same day as the QC sample. This also will keep the QC samples blind to the laboratory.

9 0 — The final two digits are the QC sample serial number. For example, the first rinsate blank collected at a particular site will have the serial number "01," the second rinsate will be "02," etc.

B.3.2 Sample Packaging and Shipment

Samples will be packaged and shipped in accordance with the following procedures.

1. Select a cooler in good condition. Seal the drain plug on the inside and outside of the cooler with tape to prevent leaks.

2. Line the cooler with a large plastic bag.

3. Place one sample container in one sealable plastic bag.

4. To prevent breakage, either:

   — Place bubble-wrap packing material around the containers and then seal with tape. Bubble wrap is not required for plastic containers, but take care when packing the coolers so containers do not directly touch each other.

or

   — Place 2 to 4 inches of inert packing material (e.g., vermiculite or cellulose insulation) on bottom of the cooler. Place the bagged containers inside the cooler so the bottles do not touch. Completely fill any remaining space with inert packing material.

5. Include a temperature blank or strip in each sample cooler.

6. Fasten the top of the large plastic bag with tape.

7. Place double-bagged ice inside cooler to preserve the samples at 4°C (±2°C).

8. Place a chain-of-custody form describing the contents of each cooler in a sealable plastic bag inside the cooler.

9. Seal the cooler with tape and custody seals so it cannot be opened without breaking the seal.

10. Clearly print "This End Up" or "This Side Up" on top of the cooler, and place upward-pointing arrows on sides of the cooler.

11. Mark cooler with the addresses of both shipper and receiver.

12. If more than one cooler is to be shipped, mark with the sequential cooler number and the total number of coolers (e.g., 1 of 3, 2 of 3, and 3 of 3).

Coolers will be shipped overnight to the laboratory. Transportation and custody procedures will meet U.S. Department of Transportation and USEPA requirements.

B.3.3 Chain-of-Custody Procedures

Chain-of-custody (COC) forms are used to record sample transfers between handlers and throughout the laboratory analysis process. Sample custody or possession will be traceable from the time of collection to receipt at the laboratory. Chain-of-custody forms must be signed as received and relinquished by each person that has custody of the samples, from sample collection to receipt at the laboratory and throughout the laboratory analysis process.

To Maintain Field Custody:

1. After sample collection, seal and label the jar.

2. Affix the custody seal (see Figure B-6) so that samples cannot be opened without breaking the seal.

3. The sampler must sign and date the seal.

Record sample custody on the COC as follows:

- Write clearly in non-erasable, waterproof black ink.

ENSAFE	*ENVIRONMENTAL AND SAFETY DESIGNS, INC.* *5724 Summer Tree Dr.* *Memphis, TN 38134* OFFICIAL SAMPLE SEAL	SAMPLE #	DATE	SEAL BROKEN BY:
		SIGNATURE		DATE:
		PRINT NAME & TITLE:		

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FIGURE B-6
AFTWF, VIEQUES, PR
ENSAFE CUSTODY SEAL

DWG DATE: 01/09/02 | DWG NAME: 5901G049

- Slash through zeros and sevens to avoid confusion with the letters O and I.

- Mark through errors with a single line, initial them, then record the correct information.

- Record the following information in the appropriate spaces on the form (see Figure B-7):

Client/project information:

- Client name and address
- Project name/number
- Project manager's name
- Signature of sampler(s)

Sample information:

- Field sample identification
- Date and time of collection (24-hour clock)
- Type of sample
- Type and size of sample containers
- Preservation temperature and chemical
- Number of samples per container
- Type of laboratory analysis required
- Remarks: descriptive comments (e.g., "strong odor")

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CHAIN OF CUSTODY RECORD

PAGE _____ OF _____

PROJECT/JOB NO: _____
COC NO: _____
PO NO: _____
REL NO: _____
LAB NAME: _____

CLIENT _____ PROJECT MANAGER _____

LOCATION _____ TELE/FAX NO. _____

SAMPLERS: (SIGNATURE) _____

FIELD SAMPLE NUMBER	DATE	TIME	SAMPLE TYPE	TYPE/SIZE OF CONTAINER	PRESERVATION		NO. OF CONTAINERS	ANALYSIS REQUIRED											REMARKS
					TEMP.	CHEMICAL													

RELINQUISHER:	DATE	RECEIVER:	DATE	RELINQUISHER:	DATE	RECEIVER:	DATE
PRINTED:	TIME	PRINTED:	TIME	PRINTED:	TIME	PRINTED:	TIME
COMPANY:		COMPANY:		COMPANY:		COMPANY:	

METHOD OF SHIPMENT: _____
SHIPMENT NO. _____
SEND RESULTS TO: _____

COMMENTS: _____

ANALYTICAL DATA RECEIVED BY (INITIALS/DATE) _____

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FIGURE B-7
AFTWF, VIEQUES, PR
ENSAFE CHAIN-OF-CUSTODY FORM

DWG DATE: 01/09/02

DWG NAME: 5901G050

Transfer, shipment, and disposal information:

- Document sample custody transfer in the appropriate section of the form.
- The person relinquishing custody must print his or her name, company name, and reason for the transfer, date, time, and signature on the form.
- Note special instructions or comments (e.g., priority turnaround) in the appropriate section of the form (these instructions should have been discussed with the laboratory prior to sample collection).
- Note post-analysis sample disposal or storage instructions.

Follow these guidelines for custody transfer and sample shipment:

1. Record the air-bill number in the appropriate section on the COC record and the field notebook. Seal the COC form in a plastic bag and place it inside the shipping cooler.
2. Secure cooler with tape and place a custody seal on each exterior side to prevent opening without breaking the seal.
3. Ship samples overnight to the selected analytical laboratory.
4. When relinquishing custody to a shipper, advise the laboratory of any time constraints on analysis.
5. Notify the laboratory as early in the week as possible regarding samples intended for Saturday delivery.

Laboratory receipt procedures are listed below.

1. A laboratory sample custodian accepts custody of the samples from the carrier and enters data about the package in a receipt log, including the status of the cooler's custody seals.

2. The sample custodian opens the coolers, checks the contents, logs in the samples, and verifies that the information on the COC agrees with samples received.

3. The custodian records information such as method of shipment, pickup, and courier in the "Remarks" section. The custodian also documents cooler temperature by checking the temperature blank or strip, as well as the general condition of sample containers.

4. The analyst records pH and verifies sample preservation before extraction, digestion, or analysis.

5. If samples are improperly preserved, the Laboratory Quality Assurance Coordinator documents this fact, along with the sample identification and other pertinent information, and notifies the project manager and site manager. All other QA/QC discrepancies are handled similarly and must be documented as an out-of-control event with appropriate corrective action.

B.4 Analytical Method Requirements

Table B-2 provides information on sample container type and size, preservation requirements, holding times, preparation methods, and analytical methods. The appropriate number of precleaned and pre-preserved (if required by the method) sample containers, will be provided by the approved laboratory. The laboratory turnaround time for analytical results will be 30 days from sample collection. The contractor's QA Manager will maintain coordination and communication between the analytical laboratory and the project management team members, assess laboratory data, and direct corrective action if problems arise.

Table B-2
Analytical Methods, Sample Containers, Preservation, and Holding Times
For Analysis of HMX, RDX, and TNT

Parameter	Analytical Method	Sample Matrix	Container Type	Sample Preservation	Holding Times
Explosives HMX, RDX, and TNT	SW-846 (8330 -modified)	Water	(2) 1-liter Amber Glass Jar with Teflon-lined septum	Chill, 4°C	Extract within 7 days, analyze within 40 days after extraction

Samples will be chemically preserved in accordance with the guidelines presented in USEPA Region 2's CERCLA Quality Assurance Manual. If required, samples will be collected in pre-preserved containers.

The laboratory contracted by the Navy will be required to produce data deliverables of the quality and format provided in Section A.9.2.

Chemical Parameters

Analytical samples will be analyzed in accordance with the applicable methods shown in Table B-2 and as outlined in:

- *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (SW-846), USEPA Office of Solid Waste and Emergency Response (OSWER), Third Edition, revised December 1996.

- USEPA Environmental Monitoring and Support Laboratory, *Methods for Chemical Analysis of Water and Wastes* (EPA-600/4-79-020), most recent revision. (MCAWW).

- USEPA CLP, *Test Methods for Evaluation of Solid Waste Physical/Chemical Methods*, (SW-846).

B.5 Quality Control Requirements

Analytical data quality will meet definitive data quality objectives that apply to sites with characterization, environmental monitoring, engineering, risk assessment, and/or confirmation of field-produced data objectives. In general, quality assurance objectives assess and document the precision, accuracy, representativeness, completeness, and comparability of all sampling and analyses performed. Quality criteria are outlined here to assure that data obtained during projects are suitable for their intended use and to meet goals established in *Guidance for the Data Quality Objectives Process*, EPA/600/R-96/055 (EPA QA/G4, September 1994). Quality control samples will be collected at the frequency presented in Table B-3 to assess the data's precision and accuracy.

Table B-3
Quality Control Sample Collection Frequencies

Duplicates	One per 10 samples collected.
Field Blank	One per sampling event (week) per source (Potable Water and Reagent Grade Water — ASTM Type III).
Equipment Rinsate Blank	One per sampling event (week) per sampling method.
MS/MSD	One per 20 samples collected per matrix; MS/MSD are to be the same sample used for duplicate analysis.
Temperature Blank	One per sample shipping cooler, when required by the lab.
Trip Blank	One per cooler containing samples for volatile analysis

QA/QC goals for each parameter to be analyzed are shown in Table B-4. The QA/QC goals specified in this table are developed statistically in accordance with the method guidelines. These goals are highly matrix dependant and may not be achieved in all circumstances. QC limits not met will be assessed during the data validation process to determine the cause of the deficiency.

If a laboratory error is found, the data validator will request that the laboratory initiate correct action and correct the error. If no laboratory error was found and the QC deficiency is determined to be the result of matrix-interference, the validator will flag the data according to algorithms set forth in USEPA data validation guidelines.

Table B-4
Organic Analyses Data QA Objectives
Matrix Spikes/Laboratory Control Samples/Surrogate Spikes

Fraction	Compound	Soil Precision (RPD)	Soil Accuracy (% Recovery)	Water Precision (RPD)	Water Accuracy (% Recovery)
Matrix Spikes (a)					
SW-846 8330 Explosives	1,3-Dinitrobenzene	25	50-150	25	50-150
	2,4-Dinitrotoluene	25	50-150	25	50-150
Surrogate Spikes (a)					
SW-846 8330 Explosives	3,4-Dinitrotoluene	—	20-130	—	25-150

Notes:
— = Not applicable to the analytical method.
(a) = Compounds spiked and accuracy and precision may change based on laboratory statistical calculations at the time of sampling and analysis.

Precision

Precision is a measure of the reproducibility of measurements and methods, defined for qualitative data as the variability of a group of values compared with its average value. To assess the precision of this project's measurement systems, duplicates will be obtained and analyzed with the samples collected. Precision, to be used as a criterion for data classification, is calculated as a relative percent difference (RPD) in analytical outcome between a given sample and corresponding duplicate:

$$\%RPD = \frac{(A-B)}{(\frac{A+B}{2})} \; x \; 100\%$$

where:

A = sample concentration
B = sample duplicate concentration

The type of duplicates used will depend on which part of the measurement system is to be evaluated. Field-duplicated samples analyzed by the same laboratory will yield information about sampling method precision and matrix homogeneity. Laboratory-duplicated samples give an indication of sample preparation and analytical method precision.

Precision is a measure of the degree to which two or more measurements are in agreement. Field precision is assessed through the collection and measurement of field duplicates at a rate of 1 duplicate per 10 analytical samples.

Accuracy

Accuracy is the degree of agreement of a measurement or the average of several measurements with an accepted reference or true value; it is a measure of bias in a system. Accuracy in the field is assessed through the use of field and trip blanks and through the adherence to all sample handling, preservation and holding times. Laboratory accuracy is assessed through the analysis of matrix spikes or standard reference materials and the determination of percent recoveries. If recoveries do not meet the required criteria, the analytical data are considered to be potentially inaccurate. This is normally expressed as the difference between measured and reference or true value or the difference as a percentage of the reference or true value. It may also be expressed as a ratio of the measurement to the true value.

$$\%R = \{(A-B) / (C)\} \times 100\%$$

where:

A = spiked sample concentration
B = unspiked sample concentration
C = spike standard concentration

Accuracy will vary from analysis to analysis because of individual sample and matrix effects. In an individual analysis, accuracy can be measured and expressed in terms of the recovery of surrogate compounds (organic analyses) or recovery of spiked compounds (inorganic compounds). This gives and indication of expected recovery for analytes tending to behave chemically like the spiked or surrogate compounds.

A *field blank* consists of sample containers filled in the field with water from each source used for decontamination. Field blanks are prepared, preserved, and stored in the same manner as the samples. The field blank is analyzed along with the field samples for constituents of interest to check for sample contamination from the water source. Samples of the ASTM Type III water and tap water will be collected weekly. Field blanks may also be collected to determine if any contaminants in the area, such as dust from a source other than that being sampled, may affect sample integrity.

An *equipment rinsate blank* is made by placing water in contact with the field sampling apparatus (e.g., stainless-steel hand auger, split barrel, bowls, etc.), after decontaminating the equipment. Equipment blanks for submersible pumps will be prepared by pumping water through the pump. The water will be collected in the same type of containers as the other samples, preserved in the same manner, and analyzed for the same parameters. One equipment rinsate blank will be collected each week. If different equipment is used in the same week (e.g., if soil samples are collected with a split-barrel sampler and hand auger), a separate rinsate blank will be collected for each piece of sampling apparatus.

MS/MSD samples prepared by the laboratory are useful in assessing the accuracy of the analytical methods, and can detect matrix effects where other sample components interfere with analyzing the chemical(s) of interest. The method of measuring analytical accuracy is percent recovery.

Analytical MS and MSD samples will be prepared by the laboratory, typically at a frequency of one MS/MSD pair per 20 samples per matrix. An additional sample volume will be collected to provide sufficient volume for the lab's MS and MSD analysis.

Representativeness

Representativeness expresses the degree to which data accurately and precisely represent a population characteristic, parameter variations at a sampling point, a process condition, or an environmental condition. Soil samples will be properly collected in accordance with USEPA protocol to ensure they are representative.

Completeness

Completeness goals for this project are set at 95% for laboratory analyses. Data completeness is calculated as the percentage of valid tests versus the total number of tests required in the project scope.

Comparability

Comparability expresses the confidence with which one data set can be compared to another. Comparability is assured by using established methods of field sampling by experienced field personnel and laboratory analyses.

B.6 Instrument/Equipment Testing, Inspection, and Maintenance Requirements

Field equipment will be tested, inspected, and maintained according to the manufacturers' specifications. The contractor's site manager will conduct/oversee these procedures at frequencies required by the equipment manufacturer. Spare parts for field equipment will be obtained from the contractor's supply office or from the equipment manufacturer, as needed. Field instruments will be checked and calibrated daily before use. Calibration checks will be documented in the field logbook. Critical spare parts

such as tape, pH probes, and batteries will be kept on-site to reduce downtime. Backup instruments and equipment will be available on-site or within one day shipment to avoid delays in the field schedule.

All laboratory equipment will be tested through a contract analytical laboratory or the rental equipment supplier. Testing, inspection, and maintenance will be according to the laboratory's QAP, which will be reviewed by the Navy and the Contractor's QA manager during contracting process. Preventive maintenance for laboratory equipment is outlined in the laboratory's QAPP.

B.7 Instrument Calibration and Frequency

Equipment used to gather, generate, or measure environmental data will be calibrated within the frequency stipulated by the manufacturer's instructions and/or analytical method in such a manner that accuracy and reproducibility of results are consistent.

Equipment to be used doing the field sampling will be examined to certify that it is in operating condition. This includes checking the manufacturer's operating manual and the instructions for each instrument to ensure that maintenance requirements are being observed. Field notes from previous sampling trips will be reviewed so that the notation on any prior equipment problems are not overlooked, and all necessary repairs to equipment have been carried out. Preventative measures should be employed so that field equipment is useable. Such preventative measures include procedures such as sending two thermometers or a spare electrode with each pH meter to be used for field measurements.

B.7.1 Field Instrument/Equipment

Calibration of field instruments is governed by the Standard Operating Procedure (SOP) for the applicable field analysis method, and such procedures take precedence over the following general discussion.

Calibration of field instruments will be performed at the intervals specified by the manufacturer or more frequently as conditions dictate. Field instruments will include a pH meter, thermometer, specific conductivity meter, nephelometer/turbidimeter, organic vapor photoionization detector. In the event that an internally calibrated field instrument fails to meet calibration/checkout procedures, it will be returned to the manufacturer for service or replacement. As a rule, instruments will be calibrated daily prior to use.

The linearity of the instrument will be checked by using a 2-point calibration, when applicable, with reference standards bracketing the expected measurement. All the calibration procedures performed will be documented in the field logbook and will include the date/time of calibration, name of person performing the calibration, reference standard used, temperature at which readings were taken and the readings. Multiple readings on one sample or standard, as well as readings on replicate samples, will likewise be documented.

The following paragraphs detail some specific calibration requirements for field instruments.

pH Meter Calibration: The pH meter will be calibrated with standard buffer solutions before being taken to the field. In the field, the meter will be calibrated daily with two buffer solutions before use. The range of the buffer solutions will be at least three or more pH units apart and will bracket the expected pH of the sample being measured.

- Ensure that the temperature of sample and buffer are the same.
- Connect pH electrode into pH meter and turn on pH meter.
- Set temperature setting based on the temperature of buffer; place electrode in first buffer solution.
- After reading has stabilized, adjust "CALIB" knob to display correct value.

- Repeat procedure for second buffer solution.

- Place pH electrode in the sample and record the pH as displayed.

- Remove pH electrode from sample and rinse off with distilled water.

- Recalibrate the pH meter every time it is turned off and turned back on, or if it starts giving erratic results.

The calibrations performed, standard used, and sample pH values are to be recorded in the field notebook. Appropriate new batteries will be purchased and kept with the meters to facilitate immediate replacement in the field as necessary.

Thermometer Calibration: Temperature readings will be taken using thermometers which have been compared to National Institute of Standards and Technology (NIST) traceable thermometer. Prior to use, the thermometers will be inspected to ensure that there is no mercury separation and will be periodically checked in the field. The thermometers used will be calibrated at least semiannually against a NIST traceable reference thermometer by immersing both thermometers in a bath of an expected known temperature such as freezing (0 degrees C) or boiling (100 degrees C) and comparing the reading.

Conductivity Meter Calibration: The conductivity cells of the specific conductivity meter will be cleaned and checked against known conductivity standards before being taken to the field. In the field, the instrument will be checked daily with to NIST or manufacturer traceable reference standards. The calibration procedure is described below.

- Place the probe in the conductivity calibration standard solution.

- Set temperature knob for temperature of standard solution.

- Turn to appropriate scale and set the instrument for the value of calibration standard.

- Rinse off the electrode with distilled water.

- Measure the conductivity for distilled water to be used for a field blank, making sure temperature is set correctly for temperature of solution to be tested.

- If the conductivity of blank (distilled water) is high, it must be discarded and a new blank sample obtained.

All readings and calibrations should be recorded in the field notebook.

Turbidity: A turbidimeter is used in comparing the turbidity of liquids by viewing light through them and how much light is eliminated. The specific calibration procedures are as follows:

- The sample cell is rinsed at least three times with organic free or distilled water.

- The cell is filled with organic free or distilled water and capped. This serves as a blank.

- Excess water and streaks are wiped off the cell with a non-abrasive lint-free paper or cloth.

- The cell is inserted in the instrument (arrow of cell to the front).

- Record the result of the "blank."

- Using manufacturer standards, repeat steps to complete calibration. Record all findings.

Organic Vapor PID: The PID will be calibrated daily with isobutylene span gas of known concentration. All calibrations will consist of introducing gas of known concentration into the monitor at atmospheric pressure. The calibration gases shall be certified by their supplier to be of a specified and known concentration. PIDs should be calibrated each time they are turned on. More frequent calibrations may be conducted based on whether field conditions warrant.

Sample Calibration Forms
Calibration Log — pH Meter:

Model: _____ Date/Time: _____
Serial Number: _____ Checked by: _____

Instrument Checklist:

	YES	NO
Is the instrument clean and in good condition?	____	____
Is the battery charge acceptable?	____	____
Is the liquid crystal display (LCD) functioning properly?	____	____
Is the probe filled with proper solution?	____	____
Are there any visible cracks or problems with the probe?	____	____

Two- or Three-Point Calibration

	Reading	**Lot #**	**Expiration Date**
Buffer 4.0:	_____	_____	_____
Buffer 7.0:	_____	_____	_____
Buffer 10.0:	_____	_____	_____
Initial Slope:	_____		

Remarks:

Calibration Log — Conductivity Meter

Model: _____ Date/Time: _____
Serial Number: _____ Checked by: _____

Instrument Checklist:

	YES	NO
Is the instrument clean and in good condition?	____	____
Is the battery charge acceptable?	____	____
Is the liquid crystal display (LCD) functioning properly?	____	____
Is the conductivity cell clean?	____	____
Are there any visible cracks or problems with the probe?	____	____

Conductivity Calibration Standards:

Source:_____ Date of Receipt:_____ Lot #/Expiration: _____

Two-Point Calibration

		NIST Lot #
100 μmhos/cm Solution:	_____	_____
1000 μmhos/cm Solution:	_____	_____

Temperature: _____ Instrument internal calibration: _____

Remarks:

Laboratory Instruments

The analytical laboratory will perform instrument calibrations and QC operations as stipulated in the USEPA analytical methods. Calibration procedures for a specific laboratory instrument will consist of initial calibration (3 or 5-points), initial calibration verification, and continuing calibration verification. Specific calibration procedure and frequencies are specified in the USEPA analytical methods.

Calibration of laboratory equipment will be based on approved written procedures. Records of calibration, repairs, or replacement will be filed and maintained by the designated laboratory personnel performing quality control activities. These records will be filed at the location where the work is performed and may be subject to QA audit. For all instruments,

the laboratory will maintain a factory-trained repair staff with in-house spare parts or will maintain service contracts with vendors.

The records of calibration will be kept as follows:

- If possible, each instrument will have record of calibration permanently affixed with an assigned record number.

- A label will be affixed to each instrument showing description, manufacturer, model numbers, date of last calibration, by whom calibrated (signature), and due date of next calibration reports and compensation or correction figures will be maintained with instrument.

- A written stepwise calibration procedure will be available for each piece of test and measurement equipment.

- Any instrument that is not calibrated to within the manufacturer's original specification will display a warning tag to alert that analyst that the device carrier only a "Limited Calibration."

In all cases where analyses are conducted according to CLP and SW-846 protocols, the calibration procedures and frequencies specified in methods will be followed exactly. Adherence to proper calibration procedures may be determined by the project QA Manager during data review.

B.8 Inspection/Acceptance Requirements for Supplies and Consumables

No special inspection or acceptance requirements are needed for the sampling outlined in this QAPP. The Contractor's Quality Assurance Manager will ensure that all sample containers

have been provided by the contract laboratory. If available, all quality assurance documentation for sample containers provided by the manufacturer will be collected and placed in the project files. The Contractor's Site Manager will inspect and accept project supplies and consumables. The identification number, data received, data opened, date tested (if performed), data to be retested (if applicable), and the expiration date will be recorded in the field log book.

B.9 Data Acquisition Requirements

No data is anticipated be used from other sources.

B.10 Data Management

Data will be managed in accordance with USEPA Region 2's CERCLA Quality Assurance Manual. This section describes the methods to be used throughout the investigation to document field work and manage collected data. Data will be managed by using the standard forms presented in this QAPP.

B.10.1 Field Documentation

The Site Supervisor will be thoroughly familiar with appropriate documentation procedures. The manager will perform or directly oversee investigation documentation. Documentation tasks will be performed on a sample-by-sample or item-by-item basis throughout the day. Sample container labels and chain-of-custody forms will be prepared as completely as possible in advance.

General Field Documentation Procedures

- Complete all documentation in waterproof black or blue ink.
- Mark through corrections with a single line, then date and initial the correction.
- Do not destroy or discard serialized documents, even if they are illegible or inaccurate.
- Maintain voided entries within project files.

Field documentation includes a master site logbook, one or more site-specific field logbooks, field forms, photographs, sample labels, and chain-of-custody records. Detailed data can be recorded in various field logbooks and/or forms and cross-referenced in the site logbook.

Logbooks: Master site and field logbooks provide a daily handwritten record of all field activities at an investigation site. All logbooks must be permanently bound and have a hard cover. The master site logbook is a record of all site activities, and entries are usually made at the end of each work day. Field logbooks contain detailed daily records kept in real time. A field logbook will be assigned to each field activity conducted during the investigation. In addition, a sample logbook will detail sample collection each day.

Master Site Logbooks: The master site logbook chronicles each day's field investigation activities in less detail than the field logbook. Site conditions and activities are referenced to field logbooks and forms for specific information.

The field project manager completes the master site logbook and signs and dates the end of each page. Pages should not be removed and, in addition, partially used pages should be lined through to prevent data entry at a later date. The front of the master site logbook should include project name and number, subcontractor name, service client, contract number, and dates of use. The logbook should also contain the following:

- List of all field logbooks and brief outline of content requirements.
- Daily temperature, weather conditions, and names and titles of personnel present.
- Levels of PPE and any changes if required.
- Name, title, organization, and purpose of any site visitors.
- Brief outline of site activities and references to appropriate logbook.
- Specific comments on problems, their resolutions, and their impact on the investigation.
- Any changes and supporting rationale.

- Brief record of all telephone calls and their effect on the investigation.
- Instrument calibration; name(s) of personnel who performed daily calibration.

Field Logbook: The cover of each field logbook must include the information provided on the cover of the site logbook. In addition, the cover must list the assigned specific area. Entries in the field logbook must be made using military time and signed by the responsible person at the bottom of each page. Unused pages or portions of pages not used must be lined out to prevent entry of additional information at a later date. Backup copies of field logbooks will be made regularly. Field logbooks will also include the following information:

- Task beginning and end time.
- Weather conditions.
- Names, titles, and organizations of personnel performing specific tasks.
- Description of level of PPE and any changes.
- Detailed descriptions of site activities and forms used in the process.
- Description of specific field tests and results.
- Detailed description of samples and any associated QC measures.
- List of equipment type and decontamination procedures (including time allotted).
- Record of instrument calibration; explain failures and briefly describe repairs and/or replacements.

Sample Logbook: A record of samples collected and shipped (including QA/QC samples), analyses requested, the airbill number of the shipment, and any pertinent information concerning sample status will be compiled in a sample logbook.

Field Data Record Forms: Subsurface boring logs, monitoring well construction diagrams, monitoring well development forms, sample records, and other forms will be used during the investigation. Blank spaces will not be left on completed forms. If information on a form

does not apply, the space will be marked "N/A." Forms will completed in the field as the task is performed. Forms will be copied regularly for backup. Field forms are discussed below:

Sample Labels

Cross-reference information in a field logbook (see Section B.3.1).

COC Records

(See Section B.3.3)

Subsurface Boring Logs

Soil boring logs will be maintained by a qualified geologist. Subsurface boring logs will be completed as the boring is advanced. Materials encountered, depth to water, obvious contamination, and any other necessary information will be recorded on the boring logs.

Monitoring Well Construction Diagrams

A monitoring well construction diagram will summarize the monitoring well construction. Well location, date drilled, drilling method, well depth, screen location, and general construction data will be included on the diagram. A general log will also be recorded in the field logbook as a cross-reference.

Photographs

Photographs will be taken of pertinent field activities as directed by the Site Supervisor. Information to be recorded in the field logbook will include:

- Date, time, location, and name of photographer.
- Description of photograph and orientation.
- Number of photographs on film roll.

After the film is developed, this information will be written on the back of each photograph.

B.10.2 Laboratory Data Deliverables

The laboratory shall perform definitive analysis in support of this project. Data will be submitted to assess precision and accuracy of the laboratory tests. The information to be provided by the laboratory is discussed in Section A.9.2

B.10.3 Other Related Data

Other related data will include illustrations, graphs, meeting summaries, audit reports, and laboratory results. This information will be compiled and reviewed for report presentation.

Meeting Summaries, Telephone Conversations, and Notes: These items will be recorded in the field logbooks along with the dates, time, and names of people involved. If requested, this information will be available for photocopying. Meetings and conversations with substantial impacts on the project will be described in a memorandum or a documented phone call to the project manager.

Illustrations, Computations, and Engineering Data: Original illustrations and graphics will be initialed and dated by the person originating the document. A second person will check for completeness and accuracy. All maps, calculations, and data will be reported or prepared to accepted standards and confidence levels.

Field Change Request Forms: Field change request forms (see Figure B-8) will be submitted when any deviation from the work plan is required. Generally, these include changes that will

FIELD CHANGE REQUEST

ENSAFE PROJECT NO. FIELD CHANGE NO.

TO _____ LOCATION _____ DATE _____

DESCRIPTION:

REASON FOR CHANGE:

RECOMMENDED DISPOSITION:

FIELD MANAGER(SIGNATURE) DATE

DISPOSITION:

SITE MANAGER DATE

DISTRIBUTION:

ENSAFE PROJECT MANAGER

ENSAFE SITE MANAGER

ENSAFE QUALITY ASSURANCE MANAGER

EPA RPM

OTHERS AS REQUIRED _____

ENSAFE

(800) 588-7962
MEMPHIS, TENNESSEE
ARKANSAS FLORIDA KENTUCKY MICHIGAN MISSISSIPPI
OHIO TENNESSEE TEXAS SOUTH CAROLINA
VIRGINIA SLOVAKIA

FIGURE B-8
AFTWF, VIEQUES, PR
FIELD CHANGE REQUEST FORM

DWG DATE: 01/09/02 | DWG NAME: 5901G051

(1) harm data quality, (2) change the cost field activities, (3) alter the scope of field activities, or (4) significantly delay the schedule.

Specific changes include:

- Number of wells.
- Number of sampling points.
- Decontamination procedures.
- Drilling method or well construction design.
- Sampling methodology.

Information should include the nature of the change, appropriate rationale, and date it will be implemented. These forms will be submitted to all parties on the QAPP distribution list.

B.10.4 Data Handling

The Contractor must employ a systematic approach to data management which saves time, money, reduces transcription errors, and decreases hard copy analytical data to a more manageable level in accordance with the Paper Reduction Act and applicable Office of Information and Resource Management requirements.

During sample collection, chain-of custodies may be produced electronically, if the equipment is available, and printed out for insertion into sample coolers. Electronic chain-of-custodies produced in the field reduce transcription errors and are easier to read than hand-written forms. In addition, sample information may be simultaneously loaded into a database, which may be accessed to keep track of sample delivery dates.

After the samples are analyzed, the laboratory may produce electronic analytical data files. The electronic files may be submitted with the hardcopy data and loaded into a database. The database should be checked for completeness/correctness against the hardcopy data. During

validation, qualifiers may be applied directly into the database by data reviewers. The database should have menu-driven data searching capabilities which allows users to query for various functions including chemicals found above site-specific action levels. In addition, the data may be directly downloaded into other application programs such as GIS, GIS/KEY, Excel, QuattroPro, Lotus, etc., for subsequent interpretation, map preparation, risk assessment, and report preparation. After project-completion, the database can also serve as an archive for analytical data for future reference.

B.10.5 Record Storage and Retrieval

All records which constitute evidence relevant to sampling and analysis activities as described in this QAPP will be maintained by the Navy or its designee. Records will be maintained for a minimum of 7 years after the final report for this investigation is submitted. The final evidence file will be held in a central repository. It will include all relevant records, reports, logs, field books, pictures, subcontractor reports, correspondence, and data reviews. The location will be secured, with limited access.

C ASSESSMENT/OVERSIGHT

C.1 Assessments and Response Actions

Audits may be conducted by the QA Manager or his designee during field activities to evaluate the performance of the entire measurement and reporting system. Parameters included in the system are well installation, sampling (data collection), laboratory analysis, and attendant QC activities.

C.1.1 Technical Systems and Surveillance Audit

The QA manager or his designee will routinely evaluate the performance of field personnel and general field operations. The QA manager will document whether field personnel perform procedures in compliance with QAPP protocols; he will have the authority to issue of stop work orders until deficiencies are corrected. Results of field audits will be submitted to the Contractor Project Manger.

C.1.2 Laboratory Systems Audit

Laboratories routinely undergo two types of audits: internal and external. The internal audit is performed by the laboratory's QA officer. External audits are carried out throughout the year by various federal and state certifying agencies. Audits are conducted to ensure that systems and operational capability are maintained. They also verify that quality control measures are being followed as specified in the analytical methods, laboratory written standard operating procedures, and laboratory quality assurance plan.

C.1.3 Performance Evaluation Audit

A performance evaluation (PE) audit is performed to evaluate a laboratory's ability to obtain accurate and precise results by a specific analytical method for samples containing known analyte concentrations. These PE audits may include submission of blind spiked check or PE samples for analysis of the parameters in question. Blind PE samples are submitted to

the laboratory as field samples to ensure that they are treated the same as field samples. PE samples may also be submitted as obvious (known) check samples, which are USEPA or National Bureau of Standards (NBS) traceable. USEPA, the Navy, or their designees may conduct a performance evaluation audit.

C.1.4 Regulatory Audits

It is understood that field personnel and subcontract laboratories are also subject to quality assurance audits by USEPA regulatory agencies. The Contractor will incorporate the results of regulatory QA/QC evaluation, and may consider action based solely on those results.

C.1.5 Corrective Actions

During the sampling, field personnel are responsible for seeing that field instruments are functioning properly and that work progresses satisfactorily. Field personnel are also responsible for performing routine preventive maintenance and quality control procedures, thereby helping ensure collection of valid field data.

If a problem is detected by field personnel, the Quality Assurance Manager shall be notified immediately, at which time corrective action will begin. Similarly, if a problem is identified during an audit by the project or regulatory Quality Assurance Manager, an immediate investigation will be undertaken and whatever corrective action deemed necessary will be taken as early as possible. Samples or analyses that do not meet quality control or quality assurance criteria may be resampled, re-analyzed, or the analysis reviewed by the Navy or its designee. The site manager is responsible for initiating field investigation rework. The Quality Assurance Manager will document cases of noncompliance with criteria, and assure that the corrective action is implemented and recorded.

If corrective action is required by the analytical laboratory, the action should be conducted in accordance with the laboratory's quality assurance program and the corrective action process outlined in the laboratory's QAP, following the guidelines provided in the laboratory's analytical methods. The necessity for corrective action is determined after the data have been evaluated.

If data completeness and representativeness have met project objectives, no corrective action will be taken. For data considered grossly deficient compared to project objectives, corrective action may include re-evaluation for limited exclusion or resampling.

C.2 Reports to Management

Once the project is complete and the resulting data obtained, a final project report will be prepared. The report will include a summary of the activities performed during the investigation and the resulting data (along with any statements about problems concerning data quality). The results will be screened against human health and ecological benchmarks, and a risk assessment will be performed, if needed. The report will be forwarded to the Navy, USEPA, and the Puerto Rico Environmental Quality Board.

D DATA VALIDATION AND USABILITY

The laboratory procedures for data reduction and reporting are included in the laboratory QAP and Standard Operating Procedures. Data reduction and reporting by the laboratory will meet the criteria needed for data validation. The following sections describe the data review, validation and verification requirements, and reconciliation of anomalous data

D.1 Data Review, Validation, and Verification Requirements

Data validation is the systematic and independent verification of data quality. It is performed independent of the laboratory. The purpose of data validation is to verify that the QC requirements of the data set have been met.

The laboratory QA/QC data necessary for validation must be submitted with analytical data packages. Sampling and analytical documentation is required of data packages to validate data quality. It should include an organized summary of the final results, a copy of the signed chain-of-custody for each sample, and all quality control documentation, including a report case narrative that explains any QA/QC or analysis problems encountered and any corrective actions taken. Section A.9.2 describes specific data deliverables that will be submitted for validation.

D.1.1 Analytical Data

The analytical data package will be validated by the project QA officer or designee. The validation steps will be performed by applying, where applicable, the USEPA Contract Laboratory Program, *National Functional Guidelines for Organic Data Review,* February 1994 and Region 2 CLP Worksheets for data review. For the non-CLP methods being performed for explosives, EPA precision and accuracy statements for the analytical methods employed will be used in conjunction with the data validation guidelines. Data validation will

Data validation will be accomplished through a series of checks and reviews that are intended to assure that the reported results are of a verifiable and acceptable quality.

D.1.2 Field Data

All fieldwork will be conducted or supervised by EnSafe personnel to ensure that proper procedures are followed. Field records will be kept of all activities that take place during the sampling program and these records will be maintained by the contractor. These records will document any obstacles encountered during the sampling program.

Procedures to evaluate field data for this project primarily include checking for transcription errors and review of field log books, on the part of field crew members. This task will be the responsibility of the Project Manager or designee, who will otherwise not participate in making any of the field measurements, or in adding notes, data or other information to the log book.

The field data package, including all field records and measurements obtained at the site by EnSafe sampling personnel, will be reviewed for completeness and accuracy by reviewing field logbooks and forms for completeness.

All fieldwork will be conducted to ensure that proper procedures are followed. Field records will be kept of all activities that take place during the sampling program and these records will be maintained by the Contractor. These records will document any obstacles encountered during the sampling program.

Procedures to evaluate field data for this project primarily include checking for transcription errors and review of field log books and forms, on the part of field crew members. This task will be the responsibility of the Project Manager or designee, who will otherwise not participate in making any of the field measurements, or in adding notes, data or other information to the log book or forms.

The field data package, including all field records and measurements obtained at the site by sampling personnel, will be reviewed for completeness and accuracy by conducting the following:

- A review of field logbooks for completeness.
- A review of field data on water and soil/sediment sampling logs for completeness.
- A verification that rinsate blanks and trip blanks were properly prepared, identified, and analyzed.
- A check on field analyses for equipment calibration and condition.
- A review of chain-of-custody forms for proper completion, signatures of field personnel and the laboratory sample custodian, and dates. A review of field data on water and soil/sediment sampling logs for completeness.
- A verification that rinsate blanks and trip blanks were properly prepared, identified, and analyzed.
- A check on field analyses for equipment calibration and condition.
- A review of chain-of-custody forms for proper completion, signatures of field personnel and the laboratory sample custodian, and dates.

D.2 Validation and Verification Methods

The analytical data deliverables, defined earlier in the QAPP, will be validated by the project QA manager or his designee. The validator will conduct a systematic review of the data for compliance with the established QC criteria based on the spike, duplicate, and blank results provided by the laboratory. Essentially, all technical holding times shall be reviewed, results of all blanks (laboratory, field, rinsate, trip), surrogate spikes, and batch matrix spikes/matrix spike duplicates.

The data review will identify any out-of-control data points and data omissions and interact with the laboratory to correct data deficiencies. Decisions to repeat sample collection and analyses may be made by the Project Manager based on the extent of the deficiencies and their importance in the overall context of the project.

The laboratory will provide data in a computerized in a format organized to facilitate data review and evaluation. The computerized data set will include the data flags provided by the laboratory. Upon validation, additional flags will be added to represent comments of the data reviewer. The laboratory-provided data flags will include such items as: 1) concentration below required detection limit, 2) estimated concentration due to poor spike recovery, and 3) concentration of chemical also found in laboratory bank. The data reviewer flags will indicate that the data are: 1) usable as a quantitative concentration, 2) usable with caution as an estimated concentration, or 3) unusable due to out-of-control QC results.

All QC summary forms summarizing this information will be checked as well. The overall completeness of the data package will also be evaluated by the data validator. Completeness checks will be administered on all data to determine whether deliverables specified in the QAPP are present.

Analytical Data Quality

Analytical data quality is assured through the use of the USEPA guidelines for QA/QC as set forth in the specific analytical methods. The laboratory will perform checks to verify that results are generated according to the method protocols. The laboratory checks will include verification that all results and QC elements are properly measured, documented, and reported. The project QA manager will validate the quality of the laboratory deliverables.

The analytical data package will be evaluated by the QA Manager or designee. The evaluation will be performed, where applicable, according to the USEPA Contract Laboratory Program, *National Functional Guidelines for Organic Data Review* (Functional Guidelines; February 1994) and Region 2 data evaluation guidelines and worksheets, where applicable for the analytical method. Data validation guidelines will be used as a guide for data evaluation because estimated data qualifiers indicating bias will not be assigned to analytical results. Data evaluation is accomplished through a series of checks and reviews intended to assure that the reported results are of verifiable and acceptable quality. The analytical data package evaluation procedure includes, but is not limited to:

- Comparison of sampling, sample extraction, and analysis dates to check that samples were extracted and/or analyzed within the proper holding times.

- Review of analytical methods and required detection limits to verify that they agree with the project data quality objectives.

- Evaluation of all blanks (rinsate, field, trip, reagent, method, and extraction blanks) to assess potential cross-contamination.

- Evaluation of surrogate spike and MS/MSD recoveries to assess accuracy.

- Evaluation of duplicate relative percent difference from field and MS/MSDs to assess precision.

- Assessment of data usability.

The possible data flags are:

- R/UR flag: One or more QC parameters grossly exceed control limits; unusable data may not be used for any purpose.

- J flag: Estimated value; one or more QC parameters were outside control limits or the value was detected below the laboratory's quantitation limit.

- U flag: Undetected; the analyte was analyzed but not detected or the analyte was found in an associated blank but at a concentration less than five times (10 times for common laboratory contaminants).

- UJ flag: Undetected and estimated; the analyte was analyzed but not detected and the quantitation limit is estimated because at least one QC parameters was outside control limits.

- D flag: Diluted result; the compound was re-analyzed at a secondary dilution factor. The "D" flag will remain on the value to alert the data user that the value from a secondary dilution was used.

The QA manager (or designee) will resolve problems that arise during data validation and implement corrective measures as needed.

D.3 Reconciliation with User Requirements

Completeness will be evaluated to determine if the completeness goal for this project has been met. If data quality indicators do not meet the project's data quality objectives as outlined in this QAPP, the data may be discarded and resampling may occur. The Quality Assurance Manager will evaluate the cause of the failure (if possible) and decide whether to discard the data and resample. If the failure is tied to the analysis, calibration, and maintenance techniques will be reassessed as identified by the appropriate lab personnel. If the failure is associated with the sample collection and resampling is needed, the samplers will be retrained.