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APPROACH TO DEVELOPMENT OF PETROLEUM CLEANUP GOALS PROTECTIVE OF THE SAN FRANCISCO BAY

NAVAL STATION TREASURE ISLAND
SAN FRANCISCO, CALIFORNIA

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1.0 INTRODUCTION

PRC Environmental Management, Inc. (PRC), received Contract Task Order (CTO) No. 0199 from the U.S. Department of the Navy, Engineering Field Activity West (Navy) under Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract No. N62474-88-D-5086. CTO No. 0199 consists of performing a remedial investigation and feasibility study (RI/FS) at Naval Station Treasure Island (NAVSTA TI), in San Francisco, California. As part of the Phase IIB RI, PRC was tasked to develop cleanup goals for soil and groundwater. This document outlines the approach for developing soil and groundwater cleanup goals for total petroleum hydrocarbons (TPH) at both installation restoration (IR), underground storage tank (UST), and underground fuel line sites at NAVSTA TI.

1.1 APPROACH, PURPOSE, AND APPLICATION

In order to close TPH-contaminated sites under the IR or UST programs, it is necessary to define cleanup goals for TPH-contaminated soil and groundwater that are protective of both human health and the environment (including ecological receptors and groundwater). Since NAVSTA TI groundwater flows to the San Francisco Bay (Bay) and there is limited terrestrial ecological habitat at NAVSTA TI, ecologically based TPH cleanup goals will be developed for both soil and groundwater that are protective of the Bay. The necessity for TPH cleanup goals protective of human health will be determined based on the results of the revised Phase II RI baseline human health risk assessment (BHHRA).

This document outlines the rationale and approach to developing ecologically based TPH cleanup goals for vadose zone soils and groundwater at each site that are protective of the Bay using contaminant fate and transport models. Human-health-based TPH cleanup goals will not be addressed in this document, but will be developed, as necessary, in the revised Phase II RI BHHRA. Ultimately, the TPH cleanup goals will be used to screen TPH-contaminated sites at NAVSTA TI for closure, long-term monitoring, or corrective action. For corrective actions, the cleanup goals will (1) define the extent of remediation that may be required and (2) determine remediation goals for in situ or ex situ treatment of soils and reuse as backfill.

The term cleanup goal is used since the calculated levels protective of the Bay may not be economically

or technically achievable. The technical and economical feasibility of achieving the cleanup goals will be determined by a feasibility analysis in conjunction with development of the cleanup goals.

1.2 REPORT ORGANIZATION

The remaining sections of this document provide a description of the following:

- Section 2.0, Relevant NAVSTA TI Background, summarizes the geology and hydrogeology, TPH-contaminated sites, and previous ecological risk assessment at NAVSTA TI.
- Section 3.0, Proposed Approach, discusses the proposed approach to develop TPH cleanup goals and the proposed unsaturated and saturated contaminant fate and transport models.
- Section 4.0, Future Activities, describes the future activities, submittals, and schedule associated with development of TPH cleanup goals for NAVSTA TI.

2.0 RELEVANT NAVSTA TI BACKGROUND

NAVSTA TI comprises two connected islands in the Bay: Treasure Island (TI) and Yerba Buena Island (YBI). NAVSTA TI, in this document, refers to the entire naval station (that is, all of TI and most of YBI). TI is a man-made island, constructed of fill material, and YBI is a natural island. The following sections summarize NAVSTA TI background information pertinent to selecting developing cleanup goals, including the geology and hydrogeology, TPH-contaminated sites, and previous ecological risk assessments at NAVSTA TI.

2.1 GEOLOGY AND HYDROGEOLOGY

The following sections summarize the geology of NAVSTA TI and the Bay sediments (the source of the fill used to build TI), as well as the hydrogeology of NAVSTA TI.

2.1.1 Bay Sediments Geology

This section summarizes the geology of Bay sediments, the source of the TI fill. Bay sediments are primarily alluvial deposits classified as Older Bay Mud Formation, sand deposits, and Younger Bay Mud Formation. The Older Bay Mud Formation is composed of firm clay with varying amounts of silt, sand, and gravel. The upper portion of the Older Bay Mud is interfingered with sand layers. Sand deposits are generally localized units of fine sand that grade into a sandy silt and clayey sandy clay. The sand deposits may or may not be covered with Younger Bay Mud. Where present, the Younger Bay Mud Formation overlies the Older Bay Mud and sand deposits, and consists of soft, plastic, silty clay or clayey silt with minor organic material and clayey fine sand (U.S. Army Corps of Engineers [USACE] 1979). Bay sediments of varying thicknesses are distributed naturally throughout the Bay.

Clayey sediments were generally avoided during dredging operations to generate fill for TI. Sources of the sand used for fill material for TI include both sand deposits as shoals on the Bay floor and sand deposits beneath a cover of Younger Bay Mud. Sand deposits on the Bay floor occur in and adjacent to existing current channels throughout the bay (Goldman 1969).

2.1.2 Treasure Island Geology

TI is a man-made island, approximately 445 acres, consisting primarily of sand sediments dredged from the Bay. Dredging and construction of the island began in 1936 and was completed in 1937. The island was constructed on the Yerba Buena Shoals, a sand spit extending north and northwest of YBI. Underlying the Yerba Buena Shoals is a soft bay mud deposit, which overlies a former channel of Temescal Creek. The estimated depth of the former channel is 95 feet below mean sea level (msl). During an earlier geologic period, Temescal Creek was a major drainage for the East Bay hills (Lee 1969).

The sediments used for construction of TI consisted primarily of fine- to medium-grained sand with lesser amounts of silt, clay, and gravel. Based on the depth of the Yerba Buena Shoals and the average elevation at TI of 10 feet above msl, the fill thickness at TI ranges from 16 feet in the southwest corner to more than 28 feet in the northeast corner. Soon after the fill was placed, more than 100 soil borings were drilled to a maximum depth of 10 feet to establish the nature of the fill. The fill consists of

layered dredge sand with frequent shell fragments and occasional clay nodules. The sand is predominantly fine-grained with small localized areas of medium to coarse sand and some gravel. Thin beds of clay remain that settled out in isolated pools of muddy water during dredging operations. The clay nodules represent fragments of cohesive or semicohesive material derived from clay beds within the sediment, excavated by dredging and rounded as they passed through the delivery pipe line (Lee 1969). Soil borings performed during the Phase I RI confirmed these descriptions of fill material (PRC 1993a).

2.1.3 Treasure Island Hydrogeology

Groundwater at TI is under unconfined conditions at an average depth of approximately 5 feet below ground surface (bgs). Groundwater flows radially from the center of the island toward the bay at an average gradient of 0.004 feet/foot. Groundwater recharge occurs primarily from infiltration of precipitation, with some contribution from landscape irrigation and leaking storm drains (PRC 1993a).

2.1.4 Yerba Buena Island Geology

YBI is a natural island, approximately 130 acres, consisting of four geologic units: landslide debris, artificial fill, the Colma Formation, and the Franciscan Assemblage. The youngest geologic unit at YBI is landslide debris resulting from the downslope movement of unstable clayey, silty sand. Small landslide areas can be found at various locations on YBI, with the largest area on the north side. Artificial fill is present along the eastern shoreline of YBI, overlying a former marsh area that presumably consisted of Younger Bay Mud.

The Colma Formation consists of fine- to medium-grained marine sand with minor amounts of sandy silt, clay, and gravel interbeds. Exposed over approximately 70 percent of the island, the Colma Formation varies in thickness from a few inches to several feet (Blake and others 1974). In a conflicting interpretation, a U.S. Geological Survey report identified this unconsolidated material as colluvium derived from the Franciscan Assemblage rather than a marine sand (Radbruch 1957).

Resistant sandstone and shale of the Franciscan Assemblage form the bedrock that unconformably underlies the landslide debris, artificial fill, and Colma Formation of YBI. Although the Franciscan

Assemblage is a melange of several sedimentary and metamorphic rock types, it appears consistent in structure and composition at YBI. Shale and sandstone outcrops of the Franciscan Assemblage at YBI generally trend southeast-northwest and dip northeast (Dames and Moore 1988).

2.1.5 Yerba Buena Island Hydrogeology

The Franciscan bedrock is relatively impervious with the exception of localized fracturing. As a result, the bedrock is a boundary to groundwater flow (Blum 1993; Phillips 1992). Before the development of YBI, there were small springs on the north slope of the island. The probable origin of the springs was precipitation that infiltrated down through the permeable Colma Formation to the impervious Franciscan bedrock, flowed along the bedrock, and outcropped at the exposed interface between the colluvium and bedrock (Dames and Moore 1949). The majority of precipitation on YBI is now collected on the surface of roads and other improved areas and drained artificially. Consequently, the small springs no longer occur on YBI.

During geotechnical and environmental investigations at YBI, amounts of groundwater sufficient for potential beneficial uses (potential yields greater than 200 gallons per day) were not present on YBI except at Site 11 - YBI Landfill. Currently, the only groundwater monitoring wells on YBI are located in the fill material at and surrounding Site 11. In the area of Site 11, groundwater characteristics are similar to those of TI. Groundwater at Site 11 flows south toward the bay at a gradient of 0.003 feet/foot. Groundwater recharge at Site 11 is primarily from infiltration of precipitation, with some contribution from landscape irrigation and leaking storm drains (PRC 1993a).

2.2 NAVSTA TI TPH-CONTAMINATED SITES

The following sections briefly describe the primary TPH-contaminated sites at NAVSTA TI for which the cleanup levels may apply.

2.2.1 TPH-Contaminated IR Sites

The following briefly describes the primary TPH-contaminated IR sites at NAVSTA TI for which the cleanup levels may apply.

- **Site 04 - Hydraulic Training School** was used to store approximately fifteen 55-gallon drums of waste oil (such as transmission oil). Polynuclear aromatic hydrocarbons (PAH) and TPH were detected in soils.

- **Site 06 - Fire Training School** was used for approximately 46 years. Four USTs, an oil/water separator, and four concrete pits are located at the site. All four of the USTs have been removed. TPH-diesel, TPH-gasoline, benzene, toluene, ethylbenzene, xylene (BTEX), and semivolatile organic compounds were detected in soil and groundwater at the site. Floating product was periodically observed in monitoring wells and is currently present in only one well.

- **Site 11 - Yerba Buena Island Landfill** was used as a landfill for an unknown period of time. TPH-diesel, pesticides, herbicides, PAHs, and metals were detected in soils, and TPH-diesel was detected in groundwater.

- **Site 12 - Old Bunker Area** consisted of ammunition bunkers with trench type disposal areas surrounding the bunkers as well as general debris disposal areas. This site is now the location of military housing. TPH-diesel and TPH-gasoline were detected in soils.

- **Site 14 - New Fuel Farm** is the primary storage and distribution area for gasoline, oils, and fuels at NAVSTA TI. Contamination at this site results from various tank and pipeline leaks and sludge disposal practices occurring since 1943. TPH-diesel was detected in soil, and TPH-diesel and BTEX were detected in groundwater. Floating product was periodically detected in piezometers, but is not currently present.

- **Site 17 - Tanks 103 and 104** are each 200,000-gallon diesel fuel storage tanks. An estimated 20,000 gallons of diesel fuel was released from the tanks onto the then unpaved ground. TPH-diesel, PAHs, and volatile organic compounds were detected in soils.

- **Site 20 - Auto Hobby Shop** has been used for steam cleaning and degreasing vehicles as well as for storage of hydraulic fluid and recycled oil. TPH-diesel was detected in soil.

- **Site 21 - Vessel Waste Oil Recovery Area** was an on-shore oil/water separation facility that now consists of five aboveground tanks with a capacity of 2,000 gallons each. The potential exists for contamination of offshore sediments from spills, and onshore soils may be contaminated from releases from the separation system. TPH-diesel was detected in soils at the site.

- **Site 22 - Navy Exchange Service Station** has a pump island that is served by seven aboveground storage tanks at the New Fuel Farm (IR Site 14). Six USTs have been removed (USTs 330A through 330F). TPH-diesel, TPH-gasoline, BTEX, and PAHs have been detected in soil and groundwater at the site.

- **Site 25 - Seaplane Maintenance Area** consists of three buildings that were used for storing and maintaining the seaplanes. Waste liquids or solvents from engine cleaning

may have been disposed of directly to the ground surface, and several underground gasoline tanks may have been abandoned in place. Three USTs (2A, 2C, and 2D) have been removed, and the UST sites have been transferred to the IR program. TPH-diesel was detected in soils, and TPH-diesel, BTEX, and PAHs were detected in groundwater at the site.

2.2.2 Other TPH-Contaminated Sites

In addition to the IR sites, there are several TPH-contaminated UST and fuel line sites at NAVSTA TI for which the cleanup levels may be applied. The majority of USTs at NAVSTA TI have been removed and have undergone characterization for potential corrective action. The fuel lines at NAVSTA TI are scheduled for removal in 1996.

2.3 PREVIOUS ECOLOGICAL RISK ASSESSMENT

As part of the Phase I RI, a preliminary ecological risk assessment was performed for NAVSTA TI (PRC 1993c). The ecological assessment consisted of an exposure assessment, ecological effect screening, and risk characterization. The ecological risk assessment identified that no terrestrial habitat was present at TI sites. Because the ecological risk assessment was preliminary in nature, ecologically based preliminary remediation goals (PRG) were not developed for NAVSTA TI. In addition, no terrestrial ecological receptors were observed on TI during a site walk conducted by the Base Realignment and Closure (BRAC) Cleanup Team (BCT) on June 3, 1994 (PRC 1994a).

3.0 CLEANUP GOAL APPROACH

The following sections describe the regulatory framework, approach to developing the cleanup goals, and the proposed models used to develop the cleanup goals.

3.1 REGULATORY FRAMEWORK

The following sections describe the regulatory requirements for cleanup goals, surface water quality standards, and approaches to developing TPH cleanup goals on a constituent or mixture basis.

3.1.1 Requirement For Cleanup Goals

To close TPH-contaminated sites under the IR or UST program, State regulations require defining cleanup goals for TPH-contaminated soil and groundwater as follows:

- **California UST Regulations** indicate that, "for waters with current or potential beneficial uses for which no numerical objectives have been designated in water quality control plans, the responsible party shall recommend target cleanup levels for long-term corrective actions to the regulatory agency for concurrence (California Code of Regulations [CCR] 1994)."
- **Water Quality Control Plan for the San Francisco Bay Basin** (Basin Plan) indicates, "for soil cleanup levels above background, the fate and transport of leachate can be modeled by the discharger using site-specific factors and appropriate models. Reasonable assumptions for minimal leachate dilution, as proposed by the discharger, may be considered by the Regional Board." For groundwater cleanup levels, the Basin Plan indicates, "proposed final cleanup levels are based on a discharger developed feasibility study of cleanup alternatives that compares cost, time to achieve cleanup standards, and a risk assessment to determine impacts on beneficial uses, human health, and the environment. Cleanup levels must also take into account the mobility, toxicity, and volume of pollutants (California Regional Water Quality Control Board [CRWQCB], San Francisco Bay Region 1995)."

3.1.2 Existing Surface Water Quality Standards

There are several sources of numerical surface water quality standards protective of aquatic life for TPH constituents, including the Basin Plan (CRWQCB 1995), the California Ocean Plan (California

State Water Resources Control Board [SWRCB] 1990), and the National Ambient Water Quality Criteria (45 Federal Register [FR] 1980). The following table summarizes these surface water quality standards.

SURFACE WATER QUALITY STANDARDS

Concentrations in μg/L

Constituent	Basin Plan[a]	California Ocean Plan[b]	National Ambient Water Quality Criteria[c]	
			acute	chronic
Benzene	--[d]	5.9	5,100	700
Ethylbenzene	--	4,100	430	--
Toluene	--	85,000	6,300	5,000
Xylene	--	--	--	--
Naphthalene	--	--	2,350	--
Total PAHs	15	--	300	--

Notes:

a Basin Plan Table III-3, Water Quality Objectives for Toxic Pollutants for Surface Waters With Salinities Greater than 5 ppt (CRWQCB 1995)

b California Ocean Plan Chapter IV(SWRCB 1990)

c National Ambient Water Quality Criteria (45 FR 1980)

d No standard established

In addition to the above numerical standards for TPH constituents in surface water, the Basin Plan also provides a general surface water objective for acute and chronic toxicity to aquatic organisms in ambient waters. Acute toxicity is defined as a median of less than 90 percent survival and less than 70 percent survival 10 percent of the time for test organisms in a 96-hour static or continuous flow test. Chronic toxicity generally results from exposures to pollutants exceeding 96 hours. Compliance with chronic toxicity can be evaluated using the bioassay methods (CRWQCB 1995).

3.1.3 Constituent or Mixture Approach

Based on the regulatory framework and discussions with the BCT, TPH cleanup goals will be developed for individual TPH constituents or TPH as a whole, as follows:

- Cleanup goals can be developed on a constituent basis using existing surface water quality standards.
- Cleanup goals can be developed for TPH as a whole values based on site-specific fuel toxicity testing (bioassays).

Consequently, either individual TPH constituents or TPH as a whole will be modeled to develop ecologically based TPH cleanup goals that are protective of the Bay. The decision to model TPH as a whole or on a constituent basis will be determined and documented based on further research by the Navy and in consultation with the BCT.

3.2 PROPOSED MODELING APPROACH

The objective of the fate and transport modeling effort is to determine ecologically based TPH cleanup goals for soil and groundwater that are protective of the Bay. The proposed approach is based on a pathway of contaminant leaching from vadose zone soils to the groundwater which eventually flows to the Bay, as follows:

Vadose Zone Soils

⇓

⇓ **(leaching)**

⇓

Groundwater ⇒(flow and transport)⇒ Surface Water (Bay)

The pathway will be modeled based on a simple conceptual model that groundwater flow between an individual site and the nearest shoreline is one-dimensional and uniform. Fate and transport models are used for establishing site-specific TPH cleanup goals by determining dilution attenuation factor (DAF) values and conversion of the allowable leachate concentrations in the groundwater to soil values at the source. Simulation of vadose zone and groundwater contaminant transport and attenuation in saturated zone requires the use of two separate models:

- Contaminant fate and transport model for saturated groundwater flow (groundwater transport model)
- Contaminant leaching model for vadose zone soils (soil leachate model)

The models will be applied as follows:

- **Groundwater transport model:** Using the shoreline as the boundary for the nearest potential ecological receptor and assigning a shoreline concentration equal to either the constituent surface water quality standard or TPH values based on site-specific fuel toxicity testing (hereafter referred to as the Bay water quality goal), the groundwater transport model will be applied to back calculate a constituent or TPH concentration in groundwater beneath the site that will not exceed the Bay water quality goal. This model will estimate the groundwater cleanup goals for each site.
- **Soil leachate model:** Subsequently, a soil leachate model will be applied to determine a TPH or constituent concentration in soil that will not leach to the Bay in concentrations exceeding the Bay water quality goal. Specifically, the soil leachate model will determine a constituent or TPH concentration for vadose zone soils that will not exceed the TPH concentrations in groundwater beneath the site as determined by the groundwater model (groundwater cleanup goals). This model will estimate the soil cleanup goals for each site.

3.3 PROPOSED MODELS

To perform the modeling in developing cleanup goals, the Navy proposes to use Analytical Transient 1-, 2-, and 3-Dimensional model (AT123D) and Seasonal Soil Compartment model (SESOIL) to simulate contaminant fate and transport in the saturated and vadose zones, respectively. These models are in the public domain, well documented, and verified.

3.2.1 Groundwater Model - AT123D

AT123D (Yeh 1981) is a collection of analytical solutions for transient one-, two-, or three-dimensional dissolved contaminant transport in a homogeneous water bearing zone with uniform one-dimensional, steady-state flow. AT123D accounts for advection, dispersion, retardation, and first-order decay. Simulation of a variety of source configurations and boundary conditions is possible, and longitudinal as well as horizontal and vertical transverse dispersion can be input independently. The model

calculates concentration distribution in space and time.

AT123D has been extensively tested, peer reviewed, and verified against other analytical and numerical models (EPA 1993). The model is PC-compatible and is available in user-friendly DOS or Windows formats. AT123D simulations can be sensitive to dispersion and partitioning coefficients, and the first order decay constant (biodegradation). The effect of these parameters on the model will be assessed through a sensitivity analysis.

3.2.2 Soil Leachate Model - SESOIL

SESOIL is a finite difference vadose zone numerical model designed for long-term hydrologic and contaminant fate simulations. Elements of the hydrologic cycle included are rainfall, soil moisture variations, infiltration, exfiltration, surface runoff, and evapotranspiration. The contaminant fate cycle simulation takes into account advection, diffusion, volatilization, adsorption and desorption, chemical degradation or decay, biological transformations, hydrolysis, and ion exchange.

The model represents transport of one chemical component through three phases (aqueous, gaseous, and adsorbed), with a fourth pure chemical phase represented as an immobile storage phase. SESOIL creates an output file, which contains monthly results for hydrologic cycle components, contaminant mass distribution, and contaminant concentration distribution for each layer or sublayer. This model generates a link file, which contains contaminant mass-to-ground water leachate quantities entering the aquifer from the vadose zone. This file is commonly used as input to the AT123D model. SESOIL is described as relatively easy to use and having a wide regulatory acceptance (Odencrantz and others 1992). The model is PC-compatible and is available in user-friendly DOS or Windows formats.

3.2.3 Model Parameters

Input parameters for AT123D and SESOIL will be gathered from a variety of site-specific sources. Groundwater velocity and tidal influence parameters were determined by studies performed during the Phase IIA RI. Soil physical parameters (organic carbon, bulk density, porosity, moisture content, grain size distribution, cation exchange capacity, permeability, specific gravity, and void ratio) and contaminant partitioning (leachability) were determined from analyses performed during the Phase IIB

RI. If cleanup goals are determined for individual TPH constituents, results of the Phase IIA RI quarterly groundwater sampling and Phase IIB groundwater sampling will be reviewed to determine the TPH constituents to model for each site. This determination will be based on the TPH constituents present at each site and their known toxicity to potential ecological receptors in the Bay. If cleanup goals are determined for TPH as a whole, site-specific fuel toxicity testing will be necessary.

4.0 FUTURE ACTIVITIES

The cleanup goal development process will consist of the following submittals:

- **Approach:** Initially, the Navy will further discuss the cleanup level approach and proposed models with the BCT prior to performing any modeling activities. To perform the modeling, the Navy will determine, in consultation with the BCT, whether the cleanup goals will be developed for either individual TPH constituents, using surface water quality standards, or TPH as a whole, using site-specific fuel toxicity testing.

- **Cleanup Goal Determination and Feasibility Analysis:** Subsequently, the Navy will perform and document the modeling effort and resulting cleanup goals, including a feasibility analysis addressing the technical and financial feasibility of achieving the cleanup goals.

A tentative schedule is attached for the above submittals.

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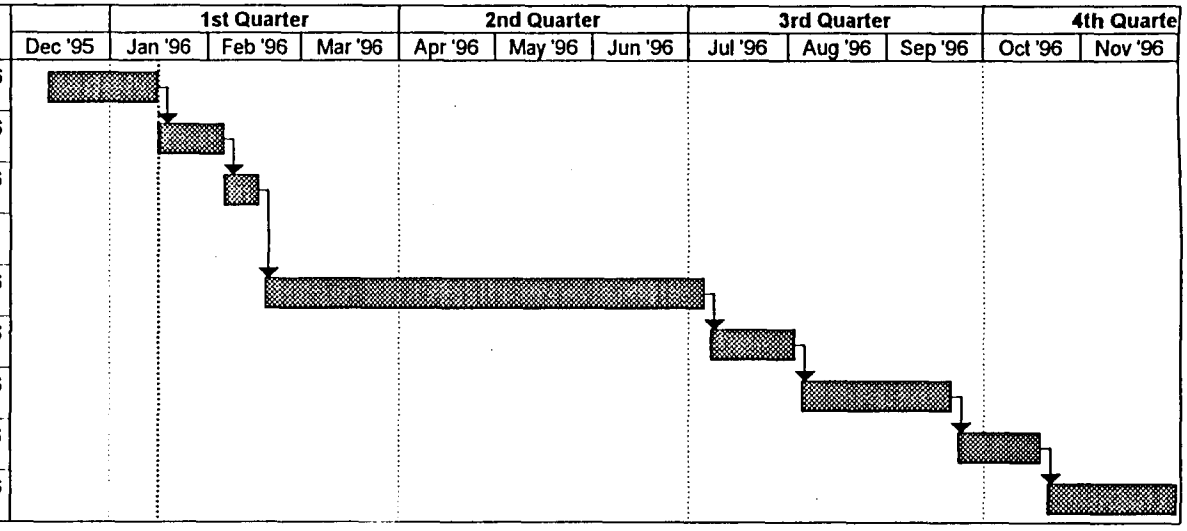
ATTACHMENT

SCHEDULE

TENTATIVE SCHEDULE

DEVELOPMENT OF PETROLEUM CLEANUP GOALS
NAVSTA TI

Task Name	Durati	Start	Finish
Draft Approach	24d	Wed 12/13/95	Mon 1/15/96
BCT Discussion/Meeting	15d	Tue 1/16/96	Mon 2/5/96
Final Approach	9d	Tue 2/6/96	Fri 2/16/96
Draft Cleanup Goals	100d	Mon 2/19/96	Fri 7/5/96
Comments	20d	Mon 7/8/96	Fri 8/2/96
Draft Final Cleanup Goals	35d	Mon 8/5/96	Fri 9/20/96
Comments	20d	Mon 9/23/96	Fri 10/18/96
Final Cleanup Goals	30d	Mon 10/21/96	Fri 11/29/96