N61165.AR.003330
CNC CHARLESTON
5090.3a

CORRECTIVE MEASURES STUDY REPORT AREA OF CONCERN 633 (AOC 633) ZONE G REVISION 1 CNC CHARLESTON SC

7/30/2004

CH2M HILL

CORRECTIVE MEASURES STUDY REPORT

AOC 633, Zone G

Charleston Naval Complex
North Charleston, South Carolina

SUBMITTED TO
U.S. Navy Southern Division
Naval Facilities Engineering Command

CH2M Jones

July 2004

Contract N62467-99-C-0960

CH2MHILL TRANSMITTAL

To: Mr. David Scaturo
South Carolina Department of Health and Environmental Control
Bureau of Land and Waste Management
2600 Bull Street
Columbia, SC 29201

From: Dean Williamson/CH2M-Jones

Date: July 30, 2004

Re: Revision 1 replacement pages for *CMS Report, AOC 633, Zone G, Revision 0* – Submitted on December 23, 2003

We Are Sending You:

X	**Attached**	Under separate cover via	
	Shop Drawings	Documents	Tracings
	Prints	Specifications	Catalogs
	Copy of letter	Other:	

Quantity	Description
2	Revision 1 replacement pages for *CMS Report, AOC 633, Zone G, Revision 0* – Submitted on December 23, 2003

If material received is not as listed, please notify us at once.

Copy To:

Dann Spariosu/USEPA, w/att
Rob Harrell/Navy, w/att
Gary Foster/CH2M HILL, w/att

THE ATTACHED PAGES SHOULD BE INSERTED AS REPLACEMENTS IN THE
CMS REPORT, AOC 633, ZONE G, REVISION 0 SUBMITTAL:

- REVISED COVER AND SPINE
- REVISED INSIDE COVER
- REVISED CERTIFICATION PAGE
- REVISED TABLE OF CONTENTS
- REVISED PAGE 1-9
- REVISED PAGE 3-4
- REVISED SECTION 4.0 TEXT
- REVISED SECTION 5.0 TEXT
- REVISED APPENDIX A
- NEW APPENDIX C RESPONSES TO SCDHEC COMMENTS ON *CMS REPORT, AOC 633, ZONE G, REVISION 0*

CH2M HILL
115 Perimeter Center Place, NE
Suite 700
Atlanta, GA 30346-1278
Tel 770.604.9095
Fax 770.604.9282

CH2MHILL

December 23, 2003

Mr. David Scaturo
South Carolina Department of Health and
Environmental Control
Bureau of Land and Waste Management
2600 Bull Street
Columbia, SC 29201

Re: CMS Report (Revision 0) – AOC 633, Zone G

Dear Mr. Scaturo:

Enclosed please find two copies of the CMS Report (Revision 0) for AOC 633 in Zone G of the Charleston Naval Complex (CNC). This report has been prepared pursuant to agreements by the CNC BRAC Cleanup Team for completing the RCRA Corrective Action process.

Please contact me at 352/335-5877, ext. 2280, if you have any questions or comments.

Sincerely,

CH2M HILL

Dean Williamson, P.E.

cc: Dann Spariosu/USEPA, w/att
Rob Harrell/Navy, w/att
Gary Foster/CH2M HILL, w/att

CORRECTIVE MEASURES STUDY REPORT

AOC 633, Zone G

Charleston Naval Complex
North Charleston, South Carolina

SUBMITTED TO
U.S. Navy Southern Division
Naval Facilities Engineering Command

PREPARED BY
CH2M-Jones

July 2004

Revision 1
Contract N62467-99-C-0960
158814.ZG.EX.03

Certification Page for Corrective Measures Study Report (Revision 1) — AOC 633, Zone G

I, Dean Williamson, certify that this report has been prepared under my direct supervision. The data and information are, to the best of my knowledge, accurate and correct, and the report has been prepared in accordance with current standards of practice for engineering.

South Carolina

P.E. No. 21428

Dean Williamson, P.E.

7/29/2004

Date

Contents

Section		Page
Acronyms and Abbreviations		**vi**
1.0	**Introduction**	**1-1**
1.1	Corrective Measures Study Report Purpose and Scope	1-2
1.2	Background Information	1-2
1.2.1	Facility Description	1-2
1.2.2	Site History	1-3
1.2.3	COC Summary and Extent of Groundwater Contamination	1-3
1.2.4	Summary of Hydrogeologic Setting	1-5
1.3	Overall Approach for Selecting Candidate Corrective Measure Alternatives for AOC 633	1-8
1.4	Report Organization	1-8
Table 1-1	Organic Chemicals Detected in Groundwater at AOC 633	1-10
Figure 1-1	Location of AOC 633 in Zone G within the CNC	1-11
Figure 1-2	Aerial Photograph of AOC 633	1-12
Figure 1-3	Monitoring Well Location	1-13
Figure 1-4	Potentiometric Surface (without GW001), October 2002	1-14
2.0	**Remedial Goal Objectives and Evaluation Criteria**	**2-1**
2.1	Remedial Action Objectives	2-1
2.2	Media Cleanup Standards	2-2
2.3	Evaluation Criteria	2-3
3.0	**Description of Candidate Corrective Measure Alternatives**	**3-1**
3.1	Introduction	3-1
3.2	Alternative 1: Monitored Natural Attenuation With Land Use Controls	3-1
3.2.1	Description of Alternative	3-1
3.2.2	Key Uncertainties	3-3
3.2.3	Other Considerations	3-3
3.3	Alternative 2: Long-term Monitoring with Continued LNAPL Recovery and Land Use Controls	3-3
3.3.1	Description of Alternative	3-3
3.3.2	Key Uncertainties	3-4

Contents, Continued

3.3.3 Other Considerations 3-4

4.0 Evaluation and Comparison of Corrective Measure Alternatives 4-1

4.1 Alternative 1: Monitored Natural Attenuation With Land Use Controls 4-1

4.1.1 Protection of Human Health and the Environment....................4-1

4.1.2 Attain MCS 4-2

4.1.3 Control the Source of Releases....................4-2

4.1.4 Compliance with Applicable Standards for the Management of Generated Wastes 4-2

4.1.5 Other Factors (a) Long-term Reliability and Effectiveness 4-2

4.1.6 Other Factors (b) Reduction in the Toxicity, Mobility, or Volume of Wastes....................

4.1.7 Other Factors (c) Short-term Effectiveness....................4-2

4.1.8 Other Factors (d) Implementability....................4-2

4.1.9 Other Factors (e) Cost....................4-3

4.2 Alternative 2: Long-term Monitoring with Continued LNAPL Recovery and Land Use Controls....................4-3

4.2.1 Protection of Human Health and the Environment....................4-3

4.2.2 Attain MCS 4-4

4.2.3 Control the Source of Releases....................4-4

4.2.4 Compliance with Applicable Standards for the Management of Generated Wastes 4-4

4.2.5 Other Factors (a) Long-term Reliability and Effectiveness 4-4

4.2.6 Other Factors (b) Reduction in the Toxicity, Mobility, or Volume of Wastes....................

4.2.7 Other Factors (c) Short-term Effectiveness....................4-4

4.2.8 Other Factors (d) Implementability....................4-4

4.2.9 Other Factors (e) Cost....................4-4

4.4 Comparative Ranking of Corrective Measure Alternatives 4-5

Table 4-1 Ranking of Corrective Measure Alternatives 4-6

5.0 Recommended Corrective Measure Alternative....................5-1

5.1 Land Use Controls....................5-1

6.0 References 6-1

Contents, Continued

Appendices

A Soil Boring Log and Well Construction Details for Monitoring Well G633GW005 and October 2003 Sampling Results

B Cost Estimates for Corrective Measure Alternatives

C CH2M-Jones' Responses to SCDHEC Comments on *CMS Report, AOC 633, Zone G, Revision 0*

Acronyms and Abbreviations

AOC	area of concern
BRAC	Base Realignment and Closure Act
CA	corrective action
CMS	corrective measures study
CNC	Charleston Naval Complex
COC	chemical of concern
COPC	chemical of potential concern
DCB	dichlorobenzene
EEG	Environmental Enterprise Group
EnSafe	EnSafe, Inc.
EPA	U.S. Environmental Protection Agency
FDS	fuel distribution system
ft bls	feet below land surface
HI	Hazard Index
ILCR	incremental lifetime cancer risk
IM	interim measure
LNAPL	light non-aqueous phase liquid
LUC	land use control
LUCMP	Land Use Control Management Plan
µg/L	microgram per liter
MCL	maximum contaminant level
MCS	media cleanup standard
MNA	monitored natural attenuation
msl	mean sea level
NAVBASE	Naval Base
PCB	polychlorinated biphenyl
RAO	remedial action objective
RBC	risk-based concentration
RBSL	risk-based screening levels
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment

Acronyms and Abbreviations, Continued

RFI	RCRA Facility Investigation
RGO	remedial goal option
SCDHEC	South Carolina Department of Health and Environmental Control
SVOA	semivolatile organic analyte
SVOC	semivolatile organic compound
VOA	volatile organic analyte
VOC	volatile organic compound
UST	underground storage tank

Section 1.0

1.0 Introduction

In 1993, Naval Base (NAVBASE) Charleston was added to the list of bases scheduled for closure as part of the Defense Base Realignment and Closure Act (BRAC), which regulates closure and transition of property to the community. The Charleston Naval Complex (CNC) was formed as a result of the dis-establishment of the Charleston Naval Shipyard and NAVBASE on April 1, 1996.

Corrective Action (CA) activities are being conducted under the Resource Conservation and Recovery Act (RCRA), with the South Carolina Department of Health and Environmental Control (SCDHEC) as the lead agency for CA activities at the CNC. All RCRA CA activities are performed in accordance with the Final Permit (Permit No. SC0 170 022 560). In April 2000, CH2M-Jones was awarded a contract to provide environmental investigation and remediation services at the CNC.

The Zone G RCRA Facility Investigation (RFI) was conducted in 1997 and 1998 to investigate the nature and extent of environmental contamination at the electrical substation site known as Area of Concern (AOC) 633 and to recommend whether additional site activities such as corrective actions would be required to eliminate or minimize unacceptable risks to human health or the environment. Results of the RFI were presented in the *Zone G RFI Report, Revision 0* (EnSafe Inc. [EnSafe], 1998).

An Interim Measures (IM) Work Plan and delineation sampling for polychlorinated biphenyl (PCB)-contaminated soil removal were performed by the Environmental Enterprise Group (EEG) in 2000. CH2M-Jones prepared and implemented several IMs for PCB soil removal and for light non-aqueous phase liquid (LNAPL) investigation/removal in 2001 and 2002.

An RFI Report Addendum and Corrective Measures Study (CMS) Work Plan were subsequently prepared for AOC 633 by CH2M Jones (CH2M-Jones, 2003). The IMs performed by CH2M-Jones were described in this report. A CMS was recommended to address shallow groundwater contamination at AOC 633. The CMS Work Plan (Section 8.0 of the RFI Report Addendum) presented the remedial action objectives (RAOs) and media cleanup standards (MCSs) proposed for AOC 633. In addition, based on SCDHEC comments on the RFI Report Addendum/CMS Work Plan, a new shallow groundwater monitoring well (G633GW005) was installed at the site during development of this CMS to confirm that the extent of contaminated groundwater had been adequately determined.

This CMS report has been prepared by CH2M-Jones to complete the next stage of the CA process for AOC 633.

1.1 Corrective Measures Study Report Purpose and Scope

This CMS report evaluates corrective measure alternatives for PCB- and LNAPL-contaminated groundwater at AOC 633 in Zone G. Figure 1-1 illustrates the location of AOC 633 within Zone G. Figure 1-2 is an aerial photograph showing the layout of AOC 633.

This CMS report consists of: 1) the identification of a set of corrective measure alternatives that are considered to be technically appropriate for addressing contaminated groundwater; 2) an evaluation of the alternatives using standard criteria from U.S. Environmental Protection Agency (EPA) RCRA guidance; and 3) the selection of a recommended (preferred) corrective measure alternative for the site.

1.2 Background Information

This section of the CMS report presents background information on the facility, site history, and a summary of the nature and extent of the chemicals of concern (COCs) at the site. This information is essential to the understanding of the remedial goal options (RGOs), MCSs, and ultimately the evaluation of corrective measure alternatives for AOC 633 in Zone G of the CNC. Additional information on the site and hydrogeology in the Zone G area of the CNC is provided in the *Zone G RFI Report, Revision 0* (EnSafe, 1998).

1.2.1 Facility Description

AOC 633 is located near Building 451C, which is an electrical substation built in 1943. The RCRA Facility Assessment (RFA) defined the AOC as Building 451C itself, but additional work determined that the AOC 633 actually consists of an abandoned outdoor concrete slab and underground electrical vault, surrounded by a fenced yard, lying directly north of Building 451C (Figure 1-2). This former switchyard is approximately 45 feet by 60 feet (ft) and is visible on historical public works maps as early as 1955, but it is no longer visible on 1987 maps. Building 451C is a block structure with a concrete roof and floor. Several high voltage switches, breakers and transformers are located in the two-room block structure.

The site also contains several outdoor steel electrical switch enclosures on concrete slabs immediately east of Building 451C. A review of the historical maps indicates that these were added in the 1980s, presumably to replace the older structure to the north.

The area where AOC 633 is located is currently zoned M-1, for marine industrial land use. Some of the electrical equipment on site is still used, but it is de-energized during environmental investigations.

1.2.2 Site History

Because of the high voltage electrical equipment that has historically been on site, AOC 633 has typically been secured with a chain link fence with a locked gate. The site was undeveloped prior to construction of the electrical substation in 1943. No remedial activities were known to have occurred at this site prior to the Zone G RFI by EnSafe in 1997. In 1989, an electrical transformer at this location was reportedly destroyed by Hurricane Hugo. According to the *Final RCRA Facility Assessment Report, Volume II* (EnSafe Inc. [EnSafe]/Allen & Hoshall, 1995), several historical releases of PCBs have been reported for this site, including a "large leak of 10C oil in 1981"; this was presumably dielectric insulating fluid, but may have been diesel or some other type of oil.

Several IMs involving excavation and offsite disposal of PCB- and LNAPL-impacted soil have been implemented. These IMs resulted in the removal of PCB-impacted soil such that the site soils do not represent an unacceptable threat to human health or the environment under either the industrial or unrestricted land use scenario. The IMs also resulted in removal of significant quantities of LNAPL-impacted soil. These IMs were previously described in IM completion reports submitted with the RFI Report Addendum/CMS Work Plan.

1.2.3 COC Summary and Extent of Groundwater Contamination

The RFI Report Addendum/CMS Work Plan for AOC 633 (CH2M-Jones, March 2003) concluded that, after implementation of several IMs to address contaminated soil, there were no COCs remaining in surface or subsurface soil for AOC 633 under the industrial or unrestricted land use scenarios.

Results of groundwater sampling from the four shallow wells installed at the site in 2002 indicated that site-related groundwater contamination was present only in well G633GW001 (see Figure 1-3 for monitoring well locations). Monitoring well G633GW001 is located in the area where the highest PCB soil contamination was found prior to the soil IMs. Well

G633GW001 has been found to contain LNAPL that was determined to be a weathered diesel product. This LNAPL was identified as a groundwater COC for AOC 633.

The LNAPL was found to contain Aroclor 1260, and 1,3- and 1,4-dichlorobenzene (DCB). Aroclor 1260 was detected at a concentration of 1.6 micrograms per liter (μg/L) in the January 2002 groundwater sample collected from well G633GW001 (after removal of LNAPL); this value exceeds the drinking water maximum contaminant level (MCL) of 0.5 μg/L for Aroclor 1260. On this basis, Aroclor 1260 was identified as a groundwater COC for AOC 633.

1,3- and 1,4-DCB (5.5 and 23 μg/L, respectively) were also detected in the groundwater sample collected from well G633GW001 (after removal of LNAPL) during the January 2002 sampling event. The reported value for 1,4-DCB is below its MCL (75 μg/L). No MCL exists for 1,3-DCB; its risk-based concentration (RBC) is 5.5 μg/L and 1,3-DCB was not detected in groundwater above this value. Accordingly, 1,3- and 1,4-DCB were not identified as groundwater COCs. Similarly, chlorobenzene was detected in the January 2002 groundwater sample at a concentration of 1.8 μg/L, well below its MCL of 100 μg/L. Chlorobenzene was not identified as a groundwater COC.

An additional groundwater sample was collected from well G633GW001 in October 2003 and analyzed for PCBs and volatile organic compounds (VOC)s, including chlorobenzenes. Aroclor 1260 was detected at a concentration of 2.2 μg/L, above its MCL of 0.5 μg/L. 1,3- and 1,4-DCB were detected at concentrations of 1.8 J and 7.4 μg/L, respectively, both below their respective MCL or RBC. No other VOCs, including chlorobenzene and toluene, were detected in this sample.

Groundwater analysis from the January 2002 sampling event indicated that wells G633GW002 and G633GW003 have not been impacted by groundwater COCs.

Analysis of groundwater samples collected in January 2002 from monitoring well G633GW004, located outside the AOC 633 fence along Hobson Avenue and upgradient of well G633GW001, detected various dissolved phase fuel hydrocarbons, but not LNAPL. The compounds in well G633GW004 are thought to be associated with an old fuel distribution system (FDS) line running adjacent to Hobson Avenue, as opposed to AOC 633 activities. The hydrocarbon contamination in the vicinity of well G633GW004 is being addressed under the SCDHEC underground tank program and is not considered part of the site-related contamination in the vicinity of well G633GW001.

In response to a SCDHEC comment during the review of the RFI Report Addendum/CMS Work Plan, an additional shallow groundwater monitoring well (G633GW005) was installed in October 2003 in the western portion of the site, downgradient of well G633GW001, at which the impacted groundwater has been identified. Monitoring well locations are shown in Figure 1-3. Groundwater samples were collected from this well in October 2003 and analyzed for groundwater COCs. Appendix A presents the boring log and well construction details for this well and analytical results for the groundwater samples collected from this well. No groundwater COCs were detected in the sample from this well, confirming that the extent of groundwater contamination at AOC 633 has been adequately delineated.

During review of the RFI Report Addendum/CMS Work Plan, SCDHEC suggested that diesel-related chemicals present in the weathered diesel LNAPL found at well G633GW001 might leach into groundwater, although the only diesel-related hydrocarbon detected in the January 2002 groundwater sample from well G633GW001 was toluene at a concentration of 0.63 μg/L, well below its MCL of 1,000 μg/L. The BCT agreed that if future groundwater monitoring indicates that diesel-related hydrocarbons for which the SCDHEC underground storage tank (UST) program has established risk-based screening levels (RBSLs) are detected in groundwater at concentrations above those RBSLs, those hydrocarbons would be identified as groundwater COCs for the site.

Table 1-1 presents a summary of organic chemicals detected at the site, excluding the FDS hydrocarbons detected in well G633GW004.

It should be noted that since implementation of the LNAPL-impacted soil IM in June 2003, LNAPL monitoring and recovery via bailing was implemented periodically through February 2003. LNAPL thickness in the well varied from 0.17 to 0.42 foot during this period. At the end of February 2003, absorbent pads were used as a passive recovery method rather than bailing to absorb LNAPL that accumulates in this well. The pads have been inspected and replaced periodically (approximately monthly) since February 2003. As a result of these efforts, the amount of LNAPL that accumulates in well G633GW001 has been observed to have decreased significantly such that only a small portion of the adsorbent sock exhibits evidence of absorbed product over the 3 to 4 weeks that it resides in the well.

1.2.4 Summary of Hydrogeologic Setting

AOC 633 is located in the north-central part of Zone G, just east of the intersection of Viaduct Road and Hobson Avenue. The topography of the area is relatively flat due to the extensive filling and industrial development of this area, with elevations ranging from 10 to 12 feet above mean sea level (msl) in western Zone G, gently sloping downward to elevations of 7 to 8 feet above msl in eastern Zone G along the Cooper River. Because the area is highly industrialized, surface water runoff is largely controlled by a system of stormwater sewers that discharge to the Cooper River.

Surface Geology

Due to extensive soil disturbance at CNC over the history of its operation, the soils from land surface to depths of approximately 6 feet are a mixture of artificial fill and native sediments. The extent of fill material present varies widely, and generally increases in thickness toward the south and east in Zone G. In the vicinity of AOC 633, undifferentiated clay, sand, gravel, dredge spoils and construction debris may be present at or near the land surface, extending to depths of greater than 6 feet. In undisturbed areas, surface deposits consist of Quaternary age (Holocene epoch to recent) fine-grained sands, silts and clays typical of a coastal plain environment, reworked by marine and river erosion prior to development by man.

Subsurface Geology

The Zone G RFI work included soil boring and monitoring well installation, from which geologic information was collected to develop geologic cross sections. These data indicate that Quaternary (Pleistocene to Holocene epoch) and Tertiary period unconsolidated sediments were the only subsurface geologic units encountered during Zone G RFI investigations.

The deepest unit identified in Zone G is the Ashley Formation, a member of the mid-Tertiary period Cooper Group. Overlying the Ashley Formation are the younger upper Tertiary and Quaternary period deposits, which are in turn overlain by the Holocene to recent surface soils.

The Ashley Formation occurs at depths of approximately 25 to 35 feet below land surface (ft bls) in Zone G. The top of the Ashley is gently rolling and slopes gently downward to the east and south, with thickness approaching 60 feet at boring location GGDG02D in northern Zone G. The Ashley Formation is comprised of brown to olive marine silts with varying amounts of clay, phosphatic sand and microfossils. The Ashley consistency is generally dense to stiff and plastic, with low vertical permeability. In the vicinity of AOC 633, the Ashley Formation occurs at a depth of approximately 25 to 30 ft bls.

In most areas of Zone G, the Ashley Formation is overlain by marine lagoon deposits consisting of undifferentiated Tertiary period silts, clays and phosphatic sands up to 20 feet in thickness.

The overlying younger (Quaternary period) deposits are back barrier and near shore shelf deposits from various past marine transgressions, with subsequent reworking by erosion and re-deposition. These overlying sediments range from approximately 15 to 85 feet thick and are comprised mainly of Pleistocene epoch Wando Formation sands, silts and clays with varying amounts of organic matter, including peat.

Hydrogeology

The shallow aquifer system at AOC 633 is an unconfined water table aquifer occurring within the Quaternary age sediments. The underlying low-permeability Ashley Formation acts as an aquitard for the shallow aquifer system and as a confining unit for deeper geologic units. The Cooper River acts as a regional groundwater discharge boundary for the aquifer to the east. The average saturated aquifer thickness in the AOC 633 area based on boring log data is approximately 20 to 25 feet. Because the shallow aquifer system is thinner and the Ashley confining unit is continuous across Zone G, only "shallow" monitoring wells are installed, with typical total depths of 15 to 25 feet. Boring logs for the monitoring wells installed at the site indicate that the shallow aquifer is comprised of interbedded sandy clays and clayey and silty sands.

Potentiometric surface data from the Zone G RFI indicate that shallow groundwater flow is generally toward the Cooper River, although local variations were observed due to industrial development, and also due to tidal influences near the waterfront. Horizontal hydraulic gradients in the vicinity of AOC 633 (flow path "C" in Section 2.3.3 of the Zone G RFI Report) averaged 0.040 to 0.057 feet/foot, with average groundwater flow velocities of 0.04 to 0.05 feet per day, or approximately 15 to 20 feet per year.

At AOC 633, the potentiometric data from the new shallow monitoring wells was used to develop a local potentiometric surface map for October 2002 (Figure 1-4), indicating horizontal hydraulic gradients of about 0.008 feet per foot, with local groundwater flow toward the west. Based on this gradient, the RFI average horizontal hydraulic conductivity of 3.8 feet per day and the average aquifer effective porosity of 0.41 from the RFI, groundwater flow velocities at AOC 633 would be expected to average about 25 feet per year, with low to moderate tidal influence.

This represents a conservative (high) groundwater flow rate, because the lowest measured effective porosity and the highest horizontal conductivity (K) measured were used for the groundwater flow calculations. Also, because of the effects of biodegradation and the retardation effects due to the presence of organic carbon in the aquifer matrix, the migration rate of the COCs would be expected to be significantly slower than the groundwater flow rate. The lack of migration of the COCs away from AOC 633 indicate that the COC migration rate is very low and that the plume appears to be generally stable.

1.3 Overall Approach for Selecting Candidate Corrective Measure Alternatives for AOC 633

The most potentially feasible groundwater corrective measure approaches for AOC 633 based on the site conditions, the limited extent of the groundwater plume, the hydogeologic setting, and the nature of contamination are:

- Monitored Natural Attenuation (MNA) with Land Use Controls (LUCs)
- Long-term Monitoring with Continued LNAPL Recovery and LUCs

This CMS evaluates both of these alternatives as potential corrective measures for AOC 633.

1.4 Report Organization

This CMS report consists of the following sections, including this introductory section:

1.0 Introduction — Presents the purpose of and background information relating to this CMS report.

2.0 Remedial Goal Objectives and Evaluation Criteria— Defines the RGOs for AOC 633, in addition to the criteria used in evaluating the corrective measure alternatives for the site.

3.0 Description of Candidate Corrective Measure Alternatives — Describes each of the candidate corrective measure alternatives for addressing PCBs and LNAPL in site groundwater.

4.0 Evaluation and Comparison of Corrective Measure Alternatives — Evaluates each alternative relative to standard criteria, then compares the alternatives and the degree to which they meet or achieve the evaluation criteria.

5.0 Recommended Corrective Measure Alternative — Describes the preferred corrective measure alternative to achieve the MCS and RGOs for PCBs and LNAPL in groundwater based on a comparison of the alternatives.

6.0 References — Lists the references used in this document.

Appendix A the soil boring log and well construction details for monitoring well G633GW005 and sample results from the October 2003 monitoring event.

Appendix B contains cost estimates developed for the proposed corrective measure alternatives.

Appendix C contains CH2M-Jones' responses to SCDHEC comments on *CMS Report, AOC 633, Zone G, Revision 0.*

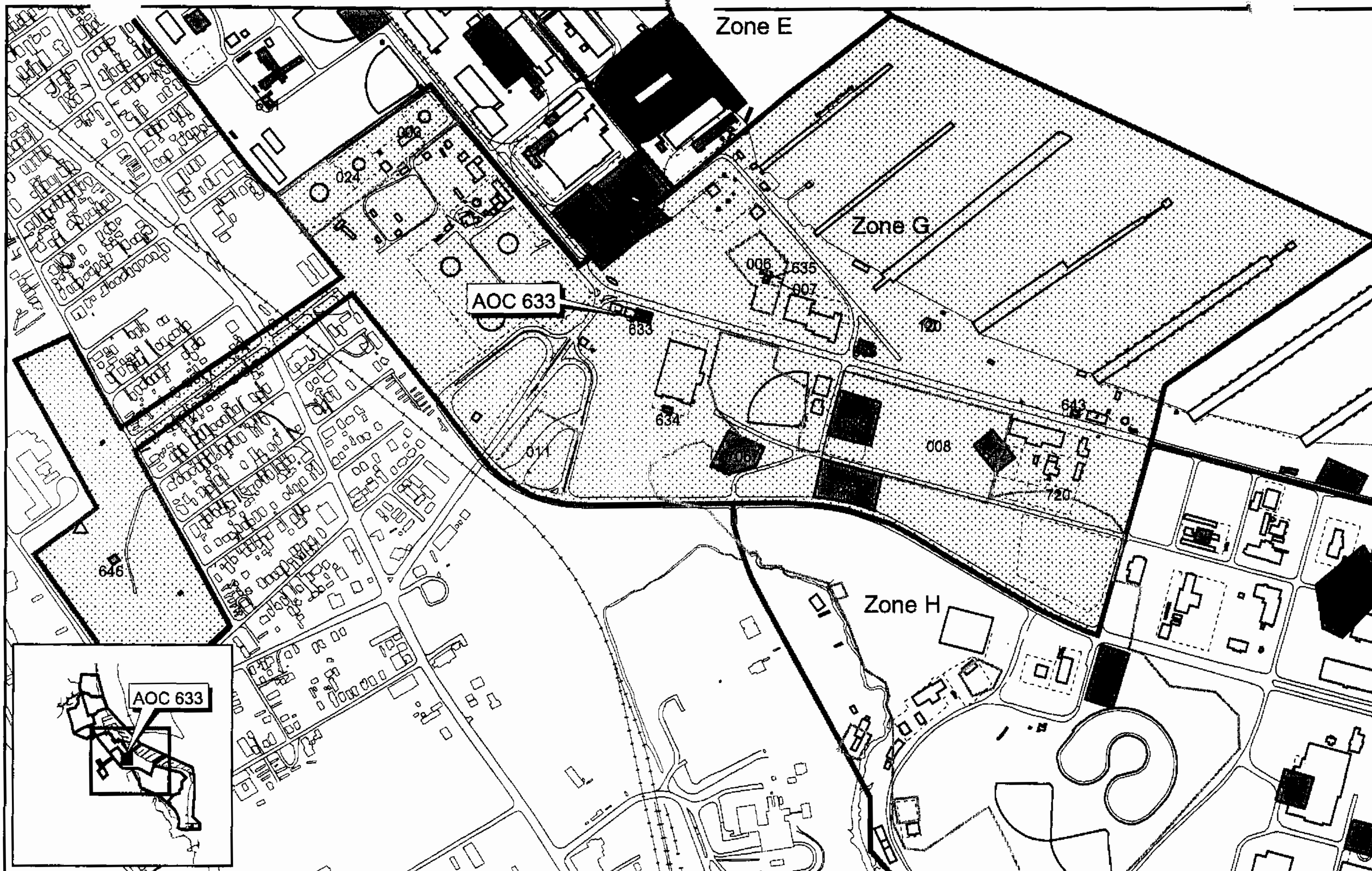
All tables and figures appear at the end of their respective sections.

TABLE 1-1
Organic Chemicals Detected in Groundwater at AOC 633
CMS Report, AOC 633, Zone G, Charleston Naval Complex

Station	Chemical Name	Result	Unit	Qualifier	Analysis Group	Date Collected	MCL	Region III RBC
G633GW001	PCB-1260 (Aroclor 1260)	**1.8**	µg/L	J	PCB	01/24/2003	0.5	NA
G633GW001	bis(2-Ethylhexyl) Phthalate	1.6	µg/L	J	SVOA	01/24/2003	6.0	NA
G633GW001	1,3-Dichlorobenzene	5.5	µg/L	=	VOA	01/24/2003	NA	0.55
G633GW001	1,4-Dichlorobenzene	23.0	µg/L	=	VOA	01/24/2003	75.0	NA
G633GW001	Chlorobenzene	1.8	µg/L	J	VOA	01/24/2003	100.0	NA
G633GW001	Toluene	0.6	µg/L	J	VOA	01/24/2003	1000.0	NA
G633GW001	PCB-1260 (Aroclor 1260)	**2.2**	µg/L	J	PCB	10/31/2003	0.5	NA
G633GW001	1,3-Dichlorobenzene	1.8	µg/L	J	VOA	10/31/2003	NA	0.55
G633GW001	1,4-Dichlorobenzene	7.4	µg/L	J	VOA	10/31/2003	75.0	NA
G633GW002	Acetone	5.4	µg/L	J	VOA	10/02/2002	NA	610
G633GW003	Acetone	2.4	µg/L	J	VOA	10/02/2002	NA	610

Notes: Bold values indicate exceedances of the COPC screening criteria.

SVOA =semivolatile organic analyte
VOA = volatile organic analyte



Fence
Railroads
Roads
Shoreline
AOC Boundary
SWMU Boundary
Buildings
Zone Boundary
Zone G

N

0 800 1600 Feet

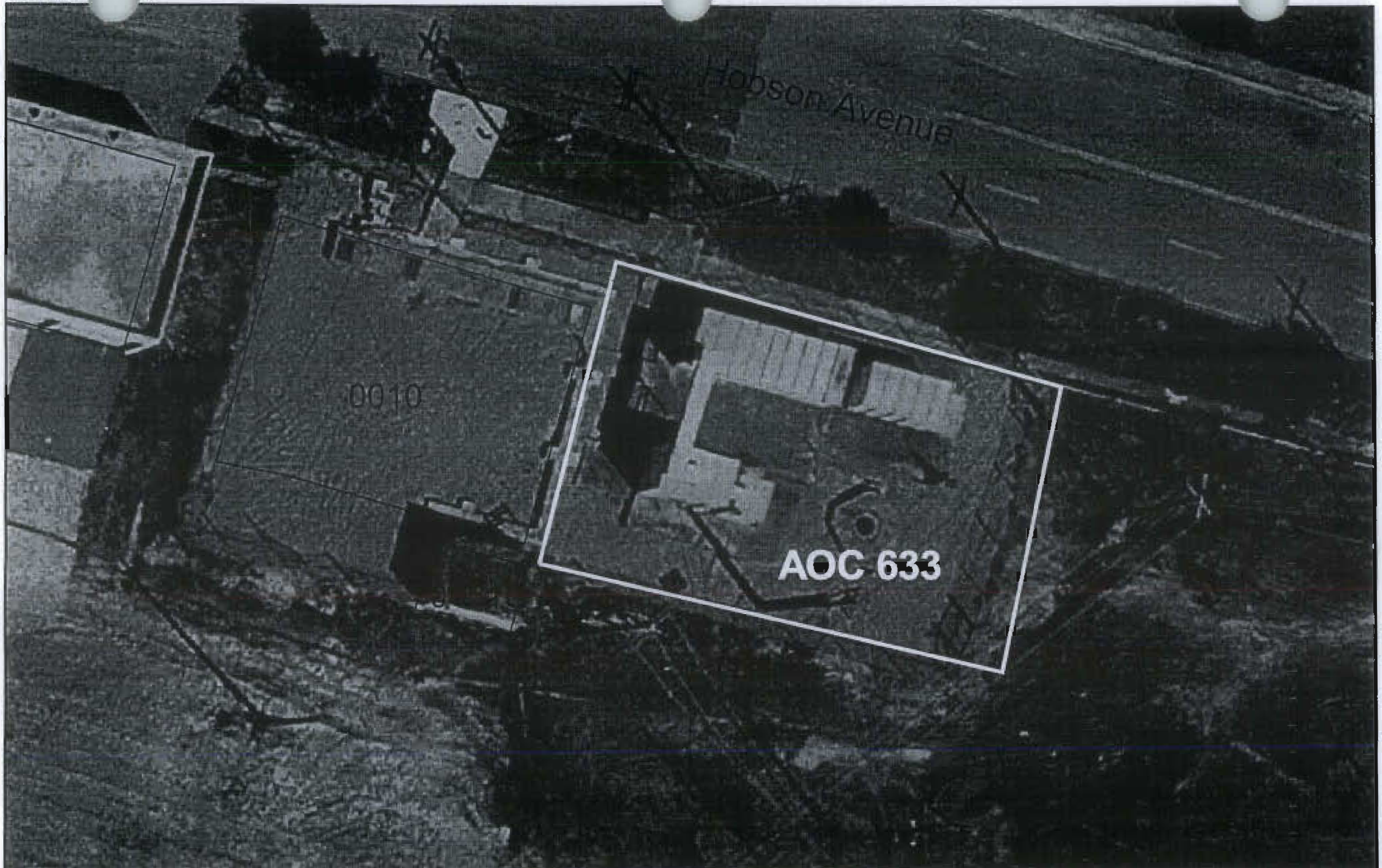
1 inch = 750 feet

Figure 1-1
Location of AOC 633
Zone G
Charleston Naval Complex

CH2MHILL

File Path: C:\18gis\Projects\Zone_G\zoneg_locationfig.apr, Date: 19 Aug 2002 11:32, User: NMOUDRY, AOC 633 Figure 1-1 Zone G within CNC

NOTE: Aerial Pho 997



Fence
Roads - Lines
SWMU / AOC
Buildings

N

0 30 60 Feet

1 inch = 25 feet

Figure 1-2
Aerial Photograph
AOC 633, Zone G
Charleston Naval Complex

CH2MHILL

File Path: C:\18gis\Projects\Zone_G\zoneg_locationfig.apr, Date: 19 Aug 2002 13:34, User: NMOUDRY, AOC 633 Figure 1-2 Aerial Photograph

NOTE: Aerial Photo Date is 1997
NOTE: Original figure created in color

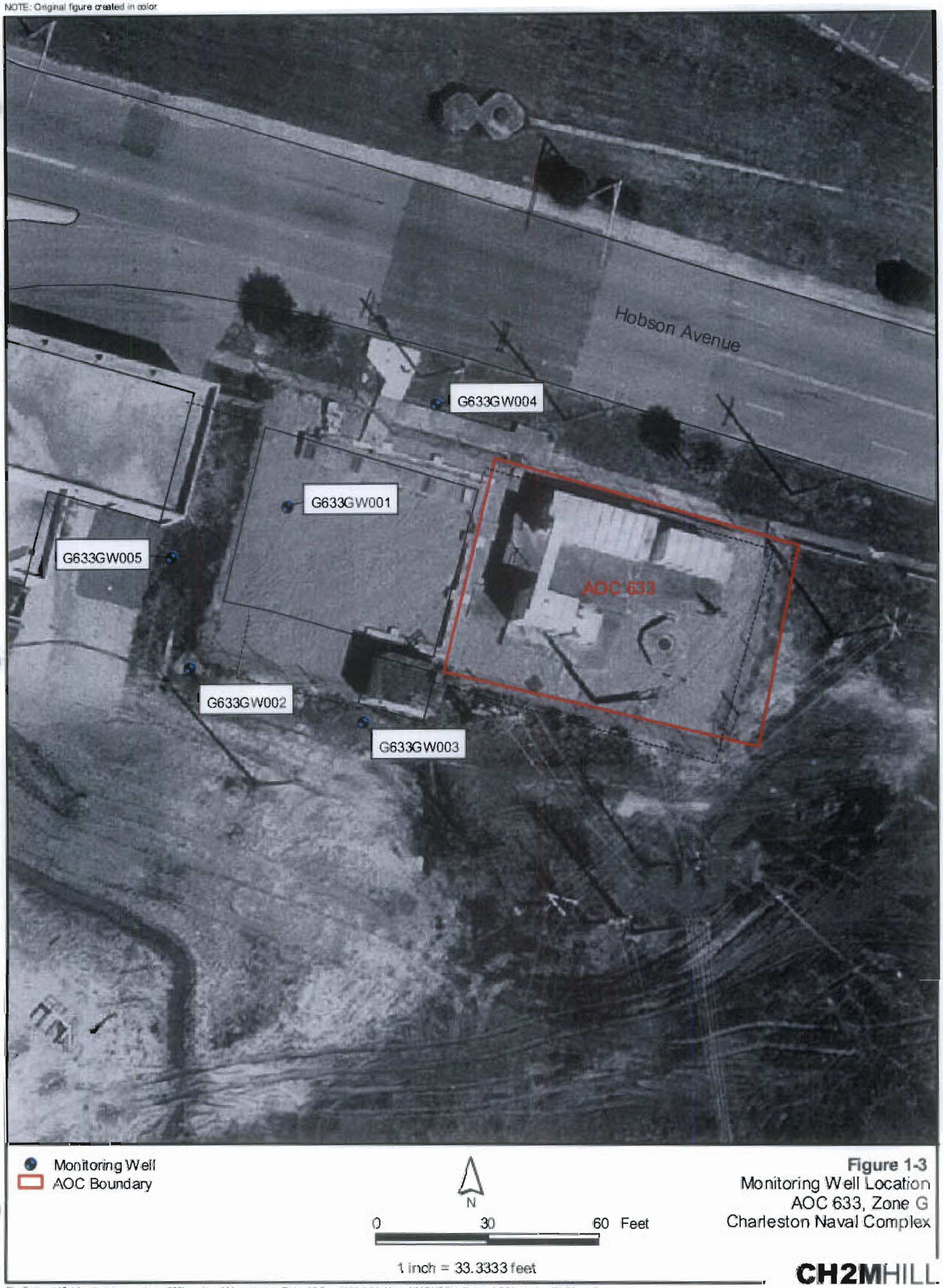
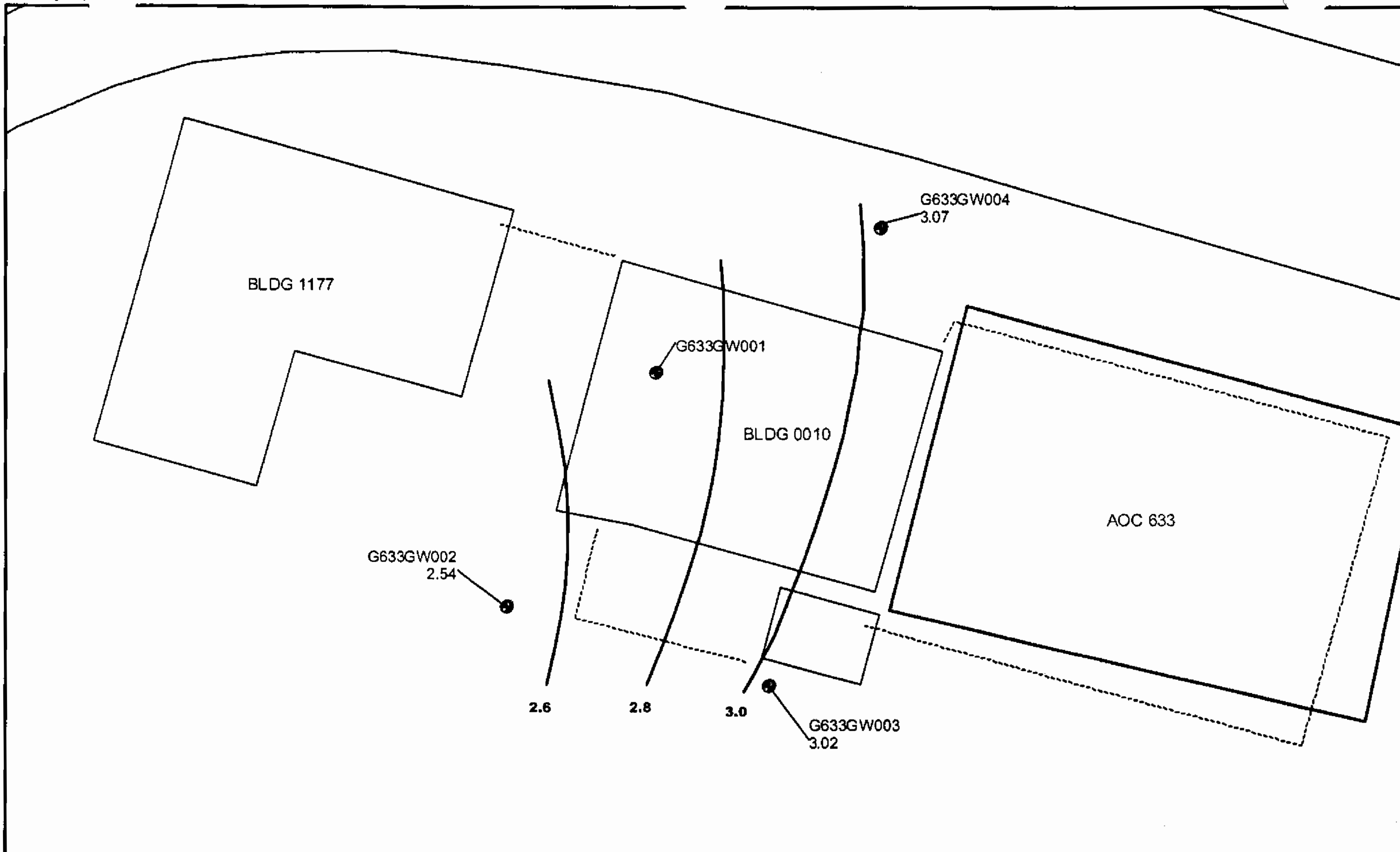


Figure 1-3
Monitoring Well Location
AOC 633, Zone G
Charleston Naval Complex

CH2MHILL

File Path: c:\18gis\projects\zone_g\aoc_633\aprs\aoc633_wells.apr, Date: 16 Dec 2003 6:31, User: NMOUDRY, Figure 1-3 Monitoring Well Location

NOTE: Original fi... l in color



NOTE: Water level values are in feet, relative to mean sea level (msl).

- Monitoring Well
- Fence
- Roads
- Potentiometric Surface (ft/msl)
- Buildings
- AOC Boundary
- Zone Boundary

N

0 10 20 Feet

1 inch = 25 feet

Figure 1-4
Potentiometric Surface (without GW001)
October 2002
AOC 633, Zone G
Charleston Naval Complex

CH2MHILL

File Path: c:\18gis\projects\zone_g\aoc_633\aprs\aoc633_cms.apr, Date: 20 Mar 2003 7:26, User: NMOUDRY, Figure 1-7 Potentiometric Map

Section 2.0

2.0 Remedial Goal Objectives and Evaluation Criteria

Typically after RAOs have been established and the risk assessment is complete, RGOs are developed for each RAO. The RGOs are based on assumptions about a particular land use scenario and include different residual risk levels for comparison. For example, to remediate surface soils to protect an onsite maintenance worker, RGOs might include remediating to anthropogenic background levels or to one of a variety of specific risk levels (such as 1E-06 or 1E-04). For each RGO, a specific MCS is determined for specific chemicals. These MCSs are expressed in conventional concentration units, such as $\mu g/L$, for specific chemicals.

RGOs and MCSs can be based on a variety of criteria, such as drinking water MCLs, specific incremental lifetime cancer risk (ILCR) target levels (e.g., 1E-04, 1E-05, or 1E-06), target Hazard Index (HI) levels (e.g., 0.1, 1.0, 3.0), or site background concentrations. For a particular RGO, specific MCSs can be determined as target concentration values that the selected alternative is required to achieve. Achieving these goals should protect human health and the environment, while achieving compliance with applicable state and federal standards. Remediating the site to those specific MCSs would be suitable to demonstrate that the RAO has been achieved.

The exposure medium of concern for AOC 633 is shallow groundwater. Because AOC 633 is located within a highly developed area (Zone G) of the CNC and there are no surface water bodies in the immediate vicinity of the site, ecological exposures were not considered necessary for evaluation. In addition, no surface or subsurface soil COCs are present at the site.

2.1 Remedial Action Objectives

RAOs are medium-specific goals that protect human health and the environment by preventing or reducing exposures under current and future land use conditions. The RAOs identified for the groundwater at AOC 633 are 1) to prevent ingestion and direct/dermal contact with groundwater having unacceptable non-carcinogenic risk; 2) to prevent migration to offsite areas; and 3) to restore the aquifer to its beneficial use.

2.2 Media Cleanup Standards

The COCs for groundwater at AOC 633 for which specific RGOs and MCSs are required are Aroclor 1260 and, if detected in groundwater in the future above at elevated concentrations, various diesel-related chemicals that may leach into groundwater. For Aroclor 1260, the proposed MCS is the drinking water MCL for PCBs of 0.5 μg/L.

For the diesel-related chemicals that may leach into groundwater, it will be necessary to first have detections of these chemicals in groundwater occur during future sampling events in order to identify which of these may represent a leaching hazard. Because of the length of time that the LNAPL appears to have been present in the aquifer and lack of detectable site-related diesel chemicals to date in groundwater, it is possible that no diesel-related chemicals for which SCDHEC's UST program has established RBSLs may be detected during the corrective measure for this site. Currently, the SCDHEC UST program has established RBSLs for the following diesel-related chemicals:

Chemical	RBSL (μg/L)
Benzene	5
Toluene	1,000
Ethylebenzene	700
Xylenes	10,000
Total PAHs	25
Naphthalenes (includes methyl naphthalenes)	25

A MCS for LNAPL of 0.10 ft (1/8 inch) was proposed in the CMS work plan. There is no standard for the removal of LNAPL to a measurable thickness in SCDHEC regulations or guidance. However, technical standards and corrective action requirements for owners and operators of USTs, as outlined in Chapter 61-92, Part 280 under the SCDHEC Bureau of Land and Waste Management, UST program, addresses the removal of free product (Code of Regulation 61-92, Section 280.64). The regulation states that *"At sites where investigations under Section 280.62(a)(6) indicate the presence of free product, owners and operators must remove* *free product to the maximum extent practicable as determined by the Department…"*. During development of the CMS work plan, it was determined that the UST program typically requires an LNAPL removal performance standard at UST sites of 0.01 feet (i.e., 1/8-inch) during the corrective action phase. This objective is typically documented in the site-specific corrective action plan prepared and submitted to the UST program. As a result, the proposed MCS for LNAPL removal at AOC 633 is to a measurable thickness of less than or equal to 0.01 feet.

2.3 Evaluation Criteria

According to the EPA RCRA CA guidance, corrective measure alternatives should be evaluated using the following five criteria:

1. Protection of human health and the environment.
2. Attainment of MCSs.
3. The control of the source of releases to minimize future releases that may pose a threat to human health and the environment.
4. Compliance with applicable standards for the management of wastes generated by remedial activities.
5. Other factors, including (a) long-term reliability and effectiveness; (b) reduction in toxicity, mobility, or volume of wastes; (c) short-term effectiveness; (d) implementability; and (e) cost.

Each of these criteria is defined in more detail below:

1. **Protection of human health and the environment.** The alternatives will be evaluated on the basis of their ability to protect human health and the environment. The ability of an alternative to achieve this criterion may or may not be independent of its ability to achieve the other criteria. For example, an alternative may be protective of human health, but may not be able to attain the MCSs if the MCSs were not developed based on human health protection factors.

2. **Attainment of MCSs.** The alternatives will be evaluated on the basis of their ability to achieve the MCS defined in this CMS. Another aspect of this criterion is the time frame required to achieve the MCS. Estimates of the time frame for the alternatives to achieve RGOs will be provided.

3. **The control the source of releases.** This criterion deals with the control of releases of contamination from the source (the area in which the contamination originated) and the prevention of future migration to uncontaminated areas.

4. **Compliance with applicable standards for management of wastes.** This criterion deals with the management of wastes derived from implementing the alternatives (i.e., treatment or disposal of VOC-contaminated residuals from groundwater treatment processes). Corrective measure alternatives will be designed to comply with all standards for management of wastes. Consequently, this criterion will not be explicitly included in the detailed evaluation presented in the CMS, but such compliance would be incorporated into the cost estimates for which this criterion is relevant.

5. **Other factors.** Five other factors are to be considered if an alternative is found to meet the four criteria described above. These other factors are as follows:

   a. Long-term reliability and effectiveness

   Corrective measure alternatives will be evaluated on the basis of their reliability, and the potential impact should the alternative fail. In other words, a qualitative assessment will be made as to the chance of the alternative's failing and the consequences of that failure.

   b. Reduction in the toxicity, mobility, or volume of wastes

   Alternatives with technologies that reduce the toxicity, mobility, or volume of the contamination will be generally favored over those that do not. Consequently, a qualitative assessment of this factor will be performed for each alternative.

   c. Short-term effectiveness

   Alternatives will be evaluated on the basis of the risk they create during the implementation of the remedy. Factors that may be considered include fire, explosion, and exposure of workers to hazardous substances.

   d. Implementability

   The alternatives will be evaluated for their implementability by considering any difficulties associated with conducting the alternatives (such as the construction disturbances they may create), operation of the alternatives, and the availability of equipment and resources to implement the technologies comprising the alternatives.

   e. Cost

   A net present value of each alternative will be developed. These cost estimates will be used for the relative evaluation of the alternatives, not to bid or budget the work.

The estimates will be based on information available at the time of the CMS and on a conceptual design of the alternative. They will be "order-of-magnitude" estimates with a generally expected accuracy of -50 percent to +100 percent for the scope of action described for each alternative. The estimates will be categorized into capital costs and operations and maintenance costs for each alternative.

Section 3.0

3.0 Description of Candidate Corrective Measure Alternatives

3.1 Introduction

Currently available groundwater remediation technologies were screened for applicability to the contaminants and site conditions present at AOC 633. The presence of PCBs (Aroclor 1260) and LNAPL in site groundwater is limited to monitoring well G633GW001 and the immediate surrounding area. Sampling results from the other four monitoring wells indicate that the LNAPL and dissolved phase PCBs have not migrated offsite and that LNAPL and PCBs were not detected in these wells.

Two candidate corrective measure alternatives were selected for this site:

- Alternative 1: MNA with LUCs
- Alternative 2: Long-term Monitoring with Continued LNAPL Recovery and LUCs

The sections below describe each selected alternative in more detail.

3.2 Alternative 1: Monitored Natural Attenuation with Land Use Controls

3.2.1 Description of Alternative

This alternative will allow the COCs to continue to attenuate naturally in the subsurface, will monitor groundwater concentrations periodically until the MCSs are reached, and will impose LUCs (such as a deed restriction) to restrict the installation of drinking water wells and allow only industrial land use (non-residential use only).

Natural attenuation allows for reduction of COC concentrations to occur by the natural processes present in the aquifer, including volatilization, hydrolysis, dilution, dispersion, adsorption, and biotic and abiotic degradation. The collective effort of these processes is termed natural attenuation. MNA is a careful evaluation of natural attenuation mechanisms using monitoring. EPA has issued a Final OSWER Directive on Monitored Natural Attenuation (EPA, 1999), in which it recognizes that MNA is appropriate as a remedial approach, "where it can be demonstrated capable of achieving a site's remedial objectives within a time frame that is reasonable compared to that offered by other methods, and where it meets the applicable remedy selection criteria for that particular OSWER program." EPA clearly states its expectation that "monitored natural attenuation will be most appropriate when used in conjunction with active remediation measures (e.g., source control) or as a follow-up to active remediation measures that already have been implemented."

The groundwater COCs identified for AOC 633 are Aroclor 1260 and LNAPL present in monitoring well G633GW001. The amount of LNAPL remaining at the site is believed to relatively minor. Much of the LNAPL was removed during the soil excavation IMs completed at the site. Only minor amounts (up to a few inches) of LNAPL have been observed in monitoring well G633GW001. The use of absorbent pads in this well over the past year has also resulted in removal of additional recoverable LNAPL from the aquifer. LNAPL accumulations in well G633GW001 over the last part of 2003 have been minor, indicating significant attenuation of residual LNAPL.

Previous analysis of this LNAPL indicated that it is a weathered diesel. The more volatile and soluble fuel hydrocarbons (such as naphthalenese) have already attenuated from this LNAPL. For this reason, no diesel-related hydrocarbons, other than a trace amount of toluene, have been detected in groundwater samples from well G633GW001. The remaining fuel hydrocarbons have low migration potential. It is expected that the diesel product will slowly attenuate over time as a result of natural biodegradation processes. Additional contingency remedies would be considered if natural attenuation indicates low performance as evidenced by increasing quantities of LNAPL in the well or a significant increase in dissolved phase concentrations.

Aroclor 1260 that is present in the LNAPL is expected to become adsorbed to the soil matrix as the diesel degrades and is not expected to migrate into groundwater. Other chemicals present in the LNAPL, such as the DCBs, are also expected to degrade and attenuate concurrently with the LNAPL. Because the quantities of LNAPL are limited at the site, the amount of these other constituents present is very limited.

Under the natural attenuation alternative, the COC plume would be evaluated using a monitoring system designed to track the plume location and concentrations. Monitoring data would be compared to the estimated or predicted transport and fate of the COCs to check the predictions accuracy. In general, the MNA alternative consists of three major features:

- A designed monitoring program.
- A tracking and data evaluation program.

- A contingency response plan in the event that the monitoring indicates excessive downgradient migration of dissolved COCs.

The MNA alternative would be implemented in conjunction with a long-term monitoring plan. The purpose of the plan is to monitor plume migration over time and to verify that natural attenuation is occurring. The plan would specify existing wells located within, upgradient, crossgradient, and downgradient of the plume. The monitoring plan would focus on monitoring for the COCs, field measurements, such as dissolved oxygen [DO], oxidation reduction potential [ORP], and turbidity, and hydrogeologic conditions (groundwater gradients, flow direction and flow rate). Additional parameters, such as ferrous iron, or common cations and anions, might also be occasionally monitored, if additional information on these parameters was needed. The data would provide ongoing characterization of plume extent, groundwater quality, hydraulic gradients, ORP indicators, and indicators of biological degradation of the COCs.

LUCs, such as deed restrictions, would be implemented to restrict the installation of drinking water wells at AOC 633. Such LUCs could be removed after COC concentrations have reduced to MCLs or lower. LUCs are planned for most of Zone G, including the AOC 633 area.

3.2.2 Key Uncertainties

The primary uncertainty for the MNA alternative is the length of time required for the LNAPL and associated chemicals to attenuate. Although the quantity of LNAPL remaining is low, it may take several years for natural attenuative mechanisms to completely degrade the fuel hydrocarbon such that the target MCS for LNAPL is achieved.

3.2.3 Other Considerations

LUCs restricting the use of groundwater at the site will be necessary during the MNA period until MCLs are achieved.

3.3 Alternative 2: Long-Term Monitoring with Continued LNAPL Recovery and Land Use Controls

3.3.1 Description of Alternative

This alternative will allow the COCs to attenuate naturally in the subsurface, will impose LUCs (such as a deed restriction) to restrict the installation of drinking water wells, and will include periodic groundwater monitoring until the MCS is reached for all COCs.

In addition, adsorbent pads will continue to be placed in monitoring well G633GW001 to passively recover LNAPL. The pads will be periodically inspected and replaced as necessary. The spent pads will be properly containerized, labeled, analyzed and disposed.

Adsorbent pads have been used in this well since early 2003. Since that time, the amount of LNAPL recovered in the pads has decreased. Currently, only a small fraction of the pad exhibits evidence of adsorbed product after a 3- to 4-week period in the well. Thus, it is expected that replacement of the pads initially on a monthly to bimonthly basis will be adequate and that over time, the need for pad replacement will decrease and eventually no longer be required as the amount of recoverable LNAPL declines.

This alternative is expected to result in quicker mass removal of residual LNAPL at the site compared to Alternative 1 because of the removal of LNAPL via absorbent pads.

In addition to the passive recovery of LNAPL from well G633GW001, the natural attenuation processes described in Alternative 1 will also continue to work to reduce the level of contamination at the site. A groundwater monitoring program identical to the one described for Alternative 1 will be required for this alternative to ensure that natural attenuation if proceeding adequately.

3.3.2 Key Uncertainties

The primary uncertainty for the MNA alternative is the length of time required for the LNAPL to achieve the target MCS. Although the quantity of LNAPL remaining is low, it may take several years for the combination of passive recovery and natural attenuative mechanisms to completely degrade the fuel hydrocarbons.

3.3.3 Other Considerations

LUCs restricting the use of groundwater at the site will be necessary during the MNA period until MCLs are achieved.

Section 4.0

4.0 Evaluation and Comparison of Corrective Measure Alternatives

The two corrective measure alternatives were evaluated relative to the evaluative criteria previously described in Section 2.0 and then subjected to a comparative evaluation. A cost estimate for each alternative was also developed; the assumptions and unit costs used for these estimates are included in Appendix B.

4.1 Alternative 1: Monitored Natural Attenuation with Land Use Controls

The assumptions for Alternative 1 include the following:

- A base-wide LUC management plan (LUCMP) will be developed for the CNC. The plan will allow for restrictions on the use of groundwater at AOC 633 and other areas, and will be developed outside the scope of this CMS.
- Periodic groundwater monitoring will be performed until results indicate that the natural attenuation is considered complete and COC concentrations are below target MCSs, estimated at approximately 10 to 15 years at this site. Samples will be collected from two groundwater wells (G633GW001 and G633GW005) on an annual basis and analyzed for PCBs and VOCs. Wells G633GW001 and G633GW005 will also be analyzed for semivolatile organic compounds (SVOCs) initially and then, provided that SVOCs are not found to be migrating, on a bi-annual basis. If SVOCs are found to be migrating, more frequent sampling will be implemented as needed to ensure the remedy is protective. Selected MNA parameters will be analyzed as needed in the groundwater samples. Standard field parameters (DO, ORP, turbidity, temperature) will also be monitored. For cost estimating purposes, monitoring will be planned for a 10-year period.

4.1.1 Protection of Human Health and the Environment

This alternative is effective at protecting human health because it uses LUCs to prevent the ingestion of and direct contact with groundwater. With regard to protection of the environment, monitoring would need to be conducted to ensure that the COC plume does not migrate into the Cooper River via direct discharge or by interception by a storm sewer, such that it could create unacceptable environmental impacts. If so, additional, active corrective measures would need to be implemented to preclude such impacts.

4.1.2 Attain MCS

Alternative 1 is expected to eventually attain the MCS. It is difficult to determine precisely how long it would take, but because of relatively low contaminant concentrations, the system should attain the MCSs within the range of 10 to 15 years.

4.1.3 Control the Source of Releases

There are no ongoing sources of releases at AOC 633; therefore, this issue is not applicable.

4.1.4 Compliance with Applicable Standards for the Management of Generated Wastes

Alternative 1 does not generate any wastes that require special management. The primary generated waste would be purge water from monitoring wells, which is easily managed to applicable standards.

4.1.5 Other Factors (a) Long-term Reliability and Effectiveness

This alternative has adequate long-term reliability and effectiveness. The amount of LNAPL remaining at the site is small and will not migrate from the area. The other contaminants in the LNAPL have not previously migrated from the vicinity of well G633GW001 and are expected to attenuate over time.

4.1.6 Other Factors (b) Reduction in the Toxicity, Mobility, or Volume of Wastes

Alternative 1 relies on natural attenuation to reduce the toxicity of the contaminated groundwater. The toxicity, mobility, and volume of contaminants is reduced by in situ biodegradation.

4.1.7 Other Factors (c) Short-term Effectiveness

Through the implementation of LUCs, Alternative 1 has short-term effectiveness in preventing ingestion of or contact with the contaminated groundwater. No significant short-term risks would be created using this alternative.

4.1.8 Other Factors (d) Implementability

Alternative 1 is easily implemented since it requires only the implementation of LUCs and an appropriate monitoring well program.

4.1.9 Other Factors (e) Cost

Alternative 1 requires no construction of treatment facilities or disposal of wastes. The significant component of cost for this alternative is for the collection and analysis of samples during groundwater monitoring.

Using the assumptions described earlier, the total present value of this alternative is $49,000.

4.2 Alternative 2: Long-term Monitoring with Continued LNAPL Recovery and Land Use Controls

The assumptions for Alternative 2 include the following:

- A base-wide LUCMP will be developed for the CNC. The plan will allow for restrictions on the use of groundwater at AOC 633 and other areas, and will be developed outside the scope of this CMS.
- Passive recovery of LNAPL from well G633GW001 via absorbent pads will continue for the first 2 years of the long-term monitoring period. Pads are assumed to be replaced on a bi-monthly basis. It is assumed that after 2 years, no additional LNAPL will accumulate in the well. The spent pads will be containerized, characterization analysis will be performed, and the wastes will be properly disposed.
- Periodic groundwater monitoring will be performed until results indicate that LNAPL recovery is considered complete and COC concentrations are below MCSs, estimated at approximately 5 to 10 years at this site. Samples will be collected from two groundwater wells (G633GW001 and G633GW005) on an annual basis and will be analyzed for PCBs and VOCs. Wells G633GW001 and G633GW005 will also be analyzed initially for SVOCs and then, provided that SVOCs are found not to be migrating, on a bi-annual basis. If SVOCs are found to be migrating, more frequent sampling will be implemented as needed to ensure the remedy is protective. Standard field parameters (DO, ORP, turbidity, temperature) will also be monitored. For cost estimating purposes, monitoring will be planned for a 5-year period.

4.2.1 Protection of Human Health and the Environment

Alternative 2 is effective at protecting human health and the environment because it uses LUCs to prevent the ingestion of and direct contact with groundwater during the time period when groundwater COC concentrations are greater than the MCS.

4.2.2 Attain MCS

Alternative 2 is expected to eventually attain the MCS, but the exact time frame is difficult to predict.

4.2.3 Control the Source of Releases

There are no ongoing sources of releases to groundwater at AOC 633; therefore, this issue is not applicable.

4.2.4 Compliance with Applicable Standards for the Management of Generated Wastes

With the exception of recovered LNAPL, Alternative 2 does not generate any other wastes that require special management. Recovered LNAPL will be managed as hazardous waste, containerized, analyzed for characterization, and disposed of properly.

4.2.5 Other Factors (a) Long-term Reliability and Effectiveness

Alternative 2 has adequate long-term reliability and effectiveness. The amount of LNAPL remaining at the site is small and will not migrate from the area. The other contaminants in the LNAPL have not previously migrated from the vicinity of well G633GW001 and are expected to attenuate over time.

4.2.6 Other Factors (b) Reduction in the Toxicity, Mobility, or Volume of Wastes

Alternative 2 reduces the volume of the waste present at the site by LNAPL recovery and removal from the aquifer. The toxicity, mobility, and volume of dissolved contaminants is reduced by natural attenuation mechanisms (adsorption, dispersion, dilution, biodegradation).

4.2.7 Other Factors (c) Short-term Effectiveness

Because of the implementation of LUCs, Alternative 2 will have short-term effectiveness in preventing ingestion of or contact with the contaminated groundwater. No unmanageable hazards would be created during its implementation.

4.2.8 Other Factors (d) Implementability

Alternative 2 is relatively easy to implement.

4.2.9 Other Factors (e) Cost

The main expense for this alternative is the sampling, analytical, and reporting costs. LNAPL recovery costs are expected to be modest because the amount of LNAPL present is small and has continued to decrease since completion of the LNAPL-removal IM and LNAPL recovery during 2003.

Using the assumptions listed above, the total present value of Alternative 2 is $48,000.

4.4 Comparative Ranking of Corrective Measure Alternatives

Each corrective measure alternative's overall ability to meet the evaluation criteria is described above. In the table below, a comparative evaluation of the degree to which each alternative meets a particular criteria is presented.

TABLE 4-1
Ranking of Corrective Measure Alternatives
Corrective Measures Study Report, AOC 633, Zone G, Charleston Naval Complex

Criterion	Alternative 1 MNA with LUCs	Alternative 2 Long-term Monitoring with Continued LNAPL Recovery and LUCs
Overall Protection of Human Health and the Environment	Protects human health and the environment	Protects human health and the environment
Attainment of MCS	Is expected to achieve MCSs in the 10 to 15-year time frame	Is expected to achieve MCSs in the 5 to 10-year time frame
Control of the source of releases	N/A	N/A
Compliance with applicable standards for the management of wastes	Complies with applicable standards	Complies with applicable standards
Long-term Reliability and Effectiveness	Expected to be reliable and effective long term	Expected to be reliable and effective long term
Reduction of Toxicity, Mobility, or Volume through Treatment	Reduces toxicity and volume via chemical degradation	Reduces toxicity and volume via chemical degradation
Short-term Effectiveness	Effective in short term due to use of LUCs	Effective in short term due to use of LUCs
Implementability	Easily implemented	Easily implemented
Cost Ranking	Inexpensive	Inexpensive
Estimated Cost (in $1,000)	$49,000	$48,000

Section 5.0

5.0 Recommended Corrective Measure Alternative

Two corrective measure alternatives were evaluated using the criteria described in Section 2.0 of this CMS report: Alternative 1: MNA with LUCs; and Alternative 2: Long-term Monitoring with Continued LNAPL Recovery and LUCs.

The RAOs identified for groundwater at AOC 633 are: 1) to prevent ingestion and direct/dermal contact with groundwater having unacceptable carcinogenic or noncarcinogenic risk; 2) to prevent migration to offsite areas; and 3) to restore the aquifer to beneficial use.

Based on the alternatives evaluation and RAOs for the site and current uncertainties associated with each alternative, the preferred corrective measure alternative is Alternative 2: Long-term Monitoring with Continued LNAPL Recovery and LUCs.

The first RAO of preventing ingestion and direct/dermal contact with contaminated groundwater is achieved at a moderate cost. The second RAO of ingestion or contact that could occur during intrusive site maintenance or if the plume migrates off site will be controlled by LUCs and appropriate management of the monitoring network. The third and final RAO of restoring the aquifer to beneficial use will be met when the COC concentrations in the aquifer are less than or equal to the MCS.

5.1 Land Use Controls

LUCs will be implemented to limit the future use of the site to control or eliminate exposure pathways to COCs at the site and to ensure the integrity and effectiveness of the presumptive remedy. With regard to real property, LUC refers to any restriction or control that limits the use of, and/or exposure to, a portion of the property, including water resources, arising from the need to protect human health and the environment. The LUCs will be primarily regarded as a component of CA that applies technologies that reduce toxicity, mobility, volume, and mass of the source of contamination and not as a standalone CA.

The term LUCs encompasses "institutional controls," which are defined as real estate restrictions, deed notifications, governmental permitting, zoning laws and other "legal" restrictions to protect human health and the environment. Institutional controls are non-engineered mechanisms used for ensuring compliance with necessary land use limitations.

LUCs also include restrictions on access (access controls), whether achieved by means of engineered barriers (e.g., fence or concrete pad), affirmative measures to achieve the desired restrictions (e.g., night lighting of an area), and prohibitive directives (e.g., restrictions on certain types of wells for the duration of the CA).

Considered altogether, the LUCs for a facility will provide a tool for directing how the property should be used in order to maintain the level of protectiveness that one or more CAs were designed to achieve. Periodic inspections will be conducted to ensure the long-term integrity of the remedy and the effectiveness of the LUCs.

LUCs will be implemented at the site for the following reason:

- To restrict potential human contact with groundwater that may have been contaminated with COCs until the groundwater cleanup objectives have been achieved. These may include restrictions on installation of wells for potable or other use and notification in the event that trenching or dewatering is required in the area of impacted groundwater.

The LUCs will be developed and implemented in accordance with the site-specific land use control implementation plan (LUCIP) agreed to by the Navy and SCDHEC. Periodic visual inspections and reviews will be conducted for the purpose of verifying that all necessary LUCs have been implemented and are being properly maintained. An annual report will be prepared and forwarded to the SCDHEC, signed by the Navy, certifying the continued retention of all LUCs implemented at AOC 633. Additionally, the recommendation for implementing LUCs will be incorporated into the RCRA Part B Permit for the CNC.

Section 6.0

6.0 References

CH2M-Jones. *RFI Report Addendum and CMS Work Plan, AOC 633, Zone G*. Revision 0. March 2003.

EnSafe Inc. *Zone G RFI Report, NAVBASE Charleston*. Revision 0. February 1998.

EnSafe Inc. /Allen & Hoshall. *Final RCRA Facility Assessment Report, Volume II*. 1995.

Freeze, R. Allen and John A. Cherry. *Groundwater*. Prentice Hall, Inc. 1979.

South Carolina Department of Health and Environmental Control (SCDHEC). RCRA Permit SC0 170 022 560. Charleston Naval Complex, Charleston, South Carolina. August 17, 1988.

South Carolina Department of Health and Environmental Control (SCDHEC). Comments on *Zone F RFI Report, Revision 0*. December 31, 1998.

U.S. Environmental Protection Agency (EPA). Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites. Office of Solid Waste and Emergency Response (OSWER) Final Directive 9200.4-17P. 1999.

Appendix A

Parameter	Units	G633GW001		G633GW002		G633GW005	
StationID		G633GW001		G633GW002		G633GW005	
SampleID		633GW001N2		633GW002N2		633GW005N2	
DateCollected		10/31/2003		10/31/2003		10/31/2003	
DateExtracted		11/08/2003		11/08/2003		11/08/2003	
DateAnalyzed		11/08/2003		11/08/2003		11/08/2003	
SDGNumber		101178		101178		101178	
Chloromethane	ug/L	10	UJ	10	UJ	10	UJ
Vinyl chloride	ug/L	10	U	10	U	10	U
Bromomethane	ug/L	10	UJ	10	UJ	10	UJ
Chloroethane	ug/L	10	U	10	U	10	U
1,1-Dichloroethene	ug/L	5	U	5	U	5	U
Acetone	ug/L	10	U	10	U	15.8	U
Carbon Disulfide	ug/L	5	U	5	U	5	U
Methylene Chloride	ug/L	5	U	5	U	5	U
trans-1,2-Dichloroethene	ug/L	5	U	5	U	5	U
1,1-Dichloroethane	ug/L	5	U	5	U	5	U
Vinyl acetate	ug/L	10	U	10	U	10	U
Methyl ethyl ketone (2-Butanone)	ug/L	10	U	10	U	11.9	=
cis-1,2-Dichloroethylene	ug/L	5	U	5	U	5	U
1,2-Dichloroethene (total)	ug/L	5	U	5	U	5	U
Chloroform	ug/L	5	U	5	U	5	U
1,1,1-Trichloroethane	ug/L	5	U	5	U	5	U
Carbon Tetrachloride	ug/L	5	U	5	U	5	U
1,2-Dichloroethane	ug/L	5	U	5	U	5	U
Benzene	ug/L	5	U	5	U	5	U
Trichloroethylene (TCE)	ug/L	5	U	5	U	5	U
1,2-Dichloropropane	ug/L	5	U	5	U	5	U
Bromodichloromethane	ug/L	5	U	5	U	5	U
2-Chloroethyl vinyl ether	ug/L	10	UJ	10	UJ	10	UJ
cis-1,3-Dichloropropene	ug/L	5	U	5	U	5	U
Methyl isobutyl ketone (4-Methyl-2-pentanone)	ug/L	10	U	10	U	10	U
Toluene	ug/L	5	U	5	U	0.56	J
trans-1,3-Dichloropropene	ug/L	5	U	5	U	5	U
1,1,2-Trichloroethane	ug/L	5	U	5	U	5	U
2-Hexanone	ug/L	10	U	10	U	10	U
Tetrachloroethylene (PCE)	ug/L	5	U	5	U	5	U

	StationID	G633GW005	
	SampleID	633HW005N2	
	DateCollected	10/31/2003	
	DateExtracted	11/08/2003	
	DateAnalyzed	11/08/2003	
	SDGNumber	101178	
Parameter	**Units**		
Chloromethane	ug/L	10	UJ
Vinyl chloride	ug/L	10	U
Bromomethane	ug/L	10	UJ
Chloroethane	ug/L	10	U
1,1-Dichloroethene	ug/L	5	U
Acetone	ug/L	11	U
Carbon Disulfide	ug/L	5	U
Methylene Chloride	ug/L	5	U
trans-1,2-Dichloroethene	ug/L	5	U
1,1-Dichloroethane	ug/L	5	U
Vinyl acetate	ug/L	10	U
Methyl ethyl ketone (2-Butanone)	ug/L	4.3	J
cis-1,2-Dichloroethylene	ug/L	5	U
1,2-Dichloroethene (total)	ug/L	5	U
Chloroform	ug/L	5	U
1,1,1-Trichloroethane	ug/L	5	U
Carbon Tetrachloride	ug/L	5	U
1,2-Dichloroethane	ug/L	5	U
Benzene	ug/L	5	U
Trichloroethylene (TCE)	ug/L	5	U
1,2-Dichloropropane	ug/L	5	U
Bromodichloromethane	ug/L	5	U
2-Chloroethyl vinyl ether	ug/L	10	UJ
cis-1,3-Dichloropropene	ug/L	5	U
Methyl isobutyl ketone (4-Methyl-2-pentanone)	ug/L	10	U
Toluene	ug/L	5	U
trans-1,3-Dichloropropene	ug/L	5	U
1,1,2-Trichloroethane	ug/L	5	U
2-Hexanone	ug/L	10	U
Tetrachloroethylene (PCE)	ug/L	5	U

Parameter	Units						
StationID		G633GW001		G633GW002		G633GW005	
SampleID		633GW001N2		633GW002N2		633GW005N2	
DateCollected		10/31/2003		10/31/2003		10/31/2003	
DateExtracted		11/08/2003		11/08/2003		11/08/2003	
DateAnalyzed		11/08/2003		11/08/2003		11/08/2003	
SDGNumber		101178		101178		101178	
Dibromochloromethane	ug/L	5	U	5	U	5	U
Chlorobenzene	ug/L	5	U	5	U	5	U
Ethylbenzene	ug/L	5	U	5	U	5	U
m+p Xylene	ug/L	5	U	5	U	5	U
o-Xylene	ug/L	5	U	5	U	5	U
Xylenes, Total	ug/L	5	U	5	U	5	U
Styrene	ug/L	5	U	5	U	5	U
Bromoform	ug/L	5	U	5	U	5	U
1,1,2,2-Tetrachloroethane	ug/L	5	U	5	U	5	U
1,3-Dichlorobenzene	ug/L	1.8	J	5	U	5	U
1,4-Dichlorobenzene	ug/L	7.4	=	5	U	5	U
1,2-Dichlorobenzene	ug/L	0.53	J	5	U	5	U
1,2,4-Trichlorobenzene	ug/L	5	U	5	U	5	U
1,2,3-Trichlorobenzene	ug/L	5	U	5	U	5	U

	StationID	G633GW005	
	SampleID	633HW005N2	
	DateCollected	10/31/2003	
	DateExtracted	11/08/2003	
	DateAnalyzed	11/08/2003	
	SDGNumber	101178	
Parameter	**Units**		
Dibromochloromethane	ug/L	5	U
Chlorobenzene	ug/L	5	U
Ethylbenzene	ug/L	5	U
m+p Xylene	ug/L	5	U
o-Xylene	ug/L	5	U
Xylenes, Total	ug/L	5	U
Styrene	ug/L	5	U
Bromoform	ug/L	5	U
1,1,2,2-Tetrachloroethane	ug/L	5	U
1,3-Dichlorobenzene	ug/L	5	U
1,4-Dichlorobenzene	ug/L	5	U
1,2-Dichlorobenzene	ug/L	5	U
1,2,4-Trichlorobenzene	ug/L	5	U
1,2,3-Trichlorobenzene	ug/L	5	U

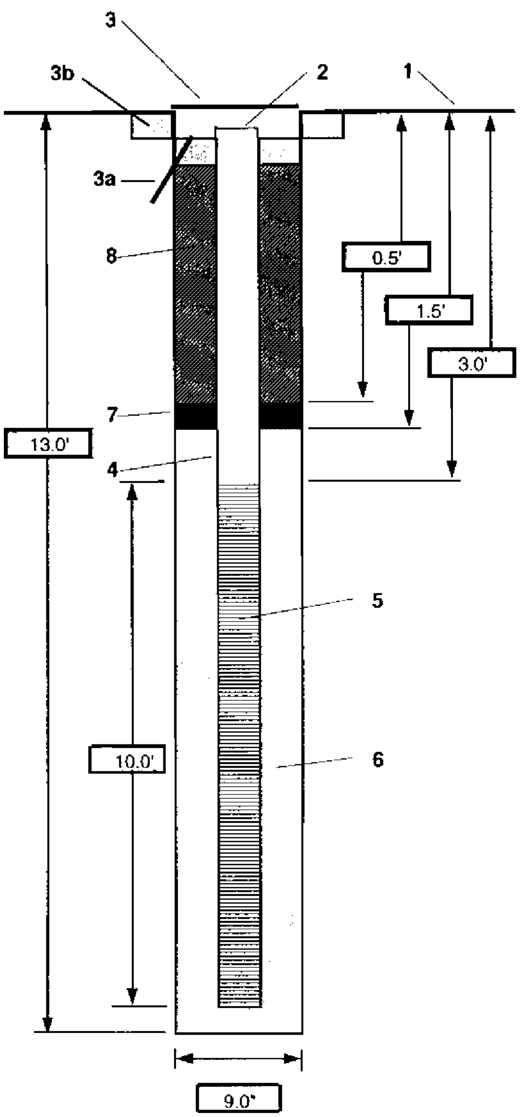
	StationID	G633GW001		G633GW002		G633GW005		G633GW005	
	SampleID	633GW001N2		633GW002N2		633GW005N2		633HW005N2	
	DateCollected	10/31/2003		10/31/2003		10/31/2003		10/31/2003	
	DateExtracted	11/05/2003		11/05/2003		11/05/2003		11/05/2003	
	DateAnalyzed	11/07/2003		11/07/2003		11/05/2003		11/07/2003	
	SDGNumber	101178		101178		101178		101178	
Parameter	**Units**								
PCB-1016 (Arochlor 1016)	ug/L	1	UJ	1	UJ	1	UJ	0.99	UJ
PCB-1221 (Arochlor 1221)	ug/L	1	UJ	1	UJ	1	UJ	0.99	UJ
PCB-1232 (Arochlor 1232)	ug/L	1	UJ	1	UJ	1	UJ	0.99	UJ
PCB-1242 (Arochlor 1242)	ug/L	1	UJ	1	UJ	1	UJ	0.99	UJ
PCB-1248 (Arochlor 1248)	ug/L	1	UJ	1	UJ	1	UJ	0.99	UJ
PCB-1254 (Arochlor 1254)	ug/L	2	UJ	2	UJ	2	UJ	2	UJ
PCB-1260 (Arochlor 1260)	ug/L	2.2	J	2	UJ	2	UJ	2	UJ

CH2MHILL

PROJECT NUMBER	WELL NUMBER	
158814	633-MW-05	SHEET 1 OF 1

WELL COMPLETION DIAGRAM

PROJECT : Charleston Naval Complex LOCATION AOC 633 Northing: 372445.7
DRILLING CONTRACTOR : Prosonic Drilling Easting: 2320137.5
DRILLING METHOD AND EQUIPMENT USED : Hollow-stem auger; truck mounted drill rig
WATER LEVELS : 2.6 START : 03 October 2003/0945 END :03 October 2003/1100 LOGGER Jed Heames/CH2M Jones



1- Ground elevation at well: 7.02

2- Top of casing elevation: 6.51

3- Wellhead protection cover type: Bolt-down manhole cover
a) drain tube?: No
b) concrete pad dimensions: 2' X 2' X6"

4- Dia./type of well casing: 2-inch PVC

5- Type/slot size of screen: PVC/0.010 slot

6- Type screen filter: 20/30 silica sand
a) Quantity used: 5 1/2 (50 lb) bags

7- Type of seal: Barroid bentonite pellets
a) Quantity used: 3/4 (50 lb) bag

8- Grout
a) Grout mix used: None used for this well due to shallow
b) Method of placement: construction
c) Vol. of well casing grout:

Development method: Surge block/Submersible pump

Development time: One hour

Estimated purge volume: 30 gallons

Comments: Well developed clear.

CH2MHILL

PROJECT NUMBER	BORING NUMBER	
158814	633-MW-05	SHEET 1 OF 1

SOIL BORING LOG

PROJECT : Charleston Naval Complex LOCATION : AOC 633
ELEVATION : 7.02 DRILLING CONTRACTOR : Prosonic Drilling Corp.
DRILLING METHOD AND EQUIPMENT USED : Hollow-stem auger, truck-mounted drill rig
WATER LEVELS : 6.51 START : 03 October 03 / 0945 END : 03 October 03 / 1100

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (IN)	#/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N)	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. OVM (ppm): Breathing Zone Above Hole
	0-1'				Sand, orange-tan, medium to coarse grain, dry	
	1-4'				Silty sand, dark gray, fine to medim-grain, moist	
5						
10						
	4-13'				Silty clay, gray, fine grain, pluff mud, saturated End of Boring	
15						
20						
25						

CH2MHILL

WELL PURGE AND SAMPLING FIELD SHEET

WELL NUMBER: 633-MW05 | **SITE:** AOC 633

FIELD CREW: Guy Willis

		CASING DIAMETER		GAL/FT OF CASING	
DEPTH TO WATER (FT):	2.56				
WELL DEPTH (FT):	12.8	2 IN.		0.1632	
WATER COLUMN (FT):	10.24	4 IN.		0.6528	
GAL/FT OF CASING	0.1632	6 IN.		1.4688	
CASING VOLUME (GAL)	1.66	8 IN.		2.611	
NO. OF VOLUMES min.(3)	3	10 IN.		4.0797	
PURGE VOLUME (GAL)	5	12 IN.		5.8748	

METHOD OF PURGING

PUMP: Peristaltic	OTHER:	BAILER : TEFLON, SS ,OTHER:	
TIME ON: 0940		BAILER VOL.. (gal)	.25 / .33
FLOW RATE (gpm): 0.21		REQUIRED PULLS:	
PUMP TIME (min): 23		VOL. PURGED (gals):	
VOL. PURGED (gals): 5		OTHER:	

FIELD PARAMETERS	FIELD MEASUREMENTS					
	Initial	1st	2nd	3rd	5th	6th
TIME	0940	0947	0955	1003		
VOL. (gal)	0	1.6	3.2	5		
pH (s.units)	6.86	6.78	6.81	6.89		
COND.(S/m)	38.2	16.9	24.9	37.6		
TURBIDITY(NTUs)	2.7	8.2	0.2	4.9		
TEMP.(C)	23.22	24.09	24.19	23.38		
DO.(mg/L)	2.43	0.22	0.17	0.08		
ORP(mV)	-221	-202	-207	-231		

OBSERVATIONS

COLOR: Clear with slight grey tint light sheen

ODOR: light odor

COMMENTS: well went dry during sampling

SAMPLE DATE/ TIME: 10-31-03 / 1005

Site - AOC 633 Well #

Date - 10/2/03 633GW005

Arrive & Setup - 1430

Crew - Pratt Shaw

Weather - Sunny/70°

TD - 12.66 1 Vol - 1.6

DTW - 3.30 3 Vol - 4.8

LWC - 9.36

Water quality via Horiba

Type of well - Flushmount

Activity - Well Development

Sediment - 0"

Start Surge - 1440

End Surge - 1448

Start Development - 1553

End Development - 0857** 10/3/03

[signature] 10/3/03

Time	Vol	DTW	Ph	Cond	Turb	Temp	Sal	obs
0846	*	8.87	5.05	25.1	3	20.4	1.54	
0850	*	9.16	5.87	20.8	3	21.1	1.28	
0857	*	10.98	6.28	19.5	0	21.4	1.15	

Well has extremly slow recovery.

** Due to time, unable to complete on 10/2/03. Secured at 1615 will resume on 10/3/03.

DTW @ 0745 = 7.99 ft. 10/3/03

Development resumed @ 0750 on 10/3/03.

* Due to high turbidity 7 gals purged prior to taking readings

[signature] 10/3/03

Appendix B

COMPARISON OF TOTAL COST OF REMEDIAL SOLUTIONS

Site: Charleston Naval Complex
Location: AOC 633
Phase: Corrective Measures Study
Base Year: 2003
Date: 12/11/03

	Alternative Number 1 MNA with Land Use Controls	Alternative Number 2 MNA, LNAPL Recovery and Land Use Controls
Total Assumed Project Duration (Years)	10	5
Capital Cost/O&M Cost	$26,800	$29,900
Annual O&M/Monitoring Cost	$2,900	$2,900
Total Present Worth of Solution	$49,000	$48,000

Disclaimer: The information in this cost estimate is based on the best available information regarding the anticipated scope of the remedial alternatives. Changes in the cost elements are likely to occur as a result of new information and data collected during the engineering design of the remedial alternative. This is an order-of-magnitude cost estimate that is expected to be within -30 to +50 percent of the actual project costs.

Element: **Sample Collection and Laboratory Costs**
Alternative: **1, 2**

Site:	Charleston Naval Complex	**Prepared By:** DFW	**Checked By:**
Location:	AOC 633	**Date:** 12/11/03	**Date:**
Phase:	Corrective Measures study		
Base Year:	2003		

WORK STATEMENT

Costs associated with water sample collection, shipment and analysis on a per event basis; no natural attenuation parameters.

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Equipment & Labor per Event					STL estimate
Sample Analysis (PCBS, VOCs, SVOCs)	2	SAMPLE	$350	$700	2 Wells
Sampling Supplies	1	EA	$200	$200	
Groundwater Sampling Equipment Rental	0.2	WK	$600	$120	Includes MultiRAE and Peristaltic Pump
Sample Shipment	1	EA	$50	$50	CH2M-Jones Estimate
Labor - Technicians	12	HR	$55	$660	3 hrs/well, 2 people, includes data validation
SUBTOTAL				**$1,730**	
Project Management	2%	of	$1,730	$35	
Technical Support	2%	of	$1,730	$35	
Construction Management	0%	of	$1,730	$0	
Subcontractor General Requirements	0%	of	$1,730	$0	
SUBTOTAL				**$1,799**	
TOTAL UNIT COST				**$1,800**	

OPERATION AND MAINTENANCE COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
SUBTOTAL				$0	
Contingency	20%		$0	$0	
SUBTOTAL				$0	
TOTAL O&M COST				**$0**	

Source of Cost Data

1. Analytical Bid Form - Charleston Naval Complex - Level III

Alternative 1: MNA and LUCs

COST ESTIMATE SUMMARY

Site:	Charleston Naval Complex	**Description:**	
Location:	AOC 633	Monitoring of the surficial aquifer.	
Phase:	Corrective Measures Study		
Base Year:	2004		
Date:	12/11/03		

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL
Monitoring Plan				
Labor - Project Manager	2	HR	$125	$250
Labor - Engineer/Hydrogeologist	8	HR	$90	$720
Labor - Editor	2	HR	$65	$130
Labor - CAD Technician	2	HR	$65	$130
Initial Groundwater Sample Collection	1	EA	$1,799	$1,799
SUBTOTAL				**$3,029**
Project Management	5%	of	$3,029	$151
Technical Support	5%	of	$3,029	$151
Cost for LUCs	1	EA	$20,000	$20,000
SUBTOTAL				**$23,332**
Contingency	15%	of	$23,332	$3,500
TOTAL CAPITAL COST				**$26,800**

OPERATIONS AND MAINTENANCE COST

	DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL
yrs 1 - 10	Annual Groundwater Sample Collection	1	EA	$1,799	**$1,799**
	Annual Report				
	Labor - Project Manager	2	HR	$125	$250
	Labor - Engineer/Hydrogeologist	6	HR	$90	$540
	Labor - Editor	2	HR	$65	$130
	Labor - CAD Technician	3	HR	$65	$195
	SUBTOTAL				**$1,115**
yrs 1 - 10	**TOTAL ANNUAL O&M COST**				**$2,900**

PRESENT VALUE ANALYSIS Discount Rate = 3.2%

End Year	COST TYPE	TOTAL COST	COST PER YEAR	TOTAL PRESENT WORTH
1	FIRST YEAR CAPITAL COST	$26,800	$26,800	$26,800
2 - 10	ANNUAL O&M COST (Year 1 - 10)	$26,100	$2,900	22,371
				$49,171
	TOTAL PRESENT WORTH OF ALTERNATIVE			**$49,000**

SOURCE INFORMATION

1. United States Environmental Protection Agency. July 2000. A Guide to Preparing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).

Alternative 1: MNA and LUCs

COST ESTIMATE SUMMARY

Site: Charleston Naval Complex
Location: AOC 633
Phase: Corrective Measures Study
Base Year: 2004
Date: 12/11/03

Description:
Monitoring of the surficial aquifer.

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL
Monitoring Plan				
Labor - Project Manager	2	HR	$125	$250
Labor - Engineer/Hydrogeologist	8	HR	$90	$720
Labor - Editor	2	HR	$65	$130
Labor - CAD Technician	2	HR	$65	$130
Initial Groundwater Sample Collection	1	EA	$1,799	$1,799
Adsorbent Pad replacement	12	ea	$200	$2,400
SUBTOTAL				**$5,429**
Project Management	5%	of	$5,429	$271
Technical Support	5%	of	$5,429	$271
Cost for LUCs	1	EA	$20,000	$20,000
SUBTOTAL				**$25,972**
Contingency	15%	of	$25,972	$3,896
TOTAL CAPITAL COST				**$29,900**

OPERATIONS AND MAINTENANCE COST

	DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL
yrs 1 - 5	Annual Groundwater Sample Collection	1	EA	$1,799	**$1,799**
	Annual Report				
	Labor - Project Manager	2	HR	$125	$250
	Labor - Engineer/Hydrogeologist	6	HR	$90	$540
	Labor - Editor	2	HR	$65	$130
	Labor - CAD Technician	3	HR	$65	$195
	SUBTOTAL				**$1,115**
yrs 1 - 5	**TOTAL ANNUAL O&M COST**				**$2,900**

PRESENT VALUE ANALYSIS

Discount Rate = 3.2%

End Year	COST TYPE	TOTAL COST	COST PER YEAR	TOTAL PRESENT WORTH
1	FIRST YEAR CAPITAL COST	$29,900	$29,900	$29,900
2 - 5	ANNUAL O&M COST (Year 1 - 10)	$26,100	$2,900	17,785
	Includes absorbent pad replacement for first 2 yrs			$47,685
	TOTAL PRESENT WORTH OF ALTERNATIVE			**$48,000**

SOURCE INFORMATION

1. United States Environmental Protection Agency. July 2000. A Guide to Preparing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).

Appendix C

Engineering Comments Prepared by Jerry Stamps

1. General
Given that groundwater monitoring is proposed in this CMS, the Navy must incorporate AOC 633 into the basewide long-term monitoring report.

CH2M-Jones Response:
Comment noted. The groundwater monitoring at this site will be incorporated into the basewide monitoring program.

2. Figure 1-4
Monitoring well G633GW005 is absent from this figure. One must conclude that that water elevation from that well was not accounted for in the groundwater flow direction determination. The Navy must ensure that water elevations from all appropriate wells are accounted for in future groundwater flow determinations that are anticipated to be a part of the basewide groundwater monitoring program.

CH2M-Jones Response:
The groundwater contours shown in Figure 1-4 were measured in October 2002. Monitoring well G633GW005 was not installed until October 2003, so it was not available for the October 2002 monitoring event. The groundwater contours measured in October 2002, as shown in Figure 1-4, were used for selecting the location of monitoring well G633GW005 as a downgradient monitoring point, in consultation with Ms. Jo Cherie Overcash.

In the future, groundwater elevations from the five site wells will be used to develop groundwater gradient figures.

3. Sections 3.3 and 4.2
This section states that absorbent pads will be placed in G633GW001to recover the LNAPL. The Navy should specify an anticipated frequency for which the absorbent pad will be inspected and replaced.

CH2M-Jones Response:
After the LNAPL and soil excavation IM activities were implemented at this site in July 2002, the amount of NAPL in well G633MW001 was checked periodically through the end of 2002 and found to contain NAPL ranging in thickness from 0.17 to 0.42 ft, with measured thickness generally declining over time. NAPL was removed from the well via a bailer after it was measured after each event.

In February 2003, the use of absorbent pads in this well was initiated due to the observed declining NAPL levels. Over the past year, the amount of NAPL that is found to accumulate in the well and absorb to the pads has continued to decline. Currently, only a fraction of the pad exhibits evidence of absorbed product after a 3 to 4 week period in the well. It is expected that replacement of the pads every 1 to 2 months will be adequate and that, over time, the need for *pads will decrease and eventually no longer be required, as the amount of NAPL from the aquifer is reduced.*

4. Sections 4.1 and Section 4.2
The Department recommends sampling downgradient well G633GW005 for SVOC analysis, in addition to the currently proposed VOC analysis, on a periodic basis to ensure that SVOC contamination is not migrating.

CH2M-Jones Response:
Comment noted. Periodic monitoring for SVOCs can be conducted. Since they are less mobile and less likely to migrate than VOCs, less frequent sampling for SVOCs would be warranted. If the monitoring indicates that SVOCs are migrating, more frequent monitoring may be appropriate.

5. LUCs
The Navy should include a LUC discussion similar to that presented in Section 5.4.1 of the SWMU 9 CMS Report. The Navy should also present the exposure assumptions evaluated in the RFI and discuss how these LUCs will be protective with regards to the exposure assumptions. The Department anticipates this information to be included in subsequent CMS Report submittals as well.

CH2M-Jones Response:
Comment noted. A discussion of LUCs as requested will be included in the revised report.

Hydrogeology Comments Prepared by Don Hargrove

1. Appendix A, Well Completion Diagram:
   a. There is a problem with the specifications for the concrete pad thickness, depth to top of the bentonite seal, and the grout thickness, as they relate to one another. Specifically, the pad is specified as extending 0.5 feet bgs, the top of the bentonite seal is also listed as 0.5 feet bgs. There is no room for the grout that is described as installed between these two components. Please verify the actual construction of this well, and revise the well completion diagram accordingly.
   b. This diagram specifies that bentonite chips were used for the seal. It should be noted that bentonite chips take longer to hydrate than pellets, and complete hydration is questionable. The hydration time that was used during construction of this well should be specified. This comment can be addressed informally, without a page revision. It is also recommended that bentonite pellets be used in the future.
   c. The well driller's name and certification number are not listed. Please revise to include this information.

CH2M-Jones Response:
The requested information and revised well construction log will be provided in the revised report. Based on a conversation with the field team leader, Darryl Gates, bentonite pellets are our

standard product for this purpose and were actually used for this well; the well construction diagram will be corrected to indicate this.

2. Neither the well development log, nor the purge log (prior to sampling) is included in this document. The following is quoted from Monitoring Well Approval #HW-03-042 for this well, dated 5 August 2003:

   "All monitoring wells must be properly developed until clear, sediment-free water samples are obtained. Specific Conductance, temperature, turbidity, and pH measurements should be taken during development. A log recording the values of these parameters should be maintained during development of the wells. This log should be submitted along with the "as-built" construction details required by R.61-71.H.d. and R.61-71.H.f."

   This information is necessary to determine if water samples taken from this well are representative of the aquifer being sampled. If this information has already been reported to the Department, please specify the document or correspondence that includes these logs. Otherwise, please revise this appendix to include these logs.

   CH2M-Jones Response:
   The requested information will be provided in the revised report.