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FINAL CORRECTIVE MEASURES STUDY FOR AREA OF CONCERN 693 FUSE AND
PRIMER HOUSE, FORMER BUILDING 117 AND AREA OF CONCERN 694 FORMER NAVAL
AMMUNITION DEPOT CNC CHARLESTON SC

9/1/2013
TETRA TECH

Comprehensive Long-term Environmental Action Navy

CONTRACT NUMBER N62467-04-D-0055



Revision 1
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Corrective Measures Study for AOC 693 - Fuse and Primer House, Former Building 117 and AOC 694 - Former Naval Ammunition Depot at

Charleston Naval Complex North Charleston, South Carolina

Contract Task Order 0104

September 2013

USEPA ID No. SC0170022560



Naval Facilities Engineering Command Southeast
4130 Faber Place Drive, Suite 202
North Charleston, South Carolina 29405

SEPTEMBER 2013

**CORRECTIVE MEASURES STUDY
FOR
AOC 693 – FUSE AND PRIMER HOUSE, FORMER BUILDING 117 AND
AOC 694 – FORMER NAVAL AMMUNITION DEPOT**

**CHARLESTON NAVAL COMPLEX
NORTH CHARLESTON, SOUTH CAROLINA**

**COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT**

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SEPTEMBER 2013

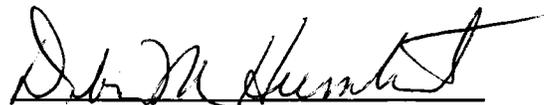
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ACRONYMS

AOC	Area of Concern
bgs	below ground surface
BEQ	Benzo(a)pyrene Equivalent
BRAC	Base Realignment and Closure
CLEAN	Comprehensive Long-Term Environmental Action Navy
CMO	Corrective Measures Objectives
CMS	Corrective Measures Study
CNC	Charleston Naval Complex
COC	Contaminant of Concern
COPC	Contaminant of Potential Concern
CTO	Contract Task Order
ECPC	Ecological Chemicals of Potential Concern
EnSafe	EnSafe Inc.
EPC	Exposure Point Concentration
°F	degrees Fahrenheit
ft	feet
ft/day	feet per day
FISC	Fleet and Industrial Supply Center
GRA	General Response Action
HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
IAS	Initial Assessment Study
ILCR	Incremental Lifetime Cancer Risk
JB	Joint Base
Kh	Hydraulic conductivity
LOAEL	Lowest-observed-adverse-effects level
LUC	Land Use Control
MCL	Maximum Contaminant Level
MCS	Media Cleanup Standards
mg/kg	milligram per kilogram
mg/kg/day	milligram per kilogram per day
msl	mean sea level
NOAEL	No-observed-adverse-effects level
O&M	Operation and Maintenance

µg/kg	microgram per kilogram
µg/L	microgram per liter
NAVFAC SE	Naval Facilities Engineering Command Southeast
ng/kg	nanogram per kilogram
NPW	Net Present Worth
OSHA	Occupational Safety and Health Administration
PA	Preliminary Assessment
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated biphenyl
pg/L	picogram per liter
PPE	Personal Protective Equipment
ppm	part per million
Qcs	Quaternary Clayey Sand and Clay
Qs	Quaternary Sand
RBC	Risk-based concentration
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
RGO	Remedial Goal Option
SCDHEC	South Carolina Department of Health and Environmental Control
SI	Site Investigation
SSL	Soil Screening Level
SVOC	semi-volatile organic compound
Ta	Ashley Formation
TDS	Total Dissolved Solids
Tetra Tech	Tetra Tech, Inc.
TEQ	Toxic Equivalent
TT	Treatment Technique
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
VOC	volatile organic compound
yd ²	square yard

1.0 INTRODUCTION

1.1 SCOPE AND OBJECTIVES

Naval Facilities Engineering Command Southeast (NAVFAC SE) has issued Contract Task Order (CTO) 0104 to Tetra Tech, Inc. (Tetra Tech) under the Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract N62467-04-D-0055 to perform a Resource Conservation and Recovery Act (RCRA) Corrective Measures Study (CMS) for Area of Concern (AOC) 693 - Fuse and Primer House, Former Building 117 and AOC 694 – Former Naval Ammunition Depot at Charleston Naval Complex (CNC) Clouter Island located in North Charleston, South Carolina.

This work is part of the United States Navy's Installation Restoration Program, which is designed to identify contamination of Navy and Marine Corps lands/facilities resulting from past operations and to institute corrective measures, as needed.

The objectives of the CMS are as follows:

- Identify Media Cleanup Standards (MCSs) based on background concentrations, promulgated federal and state standards, or risk-derived standards that are protective of human health and the environment.
- Develop corrective measures objectives (CMOs) that identify any present chemicals of concern (COCs), receptors, pathways, and cleanup standards.
- Identify and screen corrective measures technologies.
- Develop corrective measures alternatives.
- Conduct detailed analysis of corrective measures alternatives.
- Provide a recommended corrective measures alternative.

1.2 ORGANIZATION OF CORRECTIVE MEASURES STUDY

The CMS consists of seven sections. Section 1.0 is the introduction. Section 2.0 provides a description of current conditions at AOCs 693/694. Section 3.0 identifies CMOs and MCSs. The identification and screening of corrective measures technologies for soil and groundwater is conducted in Section 4.0.

Sections 5.0 and 6.0 present the development and evaluation/comparative analysis of the corrective measures alternatives, respectively. Section 7.0 presents the recommended corrective measures alternatives. In addition, this report includes one appendix containing cost estimates for corrective measures alternatives.

1.3 FACILITY BACKGROUND INFORMATION

1.3.1 Facility Location

CNC is located on the central coast of South Carolina at the mouth of the Cooper River approximately 5 miles north of the City of Charleston proper within Charleston County. CNC is comprised of a number of former Navy facilities, including the Charleston Naval Shipyard; the Naval Station, Charleston; the Naval Fleet and Industrial Supply Center (FISC); and Clouter Island. The combined facilities cover approximately 3,200 acres and consist of dry land on the west and the Cooper River to the east as shown on Figure 1-1.

Clouter Island is located on the east bank of the Cooper River and east of the CNC. Clouter Island consists of four dredge spoil areas and occupies approximately 1,400 acres of former tidal marshes.

1.3.2 Facility History

The Charleston Naval Base was located on the west bank of the Cooper River about five miles north of the City of Charleston proper. Located within the confines of the base were the Naval Fleet and Industrial Supply Center, the Naval Station, Charleston and the Naval Shipyard facilities. These activities provided the primary berthing, logistics and repair services to US Navy ships in the Charleston area. The Naval Station and Shipyard combined encompass approximately 1,800 acres. The property and the majority of the commands were slated for closure by the Base Realignment and Closure (BRAC) commission in 1993, and 1995: the Shipyard, Naval Station, FISC, and the Fleet and Mine Warfare Training Center. Operations on the complex ceased on 01 April 1996 with the complex being transferred after that.

The military remains a major industry in the Charleston area today, despite major downsizings. The round of base realignments and closures resulted in the decision for Charleston to receive the Naval Nuclear Power Training Command transferring from Orlando, Florida, bringing with it transient students attending the school each year. In October 2010, the United States Air Force Charleston Air Force Base and the United States Navy Naval Support Activity Charleston merged to form Joint Base (JB) Charleston. The facility is under the jurisdiction of the United States Air Force 628th Air Base Wing, Air Mobility Command. A joint civil-military airport, JB Charleston shares runways with Charleston

International Airport for commercial airline aircraft operations on the south side of the airfield and general aviation aircraft operations on the east side.

1.4 PHYSICAL DESCRIPTION OF FACILITY

1.4.1 Facility-Wide Geology and Soils

AOCs 693/694 are situated on poorly consolidated Quaternary age sediments that overlie the Tertiary age Ashley Formation. Quaternary age sediments at the site are sometimes covered by a very thin veneer, less than a few feet in thickness of anthropogenic fill placed during various phases of construction and site operations.

Only Quaternary and Tertiary-age sediments were encountered during the Zone K RFI (which encompasses AOCs 693 and 694) at CNC. The lowermost stratigraphic unit identified in Zone K is the Ashley Formation member of the Mid-Tertiary age Cooper Group. Overlying the Ashley are primarily younger Quaternary-age stratigraphic units, although some remnant of Upper Tertiary sediments may be present, field identification of these deposits is extremely difficult. Stratigraphic units encountered during the RFI are presented in the following sections in ascending order.

Tertiary-Age Sediments Ashley Formation

The oldest sediment encountered during the Zone K RFI investigation has been the Ashley Formation, the youngest member of the Tertiary-age Cooper Group. The Ashley Formation was deposited in an open-marine shelf environment during a rise in sea level in the late Oligocene. Due to successive sea level transgression-regression (rise and fall) sequences during late Tertiary and early Quaternary time, extensive erosion has removed many of the marine and terrigenous deposits overlying the Ashley Formation.

The Ashley Formation is an olive-yellow to olive-brown, tight, slightly calcareous, clayey silt with varying amounts of grained sand that decrease rapidly with depth. It is firm to stiff, low in plasticity, and damp to moist. Ashley Formation elevations range from 10.9 feet (ft) mean sea level (msl) to 3.8 ft msl. The unit undulates between slight ridges and troughs at the site [EnSafe, Inc. (EnSafe), 2002].

Quaternary-age Sediments

The Quaternary Period began with the Pleistocene Epoch and continues with the Holocene (Recent) Epoch. During Quaternary time, several marine transgression-regression sequences resulted in a jumbled network of terrace complexes composed of varied coastal depositional environments such as barrier islands, back-barrier lagoons, tidal inlets, and shallow-ocean-marine shelf systems. Due to

regional crustal uplift in the Charleston area during the Quaternary, many barrier to back-barrier deposits from high sea level stands are preserved as terraces. However, succeeding transgressions reworked the shallow-marine shelf deposits on the seaward side of each older barrier ridge or island. The result of this erosional and redepositional process of older sediments is that a subsequently younger sequence of deposits may exist on the seaward side, and laterally adjacent to the previous (older) coastal deposit. Therefore, it can be difficult to determine discrete formational units within the Quaternary system. Field identification of these formational units is difficult since many characteristics may only be evident at the microscopic level.

Throughout CNC, Quaternary-age sediments extend from the top of the Ashley Formation to just below ground surface. The geologic interpretation of this area in recent reports indicates these deposits to be members of the Ten Mile Hill Beds. The Ten Mile Hill Beds are of Pleistocene age and date to approximately 200,000 to 240,000 years ago. The informal designation of the Ten Mile Hill Beds to differentiate them from the older Ladson Formation, because they represent a younger sea transgression/regression than that recorded by the Ladson Formation. The Ten Mile Hill Beds consist of a sequence of three distinct facies: a clayey sand to sand associated with back-barrier deposits, a clean barrier island sand deposit, and nearshore shelf fossiliferous sand and shell deposit. Due to the difficulty in positively identifying discrete formational units, two Quaternary-age lithostratigraphic units have been correlated for the geologic cross sections presented in this report. They are described as follows: Quaternary Clayey Sand and Clay (Qcs). The Qcs unit typically unconformably overlies the Ashley Formation (Ta). This unit generally consists of green to gray-green, fine to coarse, clayey sand with varying amounts of silt. Phosphate nodules from pebble to cobble size and shell hash are often intermixed within the matrix or as distinct basal lenses. Clay lenses, when present, are often green, firm to stiff, and plastic. The Qs unit overlies the Qcs unit and extends to ground surface, although smaller Qs lenses may be present at depth. The Qs is a gray, green, brown, and orange fine to medium sand with varying silt content and very distinctive mica content. The unit is marked by a lack of cohesiveness from limited fines content (EnSafe, 2002).

Based on geotechnical data, the Qs deposits had an average grain-size composition of 93.1% sand, 3.4% silt, and 3.5% clay. Porosity estimates ranged from 43.0 to 46.9%.

1.4.2 Facility-Wide Surface Water Hydrology

Clouter Island is a north-south trending island bounded on the west by the Cooper River and on the east by Clouter Creek. The interior of Clouter Island is a dredge spoil disposal area. A narrow strip of land between the spoil disposal area and Cooper River is the location of two of the Clouter Island AOCs. There are no perennial surface water drainage features on this part of Clouter Island. Groundwater levels in temporary wells were from 1 to 5 ft below ground surface (bgs). Given its proximity to the Cooper

River, the hydrogeology of the area of Clouter Island sampled during the RFI is expected to be controlled directly by the Cooper River and its tidal fluctuations. Groundwater probably flows in the water table aquifer on Clouter Island toward Cooper River or Clouter Creek. The Ashley Formation, as determined in previous CNC investigations, is expected to be the uppermost, laterally extensive aquitard/confining unit underlying Clouter Island.

1.4.3 Surrounding Land Use

CNC is situated in a heavily industrialized area with over four and a half miles of shoreline on the Cooper River, north of the city of Charleston. The land near CNC has been developed and is a combination of residential, commercial, and industrial development. The remaining areas of the CNC consisted of administrative buildings, shipyards, ports, military quarters and family housing units, mess halls, and related maintenance, training, and community facilities.

Clouter Island is used for the disposition of harbor and river dredging spoils. A containment dike encloses four large dredge spoil cells that cover most of the island. With the exception of the dredge spoil cells and Interstate Highway 526 (Mark Clark Expressway), which crosses the north-central portion of Clouter Island, there is no other development of any type on the island.

1.4.4 Ecology

Most of CNC is heavily developed, but some portions of the facility consist of estuarine marshes that support a diverse assemblage of flora and fauna. The marshes at CNC are dominated by cordgrass (*Spartina spp*) and black needlerush (*Juncus roemerianus*). Some marshes at CNC merge with scrub-shrub wetlands where common plants include wax myrtle (*Myrica cerifera*), groundsel tree (*Baccharis halimifolia*), and salt marsh elder (*Iva frutescens*).

The lower Cooper River in the vicinity of CNC supports finfish species such as Atlantic menhaden (*Brevoortia tyrannus*), bay anchovy (*Anchoa mitchilli*), silver perch (*Bairdiella chrysoura*), weakfish (*Cynoscion regalis*), spot (*Leiostomus xanthurus*), Atlantic croaker (*Micropogonias undulatus*), red drum (*Sciaenops ocellatus*), star drum (*Stellifer lanceolatus*), summer flounder (*Paralichthys dentatus*) and southern flounder (*P. lethostigma*), as well as invertebrate species such as white shrimp (*Litopenaeus setiferus*), brown shrimp (*Farfantepenaeus aztecus*), and crabs (Van Dolah et al., 1990).

As mentioned in Section 1.4.3, Clouter Island consists almost entirely of four large dredge spoil cells. However, a narrow band of relatively undisturbed vegetation lies between the shoreline of the island and the outer edge of the containment dike that encloses the dredge spoil cells. Some portions of this narrow area, especially at the northern and southern ends of Clouter Island, consist of estuarine marshes that

are dominated by cordgrass and black needlerush. Non-marsh habitat in this narrow band inward from the Clouter Island shoreline consists of bottomland hardwoods. The natural community at AOCs 693/694 is comprised of bottomland hardwoods dominated by southern hackberry (*Celtis laevigata*), with a dense, scrub/shrub community containing shrubs and trees such as wax myrtle, tallow tree (*Sapium sebiferum*), red mulberry (*Morus rubra*), and groundsel tree.

No plants that are federally-listed or state-listed as endangered, threatened, or otherwise of concern are known to occur at CNC [U.S. Army Corps of Engineers (USACE), 2006]. The only federally-listed animal species known to occur in the vicinity of the CNC are the American alligator (*Alligator mississippiensis*), West Indian manatee (*Trichechus manatus*), loggerhead turtle (*Caretta caretta*) and shortnose sturgeon (*Acipenser brevirostrum*) (USACE, 2006).

The alligator is federally-listed as “threatened due to similarity of appearance.” Alligators are common in coastal South Carolina and in many parts of their range, and the alligator has this federal designation due to its similarity of appearance to the endangered American crocodile (*Crocodylus acutus*) and other rare crocodylians. Alligators are known to occur in the vicinity of CNC and transient individuals could potentially occur in freshwater and brackish habitats at CNC and Clouter Island.

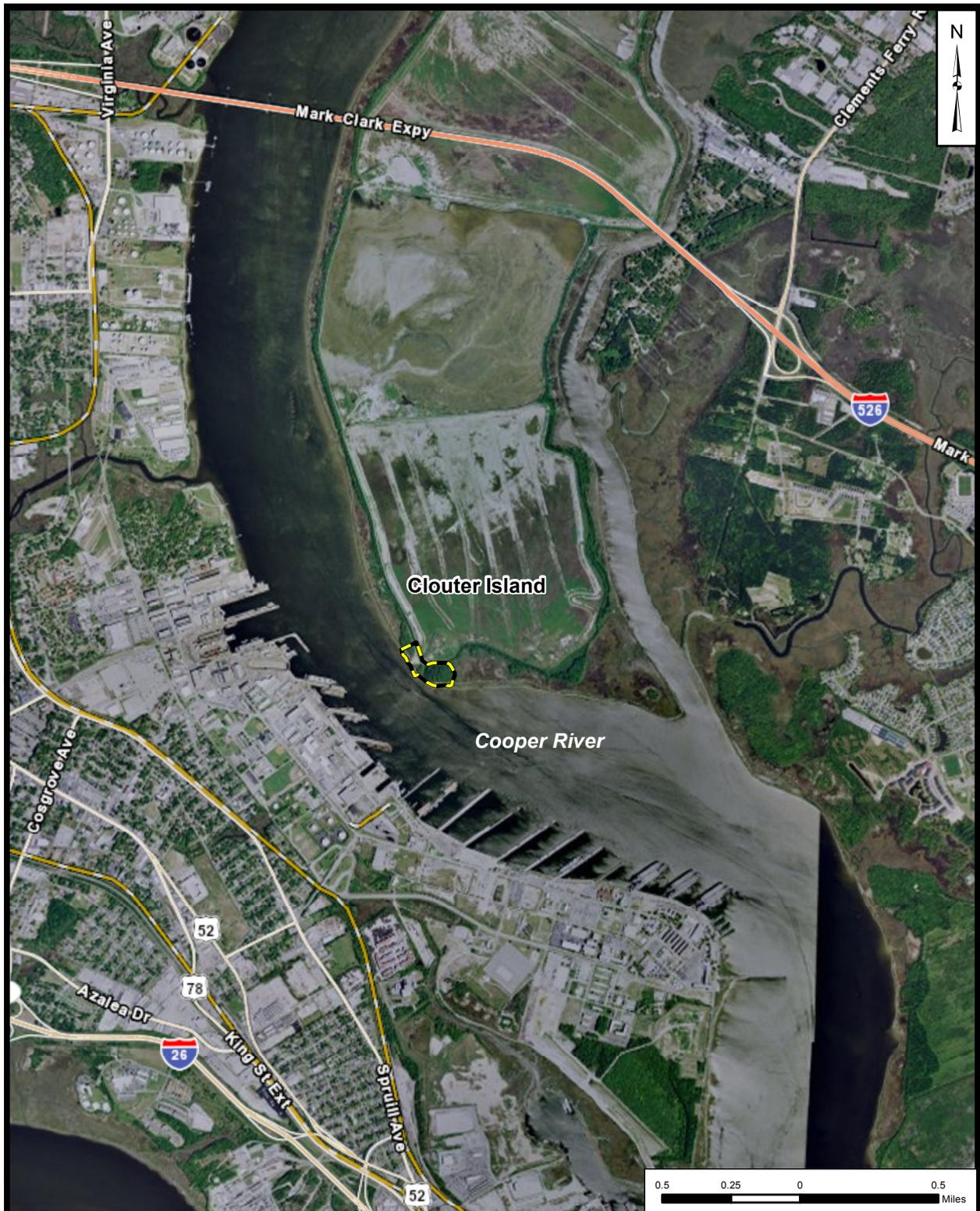
Manatees, federally-listed as endangered, sometimes enter Charleston Harbor in the summer as they migrate up and down the coast. They are occasionally observed in the Cooper River (USACE, 2006).

Loggerhead turtles, federally-listed as threatened, migrate up and down South Carolina’s coast and are often observed in the entrance to Charleston Harbor during spring, summer, and fall. They are rarely seen in the Cooper River and its estuarine system (USACE, 2006).

Shortnose sturgeon, federally-listed as endangered, inhabit the main channels of rivers and spend most of their lives in fresh and brackish water, only rarely venturing into the ocean. Shortnose sturgeon spawn in fresh water, and the nearest known spawning habitat is more than 40 miles upriver from CNC (USACE, 2006). Shortnose sturgeon could occur in the Cooper River near CNC.

Several state-listed animal species have been recorded as occurring in Charleston County, but only the bald eagle (*Haliaeetus leucocephalus*), least tern (*Sterna antillarum*), and brown pelican (*Pelecanus occidentalis*) are known to occur at CNC. The bald eagle is state-listed as endangered. The USFWS removed the bald eagle from the federal list of threatened and endangered species in 2007. Bald eagles are occasionally seen at CNC, but no eagle nests are known to exist at CNC (USACE, 2006). The least tern, state-listed as threatened, nests in low-lying sandbars or on graveled rooftops in lieu of beaches. There is no active nesting of least terns at CNC, but nesting has occurred sporadically on rooftops at

CNC as recently as 2003 (USACE, 2006). Brown pelicans, classified as a State Species of Concern, are commonly seen in flight over CNC (USACE, 2006). Brown pelicans often nest on remote natural and dredged-material islands along the coast, but no there are no nesting sites of brown pelicans or any colonial waterbird species at CNC (USACE, 2006).



Legend	 AOC 693/694
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DRAWN BY MJN	DATE 10/1/2012
CHECKED BY SSH	DATE 10/1/2012
COST/SCHED-AREA	
SCALE AS NOTED	



LOCATION MAP
AOC 693/694
CHARLESTON NAVAL COMPLEX
NORTH CHARLESTON
SOUTH CAROLINA

CONTRACT NO. CTO-JM62	
APPROVED BY SSH	DATE 10/1/2012
APPROVED BY	DATE
FIGURE NO. 1-1	REV. 1

2.0 DESCRIPTION OF CURRENT CONDITIONS

This section provides the site description, site-specific geology and hydrogeology, nature and extent of contamination, contaminant fate and transport, and risk assessment summary for AOC 693 – Fuse and Primer House, Former Building 117 and AOC 694 – Former Naval Ammunition Depot found on Clouter Island within the former CNC.

2.1 SITE DESCRIPTION

Clouter Island is located on the east bank of the Cooper River east of the CNC and consists of four dredge spoil cells, of which three were owned by the Navy. The northern portion of the island is owned by the South Carolina State Ports Authority and is utilized by the USACE. The portion of Clouter Island and associated facilities owned by the Navy were transferred to the USACE in 1996. The island is approximately 1,400 acres and has historically been used as the site for deposition of harbor and river dredging spoils. The locations of AOC 693 and AOC 694 within Clouter Island are presented on Figure 2-1. AOCs 693/694 are located outside (south) of the bermed area used for depositing dredged spoils from the surrounding rivers. The area consists primarily of low lying brush and marsh.

AOCs 693/694 were identified on the island because of the former ammunition depot and past uses. The ammunition depot was used to store various types of military ordnance. The former storage buildings have since been removed with the foundations for these buildings left in place. AOC 693 consists of Building 117, a two-room fuse and primer house, which operated from 1930 to 1939, remains intact. No visual evidence of past operations is present in the building. AOC 694, the former Naval Ammunition Depot in operation from the 1920s to the 1940s, consists of an area surrounding former Building 117. The exact location and dimensions of this former explosives storage area are not known. Remnants of three other structures also remain within the former depot. The northernmost structure is the foundation of Building 106, the Fixed Ammo Storehouse. The foundation of Building 102, the Shell House, is approximately 200 ft south of Building 106. The former site of Building 103, the Magazine, is located between the remains of Buildings 102 and 117. Several buried ordnance shells were discovered on the island and removed in 1985. Dredge materials have been deposited in this area after discontinuing use as an ammunition depot. Facilities 376 and 377 were used by the Navy as part of dredging operations and are located on the western part of the island approximately 1,800 ft north of Building 102.

Waste materials associated with the former ammunition depot include military explosives. Based on their toxicity characteristic, some explosives contain leachable concentrations of metals. Historically, primer components may have included antimony, barium, lead, or mercury. A survey conducted by an unexploded ordnance subcontractor was designed to identify the presence of unexploded ordnance from

ground surface to a depth of 5 ft bgs throughout the AOCs 693/694 area. The purpose of the UXO survey was to assess selected soil sampling locations and temporary monitoring well locations for UXO potential, and to screen access routes to and from these locations in order to avoid potential UXO sites. The UXO avoidance screening was performed concurrently with the first round of RFI sampling in January 1997; thus, the UXO "survey" was conducted after spoils were placed on the AOCs and after the area was no longer used for dredge disposal. Screening of sample locations did not result in the discovery of UXO. Materials of concern identified in the final RFI for AOCs 693/694 are metals and explosives with potential receptors being current and future site users involved in invasive activities.

Dredge spoils are slurried from the Cooper River to the island to maintain the Cooper River ship channel. Due to the nature of this site being used as a dredge spoil area, there is some difficulty in distinguishing the source of the contamination and possible future sources due to continued dredging disposal activities, such as typical excavation and diking activities that may contribute to the site by uncovering or exposing contaminants from deeper soils rather than past operations of AOCs 693/694. The site will remain a dredge spoils area for the Cooper River. There are no plans for any other use of the property

2.2 PREVIOUS AOCs 693/694 INVESTIGATIONS

The following investigations have been performed previously at AOCs 693/694:

Final RCRA Facility Assessment, 1995, (EnSafe, 1995).

Zone K RFI Report, 1999, (EnSafe, 1999).

Clouter Island RFI Report Addendum, 2002, (EnSafe, 2002).

RFI field activities for Clouter Island began in 1996. Investigations were performed in accordance with the Final Zone K RFI Work Plan (EnSafe/Allen & Hoshall, 1996). AOCs 693 and 694 were investigated together due to proximity and similar histories. Soil samples collected during the 1997 phase of the RFI were collected from 25 locations (four locations for AOC 693 and 21 for AOC 694) around the site. Shallow temporary wells were installed in April 1997. Quarterly groundwater sampling of these wells began in May 1997 and was completed in March 1998. Additional sampling was performed in January 1999. Soil sampling for dioxins and metals only was performed at four locations, and groundwater samples for dioxins, metals, and total dissolved solids (TDS) analyses were collected.

The Zone K RFI Work Plan Addendum (EnSafe, November 1999) that included AOCs 693/694 was developed based on results of the initial RFI and implemented in 1999. The work plan addendum focused on delineating data gaps identified in the RFI report and further investigation of the former buildings. Soil samples were collected from eight locations during October 1999 for development of the November 1999 work plan addendum and site-specific soil screening levels (SSLs). Soil samples were

collected from 25 locations and groundwater was collected twice (December 1999 and January 2000) from temporary shallow wells installed in December 1999. Soil samples were collected in April 2002 from 10 locations to delineate lead exceedances. Several new temporary shallow wells were installed to determine if lead was leaching into groundwater and to delineate the extent of arsenic in groundwater. All new and existing temporary wells installed for the RFI were abandoned subsequent to the completion of the sampling event. An additional round of soil samples were collected in May 2002 from four locations to complete delineation of lead detected in April 2002.

2.3 PHYSICAL DESCRIPTION OF STUDY AREA

2.3.1 Climate and Meteorology

CNC and Clouter Island are in the coastal region of South Carolina, where the climate is mild. This low-lying coastal area has a temperature regime that clearly reflects the influences of its maritime and southerly location. The climate is subtropical, with long and rather hot summers followed by short and mild winters.

The average annual temperature at CNC is about 67 degrees Fahrenheit (°F). Average daily maximum and minimum temperatures in the winter are about 78°F and 56°F, respectively. Freezing temperatures occur about 21 days of each year. Maximum daily temperatures in the summer tend to be above 90°F, with minimum daily temperatures in the 65°F to 70°F range. The record high and low temperatures during the period of record (1938 to 2011) were 105°F and 6°F, respectively.

The average precipitation is about 52 inches per year, with a normal range of 51 to 57 inches during most years. Seventy percent of the rainfall occurs from April through October, during which time an average of about 37 inches of rain is received. Winter precipitation normally comes in the form of rain, with measurable snowfall seldom occurring. Freezing rain occurs some winters, but damaging ice storms are rare. Thunderstorms occur on average 54 times per year, with most occurring in the spring and summer months. Hurricanes are rare to this area, but tropical storms occur on average about every 2 or 3 years. The tropical storm season is generally considered to be the period from July through October. April and May are the months of greatest tornado hazard, although the tornado season in this region is approximately March through October.

2.3.2 Topography

CNC is located in the Lower Coastal Plain physiographic province on the Cooper River side of the Charleston Peninsula, which is formed by the confluence of the Cooper and Ashley Rivers. Elevations at Clouter Island rise to approximately 18 ft msl at the base of the dredge spoils containment dike that rises

to elevations between 25 and 30 ft msl. The containment dike and dredge spoil are a topographic high, covering all but a narrow margin of the island. Elevations in the study range between 4 ft and 30 ft msl.

2.3.3 Site-Specific Geology

Clouter Island is flat, with low elevations, similar to CNC. Naturally deposited sediments at Clouter Island typically consist of fine to medium sand with varying amounts of silt and clay to a depth of 20 to 105 ft bgs. Below these sediments, the lithology typically changes to a dense, slightly calcareous clayey silt, which is referred to as the Ashley Formation. A portion of Clouter Island has been altered by dredge spoil disposal practices. A dike, designed to retain liquefied spoils during deposition and allow spoil dewatering, encloses most of the southern end of Clouter Island. This dike parallels the Cooper River shoreline a short distance toward the interior of the island. The dike has modified the former natural dendritic drainage pattern observed in early aerial photographs of the area. The island interior drains through constructed dewatering spillways. Ground surface within the dredge spoil area has been raised through spoil deposition.

2.3.4 Site-Specific Hydrogeology

The hydrogeologic conditions at AOCs 693/694 were interpreted from data obtained during the subsurface investigation activities at the site including drilling and well installation, groundwater sampling, and groundwater level measurements.

2.3.4.1 Hydrogeologic Framework

Lithologic information regarding the surficial aquifer at Clouter Island is limited to depths ranging from 5 to 11 ft bgs. The surficial aquifer at Clouter Island consists primarily of fine to medium grained sand that may locally be clayey or silty, and a grey, fine to coarse-grained loose sand with shell fragments. There are occurrences of organic rich clayey silt locally known as marsh clay and are typically of low hydraulic conductivity.

The entire area of investigation for Clouter Island is less than 5 ft msl. Given its proximity to the Cooper River, the hydrogeology of the area of Clouter Island is expected to be controlled directly by the Cooper River and its tidal fluctuations. Groundwater flows in the water table aquifer on Clouter Island toward Cooper River or Clouter Creek. The Ashley Formation, as determined in previous CNC investigations, is expected to be the uppermost laterally extensive aquitard/confining unit underlying Clouter Island.

2.3.4.2 Groundwater Flow Direction

Groundwater flow in the surficial aquifer tends to follow topography and flows toward the Cooper and Ashley River drainages, which bound the Charleston peninsula. Water-level measurements were collected from AOC 694 monitoring wells during groundwater sampling events. However, there is no top-of-casing elevation data for initial temporary wells that have been abandoned. Consequently, there is limited groundwater elevation data for gradient and flow velocity evaluation. Depth-to-water measurements were not synoptic, and evaluation for tidal influence is not possible. However, depth-to-water data remain fairly uniform over the lifetimes of wells except for one well formerly located in the dredge spoil material behind the retention dike. Depth-to-water data variations of 2.16 ft to 2.80 ft occurred below the measurement reference during sampling events. Changes in depth-to-water data for other wells were less than or equal to 0.70 to 1.18 ft. Changes in depth-to-water data for wells installed in native sediments were generally less than one foot and typically less than or equal to 0.50 ft.

2.3.4.3 Hydraulic Conductivity

Slug tests were conducted in eight monitoring wells for the 1999 RFI at the site to estimate the horizontal hydraulic conductivity of the surficial aquifer. The horizontal hydraulic conductivity results from slug tests were averaged (geometric mean) to produce a representative effective conductivity value for the two Quaternary-age lithologic units, Quaternary Sand and the Quaternary clayey sand and clay. The geometric mean value is the best representative measure of the arithmetic average hydraulic conductivity of the rising-head values. The results for the Quaternary Sand ranged from 6.05 feet per day (ft/day) to 31.03 ft/day, with a geometric mean of 9.76 ft/day. The results for the Quaternary clayey sand and clay ranged from 0.39 ft/day to 4.41 ft/day, with a geometric mean of 1.84 ft/day. In the 2002 RFI Addendum report, no geotechnical or hydraulic testing was performed on Clouter Island sediments.

2.3.4.4 Groundwater Velocity

During the RFI field activities in 1996 through 1999 groundwater velocities were computed using the shallow and deep groundwater flow paths along which horizontal hydraulic gradients had been calculated. Porosity values from geotechnical data were used along with hydraulic conductivity values for both the shallow and deep wells. Groundwater seepage velocity calculations and data are presented in the 1999 RFI report. The average maximum groundwater velocity for the shallow groundwater beneath AOCs 693/694 is 0.0978 ft/day (35.7 ft per year). The average maximum groundwater velocity for the deep groundwater beneath AOCs 693/694 is 0.0395 ft/day (14.4 ft per year).

In the 2002 RFI Addendum flow velocities were estimated using porosity and hydraulic conductivity (Kh) values obtained from geotechnical laboratory analysis and hydraulic testing. The predominant sand encountered between 5 and 10 ft bgs in Clouter Island well borings is very similar to sand units described

for CNC in the Zone E RFI Report (EnSafe 1999). The effective horizontal Kh of 11 ft/day and porosity of 0.45 were used to calculate flow velocities for Clouter Island groundwater. The average maximum groundwater velocity for the shallow groundwater beneath AOCs 693/694 is 0.391 ft/day (142.7 ft per year)

2.4 NATURE AND EXTENT OF CONTAMINATION

The nature and extent of contamination in soil and groundwater at AOCs 693/694 is presented in the Zone K RFI Report (EnSafe, 1999) and the Zone K Clouter Island RFI Report Addendum (EnSafe, 2002) and is summarized below. The nature and extent of current soil and groundwater contamination was delineated during three separate RFI investigative events spanning from 1997 through 2002. Ordnance, metals, paints, oils, and solvents were suspected to be possible sources of contamination; however only heavy metals and benzo(a)pyrene equivalents (BEQs) were consistently detected above the residential Risk-Based Concentration (RBCs) in both soil and groundwater. Low levels of volatile organic compound (VOC) and semi-volatile organic compound (SVOC) contaminants were also found in groundwater, but inorganics are the primary groundwater contaminants. Due to the nature of this site being used as a dredge spoil area, there is some difficulty in distinguishing the source of the contamination and possible future sources. More specifically, continued dredging disposal activities such as typical excavation and diking activities may contribute to the site by uncovering or exposing contaminants from deeper soils rather than past operations of AOCs 693/694. Tables 2-1 through 2-6 present historical surface soil, subsurface soil, and groundwater exceedances for organic compounds and inorganic elements. Soil and groundwater sample locations are shown on Figures 2-1 and 2-2, respectively.

2.4.1 Contamination of Soil at AOCs 693/694

Surface soils were screened against soil-to-groundwater site-specific soil screening levels (SSLs) criteria because of the shallow groundwater table at Clouter Island. The surface interval sample results were also compared to Risk-Based Concentrations (RBCs) and to 2 times the mean background values from the RFI Report and Addendum and the November 2001 background study for Clouter Island, whereas, subsurface sample results were compared to SSLs only.

2.4.1.1 Surface Soil

The only organic compound detected in surface soils that exceeded SSL screening criteria was 3,3-dichlorobenzidine. Five inorganics (antimony, lead, mercury, selenium, and thallium) were detected in surface soil samples at concentrations exceeding SSL screening criteria. Antimony exceeded the SSL of 20.9 milligrams per kilogram (mg/kg). Lead exceeded the SSL of 1,060 mg/kg. Mercury exceeded the

SSL of 1.15 mg/kg. Selenium exceeded the SSL of 2.86 mg/kg. Thallium exceeded the SSL of 0.392 mg/kg.

VOCs were detected in surface soil but there were no RBC exceedances for any of the detected compounds. Five SVOCs in surface soil exceeded RBC screening criteria: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene. The SVOC exceedances were recalculated as BEQs. Thirteen upper interval (0-1 ft) samples exceeded the residential RBC for BEQs of 87.5 micrograms per kilogram ($\mu\text{g}/\text{kg}$). Pesticide and polychlorinated biphenyl (PCB) compounds were detected in surface soil; however, only Aroclor-1260 exceeded the RBC screening criteria of 319 $\mu\text{g}/\text{kg}$. Twenty-one dioxin/dibenzofuran compounds were detected in surface soil. Detections of these compounds have been converted to Toxic Equivalents (TEQs). Three upper interval samples exceeded the residential RBC for TEQs of 4.3 ng/kg.

Twenty-five inorganics were detected in surface soil samples. Calcium, magnesium, potassium, and sodium were removed from further evaluation because they are considered essential nutrients. There were no cyanide detections in soil.

Aluminum was detected with a range of 1,370 to 44,700 mg/kg and exceeded both the aluminum RBC (7,820 mg/kg) and 2 times the RFI and 2001 background values (32,100/29,310 mg/kg). Antimony was detected with a range of 0.28 to 38.70 mg/kg and exceeded the residential RBC (3.13 mg/kg) and the background values (2.16/1.7 mg/kg). Arsenic was detected with a range of 3.80 to 27.30 mg/kg. All samples exceeded the residential RBC (0.426 mg/kg) and some exceeded the background values (23.0/22 mg/kg). Chromium was detected with a range of 4.80 to 116.0 mg/kg and exceeded the hexavalent chromium residential RBC (23.5 mg/kg), and some detections also exceeded the background values (69.1/62 mg/kg).

Copper was detected with a range of 4.30 to 1,150 mg/kg and exceeded the residential RBC (313 mg/kg) and the background concentrations (119/94 mg/kg). Iron was detected in all samples with a range of 2,170 to 43,200 mg/kg. Samples exceeded the residential RBC (2,350 mg/kg) and the background values (35,200/33,150 mg/kg). Lead was detected in all samples with a range of 5.30 to 3,060 mg/kg. Samples exceeded the residential RBC (400 mg/kg) with some samples also exceeding the background values (98.3/82 mg/kg). The lead exceedances are bounded in all directions by non-exceedances.

Thallium was detected with a range of 0.47 to 1.50 mg/kg. Samples exceeded the residential RBC (0.548 mg/kg) and the 2001 background value (1.32 mg/g). Vanadium was detected in all samples with a range of 4.30 to 94.50 mg/kg. Samples exceeded the residential RBC (54.8 mg/kg) and some samples exceeded the background values (75.9/70 mg/kg).

2.4.1.2 Subsurface Soil

There were no detected organic compounds that exceeded SSL screening criteria in the subsurface soils. Three inorganics (antimony, mercury, and thallium) were detected in subsurface soil samples at concentrations exceeding SSL screening criteria. Antimony exceeded the SSL of 20.9 mg/kg in one sample. Mercury exceeded the SSL of 1.15 mg/kg in one sample. Thallium exceeded the SSL of 0.392 mg/kg in 10 samples.

2.4.2 Contamination of Groundwater at AOCs 693/694

Groundwater concentrations were compared to Maximum Contaminant Levels (MCLs). If no MCL concentration was listed for a compound, detected concentrations were evaluated using Tap Water RBC criteria. Table 2-5 presents VOC, TEQ and SVOC exceedances in groundwater screened against the RBC/MCL criteria. Table 2-6 presents inorganic exceedances in groundwater screened against the RBC/MCL criteria and 2 times the background values from the RFI Report and Addendum and from the November 2001 background study for Clouter Island..

Five VOCs (4-methyl-2-pentanone, acetone, carbon disulfide, chloromethane, and trichloroethene) were detected in Clouter Island groundwater. Chloromethane was the only detected compound that exceeded the applicable screening concentration. Chloromethane exceeded the Tap Water RBC [2.1 picograms per liter ($\mu\text{g/L}$)]. The single chloromethane detection is bounded in all directions by non-detects.

Six SVOCs [benzo(g,h,i)perylene, benzoic acid, fluoranthene, naphthalene, phenanthrene, and pyrene] were detected in Clouter Island groundwater samples. Naphthalene was the only detected compound that exceeded the applicable screening concentration. Naphthalene exceeded the Tap Water RBC (0.65 $\mu\text{g/L}$). There is no listed MCL for naphthalene; therefore, the Tap Water RBC was used for screening this compound. The single naphthalene exceedance is bounded in all directions by non-detects.

Dioxin/dibenzofuran compounds were detected in Clouter Island groundwater samples. Detections were converted to TEQs for screening and evaluation. Eight detected concentrations of TEQs exceeded the MCL of 0.03 picograms per liter (pg/L).

Inorganic detections in groundwater were screened against 2 times the background, then MCLs. If no MCL value was listed for a compound, detected concentrations were evaluated using Tap Water RBC criteria. Twenty-five inorganics were detected in Clouter Island groundwater. Calcium, magnesium, potassium, and sodium were removed from the evaluation because they are considered essential

nutrients. Thirteen analytes had detections that exceeded 2 times their Clouter Island background concentrations and/or MCL/RBC.

Aluminum was detected with a range of 32.10 to 940 µg/L. There is no listed MCL or background concentration for aluminum. None of the groundwater detections exceeded the Tap Water RBC of 16,000 µg/L.

Antimony was detected with a range of 3.80 to 5.90 µg/L. There is no listed background. One detection exceeded the MCL for antimony (6 µg/L).

Arsenic was detected with a range of 2.40 to 74.7 µg/L. Samples exceeded the background concentrations of 15.1 and 14 µg/L, and the arsenic MCL value of 10 µg/L. Arsenic was delineated.

Barium was detected with a range of 17.4 to 142 µg/L. Barium exceeded the background concentration of 95.9 and 96 µg/L; however, none of the detections exceeded the barium MCL of 2,000 µg/L.

Beryllium was detected with a range of 0.23 to 4.90 µg/L. None of the groundwater samples exceeded the Tap Water RBC of 16 µg/L. However, one groundwater detection (4.9 µg/L) exceeded the beryllium MCL of 4 µg/L.

Cadmium was detected with a range of 0.40 to 19.30 µg/L. All detections equaled or exceeded the background concentration of 0.4 µg/L. Of those, one detection exceeded the cadmium MCL concentration of 5 µg/L.

Chromium was detected with a range of 0.72 to 42.30 µg/L. There is no listed background, however, the MCL (100 µg/L) for total chromium was not exceeded.

Cobalt was detected with a range of 0.58 to 18.90 µg/L. There are no listed background or MCL concentrations for cobalt. One groundwater detection exceeded the Tap Water RBC of 4.7 µg/L.

Copper was detected with a range of 1.50 to 54.70 µg/L. Samples exceeded the background concentrations of 5.8 and 10 µg/L; however, none of the detections exceeded the copper MCL/Treatment Technique (TT) Action Level of 1,300 µg/L.

Cyanide was detected at a single concentration of 2.00 µg/L. There is no listed background concentration for cyanide; therefore, the cyanide MCL value of 200 µg/L was used to screen the detection, which the detection did not exceed.

Iron was detected with a range of 266 to 25,200 µg/L. Samples exceeded the background concentration of 9.170 µg/L and the Tap Water RBC value of 11,000 µg/L. There is not a listed MCL value for iron.

Lead was detected with a range of 0.98 to 2.70 µg/L. There is no listed background concentration; therefore, the lead MCL/TT Action Level of 15 µg/L was used for screening this compound. None of the detections exceeded the MCL/TT Action Level.

Manganese was detected with a range of 76 to 4,020 µg/L. Samples exceeded the background concentration of 1,210 µg/L. All but eight groundwater detections exceeded the manganese Tapwater RBC value of 320 µg/L.

Mercury was detected with a range of 0.10 to 7.60 µg/L. There is no listed background concentration for mercury; therefore, the MCL value of 2 µg/L was used to screen the detections. One groundwater detection exceeded the MCL value.

Nickel was detected with a range of 0.73 to 19.30 µg/L. Samples exceeded the background concentrations of 2.84 and 8 µg/L; however, none of the detections exceeded the nickel Tapwater RBC concentration of 300 µg/L.

Selenium was detected with a range of 3.00 to 8.30 µg/L. There is no listed background concentration for selenium; therefore, the MCL value of 50 µg/L was used to screen the detections, which none exceeded.

Silver was detected with a range of 0.81 to 35.30 µg/L. There is no listed background concentration or MCL value for silver. The Tapwater RBC value of 71 µg/L was used to screen this compound. No groundwater detection exceeded the silver Tapwater RBC value.

Thallium was detected with a range of 4.90 to 9.90 µg/L. There is no listed background concentration for thallium; therefore, the MCL value of 2 µg/L was used to screen this compound. Four detections exceeded the MCL value for thallium.

Tin was detected with a range of 3.50 to 367 µg/L. Samples exceeded the background concentrations of 34.6 and 80 µg/L. However, the samples did not exceed the Tap Water RBC concentration of 9,300 µg/L. There is no MCL listed for tin.

Vanadium was detected with a range of 1.14 to 14.90 µg/L. Detections of vanadium equaled or exceeded the background concentrations of 9.1 and 10 µg/L; however, none of the detections exceeded the vanadium Tapwater RBC concentration of 78 µg/L. There is no MCL listed for vanadium.

Zinc was detected with a range of 3.40 to 861 µg/L. There is no listed background concentration or MCL value for zinc; therefore, the Tapwater RBC value of 4,700 µg/L was used to screen this element. None of the detections of zinc exceeded the Tapwater RBC value.

2.4.3 Groundwater Potability at AOCs 693/694

Groundwater analytical data from Clouter Island wells were compared to MCLs and RBCs (in the absence of a MCL). These criteria are typically used for screening drinking water supplies and provide a conservative screen for comparing groundwater data from potentially non-potable aquifers. The shallow water table aquifer at Clouter Island lies approximately 3 to 5 ft bgs, is recharged by water infiltrating through brackish water dredge spoil material located upgradient of the site, and would not likely be considered as a potable water source due to proximity of the brackish water Cooper River. A TDS concentration of 10,000 parts per million (ppm) was a preliminary screen to potentially preclude groundwater at a site from risk-based evaluation and subsequent remediation.

Groundwater samples at Clouter Island were not subjected to TDS analysis. However, an assessment of the major parameters can be evaluated to estimate the TDS concentration. Groundwater samples were collected using low-flow techniques, thus turbidity was not generally a factor that would affect TDS estimates. Several filtered and unfiltered samples were also collected and analyzed, and concentration differences between the two were minimal.

Four major components of seawater, calcium, magnesium, potassium and sodium, were detected in site groundwater at concentrations indicative of saltwater (brackish water) influence. The area investigated lies within 200 ft of the river where groundwater effected by saltwater intrusion and tides would be expected. Concentrations of the four major analytes totaled an average of 3,348 ppm and ranged from 659 to 5,946 ppm among the maximum concentrations detected in each well. The major component of seawater, chlorine, was not analyzed for in the samples. Ratios between chlorine and the four parameters mentioned above can be calculated, and estimates of the chlorine concentration derived by multiplying the ratio times the concentration of each of the four parameters using these relationships. An average chlorine concentration for each well and an overall site average was generated. The chlorine estimates for each well were then added to the measured analytes, calcium, magnesium, potassium, and sodium, to determine the TDS estimate for each well. The TDS estimates ranged from 6,817 to 15,911 ppm with a site average of 10,147 ppm.

Salinity measurements made while purging of the well prior to groundwater sampling may be compared with estimated TDS values. Salinity measured using a Horiba U-10 water checker during well purge ranged from 0.56% to 1.85 % with an average of 1.0% (10,000 ppm). The comparison of the TDS estimates and salinity measurements correlate and support the TDS estimation process. Therefore, shallow groundwater at Clouter Island would yield TDS concentrations greater than 10,000 ppm and would not be considered as a potable water source based on the derived TDS value estimates. Consequently, risk-based evaluations based on drinking water use of groundwater would be overly conservative and unnecessary. No further assessment or remediation of groundwater was recommended in the Zone K Clouter Island RFI Report Addendum (EnSafe, 2002). As part of the response to comments on the EnSafe RFI Addendum, the Department of Health and Environmental Control commented that the state of South Carolina recognizes that all groundwater in the state is considered potable due to the level of cleanup required under the Clean Water Act for drinking water; therefore, the argument that the groundwater on site was not potable was not viable and a full risk assessment was necessary to determine the risk to human receptors and ecological receptors.

2.5 RISK ASSESSMENT

Human health and ecological risk assessments were conducted for AOCs 693/694 as part of the RFI and are summarized below. Refer to the Zone K RFI Report (EnSafe, 1999) and the Zone K Clouter Island RFI Report Addendum (EnSafe, 2002) for the human health risk assessment. See the Zone K RFI Report (EnSafe, 1999) for the ecological risk assessment.

2.5.1 Baseline Human Health Risk Assessment

The baseline human health risk assessment (HHRA) for AOCs 693/694 was performed to characterize the potential risks to likely human receptors under current and future land use. Potential receptors under current land use are site workers. Potential receptors under future land use are site workers and hypothetical on-site residents (adolescent and adult). Although future land use is likely to be the same as current land use, future land use was evaluated in the baseline human health risk assessment, primarily for decision-making purposes. The future land use evaluation was based on the assumption that if various site conditions were to change in the future, potential exposure could occur if the site were developed.

2.5.1.1 Zone K RFI Report (EnSafe, 1999)

The EnSafe (1999) HHRA identified the following contaminants of potential concern (COPCs) in surface soil: BEQs, aluminum, antimony, arsenic, chromium, copper, lead, vanadium, and Aroclor-1260. Arsenic, cadmium, and manganese were identified as COPCs in shallow groundwater.

Risks posed by these COPCs at AOCs 693/694 were quantitatively assessed for future site residents and future site workers under reasonable maximum exposure assumptions. The future site resident scenario was based on the premise that existing structures would be removed and replaced with dwellings. The future site worker scenario assumed continuous exposure to surface soil conditions. The HHRA assumed that current site workers' exposure would be less than for the future site worker scenario because of the limited soil contact to current workers (existing concrete surfaces would prevent direct contact to portions of the site). Therefore, the future worker assessment was considered to conservatively represent current site users. The incidental ingestion and dermal contact pathways were assessed for surface soils. The ingestion pathway was assessed for groundwater.

2.5.1.1.1 Risk Assessment Results for Exposure to Soil

Residential Scenario

Residential soil pathway COCs identified for AOCs 693/694 were aluminum, antimony, arsenic, chromium, vanadium, and BEQs. Arsenic was the primary contributor to risk estimates, and BEQs were the secondary contributor to risk estimates. Aluminum and arsenic were primary contributors to hazard estimates exceeding unity, and secondary contributors were antimony, chromium, copper, and vanadium.

Site Worker Scenario

Arsenic and BEQs were identified as COCs for the industrial surface soil pathway. Although the cumulative industrial incremental lifetime cancer risk (ILCR) estimate for BEQs was 1E-06, the maximum detected concentration of BEQs was less than its industrial risk based concentration, so BEQs were considered to be borderline COCs for the industrial scenario. Arsenic was the primary contributor to risk estimates exceeding 1E-06 for the industrial scenario; arsenic risk estimates ranged from 1E-07 to 1E-05, which is less than or between the U.S. Environmental Protection Agency's (USEPA's) acceptable range of 1E-06 and 1E-04. Hazard indices ranged from 0.00001 to 0.06.

2.5.1.1.2 Risk Assessment Results for Exposure to Groundwater

Residential Scenario

Arsenic, cadmium, and manganese were identified as groundwater COCs. Arsenic was the sole contributor to ILCR projections. Arsenic, cadmium, and manganese were contributors to hazard index projections.

Site Worker Scenario

As in the residential scenario, arsenic, cadmium, and manganese were identified as groundwater COCs. Arsenic was the sole contributor to ILCR projections, while arsenic, cadmium, and manganese were contributors to hazard index projections.

2.5.1.2 Clouter Island RFI Report Addendum (EnSafe, 2002)

Subsequent to the Zone K RFI (EnSafe, 1999), additional soil and groundwater samples were collected to address data gaps. The EnSafe (2002) HHRA evaluated historical data and the most recently collected data to evaluate risks based on future industrial and future residential land uses. The 2002 HHRA identified 14 chemicals as surface soil COPCs that were retained in the quantitative risk assessment: aluminum, antimony, chromium, copper, iron, lead, manganese, vanadium, Aroclor-1260, benzo(a)anthracene, benzo(a)pyrene, and benzo(b)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene. Polycyclic aromatic hydrocarbons (PAHs) were evaluated using BEQ concentrations. Eight metals were identified as COPCs in groundwater and were retained in the quantitative risk assessment: arsenic, cadmium, chromium, iron, manganese, mercury, silver, and thallium.

Hypothetical future residents and workers were considered to be potentially exposed populations. The future site resident scenario assumed that existing structures would be removed and replaced with dwellings. Because the 1999 risk assessment did not identify unacceptable site worker risks or hazards due to soil exposure, the future site worker exposed to soil was not addressed in the 2002 evaluation. However, incidental groundwater ingestion by the future site worker was evaluated. Exposure pathways for hypothetical future residents consisted of incidental ingestion, dermal contact, and inhalation of chemicals in surface soils, and incidental ingestion of groundwater. HHRA results are summarized in Table 2-7 and described below.

2.5.1.2.1 Risk Assessment Results for Exposure to Soil

Aluminum, antimony, manganese, vanadium, and BEQs were identified as COCs in the upper soil interval. The cumulative soil pathway residential exposure ILCR risk was 1E-05. This risk estimate is less than 1E-04, which is the upper bound of USEPA's risk range. For the residential scenario, the hazard index (HI) for soil was 2 for the child, with iron contributing 82 percent of the total risk. The HI for the adult resident was 0.3.

2.5.1.2.2 Risk Assessment Results for Exposure to Groundwater

The projected ILCR for the future residential groundwater ingestion pathway was 8E-04 and the estimated risk for the future worker groundwater ingestion pathway was 2E-04. Both risk values exceed USEPA's acceptable range of 1E-06 to 1E-04. Arsenic was the sole contributor to the ILCR values for both the residential and worker groundwater pathways.

The HI for the adult resident was 9, and the HI for the child resident was 20. Arsenic, iron, manganese, and thallium were primary contributors to the projected HIs for the groundwater ingestion pathway. Cadmium, chromium, mercury, and silver were secondary contributors. The HI for the future worker for the groundwater pathway was 3; arsenic and thallium were primary contributors to the HI.

2.5.1.3 **Summary**

The 2002 RFI recommended no further action for soil because the iron intake from incidental soil ingestion at AOCs 693/694 [0.3 milligrams per kilogram per day (mg/kg/day)] would be less than the recommended daily intake from an iron supplement (Iron was responsible for 82 percent of the soil risk to the child resident).

The groundwater associated HI for the resident adult was 9, and the groundwater associated HI for the resident child was 20, but the 2002 RFI pointed out that groundwater is not considered a potential potable source. With this in mind, the 2002 RFI recommended no further action for groundwater.

2.5.2 **Ecological Risk Assessment**

The EnSafe (1999) report evaluated ecological risks to terrestrial receptors in what the report referred to as "Subzones K2 and K3", which correspond to AOCs 693/694. According to the ecological risk assessment, the natural community at AOCs 693/694 consists of bottomland hardwoods dominated largely by southern hackberry (*Celtis laevigata*) and a dense, scrub/shrub community dominated by species such as wax myrtle (*Myrica cerifera*), tallow tree (*Sapium sebiferum*), and red mulberry (*Morus rubra*).

The ecological risk assessment was based on surface soil data from four surface soil samples collected at AOC 693 and 65 grid-based surface samples collected throughout AOC 694. The soil data were evaluated for exposure to terrestrial invertebrates, plants, and wildlife. Detected analytes were compared to corresponding USEPA ecological soil benchmarks to identify ecological chemicals of potential concern (ECPCs).

Potential risks to soil invertebrates and plants were evaluated by comparisons to literature-derived threshold effects levels. Potential risks to wildlife from ECPCs in surface soil were evaluated using a terrestrial food chain model to predict the contaminant dose via the diet and incidental ingestion of soil. Predicted doses for representative wildlife species were then compared to toxicity reference values representing thresholds for chronic and subchronic toxicity. Representative wildlife species for the food chain modeling consisted of the short-tailed shrew (*Blarina brevicauda*), Eastern cottontail rabbit (*Sylvilagus floridanus*), and American robin (*Turdus migratorius*).

2.5.2.1 Risk Assessment Results for Soil Invertebrates and Plants

Concentrations of aluminum, chromium, copper, mercury, vanadium, and zinc in some samples pose potential risk to soil invertebrates.

Concentrations of some metals, especially arsenic, copper, and zinc, in some samples indicate risks to terrestrial vegetation. It was noted, however, that no evidence of stressed vegetation was identified during frequent trips to the area where samples were collected.

2.5.2.2 Risk Assessment Results for Wildlife

A low level of chronic risk [based on laboratory derived lowest-observed-adverse-effects levels (LOAELs)] was predicted for herbivorous mammals represented by the cottontail rabbit, based primarily on exposure to arsenic and copper, with an HI of 4.68. Subchronic effects [based on laboratory derived no-observed-adverse-effects levels (NOAELs)] were predicted for the rabbit, based primarily on arsenic, copper, cadmium, and lead, with an HI of 19.99.

LOAEL HIs for carnivorous mammals represented by the short-tailed shrew and birds represented by the robin were less than 1, and NOAEL HIs for the shrew (1.81) and robin (4.34) only slightly exceeded 1, indicating that arsenic, copper, and other ECPCs pose minimal risks to these representative receptors.

2.6 CONTAMINANT FATE AND TRANSPORT

This section qualitatively discusses the transport potential, contaminant persistence, and observed trends of chemicals retained as COPCs. Additional detail is provided in the Zone K RFI Report (Ensafe, 1999) and the Zone K Clouter Island RFI Report Addendum (EnSafe, 2002).

2.6.1 Inorganics and Transport Potential

Because inorganics are frequently incorporated into the soil matrix and remain bound to particulate matter, they also migrate from source areas via bulk movement processes (erosion).

There are some instances, however, where metals are found at such concentrations or in such forms (i.e., oxidation states) that they may migrate in solution. It is possible that industrial activities could saturate all available exchange sites in soil and result in a metal being mobilized. Metals are also more mobile under acidic conditions, which may exist in areas where plating-type activities have occurred. Finally, metal solutions may be utilized in some industrial applications. In these cases, it is possible for metals to migrate vertically through the soil column and reach the groundwater. Therefore, the metals detected in groundwater samples may represent the total of dissolved metals and metals adhering to any suspended soil material that may be present in the samples.

Because metals are naturally occurring substances, they were detected in both surface soil and groundwater samples from AOCs 693/694.

2.6.2 Contaminant Persistence

The persistence of various classes of chemicals is discussed in this section. Several transformation mechanisms affect chemical persistence, such as hydrolysis, biodegradation, photolysis, and oxidation/reduction reactions. The following general classes of chemicals were retained as COPCs in soil and groundwater for AOCs 693/694 and are discussed below:

- PAHs (BEQs)
- Metals (aluminum, antimony, arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, silver, thallium, and vanadium)
- PCBs

2.6.2.1 PAHs

PAHs in the form of BEQs have been detected in sediment in all three water bodies at Zone J. The physiochemical properties of the PAHs (water solubility, vapor pressure, Henry's law constant, K_{ow} , and K_{oc}) explain, to a large extent, the observed partitioning of these contaminants among the environmental media (soil, groundwater, surface water, sediment). The transport and partitioning of an individual PAH compound is roughly related to the molecular weight of the compound. PAHs fall into one of three categories, low molecular weight (two to three benzene rings, e.g., acenaphthene, anthracene, fluorene, and phenanthrene), medium molecular weight (four benzene rings, e.g., fluoranthene and pyrene), and high molecular weight (five or more benzene rings, e.g., benzo(a)pyrene, dibenzo(a,h)anthracene and indeno(1,2,3-c,d)pyrene) compounds. Typically those PAHs with lower molecular weights will be more mobile within a given medium. For example, a low molecular weight PAH will be much more likely to volatilize, than a high molecular weight PAH. Low molecular weight PAHs tend to have lower K_{oc} values

and a moderate potential to be adsorbed to organic carbon in soil and sediments compared to high molecular weight PAHs, which have stronger tendencies to adsorb to organic carbon.

In the CNC area, the coastal terrace deposits are underlain by unconsolidated to weakly consolidated Holocene to Miocene clastic sediments, which are composed of calcareous and organic-rich clays, silts, and sands. Thus, the PAH contamination is generally expected to adhere strongly to these sediments and not significantly migrate vertically or horizontally.

The following narrative provides a brief summary of chemical fate information for PAH compounds from the literature.

Chemical Fate in a Surface Water Column

In water, PAH compounds tend to be physically removed by volatilization to the atmosphere, by binding to suspended particles or sediments, or by being accumulated by or absorbed onto aquatic biota. The Henry's Law Constant determines how readily an individual PAH compound will volatilize from surface water to air. Ideal conditions for volatilization of PAHs from surface water would be high temperature, low depth (from the water surface), and high wind. However, because of their low solubility and high affinity for organic carbon, PAHs in aquatic systems are primarily found adsorbed to particles that either have settled to the bottom or are suspended in the water column. In an estuary, volatilization and adsorption to suspended sediments with subsequent deposition are the primary physical removal processes for medium and high molecular weight PAHs, whereas volatilization and biodegradation are the major removal processes for low molecular weight PAHs. In some instances, PAHs will settle quickly to sediment, but may be recycled back into the water column from the sediment surface. This scenario is more likely for PAHs with lower molecular weights than for those with higher molecular weights, which tend to stay bound to sediment. Low molecular weight PAHs also have a lesser tendency to be adsorbed to organic carbon than high molecular weight PAHs.

The most important chemical/biological processes contributing to the degradation of PAHs in water are photo-oxidation, chemical oxidation, and biodegradation by aquatic microorganisms. Temperature, depth, flow rate, and oxygen content impact the overall fate of a PAH in water. The rate and extent of photodegradation vary widely among PAHs and do not follow a discernible pattern. PAHs in water can be chemically oxidized by chlorination and ozonation. However, the PAH-related by-products resulting from chlorination are not fully known, and there appears to be no correlation between biodegradability and molecular weight.

Chemical Fate in Soil and Sediment

In soil, PAHs can volatilize, undergo abiotic degradation (photolysis and oxidation), biodegrade, or accumulate in plants. In sediment, PAHs can biodegrade or accumulate in aquatic organisms. Sorption of PAHs to soil and sediment increases with increasing organic carbon content and with increasing surface area of the sorbent particles (e.g., greater sorption to clays than sands). For example, three to four times more anthracene and about 2 times more fluoranthene, benzo(a)anthracene and benzo(a)pyrene can be retained by marsh sediment than by sand. Sorption of PAHs to organic matter and soil particulates influences bioavailability and biotransformation potential.

Microbial metabolism is the major process for degradation of PAHs in soils. Chemical degradation (photolysis, hydrolysis, and oxidation) is generally not considered as significant. PAH losses from surface soil because of volatilization and photolysis can be substantial for low molecular weight PAHs; however, losses for medium and high molecular weight compounds are typically insignificant. The rate and extent of biodegradation of PAHs in soil are affected by environmental factors such as the organic content, structure, and particle size of the soil, characteristics of the microbial population, presence of other contaminants such as metals and cyanides that may be toxic to microorganisms, and physical and chemical properties of the individual PAHs. Other environmental factors that influence the rate of PAH degradation in soil include temperature, pH, oxygen concentration, PAH concentrations, and contamination history of soil, soil type, moisture, nutrients, and other substances that may act as substrate co-metabolites. Biodegradation of PAHs in soil is faster for low molecular weight compounds than high molecular weight compounds. The pathways of microbial degradation are well known for some PAHs. Mean half-lives (or the rate of degradation of PAHs) are positively correlated with $\log K_{ow}$ and inversely correlated with \log water solubility.

In studies, the rate of microbial transformation of PAHs in freshwater sediments from both pristine and oil-contaminated streams was 10 to 400 times greater in contaminated sediment than uncontaminated sediment. Absolute rates of PAH transformation were 3,000 to 125,000 times greater in the contaminated sediment. Turnover times in the oil-contaminated sediment increased 30 to 100-fold per additional benzene ring from naphthalene through benzo(a)anthracene. Naphthalene was broken down in hours, but the turnover times for benzo(a)anthracene and benzo(a)pyrene were approximately 400 days and 3.3 years, respectively. Therefore, the four- and five-ring PAHs may persist even in sediments that have received chronic PAH inputs. As noted previously, the rate of PAH biodegradation may also be decreased by the degree of contamination. Half-lives may be longer when contaminants at the site are toxic to degrading microorganisms.

Bioconcentration

PAHs can accumulate in aquatic organisms from water, sediments, and food. Bioconcentration is greater for high molecular weight PAHs than for low molecular weight PAHs. Some aquatic organisms are able to metabolize and eliminate PAHs. However, in others, PAHs are transformed into carcinogenic and mutagenic intermediates, and exposure to PAHs has been linked to the development of tumors in fish. Sediment-associated PAHs can accumulate in bottom-dwelling invertebrates and fish.

2.6.2.2 Metals

Concentrations of metals (particularly aluminum, antimony, arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, silver, thallium, and vanadium) in excess of background concentrations have been detected in surface soil and groundwater at AOCs 693/694.

Overview of Metals Fate and Transport Information from Literature

The following narrative provides a brief summary of chemical fate information for metals from the literature.

Metals are highly persistent and do not readily biodegrade, photolyze, or hydrolyze. The transport of metals in the subsurface is influenced by a variety of complex mechanisms and interactions. The major fate mechanisms for metals are adsorption to the soil matrix and bioaccumulation. The interactions are not well understood in many cases due to the fact that natural systems are mixtures of various reactive substances that can vary over distances in the subsurface and can vary with time as subsurface conditions change. Transport of metals in the subsurface environment can be a function of the following mechanisms:

Advection: Metals particles are transported with the flow of groundwater. Advection is one of the primary mechanisms by which constituents are transported from a source area in the form of a plume. Advection results in the reduction of constituent concentrations by dilution with surrounding groundwater but does not result in mass reduction.

Dispersion: Dispersion is the mixing of constituents in groundwater primarily caused by its movement through a complex network of small openings (i.e., pores) located between the individual grains of sand, silt, and clay. Dispersion is one of the primary mechanisms by which constituents are transported from a source area in the form of a plume. Dispersion results in the reduction of constituent concentrations by dilution with surrounding groundwater, but not by mass reduction.

Sorption/Desorption: The complex chemical processes (e.g., ionic attraction, oxidation-reduction reactions, complexation with an organic constituent) by which constituents partition between the aqueous phase and solid phase (soil) in the aquifer matrix. A particular trace metal will typically compete for available adsorption sites with other trace metals, hydrogen, calcium, and sulfate. The sorption (i.e., attachment) of a constituent onto a mineral surface or organic matter results in the retardation (i.e., slowing or delaying) of constituent transport in the aquifer.

Speciation: The process of changing the ionic strength and reactivity of a constituent. Speciation may cause significant differences in the sorption behavior of the constituent.

Dissolution/Precipitation: The dissolving or solidifying of a constituent as a result of a chemical reaction. For trace metals, dissolution and precipitation behavior are largely a function of pH (i.e., acidity or alkalinity) and the initial distributions of the aqueous, solid, and adsorbed masses of each constituent. Dissolution of a constituent from a source area typically provides a continuous or intermittent influx of constituents to the groundwater until geochemical equilibrium conditions are achieved.

Many studies have found that the predominant adsorbates of metal ions are iron and manganese oxides and organic matter such as detrital plant material and humic coatings on mineral surfaces. Metal hydroxides of iron, aluminum, and manganese are important reductive surfaces in subsurface materials with respect to interactions with charged species such as hydrogen, aluminum, cadmium, zinc, lead, and copper and with negatively charged species such as phosphate, sulfate, bicarbonate, and fluoride. The adsorption of species on oxides is strongly dependent on pH due to the variable, pH-dependent, surface charge and potential of metal hydroxides and to a pH-dependent speciation of the adsorbate.

2.6.2.3 PCBs

PCBs are considered to be very persistent organic chemicals. Biodegradation is the only process known to transform PCBs under environmental conditions, and only the lighter compounds are measurably biodegraded (USEPA, 1979). Although some microorganisms (e.g., *Phanaerochaete chrysosporium*) may biodegrade PCBs, such fungi may not exist in local soil. There is experimental evidence to suggest that heavier PCBs (five or more chlorines per molecule) can undergo photolytic degradation, but there are no data to suggest that this process operates under environmental conditions (USEPA, 1979). Base-, acid-, and neutral-promoted hydrolysis are considered to be inconsequential degradation mechanisms for PCBs (USEPA, 1982).

TABLE 2-1

HISTORICAL EXCEEDANCES OF ORGANICS IN SURFACE SOIL
AOCs 693 and 694
CHARLESTON NAVAL COMPLEX, NORTH CHARLESTON, SOUTH CAROLINA
PAGE 1 OF 4

Parameter	Sample ID	Sample Location	Sample Date	Concentration	RBC ¹	SSL ²
Semivolatile Organic Compounds (UG/KG)						
3,3'-DICHLOROBENZIDINE	694SB02801	K694SB028	11/18/1999	1.40E+03	J	2.93E+01
	694SB02901	K694SB029	11/18/1999	1.60E+02	J	2.93E+01
BAP EQUIVALENT-HALFND	694SB00301	K694SB003	1/16/1997	3.98E+02		NC
	694SB00901	K694SB009	1/16/1997	5.69E+02		NC
	694SB01301	K694SB013	1/16/1997	7.99E+02		NC
	694SB013T1	K694SB013	10/13/1999	5.66E+02		NC
	694SB01601	K694SB016	1/16/1997	3.39E+02		NC
	694SB01801	K694SB018	1/17/1997	5.32E+02		NC
	694SB01901	K694SB019	1/17/1997	4.09E+02		NC
	694SB02801	K694SB028	11/18/1999	3.08E+03		NC
	694SB02901	K694SB029	11/18/1999	8.03E+02		NC
	694SB03501	K694SB035	11/18/1999	3.09E+02		NC
	694SB03701	K694SB037	12/21/1999	4.45E+02		NC
	694SB03801	K694SB038	12/21/1999	5.13E+02		NC
	694SB03901	K694SB039	12/21/1999	4.89E+02		NC
	694SB04001	K694SB040	12/21/1999	1.81E+02		NC
	694SB04101	K694SB041	12/21/1999	4.36E+02		NC
	694SB04201	K694SB042	12/20/1999	2.84E+02		NC
	694SB04301	K694SB043	12/20/1999	2.88E+02		NC
	694SB04401	K694SB044	12/20/1999	2.87E+02		NC
	694SB04501	K694SB045	12/20/1999	1.95E+03		NC
	694SB04701	K694SB047	12/20/1999	1.49E+02		NC
694SB04801	K694SB048	12/20/1999	1.35E+02		NC	
694SB05201	K694SB052	12/21/1999	6.11E+02		NC	

TABLE 2-1

HISTORICAL EXCEEDANCES OF ORGANICS IN SURFACE SOIL
AOCs 693 and 694
CHARLESTON NAVAL COMPLEX, NORTH CHARLESTON, SOUTH CAROLINA
PAGE 2 OF 4

Parameter	Sample ID	Sample Location	Sample Date	Concentration	RBC ¹	SSL ²
Semivolatile Organic Compounds (UG/KG)						
BAP EQUIVALENT-POS	694SB00301	K694SB003	1/16/1997	1.20E+02	8.75E+01	NC
	694SB00901	K694SB009	1/16/1997	3.59E+02	8.75E+01	NC
	694SB01301	K694SB013	1/16/1997	5.35E+02	8.75E+01	NC
	694SB01601	K694SB016	1/16/1997	1.05E+02	8.75E+01	NC
	694SB01801	K694SB018	1/17/1997	3.37E+02	8.75E+01	NC
	694SB02801	K694SB028	11/18/1999	3.08E+03	8.75E+01	NC
	694SB02901	K694SB029	11/18/1999	8.03E+02	8.75E+01	NC
	694SB03501	K694SB035	11/18/1999	3.09E+02	8.75E+01	NC
	694SB04001	K694SB040	12/21/1999	1.81E+02	8.75E+01	NC
	694SB04101	K694SB041	12/21/1999	4.36E+02	8.75E+01	NC
	694SB04501	K694SB045	12/20/1999	1.95E+03	8.75E+01	NC
	694SB04701	K694SB047	12/20/1999	1.49E+02	8.75E+01	NC
	694SB04801	K694SB048	12/20/1999	1.35E+02	8.75E+01	NC
BENZO(A)ANTHRACENE	694SB04501	K694SB045	12/20/1999	1.00E+03	8.75E+02	1.00E+04
BENZO(A)PYRENE	694SB00301	K694SB003	1/16/1997	1.00E+02	J 8.75E+01	4.29E+04
	694SB00901	K694SB009	1/16/1997	2.80E+02	J 8.75E+01	4.29E+04
	694SB01301	K694SB013	1/16/1997	4.40E+02	J 8.75E+01	4.29E+04
	694SB01601	K694SB016	1/16/1997	8.90E+01	J 8.75E+01	4.29E+04
	694SB01801	K694SB018	1/17/1997	2.60E+02	J 8.75E+01	4.29E+04
	694SB02801	K694SB028	11/18/1999	1.60E+03	J 8.75E+01	4.29E+04
	694SB02901	K694SB029	11/18/1999	3.60E+02	J 8.75E+01	4.29E+04
	694SB03501	K694SB035	11/18/1999	1.10E+02	J 8.75E+01	4.29E+04
	694SB04001	K694SB040	12/21/1999	1.10E+02	J 8.75E+01	4.29E+04
	694SB04101	K694SB041	12/21/1999	2.70E+02	J 8.75E+01	4.29E+04
	694SB04501	K694SB045	12/20/1999	1.20E+03	8.75E+01	4.29E+04
	694SB04701	K694SB047	12/20/1999	9.30E+01	J 8.75E+01	4.29E+04

TABLE 2-1

HISTORICAL EXCEEDANCES OF ORGANICS IN SURFACE SOIL
AOCs 693 and 694
CHARLESTON NAVAL COMPLEX, NORTH CHARLESTON, SOUTH CAROLINA
PAGE 3 OF 4

Parameter	Sample ID	Sample Location	Sample Date	Concentration	RBC ¹	SSL ²
Semivolatile Organic Compounds (UG/KG)						
BENZO(B)FLUORANTHENE	694SB02801	K694SB028	11/18/1999	1.20E+03 J	8.75E+02	3.10E+04
	694SB04501	K694SB045	12/20/1999	2.00E+03	8.75E+02	3.10E+04
DIBENZO(A,H)ANTHRACENE	694SB02801	K694SB028	11/18/1999	1.10E+03 J	8.75E+01	9.58E+03
	694SB02901	K694SB029	11/18/1999	3.60E+02 J	8.75E+01	9.58E+03
	694SB03501	K694SB035	11/18/1999	1.60E+02 J	8.75E+01	9.58E+03
	694SB04101	K694SB041	12/21/1999	9.40E+01 J	8.75E+01	9.58E+03
	694SB04501	K694SB045	12/20/1999	3.70E+02 J	8.75E+01	9.58E+03
INDENO(1,2,3-CD)PYRENE	694SB02801	K694SB028	11/18/1999	1.90E+03 J	8.75E+02	8.75E+04
Dioxins/Furans (NG/KG)						
TEQ-POS	694SB02401	K694SB024	1/13/1999	5.63E+00	4.30E+00	NC
	694SB02501	K694SB025	1/13/1999	6.42E+00	4.30E+00	NC
	694SB02601	K694SB026	1/13/1999	7.05E+00	4.30E+00	NC
TEQ-HALFND	694SB01401	K694SB014	1/17/1997	4.62E+00	4.30E+00	NC
	694SB02401	K694SB024	1/13/1999	6.97E+00	4.30E+00	NC
	694SB02501	K694SB025	1/13/1999	7.69E+00	4.30E+00	NC
	694SB02601	K694SB026	1/13/1999	7.59E+00	4.30E+00	NC

TABLE 2-1

HISTORICAL EXCEEDANCES OF ORGANICS IN SURFACE SOIL
 AOCs 693 and 694
 CHARLESTON NAVAL COMPLEX, NORTH CHARLESTON, SOUTH CAROLINA
 PAGE 4 OF 4

Parameter	Sample ID	Sample Location	Sample Date	Concentration	RBC ¹	SSL ²
Semivolatile Organic Compounds (UG/KG)						
PCB Congeners (UG/KG)						
AROCLOR-1260	694SB01401	K694SB014	1/17/1997	5.96E+02	3.19E+02	3.25E+04
	694SB04001	K694SB040	12/21/1999	3.50E+02 J	3.19E+02	3.25E+04

1 Risk Based Concentration (RBC) - USEPA Residential Soil Screening Level, USEPA Regional Screening Levels Table, May 2013.

2 Soil Screening Level (SSL) - Site Specific Soil Screening Levels, developed and presented in Clouter Island RFI Report Addendum, Charleston Naval Complex. September 2002. (EnSafe, 2002).

Shading indicates that the detected concentration exceeds at least one of the screening criteria.

NC - No Criteria available

TEQ - Toxicity equivalent

BAP - Benzo(a)pyrene

HALFND - Average of all analytical results including one-half of the detection limit for non-detects

POS - Average of detected concentrations only

J - Estimated concentration.

UG/KG - microgram per kilogram

NG/KG - nanogram per kilogram

TABLE 2-2

HISTORICAL EXCEEDANCES OF INORGANICS IN SURFACE SOIL
AOCs 693 and 694
CHARLESTON NAVAL COMPLEX, NORTH CHARLESTON, SOUTH CAROLINA
PAGE 1 OF 7

Parameter	Sample ID	Sample Location	Sample Date	Concentration	RFI 2X MEAN BG ¹	2001 2X MEAN BG ²	RBC ³	SSL ⁴
Inorganic Elements (MG/KG)								
ALUMINUM	693SB00101	K693SB001	1/15/1997	2.48E+04	3.21E+04	2.93E+04	7.82E+03	3.06E+06
	693SB00201	K693SB002	1/14/1997	3.90E+04	3.21E+04	2.93E+04	7.82E+03	3.06E+06
	693SB00301	K693SB003	1/14/1997	3.91E+04	3.21E+04	2.93E+04	7.82E+03	3.06E+06
	693SB00401	K693SB004	1/15/1997	1.17E+04	3.21E+04	2.93E+04	7.82E+03	3.06E+06
	694SB00201	K694SB002	1/15/1997	3.01E+04	3.21E+04	2.93E+04	7.82E+03	3.06E+06
	694SB00301	K694SB003	1/16/1997	3.31E+04	3.21E+04	2.93E+04	7.82E+03	3.06E+06
	694SB00401	K694SB004	1/16/1997	2.82E+04	3.21E+04	2.93E+04	7.82E+03	3.06E+06
	694SB00501	K694SB005	1/15/1997	4.47E+04	3.21E+04	2.93E+04	7.82E+03	3.06E+06
	694SB005T1	K694SB005	10/13/1999	3.52E+04	3.21E+04	2.93E+04	7.82E+03	3.06E+06
	694SB00701	K694SB007	1/15/1997	1.71E+04	3.21E+04	2.93E+04	7.82E+03	3.06E+06
	694SB00801	K694SB008	1/16/1997	3.32E+04	3.21E+04	2.93E+04	7.82E+03	3.06E+06
	694SB00901	K694SB009	1/16/1997	1.41E+04	3.21E+04	2.93E+04	7.82E+03	3.06E+06
	694SB009T1	K694SB009	10/13/1999	2.25E+04	3.21E+04	2.93E+04	7.82E+03	3.06E+06
	694SB01001	K694SB010	1/17/1997	2.14E+04	3.21E+04	2.93E+04	7.82E+03	3.06E+06
	694SB01101	K694SB011	1/16/1997	1.70E+04	3.21E+04	2.93E+04	7.82E+03	3.06E+06
	694SB012T1	K694SB012	10/13/1999	1.25E+04	3.21E+04	2.93E+04	7.82E+03	3.06E+06
	694SB01301	K694SB013	1/16/1997	1.79E+04	3.21E+04	2.93E+04	7.82E+03	3.06E+06
	694SB014T1	K694SB014	10/13/1999	2.28E+04	3.21E+04	2.93E+04	7.82E+03	3.06E+06
	694SB01501	K694SB015	1/17/1997	1.24E+04	3.21E+04	2.93E+04	7.82E+03	3.06E+06
	694SB01601	K694SB016	1/16/1997	1.61E+04	3.21E+04	2.93E+04	7.82E+03	3.06E+06
	694SB01701	K694SB017	1/17/1997	1.23E+04	3.21E+04	2.93E+04	7.82E+03	3.06E+06
	694SB01801	K694SB018	1/17/1997	1.23E+04	3.21E+04	2.93E+04	7.82E+03	3.06E+06
	694SB019T1	K694SB019	10/13/1999	2.55E+04	3.21E+04	2.93E+04	7.82E+03	3.06E+06
	694SB02401	K694SB024	1/13/1999	2.42E+04	3.21E+04	2.93E+04	7.82E+03	3.06E+06
	694SB02501	K694SB025	1/13/1999	1.70E+04	3.21E+04	2.93E+04	7.82E+03	3.06E+06
	694SB02601	K694SB026	1/13/1999	2.01E+04	3.21E+04	2.93E+04	7.82E+03	3.06E+06
	694SB02701	K694SB027	1/13/1999	2.81E+04	3.21E+04	2.93E+04	7.82E+03	3.06E+06
	694SB03001	K694SB030	11/18/1999	2.73E+04	3.21E+04	2.93E+04	7.82E+03	3.06E+06
	694SB03101	K694SB031	11/18/1999	2.67E+04	3.21E+04	2.93E+04	7.82E+03	3.06E+06
	694SB03201	K694SB032	11/18/1999	2.12E+04	3.21E+04	2.93E+04	7.82E+03	3.06E+06
	694SB03301	K694SB033	11/18/1999	1.77E+04	3.21E+04	2.93E+04	7.82E+03	3.06E+06
	694SB03501	K694SB035	11/18/1999	2.07E+04	3.21E+04	2.93E+04	7.82E+03	3.06E+06
	694SB03601	K694SB036	11/18/1999	3.99E+04	3.21E+04	2.93E+04	7.82E+03	3.06E+06
	694SB03701	K694SB037	12/21/1999	3.30E+04 J	3.21E+04	2.93E+04	7.82E+03	3.06E+06
	694SB03801	K694SB038	12/21/1999	2.39E+04 J	3.21E+04	2.93E+04	7.82E+03	3.06E+06
	694SB03901	K694SB039	12/21/1999	1.44E+04 J	3.21E+04	2.93E+04	7.82E+03	3.06E+06
	694SB04001	K694SB040	12/21/1999	2.69E+04 J	3.21E+04	2.93E+04	7.82E+03	3.06E+06
	694SB04101	K694SB041	12/21/1999	1.21E+04 J	3.21E+04	2.93E+04	7.82E+03	3.06E+06
	694SB04201	K694SB042	12/20/1999	2.39E+04	3.21E+04	2.93E+04	7.82E+03	3.06E+06
	694SB04301	K694SB043	12/20/1999	1.38E+04	3.21E+04	2.93E+04	7.82E+03	3.06E+06
	694SB04401	K694SB044	12/20/1999	1.45E+04	3.21E+04	2.93E+04	7.82E+03	3.06E+06
	694SB04501	K694SB045	12/20/1999	1.22E+04	3.21E+04	2.93E+04	7.82E+03	3.06E+06
	694SB04901	K694SB049	12/20/1999	1.74E+04	3.21E+04	2.93E+04	7.82E+03	3.06E+06
	694SB05101	K694SB051	12/21/1999	3.22E+04 J	3.21E+04	2.93E+04	7.82E+03	3.06E+06
	694SB05201	K694SB052	12/21/1999	3.21E+04 J	3.21E+04	2.93E+04	7.82E+03	3.06E+06

TABLE 2-2

HISTORICAL EXCEEDANCES OF INORGANICS IN SURFACE SOIL
AOCs 693 and 694
CHARLESTON NAVAL COMPLEX, NORTH CHARLESTON, SOUTH CAROLINA
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Parameter	Sample ID	Sample Location	Sample Date	Concentration	RFI 2X MEAN BG ¹	2001 2X MEAN BG ²	RBC ³	SSL ⁴
Inorganic Elements (MG/KG)								
ANTIMONY	694SB00201	K694SB002	1/15/1997	2.50E+00	J 2.16E+00	1.70E+00	3.13E+00	2.09E+01
	694SB00501	K694SB005	1/15/1997	3.30E+00	J 2.16E+00	1.70E+00	3.13E+00	2.09E+01
	694SB00901	K694SB009	1/16/1997	3.70E+00	J 2.16E+00	1.70E+00	3.13E+00	2.09E+01
	694SB009T1	K694SB009	10/13/1999	2.10E+00	J 2.16E+00	1.70E+00	3.13E+00	2.09E+01
	694SB01201	K694SB012	1/16/1997	2.79E+01	J 2.16E+00	1.70E+00	3.13E+00	2.09E+01
	694SB01401	K694SB014	1/17/1997	5.60E+00	J 2.16E+00	1.70E+00	3.13E+00	2.09E+01
	694SB01801	K694SB018	1/17/1997	2.20E+00	J 2.16E+00	1.70E+00	3.13E+00	2.09E+01
	694SB01901	K694SB019	1/17/1997	5.10E+00	J 2.16E+00	1.70E+00	3.13E+00	2.09E+01
	694SB03201	K694SB032	11/18/1999	1.90E+00	J 2.16E+00	1.70E+00	3.13E+00	2.09E+01
	694SB03301	K694SB033	11/18/1999	3.10E+00	J 2.16E+00	1.70E+00	3.13E+00	2.09E+01
	694SB03401	K694SB034	11/18/1999	8.20E+00	J 2.16E+00	1.70E+00	3.13E+00	2.09E+01
	694SB03501	K694SB035	11/18/1999	4.40E+00	J 2.16E+00	1.70E+00	3.13E+00	2.09E+01
	694SB04001	K694SB040	12/21/1999	1.24E+01	J 2.16E+00	1.70E+00	3.13E+00	2.09E+01
	694SB04101	K694SB041	12/21/1999	3.87E+01	J 2.16E+00	1.70E+00	3.13E+00	2.09E+01
	694SB04201	K694SB042	12/20/1999	1.12E+01	J 2.16E+00	1.70E+00	3.13E+00	2.09E+01
	694SB05001	K694SB050	12/20/1999	2.20E+00	J 2.16E+00	1.70E+00	3.13E+00	2.09E+01
	ARSENIC	693SB00101	K693SB001	1/15/1997	1.81E+01	2.30E+01	2.20E+01	4.26E-01
693SB00201		K693SB002	1/14/1997	2.19E+01	2.30E+01	2.20E+01	4.26E-01	7.16E+02
693SB00301		K693SB003	1/14/1997	1.79E+01	2.30E+01	2.20E+01	4.26E-01	7.16E+02
693SB00401		K693SB004	1/15/1997	1.12E+01	2.30E+01	2.20E+01	4.26E-01	7.16E+02
694SB00201		K694SB002	1/15/1997	1.47E+01	2.30E+01	2.20E+01	4.26E-01	7.16E+02
694SB00301		K694SB003	1/16/1997	1.63E+01	2.30E+01	2.20E+01	4.26E-01	7.16E+02
694SB00401		K694SB004	1/16/1997	1.25E+01	2.30E+01	2.20E+01	4.26E-01	7.16E+02
694SB00501		K694SB005	1/15/1997	2.58E+01	2.30E+01	2.20E+01	4.26E-01	7.16E+02
694SB005T1		K694SB005	10/13/1999	1.65E+01	2.30E+01	2.20E+01	4.26E-01	7.16E+02
694SB00701		K694SB007	1/15/1997	1.17E+01	2.30E+01	2.20E+01	4.26E-01	7.16E+02
694SB00801		K694SB008	1/16/1997	1.65E+01	2.30E+01	2.20E+01	4.26E-01	7.16E+02
694SB00901		K694SB009	1/16/1997	1.06E+01	2.30E+01	2.20E+01	4.26E-01	7.16E+02
694SB009T1		K694SB009	10/13/1999	1.18E+01	2.30E+01	2.20E+01	4.26E-01	7.16E+02
694SB01001		K694SB010	19970117	2.15E+01	J 2.30E+01	2.20E+01	4.26E-01	7.16E+02
694SB01101		K694SB011	1/16/1997	1.21E+01	2.30E+01	2.20E+01	4.26E-01	7.16E+02
694SB01201		K694SB012	1/16/1997	7.20E+00	J 2.30E+01	2.20E+01	4.26E-01	7.16E+02
694SB012T1		K694SB012	10/13/1999	6.60E+00	2.30E+01	2.20E+01	4.26E-01	7.16E+02
694SB01301		K694SB013	1/16/1997	1.74E+01	2.30E+01	2.20E+01	4.26E-01	7.16E+02
694SB01401		K694SB014	1/17/1997	1.21E+01	J 2.30E+01	2.20E+01	4.26E-01	7.16E+02
694SB014T1		K694SB014	10/13/1999	1.28E+01	2.30E+01	2.20E+01	4.26E-01	7.16E+02
694SB01501		K694SB015	1/17/1997	8.00E+00	J 2.30E+01	2.20E+01	4.26E-01	7.16E+02
694SB01601		K694SB016	1/16/1997	8.60E+00	2.30E+01	2.20E+01	4.26E-01	7.16E+02
694SB01701		K694SB017	1/17/1997	9.70E+00	J 2.30E+01	2.20E+01	4.26E-01	7.16E+02
694SB01801		K694SB018	1/17/1997	7.40E+00	J 2.30E+01	2.20E+01	4.26E-01	7.16E+02
694SB01901		K694SB019	1/17/1997	9.00E+00	J 2.30E+01	2.20E+01	4.26E-01	7.16E+02
694SB019T1		K694SB019	10/13/1999	1.39E+01	2.30E+01	2.20E+01	4.26E-01	7.16E+02
694SB02401		K694SB024	1/13/1999	1.38E+01	2.30E+01	2.20E+01	4.26E-01	7.16E+02
694SB02501		K694SB025	1/13/1999	1.24E+01	2.30E+01	2.20E+01	4.26E-01	7.16E+02
694SB02601		K694SB026	1/13/1999	1.35E+01	2.30E+01	2.20E+01	4.26E-01	7.16E+02
694SB02701		K694SB027	1/13/1999	1.72E+01	2.30E+01	2.20E+01	4.26E-01	7.16E+02

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HISTORICAL EXCEEDANCES OF INORGANICS IN SURFACE SOIL
AOCs 693 and 694
CHARLESTON NAVAL COMPLEX, NORTH CHARLESTON, SOUTH CAROLINA
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Parameter	Sample ID	Sample Location	Sample Date	Concentration	RFI 2X MEAN BG ¹	2001 2X MEAN BG ²	RBC ³	SSL ⁴	
Inorganic Elements (MG/KG)									
	694SB02901	K694SB029	11/18/1999	4.50E+00	2.30E+01	2.20E+01	4.26E-01	7.16E+02	
	694SB03001	K694SB030	11/18/1999	1.61E+01	2.30E+01	2.20E+01	4.26E-01	7.16E+02	
	694SB03101	K694SB031	11/18/1999	1.58E+01	2.30E+01	2.20E+01	4.26E-01	7.16E+02	
	694SB03201	K694SB032	11/18/1999	1.20E+01	2.30E+01	2.20E+01	4.26E-01	7.16E+02	
	694SB03301	K694SB033	11/18/1999	1.05E+01	2.30E+01	2.20E+01	4.26E-01	7.16E+02	
	694SB03401	K694SB034	11/18/1999	7.10E+00	2.30E+01	2.20E+01	4.26E-01	7.16E+02	
	694SB03501	K694SB035	11/18/1999	1.01E+01	2.30E+01	2.20E+01	4.26E-01	7.16E+02	
	694SB03601	K694SB036	11/18/1999	2.00E+01	2.30E+01	2.20E+01	4.26E-01	7.16E+02	
	694SB03701	K694SB037	12/21/1999	1.50E+01	2.30E+01	2.20E+01	4.26E-01	7.16E+02	
	694SB03801	K694SB038	12/21/1999	1.35E+01	2.30E+01	2.20E+01	4.26E-01	7.16E+02	
	694SB03901	K694SB039	12/21/1999	8.50E+00	2.30E+01	2.20E+01	4.26E-01	7.16E+02	
	694SB04001	K694SB040	12/21/1999	2.64E+01	2.30E+01	2.20E+01	4.26E-01	7.16E+02	
	694SB04101	K694SB041	12/21/1999	2.73E+01	2.30E+01	2.20E+01	4.26E-01	7.16E+02	
	694SB04201	K694SB042	12/20/1999	1.94E+01	2.30E+01	2.20E+01	4.26E-01	7.16E+02	
	694SB04301	K694SB043	12/20/1999	7.90E+00	2.30E+01	2.20E+01	4.26E-01	7.16E+02	
	694SB04401	K694SB044	12/20/1999	9.70E+00	2.30E+01	2.20E+01	4.26E-01	7.16E+02	
	694SB04501	K694SB045	12/20/1999	1.12E+01	2.30E+01	2.20E+01	4.26E-01	7.16E+02	
	694SB04601	K694SB046	12/20/1999	3.80E+00	2.30E+01	2.20E+01	4.26E-01	7.16E+02	
	694SB04901	K694SB049	12/20/1999	1.02E+01	2.30E+01	2.20E+01	4.26E-01	7.16E+02	
	694SB05001	K694SB050	12/20/1999	6.60E+00	2.30E+01	2.20E+01	4.26E-01	7.16E+02	
	694SB05101	K694SB051	12/21/1999	1.90E+01	2.30E+01	2.20E+01	4.26E-01	7.16E+02	
	694SB05201	K694SB052	12/21/1999	1.96E+01	2.30E+01	2.20E+01	4.26E-01	7.16E+02	
	CHROMIUM	693SB00101	K693SB001	1/15/1997	5.96E+01	6.91E+01	6.20E+01	2.35E+01	4.42E+03
		693SB00201	K693SB002	1/14/1997	6.72E+01	6.91E+01	6.20E+01	2.35E+01	4.42E+03
		693SB00301	K693SB003	1/14/1997	7.50E+01	6.91E+01	6.20E+01	2.35E+01	4.42E+03
		693SB00401	K693SB004	1/15/1997	2.94E+01	6.91E+01	6.20E+01	2.35E+01	4.42E+03
		694SB00201	K694SB002	1/15/1997	5.19E+01	6.91E+01	6.20E+01	2.35E+01	4.42E+03
		694SB00301	K694SB003	1/16/1997	6.30E+01	6.91E+01	6.20E+01	2.35E+01	4.42E+03
		694SB00401	K694SB004	1/16/1997	5.32E+01	6.91E+01	6.20E+01	2.35E+01	4.42E+03
		694SB00501	K694SB005	1/15/1997	7.73E+01	6.91E+01	6.20E+01	2.35E+01	4.42E+03
		694SB005T1	K694SB005	10/13/1999	6.57E+01	6.91E+01	6.20E+01	2.35E+01	4.42E+03
		694SB00701	K694SB007	1/15/1997	3.81E+01	6.91E+01	6.20E+01	2.35E+01	4.42E+03
694SB00801		K694SB008	1/16/1997	5.97E+01	6.91E+01	6.20E+01	2.35E+01	4.42E+03	
694SB00901		K694SB009	1/16/1997	6.95E+01	6.91E+01	6.20E+01	2.35E+01	4.42E+03	
694SB009T1		K694SB009	10/13/1999	4.61E+01	6.91E+01	6.20E+01	2.35E+01	4.42E+03	
694SB01001		K694SB010	1/17/1997	4.87E+01	6.91E+01	6.20E+01	2.35E+01	4.42E+03	
694SB01101		K694SB011	1/16/1997	5.57E+01	6.91E+01	6.20E+01	2.35E+01	4.42E+03	
694SB01201		K694SB012	1/16/1997	4.33E+01	6.91E+01	6.20E+01	2.35E+01	4.42E+03	
694SB01301		K694SB013	1/16/1997	4.12E+01	6.91E+01	6.20E+01	2.35E+01	4.42E+03	
694SB01401		K694SB014	1/17/1997	6.39E+01	6.91E+01	6.20E+01	2.35E+01	4.42E+03	
694SB014T1		K694SB014	10/13/1999	4.31E+01	6.91E+01	6.20E+01	2.35E+01	4.42E+03	
694SB01501		K694SB015	1/17/1997	2.90E+01	6.91E+01	6.20E+01	2.35E+01	4.42E+03	
694SB01601		K694SB016	1/16/1997	3.32E+01	6.91E+01	6.20E+01	2.35E+01	4.42E+03	
694SB01701		K694SB017	1/17/1997	3.06E+01	6.91E+01	6.20E+01	2.35E+01	4.42E+03	
694SB01801		K694SB018	1/17/1997	3.44E+01	6.91E+01	6.20E+01	2.35E+01	4.42E+03	
694SB01901		K694SB019	1/17/1997	7.50E+01	6.91E+01	6.20E+01	2.35E+01	4.42E+03	

TABLE 2-2

HISTORICAL EXCEEDANCES OF INORGANICS IN SURFACE SOIL
AOCs 693 and 694
CHARLESTON NAVAL COMPLEX, NORTH CHARLESTON, SOUTH CAROLINA
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Parameter	Sample ID	Sample Location	Sample Date	Concentration	RFI 2X MEAN BG ¹	2001 2X MEAN BG ²	RBC ³	SSL ⁴	
Inorganic Elements (MG/KG)									
	694SB019T1	K694SB019	10/13/1999	4.18E+01	J	6.91E+01	6.20E+01	2.35E+01	4.42E+03
	694SB02401	K694SB024	1/13/1999	6.05E+01	J	6.91E+01	6.20E+01	2.35E+01	4.42E+03
	694SB02501	K694SB025	1/13/1999	3.58E+01	J	6.91E+01	6.20E+01	2.35E+01	4.42E+03
	694SB02601	K694SB026	1/13/1999	3.86E+01	J	6.91E+01	6.20E+01	2.35E+01	4.42E+03
	694SB02701	K694SB027	1/13/1999	5.13E+01	J	6.91E+01	6.20E+01	2.35E+01	4.42E+03
	694SB03001	K694SB030	11/18/1999	4.87E+01	J	6.91E+01	6.20E+01	2.35E+01	4.42E+03
	694SB03101	K694SB031	11/18/1999	4.82E+01	J	6.91E+01	6.20E+01	2.35E+01	4.42E+03
	694SB03201	K694SB032	11/18/1999	4.29E+01	J	6.91E+01	6.20E+01	2.35E+01	4.42E+03
	694SB03301	K694SB033	11/18/1999	4.49E+01	J	6.91E+01	6.20E+01	2.35E+01	4.42E+03
	694SB03401	K694SB034	11/18/1999	4.44E+01	J	6.91E+01	6.20E+01	2.35E+01	4.42E+03
	694SB03501	K694SB035	11/18/1999	6.66E+01	J	6.91E+01	6.20E+01	2.35E+01	4.42E+03
	694SB03601	K694SB036	11/18/1999	7.96E+01	J	6.91E+01	6.20E+01	2.35E+01	4.42E+03
	694SB03701	K694SB037	12/21/1999	5.70E+01	J	6.91E+01	6.20E+01	2.35E+01	4.42E+03
	694SB03801	K694SB038	12/21/1999	4.93E+01	J	6.91E+01	6.20E+01	2.35E+01	4.42E+03
	694SB03901	K694SB039	12/21/1999	2.58E+01	J	6.91E+01	6.20E+01	2.35E+01	4.42E+03
	694SB04001	K694SB040	12/21/1999	1.16E+02	J	6.91E+01	6.20E+01	2.35E+01	4.42E+03
	694SB04101	K694SB041	12/21/1999	7.85E+01	J	6.91E+01	6.20E+01	2.35E+01	4.42E+03
	694SB04201	K694SB042	12/20/1999	4.92E+01	J	6.91E+01	6.20E+01	2.35E+01	4.42E+03
	694SB04301	K694SB043	12/20/1999	3.01E+01	J	6.91E+01	6.20E+01	2.35E+01	4.42E+03
	694SB04401	K694SB044	12/20/1999	3.12E+01	J	6.91E+01	6.20E+01	2.35E+01	4.42E+03
	694SB04501	K694SB045	12/20/1999	3.14E+01	J	6.91E+01	6.20E+01	2.35E+01	4.42E+03
	694SB04901	K694SB049	12/20/1999	4.24E+01	J	6.91E+01	6.20E+01	2.35E+01	4.42E+03
	694SB05001	K694SB050	12/20/1999	3.02E+01	J	6.91E+01	6.20E+01	2.35E+01	4.42E+03
	694SB05101	K694SB051	12/21/1999	6.53E+01	J	6.91E+01	6.20E+01	2.35E+01	4.42E+03
	694SB05201	K694SB052	12/21/1999	6.46E+01	J	6.91E+01	6.20E+01	2.35E+01	4.42E+03
COPPER	694SB00901	K694SB009	1/16/1997	2.60E+02	J	1.19E+02	9.40E+01	3.13E+02	7.30E+04
	694SB01401	K694SB014	1/17/1997	1.02E+03	J	1.19E+02	9.40E+01	3.13E+02	7.30E+04
	694SB01801	K694SB018	1/17/1997	9.97E+01	J	1.19E+02	9.40E+01	3.13E+02	7.30E+04
	694SB01901	K694SB019	1/17/1997	1.60E+02	J	1.19E+02	9.40E+01	3.13E+02	7.30E+04
	694SB03401	K694SB034	11/18/1999	1.04E+02	J	1.19E+02	9.40E+01	3.13E+02	7.30E+04
	694SB04001	K694SB040	12/21/1999	3.09E+02	J	1.19E+02	9.40E+01	3.13E+02	7.30E+04
	694SB04101	K694SB041	12/21/1999	1.15E+03	J	1.19E+02	9.40E+01	3.13E+02	7.30E+04
	694SB05001	K694SB050	12/20/1999	1.11E+02	J	1.19E+02	9.40E+01	3.13E+02	7.30E+04
	693SB00101	K693SB001	1/15/1997	3.14E+04	J	3.52E+04	3.32E+04	2.35E+03	1.33E+06
	693SB00201	K693SB002	1/14/1997	4.32E+04	J	3.52E+04	3.32E+04	2.35E+03	1.33E+06
IRON	693SB00301	K693SB003	1/14/1997	3.72E+04	J	3.52E+04	3.32E+04	2.35E+03	1.33E+06
	693SB00401	K693SB004	1/15/1997	1.79E+04	J	3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB00201	K694SB002	1/15/1997	2.15E+04	J	3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB00301	K694SB003	1/16/1997	3.13E+04	J	3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB00401	K694SB004	1/16/1997	2.51E+04	J	3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB00501	K694SB005	1/15/1997	4.07E+04	J	3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB005T1	K694SB005	10/13/1999	3.47E+04	J	3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB00601	K694SB006	1/15/1997	5.44E+03	J	3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB00701	K694SB007	1/15/1997	1.86E+04	J	3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB00801	K694SB008	1/16/1997	2.97E+04	J	3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB00901	K694SB009	1/16/1997	2.51E+04	J	3.52E+04	3.32E+04	2.35E+03	1.33E+06

TABLE 2-2

HISTORICAL EXCEEDANCES OF INORGANICS IN SURFACE SOIL
AOCs 693 and 694
CHARLESTON NAVAL COMPLEX, NORTH CHARLESTON, SOUTH CAROLINA
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Parameter	Sample ID	Sample Location	Sample Date	Concentration	RFI 2X MEAN BG ¹	2001 2X MEAN BG ²	RBC ³	SSL ⁴	
Inorganic Elements (MG/KG)									
	694SB009T1	K694SB009	10/13/1999	2.30E+04	J	3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB01001	K694SB010	1/17/1997	3.37E+04		3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB01101	K694SB011	1/16/1997	1.93E+04	J	3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB01201	K694SB012	1/16/1997	1.08E+04		3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB012T1	K694SB012	10/13/1999	1.18E+04	J	3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB01301	K694SB013	1/16/1997	2.76E+04	J	3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB01401	K694SB014	1/17/1997	2.81E+04		3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB014T1	K694SB014	10/13/1999	2.08E+04	J	3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB01501	K694SB015	1/17/1997	1.33E+04		3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB01601	K694SB016	1/16/1997	1.54E+04	J	3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB01701	K694SB017	1/17/1997	1.79E+04		3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB01801	K694SB018	1/17/1997	1.16E+04		3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB01901	K694SB019	1/17/1997	1.86E+04		3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB019T1	K694SB019	10/13/1999	2.23E+04	J	3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB02401	K694SB024	1/13/1999	3.03E+04		3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB02501	K694SB025	1/13/1999	2.08E+04		3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB02601	K694SB026	1/13/1999	2.23E+04		3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB02701	K694SB027	1/13/1999	2.95E+04		3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB02901	K694SB029	11/18/1999	6.63E+03		3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB03001	K694SB030	11/18/1999	2.83E+04		3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB03101	K694SB031	11/18/1999	2.85E+04		3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB03201	K694SB032	11/18/1999	2.05E+04		3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB03301	K694SB033	11/18/1999	1.64E+04		3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB03401	K694SB034	11/18/1999	1.28E+04		3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB03501	K694SB035	11/18/1999	1.85E+04		3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB03601	K694SB036	11/18/1999	4.26E+04		3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB03701	K694SB037	12/21/1999	3.19E+04		3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB03801	K694SB038	12/21/1999	2.69E+04		3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB03901	K694SB039	12/21/1999	1.42E+04		3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB04001	K694SB040	12/21/1999	3.86E+04		3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB04101	K694SB041	12/21/1999	3.77E+04		3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB04201	K694SB042	12/20/1999	2.88E+04		3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB04301	K694SB043	12/20/1999	1.34E+04		3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB04401	K694SB044	12/20/1999	1.46E+04		3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB04501	K694SB045	12/20/1999	1.59E+04		3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB04601	K694SB046	12/20/1999	5.58E+03		3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB04901	K694SB049	12/20/1999	1.51E+04		3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB05001	K694SB050	12/20/1999	1.01E+04		3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB05101	K694SB051	12/21/1999	3.61E+04		3.52E+04	3.32E+04	2.35E+03	1.33E+06
	694SB05201	K694SB052	12/21/1999	3.85E+04		3.52E+04	3.32E+04	2.35E+03	1.33E+06
LEAD	694SB00901	K694SB009	1/16/1997	4.81E+02		9.83E+01	8.20E+01	4.00E+02	1.06E+03
	694SB009T1	K694SB009	10/13/1999	1.12E+02	J	9.83E+01	8.20E+01	4.00E+02	1.06E+03
	694SB01101	K694SB011	1/16/1997	9.86E+01		9.83E+01	8.20E+01	4.00E+02	1.06E+03
	694SB01201	K694SB012	1/16/1997	1.05E+02		9.83E+01	8.20E+01	4.00E+02	1.06E+03
	694SB01401	K694SB014	1/17/1997	3.91E+02		9.83E+01	8.20E+01	4.00E+02	1.06E+03
	694SB01801	K694SB018	1/17/1997	1.33E+02		9.83E+01	8.20E+01	4.00E+02	1.06E+03

TABLE 2-2

HISTORICAL EXCEEDANCES OF INORGANICS IN SURFACE SOIL
AOCs 693 and 694
CHARLESTON NAVAL COMPLEX, NORTH CHARLESTON, SOUTH CAROLINA
PAGE 6 OF 7

Parameter	Sample ID	Sample Location	Sample Date	Concentration	RFI 2X MEAN BG ¹	2001 2X MEAN BG ²	RBC ³	SSL ⁴	
Inorganic Elements (MG/KG)									
MERCURY	694SB01901	K694SB019	1/17/1997	1.77E+02	J	9.83E+01	8.20E+01	4.00E+02	1.06E+03
	694SB03401	K694SB034	11/18/1999	8.86E+01	J	9.83E+01	8.20E+01	4.00E+02	1.06E+03
	694SB03501	K694SB035	11/18/1999	1.49E+02	J	9.83E+01	8.20E+01	4.00E+02	1.06E+03
	694SB04001	K694SB040	12/21/1999	3.80E+02	J	9.83E+01	8.20E+01	4.00E+02	1.06E+03
	694SB04101	K694SB041	12/21/1999	3.06E+03	J	9.83E+01	8.20E+01	4.00E+02	1.06E+03
	694SB00801	K694SB008	1/16/1997	4.90E-01	J	6.30E-01	4.80E-01	2.35E+00	1.15E+00
	694SB00901	K694SB009	1/16/1997	5.70E-01	J	6.30E-01	4.80E-01	2.35E+00	1.15E+00
	694SB012T1	K694SB012	10/13/1999	1.10E+00	J	6.30E-01	4.80E-01	2.35E+00	1.15E+00
	694SB01401	K694SB014	1/17/1997	9.60E-01	J	6.30E-01	4.80E-01	2.35E+00	1.15E+00
	694SB01901	K694SB019	1/17/1997	1.70E+00	J	6.30E-01	4.80E-01	2.35E+00	1.15E+00
SELENIUM	694SB03401	K694SB034	11/18/1999	5.50E-01	J	6.30E-01	4.80E-01	2.35E+00	1.15E+00
	694SB03501	K694SB035	11/18/1999	1.10E+00	J	6.30E-01	4.80E-01	2.35E+00	1.15E+00
	694SB04001	K694SB040	12/21/1999	1.30E+00	J	6.30E-01	4.80E-01	2.35E+00	1.15E+00
	694SB00501	K694SB005	1/15/1997	4.70E+00	J	1.24E+00	1.16E+00	3.91E+01	2.86E+00
	694SB01001	K694SB010	1/17/1997	2.20E+00	J	1.24E+00	1.16E+00	3.91E+01	2.86E+00
	694SB01401	K694SB014	1/17/1997	1.50E+00	J	1.24E+00	1.16E+00	3.91E+01	2.86E+00
	694SB01901	K694SB019	1/17/1997	1.20E+00	J	1.24E+00	1.16E+00	3.91E+01	2.86E+00
	694SB02401	K694SB024	1/13/1999	1.20E+00	J	1.24E+00	1.16E+00	3.91E+01	2.86E+00
	694SB03301	K694SB033	11/18/1999	1.60E+00	J	1.24E+00	1.16E+00	3.91E+01	2.86E+00
	694SB03601	K694SB036	11/18/1999	1.20E+00	J	1.24E+00	1.16E+00	3.91E+01	2.86E+00
THALLIUM	694SB03701	K694SB037	12/21/1999	1.30E+00	J	1.24E+00	1.16E+00	3.91E+01	2.86E+00
	694SB05101	K694SB051	12/21/1999	1.40E+00	J	1.24E+00	1.16E+00	3.91E+01	2.86E+00
	694SB005T1	K694SB005	10/13/1999	1.40E+00	J	NC	1.32E+00	5.48E-01	3.92E-01
	694SB009T1	K694SB009	10/13/1999	1.00E+00	J	NC	1.32E+00	5.48E-01	3.92E-01
	694SB014T1	K694SB014	10/13/1999	5.70E-01	J	NC	1.32E+00	5.48E-01	3.92E-01
	694SB019T1	K694SB019	10/13/1999	4.60E-01	J	NC	1.32E+00	5.48E-01	3.92E-01
	694SB02901	K694SB029	11/18/1999	4.70E-01	J	NC	1.32E+00	5.48E-01	3.92E-01
	694SB03001	K694SB030	11/18/1999	9.60E-01	J	NC	1.32E+00	5.48E-01	3.92E-01
	694SB03101	K694SB031	11/18/1999	9.10E-01	J	NC	1.32E+00	5.48E-01	3.92E-01
	694SB03201	K694SB032	11/18/1999	9.30E-01	J	NC	1.32E+00	5.48E-01	3.92E-01
	694SB03301	K694SB033	11/18/1999	6.60E-01	J	NC	1.32E+00	5.48E-01	3.92E-01
	694SB03401	K694SB034	11/18/1999	6.60E-01	J	NC	1.32E+00	5.48E-01	3.92E-01
	694SB03501	K694SB035	11/18/1999	1.00E+00	J	NC	1.32E+00	5.48E-01	3.92E-01
	694SB03601	K694SB036	11/18/1999	1.10E+00	J	NC	1.32E+00	5.48E-01	3.92E-01
	694SB03701	K694SB037	12/21/1999	1.40E+00	J	NC	1.32E+00	5.48E-01	3.92E-01
	694SB03801	K694SB038	12/21/1999	1.10E+00	J	NC	1.32E+00	5.48E-01	3.92E-01
	694SB03901	K694SB039	12/21/1999	1.10E+00	J	NC	1.32E+00	5.48E-01	3.92E-01
	694SB04001	K694SB040	12/21/1999	1.10E+00	J	NC	1.32E+00	5.48E-01	3.92E-01
	694SB04101	K694SB041	12/21/1999	1.30E+00	J	NC	1.32E+00	5.48E-01	3.92E-01
	694SB04201	K694SB042	12/20/1999	1.20E+00	J	NC	1.32E+00	5.48E-01	3.92E-01
694SB04301	K694SB043	12/20/1999	5.20E-01	J	NC	1.32E+00	5.48E-01	3.92E-01	
694SB04401	K694SB044	12/20/1999	8.20E-01	J	NC	1.32E+00	5.48E-01	3.92E-01	
694SB04901	K694SB049	12/20/1999	8.50E-01	J	NC	1.32E+00	5.48E-01	3.92E-01	
694SB05001	K694SB050	12/20/1999	4.90E-01	J	NC	1.32E+00	5.48E-01	3.92E-01	
694SB05101	K694SB051	12/21/1999	1.20E+00	J	NC	1.32E+00	5.48E-01	3.92E-01	
694SB05201	K694SB052	12/21/1999	1.50E+00	J	NC	1.32E+00	5.48E-01	3.92E-01	

TABLE 2-2

HISTORICAL EXCEEDANCES OF INORGANICS IN SURFACE SOIL
AOCs 693 and 694
CHARLESTON NAVAL COMPLEX, NORTH CHARLESTON, SOUTH CAROLINA
PAGE 7 OF 7

Parameter	Sample ID	Sample Location	Sample Date	Concentration	RFI 2X MEAN BG ¹	2001 2X MEAN BG ²	RBC ³	SSL ⁴
Inorganic Elements (MG/KG)								
VANADIUM	693SB00101	K693SB001	1/15/1997	7.12E+01	7.59E+01	7.00E+01	5.48E+01	7.79E+03
	693SB00201	K693SB002	1/14/1997	8.78E+01	7.59E+01	7.00E+01	5.48E+01	7.79E+03
	693SB00301	K693SB003	1/14/1997	8.63E+01	7.59E+01	7.00E+01	5.48E+01	7.79E+03
	694SB00301	K694SB003	1/16/1997	7.07E+01	7.59E+01	7.00E+01	5.48E+01	7.79E+03
	694SB00401	K694SB004	1/16/1997	5.58E+01	7.59E+01	7.00E+01	5.48E+01	7.79E+03
	694SB00501	K694SB005	1/15/1997	9.22E+01	7.59E+01	7.00E+01	5.48E+01	7.79E+03
	694SB005T1	K694SB005	10/13/1999	7.90E+01	7.59E+01	7.00E+01	5.48E+01	7.79E+03
	694SB00801	K694SB008	1/16/1997	6.61E+01	7.59E+01	7.00E+01	5.48E+01	7.79E+03
	694SB00901	K694SB009	1/16/1997	5.70E+01	7.59E+01	7.00E+01	5.48E+01	7.79E+03
	694SB02401	K694SB024	1/13/1999	6.14E+01	7.59E+01	7.00E+01	5.48E+01	7.79E+03
	694SB02701	K694SB027	1/13/1999	6.52E+01	7.59E+01	7.00E+01	5.48E+01	7.79E+03
	694SB03001	K694SB030	11/18/1999	5.93E+01	7.59E+01	7.00E+01	5.48E+01	7.79E+03
	694SB03101	K694SB031	11/18/1999	5.81E+01	7.59E+01	7.00E+01	5.48E+01	7.79E+03
	694SB03601	K694SB036	11/18/1999	9.45E+01	7.59E+01	7.00E+01	5.48E+01	7.79E+03
	694SB03701	K694SB037	12/21/1999	7.06E+01	7.59E+01	7.00E+01	5.48E+01	7.79E+03
	694SB03801	K694SB038	12/21/1999	5.68E+01	7.59E+01	7.00E+01	5.48E+01	7.79E+03
	694SB04001	K694SB040	12/21/1999	7.02E+01	7.59E+01	7.00E+01	5.48E+01	7.79E+03
	694SB04201	K694SB042	12/20/1999	5.56E+01	7.59E+01	7.00E+01	5.48E+01	7.79E+03
	694SB05101	K694SB051	12/21/1999	8.15E+01	7.59E+01	7.00E+01	5.48E+01	7.79E+03
	694SB05201	K694SB052	12/21/1999	8.01E+01	7.59E+01	7.00E+01	5.48E+01	7.79E+03

1 Site-specific background concentrations developed and presented in the Final Zone K RFI Report, Charleston Naval Complex. June 1999. (EnSafe, 1999).

2 Site-specific background concentrations developed and presented in the Technical Memorandum: A Summary of Inorganic Chemical Concentrations in Background Soil and Groundwater at the CNC, CH2M Hill, 2001.

3 Risk Based Concentration (RBC) - USEPA Residential Soil Screening Level, USEPA Regional Screening Levels Table, May 2013.

4 Soil Screening Level (SSL) - Site Specific Soil Screening Levels, developed and presented in Clouter Island RFI Report Addendum, Charleston Naval Complex. September 2002. (EnSafe, 2002).

Shading indicates that the detected concentration exceeds 2001 2X mean background and one or more screening criteria.

J - estimated concentration.

MG/KG- milligram per kilogram

TABLE 2-3

HISTORICAL EXCEEDANCES OF ORGANICS IN SUBSURFACE SOIL
AOCs 693 and 694
CHARLESTON NAVAL COMPLEX, NORTH CHARLESTON, SOUTH CAROLINA

Parameter	Sample ID	Sample Location	Sample Date	Concentration	SSL ¹
Semivolatile Organic Compounds (UG/KG)					
BAP EQUIVALENT-HALFND	694SB01102	K694SB011	1/16/1997	7.19E+02	NC
	694SB01202	K694SB012	1/17/1997	3.47E+02	NC
	694SB02802	K694SB028	11/18/1999	2.02E+02	NC
	694SB02902	K694SB029	11/18/1999	2.84E+02	NC
	694SB04302	K694SB043	12/20/1999	3.44E+02	NC
	694SB04402	K694SB044	12/20/1999	2.82E+02	NC
	694SB04502	K694SB045	12/20/1999	4.43E+02	NC
BAP EQUIVALENT-POS	694SB01102	K694SB011	1/16/1997	5.14E+02	NC
	694SB01202	K694SB012	1/17/1997	9.91E+01	NC
	694SB02802	K694SB028	11/18/1999	1.78E+02	NC
	694SB02902	K694SB029	11/18/1999	2.58E+02	NC
	694SB04502	K694SB045	12/20/1999	1.93E+02	NC
BENZO(A)PYRENE	694SB01102	K694SB011	1/16/1997	4.10E+02	4.29E+04
	694SB02902	K694SB029	11/18/1999	9.40E+01 J	4.29E+04
	694SB04502	K694SB045	12/20/1999	1.40E+02 J	4.29E+04
DIBENZO(A,H)ANTHRACENE	694SB02902	K694SB029	11/18/1999	1.40E+02 J	9.58E+03

¹ Soil Screening Level (SSL) - Site Specific Soil Screening Levels, developed and presented in Clouter Island RFI Report Addendum, Charleston Naval Complex. September 2002. (EnSafe, 2002).

Shading indicates that the detected concentration exceeds at least one of the screening criteria.

NC - No Criteria available

BAP - Benzo(a)pyrene

HALFND - Average of all analytical results including one-half of the detection limit for non-detects

POS - Average of detected concentrations only

J - estimated concentration.

UG/KG - microgram per kilogram

TABLE 2-4

HISTORICAL EXCEEDANCES OF INORGANICS IN SUBSURFACE SOIL
AOCs 693 and 694
CHARLESTON NAVAL COMPLEX, NORTH CHARLESTON, SOUTH CAROLINA
PAGE 1 OF 2

Parameter	Sample ID	Sample Location	Sample Date	Concentration	RFI 2X MEAN BG ¹	2001 2X MEAN BG ²	SSL ³	
Inorganic Elements (MG/KG)								
ANTIMONY	694SB00802	K694SB008	1/16/1997	2.20E+00	J	2.16E+00	4.00E-01	2.09E+01
	694SB00902	K694SB009	1/16/1997	1.40E+00	J	2.16E+00	4.00E-01	2.09E+01
	694SB009T2	K694SB009	10/13/1999	2.40E+00	J	2.16E+00	4.00E-01	2.09E+01
	694SB01102	K694SB011	1/16/1997	1.90E+00	J	2.16E+00	4.00E-01	2.09E+01
	694SB012T2	K694SB012	10/13/1999	1.30E+00	J	2.16E+00	4.00E-01	2.09E+01
	694SB014T2	K694SB014	10/13/1999	4.20E-01	J	2.16E+00	4.00E-01	2.09E+01
	694SB01502	K694SB015	1/17/1997	7.00E-01	J	2.16E+00	4.00E-01	2.09E+01
	694SB01602	K694SB016	1/16/1997	1.10E+00	J	2.16E+00	4.00E-01	2.09E+01
	694SB019T2	K694SB019	10/13/1999	1.90E+00	J	2.16E+00	4.00E-01	2.09E+01
	694SB02602	K694SB026	1/13/1999	4.70E+00	J	2.16E+00	4.00E-01	2.09E+01
	694SB02902	K694SB029	11/18/1999	1.15E+01		2.16E+00	4.00E-01	2.09E+01
	694SB03002	K694SB030	11/18/1999	2.90E+00	J	2.16E+00	4.00E-01	2.09E+01
	694SB03202	K694SB032	11/18/1999	2.00E+00	J	2.16E+00	4.00E-01	2.09E+01
	694SB03302	K694SB033	11/18/1999	3.68E+01		2.16E+00	4.00E-01	2.09E+01
	694SB03402	K694SB034	11/18/1999	6.20E-01	J	2.16E+00	4.00E-01	2.09E+01
	694SB04102	K694SB041	12/21/1999	1.50E+00	J	2.16E+00	4.00E-01	2.09E+01
	694SB04402	K694SB044	12/20/1999	6.70E-01	J	2.16E+00	4.00E-01	2.09E+01
	694SB04502	K694SB045	12/20/1999	4.30E-01	J	2.16E+00	4.00E-01	2.09E+01
694SB04902	K694SB049	12/20/1999	4.30E-01	J	2.16E+00	4.00E-01	2.09E+01	
CHROMIUM	693SB00102	K693SB001	1/15/1997	4.00E+01		6.91E+01	5.20E+01	4.42E+03
	694SB00702	K694SB007	1/15/1997	4.93E+01		6.91E+01	5.20E+01	4.42E+03
	694SB00802	K694SB008	1/16/1997	6.38E+01		6.91E+01	5.20E+01	4.42E+03
	694SB00902	K694SB009	1/16/1997	4.87E+01		6.91E+01	5.20E+01	4.42E+03
	694SB009T2	K694SB009	10/13/1999	3.44E+01		6.91E+01	5.20E+01	4.42E+03
	694SB01102	K694SB011	1/16/1997	4.67E+01		6.91E+01	5.20E+01	4.42E+03
	694SB01202	K694SB012	1/17/1997	3.84E+01		6.91E+01	5.20E+01	4.42E+03
	694SB012T2	K694SB012	10/13/1999	3.69E+01		6.91E+01	5.20E+01	4.42E+03
	694SB014T2	K694SB014	10/13/1999	2.56E+01		6.91E+01	5.20E+01	4.42E+03
	694SB01602	K694SB016	1/16/1997	3.35E+01		6.91E+01	5.20E+01	4.42E+03
	694SB019T2	K694SB019	10/13/1999	6.11E+01		6.91E+01	5.20E+01	4.42E+03
	694SB02402	K694SB024	1/13/1999	2.47E+01	J	6.91E+01	5.20E+01	4.42E+03
	694SB02602	K694SB026	1/13/1999	5.87E+01	J	6.91E+01	5.20E+01	4.42E+03
	694SB02702	K694SB027	1/13/1999	6.40E+01	J	6.91E+01	5.20E+01	4.42E+03

TABLE 2-4

HISTORICAL EXCEEDANCES OF INORGANICS IN SUBSURFACE SOIL
AOCs 693 and 694
CHARLESTON NAVAL COMPLEX, NORTH CHARLESTON, SOUTH CAROLINA
PAGE 2 OF 2

Parameter	Sample ID	Sample Location	Sample Date	Concentration	RFI 2X MEAN BG ¹	2001 2X MEAN BG ²	SSL ³
Inorganic Elements (MG/KG)							
	694SB02902	K694SB029	11/18/1999	5.97E+01 J	6.91E+01	5.20E+01	4.42E+03
	694SB03002	K694SB030	11/18/1999	5.23E+01	6.91E+01	5.20E+01	4.42E+03
	694SB03102	K694SB031	11/18/1999	4.35E+01	6.91E+01	5.20E+01	4.42E+03
	694SB03202	K694SB032	11/18/1999	5.07E+01 J	6.91E+01	5.20E+01	4.42E+03
	694SB03302	K694SB033	11/18/1999	5.42E+01 J	6.91E+01	5.20E+01	4.42E+03
	694SB03402	K694SB034	11/18/1999	4.41E+01	6.91E+01	5.20E+01	4.42E+03
	694SB04102	K694SB041	12/21/1999	3.32E+01	6.91E+01	5.20E+01	4.42E+03
	694SB04302	K694SB043	12/20/1999	4.85E+01	6.91E+01	5.20E+01	4.42E+03
	694SB04402	K694SB044	12/20/1999	2.49E+01	6.91E+01	5.20E+01	4.42E+03
	694SB04502	K694SB045	12/20/1999	3.39E+01	6.91E+01	5.20E+01	4.42E+03
	694SB04902	K694SB049	12/20/1999	4.21E+01	6.91E+01	5.20E+01	4.42E+03
	694SB05002	K694SB050	12/20/1999	2.78E+01	6.91E+01	5.20E+01	4.42E+03
MERCURY	694SB00802	K694SB008	1/16/1997	1.40E+00 J	6.30E-01	4.00E-01	1.15E+00
	694SB00902	K694SB009	1/16/1997	5.30E-01 J	6.30E-01	4.00E-01	1.15E+00
	694SB019T2	K694SB019	10/13/1999	1.50E+00	6.30E-01	4.00E-01	1.15E+00

1 Site-specific background concentrations developed and presented in the Final Zone K RFI Report, Charleston Naval Complex. June 1999. (EnSafe, 1999).

2 Site-specific background concentrations developed and presented in the Technical Memorandum: A Summary of Inorganic Chemical Concentrations in Background Soil and Groundwater at the CNC, CH2M Hill, 2001.

3 Soil Screening Level (SSL) - Site Specific Soil Screening Levels, developed and presented in Clouter Island RFI Report Addendum, Charleston Naval Complex. September 2002. (EnSafe, 2002).

Shading indicates that the detected concentration exceeds 2001 2X mean background and SSL.

J - estimated concentration.

MG/KG - milligram per kilogram

TABLE 2-5

HISTORICAL EXCEEDANCES OF ORGANICS IN GROUNDWATER
 AOCs 693 and 694
 CHARLESTON NAVAL COMPLEX, NORTH CHARLESTON, SOUTH CAROLINA
 PAGE 1 OF 2

Parameter	Sample ID	Sample Location	Sample Date	Concentration	Tap Water RBC ¹	Tap Water MCL ²
Dioxins (PG/L)						
1,2,3,4,6,7,8-HPCDF	694GW00201	K694GW002	5/16/1997	4.44E+00 J	5.20E-05	NA
1,2,3,4,6,7,8,9-OCDD	694GW00202	K694GW002	7/17/1997	1.43E+01	1.70E-03	NA
	694GW00203	K694GW002	12/17/1997	3.18E+01 J	1.70E-03	NA
	694GW00301	K694GW003	5/16/1997	8.99E+00 J	1.70E-03	NA
	694GW00302	K694GW003	7/17/1997	1.24E+01	1.70E-03	NA
	694GW00303	K694GW003	12/17/1997	5.81E+01 J	1.70E-03	NA
	694GW00401b	K694GW004	5/15/1997	5.18E+01 J	1.70E-03	NA
	694GW00402	K694GW004	7/21/1997	8.21E+01	1.70E-03	NA
	694GW00403	K694GW004	1/12/1998	2.62E+00 J	1.70E-03	NA
	694GW00501b	K694GW005	5/15/1997	7.52E+00 J	1.70E-03	NA
	694GW00502	K694GW005	7/17/1997	5.70E+01	1.70E-03	NA
	694GW00503	K694GW005	12/18/1997	1.31E+01 J	1.70E-03	NA
	694GW00601b	K694GW006	5/15/1997	9.49E+00 J	1.70E-03	NA
	694GW00602a	K694GW006	7/17/1997	5.15E+01	1.70E-03	NA
	694GW00603	K694GW006	12/19/1997	5.17E+00 J	1.70E-03	NA
	694GW00701a	K694GW007	5/15/1997	8.41E+00 J	1.70E-03	NA
	694GW00702	K694GW007	7/17/1997	1.53E+01 J	1.70E-03	NA
694GW00703	K694GW007	12/18/1997	1.27E+01 J	1.70E-03	NA	
1,2,3,4,6,7,8,9-OCDF	694GW00402	K694GW004	7/21/1997	1.01E+01	1.70E-03	NA
	694GW00602a	K694GW006	7/17/1997	4.46E+00	1.70E-03	NA
1,2,3,4,6,7,8-HPCDD	694GW00202	K694GW002	7/17/1997	3.74E+00	5.20E-05	NA
	694GW00401b	K694GW004	5/15/1997	5.42E+00 J	5.20E-05	NA
	694GW00602a	K694GW006	7/17/1997	8.70E+00	5.20E-05	NA
1,2,3,4,6,7,8-HPCDF	694GW00202	K694GW002	7/17/1997	1.28E+00 J	5.20E-05	NA
	694GW00602a	K694GW006	7/17/1997	2.61E+00 J	5.20E-05	NA
TEQ	694GW00201	K694GW002	5/16/1997	4.44E-02	5.20E-07	3.00E-05
	694GW00202	K694GW002	7/17/1997	5.45E-02	5.20E-07	3.00E-05
	694GW00203	K694GW002	12/17/1997	9.54E-03	5.20E-07	3.00E-05
	694GW00301	K694GW003	5/16/1997	2.70E-03	5.20E-07	3.00E-05
	694GW00302	K694GW003	7/17/1997	3.72E-03	5.20E-07	3.00E-05
	694GW00303	K694GW003	12/17/1997	1.74E-02	5.20E-07	3.00E-05
	694GW00401b	K694GW004	5/15/1997	6.97E-02	5.20E-07	3.00E-05
	694GW00402	K694GW004	7/21/1997	2.77E-02	5.20E-07	3.00E-05
	694GW00403	K694GW004	1/12/1998	7.86E-04	5.20E-07	3.00E-05
	694GW00501b	K694GW005	5/15/1997	2.26E-03	5.20E-07	3.00E-05
	694GW00502	K694GW005	7/17/1997	1.71E-02	5.20E-07	3.00E-05
	694GW00503	K694GW005	12/18/1997	3.93E-03	5.20E-07	3.00E-05
	694GW00601b	K694GW006	5/15/1997	2.85E-03	5.20E-07	3.00E-05
	694GW00602a	K694GW006	7/17/1997	1.30E-01	5.20E-07	3.00E-05
	694GW00603	K694GW006	12/19/1997	1.55E-03	5.20E-07	3.00E-05

TABLE 2-5

HISTORICAL EXCEEDANCES OF ORGANICS IN GROUNDWATER
AOCs 693 and 694
CHARLESTON NAVAL COMPLEX, NORTH CHARLESTON, SOUTH CAROLINA
PAGE 2 OF 2

Parameter	Sample ID	Sample Location	Sample Date	Concentration	Tap Water RBC ¹	Tap Water MCL ²
Dioxins (PG/L)						
	694GW00701a	K694GW007	5/15/1997	2.52E-03	5.20E-07	3.00E-05
	694GW00702	K694GW007	7/17/1997	4.59E-03	5.20E-07	3.00E-05
	694GW00703	K694GW007	12/18/1997	3.81E-03	5.20E-07	3.00E-05
TEQ HALFND	694GW00201	K694GW002	5/16/1997	5.40E+00	5.20E-07	3.00E-05
	694GW00202	K694GW002	7/17/1997	1.98E+00	5.20E-07	3.00E-05
	694GW00203	K694GW002	12/17/1997	5.69E+00	5.20E-07	3.00E-05
	694GW00301	K694GW003	5/16/1997	3.68E+00	5.20E-07	3.00E-05
	694GW00302	K694GW003	7/17/1997	1.10E+01	5.20E-07	3.00E-05
	694GW00303	K694GW003	12/17/1997	2.65E+01	5.20E-07	3.00E-05
	694GW00401b	K694GW004	5/15/1997	4.91E+00	5.20E-07	3.00E-05
	694GW00402	K694GW004	7/21/1997	1.57E+01	5.20E-07	3.00E-05
	694GW00403	K694GW004	1/12/1998	2.22E+00	5.20E-07	3.00E-05
	694GW00501b	K694GW005	5/15/1997	4.40E+00	5.20E-07	3.00E-05
	694GW00502	K694GW005	7/17/1997	1.36E+01	5.20E-07	3.00E-05
	694GW00503	K694GW005	12/18/1997	6.32E+00	5.20E-07	3.00E-05
	694GW00601b	K694GW006	5/15/1997	5.27E+00	5.20E-07	3.00E-05
	694GW00602a	K694GW006	7/17/1997	1.75E+00	5.20E-07	3.00E-05
	694GW00603	K694GW006	12/19/1997	3.07E+00	5.20E-07	3.00E-05
	694GW00701a	K694GW007	5/15/1997	4.49E+00	5.20E-07	3.00E-05
	694GW00702	K694GW007	7/17/1997	1.52E+01	5.20E-07	3.00E-05
	694GW00703	K694GW007	12/18/1997	6.18E+00	5.20E-07	3.00E-05
TOTAL HPCDD	694GW00202	K694GW002	7/17/1997	3.74E+00	1.10E-05	NA
	694GW00602a	K694GW006	7/17/1997	1.67E+01	1.10E-05	NA
Volatile Organic Compounds (UG/L)						
TRICHLOROETHENE	694GW00204	K694GW002	3/16/1998	2.00E+00 J	4.40E-01	5.00E+00
4-METHYL-2-PENTANONE	694GW00603	K694GW006	12/19/1997	1.00E+01 J	1.00E+03	NA
CARBON DISULFIDE	694GW00603	K694GW006	12/19/1997	2.00E+00 J	7.20E+02	NA
CHLOROMETHANE	694GW01301	K694GW013	12/10/1999	8.00E+00 J	1.90E+02	NA

1 Risk Based Concentration (RBC) - USEPA Tapwater Screening Level, USEPA Regional Screening Levels Table, May 2013.
2 Maximum Contaminant Level (MCL) -USEPA Maximum Contaminant Levels, USEPA Regional Screening Levels Table, May 2013.
Shading indicates that the detected concentration exceeds at least one of the screening criteria.
J - estimated concentration.
PG/L - picogram per liter
UG/L - microgram per liter

TABLE 2-6

HISTORICAL EXCEEDANCES OF INORGANICS IN GROUNDWATER
 AOCs 693 and 694
 CHARLESTON NAVAL COMPLEX, NORTH CHARLESTON, SOUTH CAROLINA
 PAGE 1 OF 4

Parameter	Sample ID	Sample Location	Sample Date	Concentration	RFI 2X MEAN BG ¹	2001 2X MEAN BG ²	TAP WATER RBC ³	MCL/TT ACTION LEVEL ⁴	
Inorganic Elements (UG/L)									
ANTIMONY	694GW00801	K694GW008	12/10/1999	3.80E+00	J	NA	NA	6.00E+00	6.00E+00
	694GW00901	K694GW009	12/10/1999	5.90E+00	J	NA	NA	6.00E+00	6.00E+00
	694GW009F3	K694GW009	4/19/2002	6.30E+00	J	NA	NA	6.00E+00	6.00E+00
ARSENIC	694GW00201	K694GW002	5/16/1997	6.69E+01		1.51E+01	NA	4.50E-02	1.00E+01
	694GW00202	K694GW002	7/17/1997	6.33E+01	J	1.51E+01	NA	4.50E-02	1.00E+01
	694GW00203	K694GW002	12/17/1997	5.77E+01		1.51E+01	NA	4.50E-02	1.00E+01
	694GW00204	K694GW002	3/16/1998	5.12E+01		1.51E+01	NA	4.50E-02	1.00E+01
	694GW00301	K694GW003	5/16/1997	4.32E+01		1.51E+01	NA	4.50E-02	1.00E+01
	694GW00302	K694GW003	7/17/1997	4.88E+01		1.51E+01	NA	4.50E-02	1.00E+01
	694GW00303	K694GW003	12/17/1997	3.89E+01		1.51E+01	NA	4.50E-02	1.00E+01
	694GW00304	K694GW003	3/17/1998	4.76E+01		1.51E+01	NA	4.50E-02	1.00E+01
	694GW00502	K694GW005	7/17/1997	3.20E+00	J	1.51E+01	NA	4.50E-02	1.00E+01
	694GW00504	K694GW005	3/19/1998	2.40E+00	J	1.51E+01	NA	4.50E-02	1.00E+01
	694GW00601b	K694GW006	5/15/1997	3.40E+00	J	1.51E+01	NA	4.50E-02	1.00E+01
	694GW00801	K694GW008	12/10/1999	1.26E+01		1.51E+01	NA	4.50E-02	1.00E+01
	694GW00901	K694GW009	12/10/1999	4.93E+01		1.51E+01	NA	4.50E-02	1.00E+01
	694GW00902	K694GW009	1/13/2000	7.47E+01		1.51E+01	NA	4.50E-02	1.00E+01
	694GW00903	K694GW009	4/19/2002	4.54E+01		1.51E+01	NA	4.50E-02	1.00E+01
	694GW009F3	K694GW009	4/19/2002	4.56E+01		1.51E+01	NA	4.50E-02	1.00E+01
	694GW01101	K694GW011	12/10/1999	5.00E+00	J	1.51E+01	NA	4.50E-02	1.00E+01
	694GW01303	K694GW013	4/22/2002	6.30E+00	U	1.51E+01	NA	4.50E-02	1.00E+01
	694GW013F3	K694GW013	4/22/2002	8.20E+00	U	1.51E+01	NA	4.50E-02	1.00E+01
	694GW01402	K694GW014	1/13/2000	3.80E+00	J	1.51E+01	NA	4.50E-02	1.00E+01
694GW01501	K694GW015	4/19/2002	1.46E+01	U	1.51E+01	NA	4.50E-02	1.00E+01	
694GW015F1	K694GW015	4/19/2002	1.57E+01		1.51E+01	NA	4.50E-02	1.00E+01	
694GW01601	K694GW016	4/19/2002	9.00E+00	U	1.51E+01	NA	4.50E-02	1.00E+01	
694GW016F1	K694GW016	4/19/2002	1.10E+01	U	1.51E+01	NA	4.50E-02	1.00E+01	
BERYLLIUM	694GW00202	K694GW002	7/17/1997	4.90E+00	J	NA	NA	1.30E+00	4.00E+00
	694GW00503	K694GW005	12/18/1997	2.30E-01		NA	NA	1.30E+00	4.00E+00
	694GW00603	K694GW006	12/19/1997	4.00E-01	J	NA	NA	1.30E+00	4.00E+00
	694GW006F5	K694GW006	1/13/1999	1.10E-01	J	NA	NA	1.30E+00	4.00E+00
	694GW006U5	K694GW006	1/13/1999	1.20E-01	J	NA	NA	1.30E+00	4.00E+00
	694GW00802	K694GW008	1/13/2000	5.00E-01	J	NA	NA	1.30E+00	4.00E+00
	694GW00902	K694GW009	1/13/2000	3.70E-01	J	NA	NA	1.30E+00	4.00E+00
	694GW01102	K694GW011	1/13/2000	6.00E-01	J	NA	NA	1.30E+00	4.00E+00
	694GW01202	K694GW012	1/13/2000	6.40E-01	J	NA	NA	1.30E+00	4.00E+00
	694GW01302	K694GW013	1/13/2000	6.70E-01	J	NA	NA	1.30E+00	4.00E+00
694GW01402	K694GW014	1/13/2000	7.30E-01	J	NA	NA	1.30E+00	4.00E+00	

TABLE 2-6

HISTORICAL EXCEEDANCES OF INORGANICS IN GROUNDWATER
 AOCs 693 and 694
 CHARLESTON NAVAL COMPLEX, NORTH CHARLESTON, SOUTH CAROLINA
 PAGE 2 OF 4

Parameter	Sample ID	Sample Location	Sample Date	Concentration	RFI 2X MEAN BG ¹	2001 2X MEAN BG ²	TAP WATER RBC ³	MCL/TT ACTION LEVEL ⁴	
Inorganic Elements (UG/L)									
CADMIUM	694GW00302	K694GW003	7/17/1997	5.60E-01	J	4.00E-01	0.00E+00	6.90E+00	5.00E+00
	694GW00401b	K694GW004	5/15/1997	2.10E+00	J	4.00E-01	0.00E+00	6.90E+00	5.00E+00
	694GW00601b	K694GW006	5/15/1997	5.90E+00		4.00E-01	0.00E+00	6.90E+00	5.00E+00
	694GW00801	K694GW008	12/10/1999	8.10E-01	J	4.00E-01	0.00E+00	6.90E+00	5.00E+00
	694GW009F3	K694GW009	4/19/2002	8.00E-01	U	4.00E-01	0.00E+00	6.90E+00	5.00E+00
	694GW00903	K694GW009	4/19/2002	8.00E-01	U	4.00E-01	0.00E+00	6.90E+00	5.00E+00
	694GW013F3	K694GW013	4/22/2002	8.00E-01	U	4.00E-01	0.00E+00	6.90E+00	5.00E+00
	694GW01303	K694GW013	4/22/2002	8.00E-01	U	4.00E-01	0.00E+00	6.90E+00	5.00E+00
	694GW015F1	K694GW015	4/19/2002	8.00E-01	U	4.00E-01	0.00E+00	6.90E+00	5.00E+00
	694GW01501	K694GW015	4/19/2002	8.00E-01	U	4.00E-01	0.00E+00	6.90E+00	5.00E+00
	694GW016F1	K694GW016	4/19/2002	8.00E-01	U	4.00E-01	0.00E+00	6.90E+00	5.00E+00
694GW01601	K694GW016	4/19/2002	8.00E-01	U	4.00E-01	0.00E+00	6.90E+00	5.00E+00	
COBALT	694GW00202	K694GW002	7/17/1997	1.89E+01	J	NA	NA	4.70E+00	NA
	694GW00403	K694GW004	1/12/1998	3.20E+00		NA	NA	4.70E+00	NA
	694GW00404	K694GW004	3/17/1998	2.50E+00	J	NA	NA	4.70E+00	NA
	694GW00801	K694GW008	12/10/1999	4.40E+00	J	NA	NA	4.70E+00	NA
	694GW01401	K694GW014	12/10/1999	5.80E-01	J	NA	NA	4.70E+00	NA
IRON	694GW00201	K694GW002	5/16/1997	2.48E+04	J	2.35E+02	9.17E+03	1.10E+04	NA
	694GW00202	K694GW002	7/17/1997	2.52E+04		2.35E+02	9.17E+03	1.10E+04	NA
	694GW00203	K694GW002	12/17/1997	2.01E+04	J	2.35E+02	9.17E+03	1.10E+04	NA
	694GW00204	K694GW002	3/16/1998	1.98E+04		2.35E+02	9.17E+03	1.10E+04	NA
	694GW00301	K694GW003	5/16/1997	1.11E+04	J	2.35E+02	9.17E+03	1.10E+04	NA
	694GW00302	K694GW003	7/17/1997	1.04E+04		2.35E+02	9.17E+03	1.10E+04	NA
	694GW00303	K694GW003	12/17/1997	8.16E+03	J	2.35E+02	9.17E+03	1.10E+04	NA
	694GW00304	K694GW003	3/17/1998	1.12E+04		2.35E+02	9.17E+03	1.10E+04	NA
	694GW00401b	K694GW004	5/15/1997	7.22E+02	J	2.35E+02	9.17E+03	1.10E+04	NA
	694GW00402	K694GW004	7/21/1997	2.66E+02		2.35E+02	9.17E+03	1.10E+04	NA
	694GW00501b	K694GW005	5/15/1997	1.72E+03	J	2.35E+02	9.17E+03	1.10E+04	NA
	694GW00502	K694GW005	7/17/1997	2.84E+03		2.35E+02	9.17E+03	1.10E+04	NA
	694GW00503	K694GW005	12/18/1997	2.07E+03	J	2.35E+02	9.17E+03	1.10E+04	NA
	694GW00504	K694GW005	3/19/1998	1.47E+03		2.35E+02	9.17E+03	1.10E+04	NA
	694GW00601b	K694GW006	5/15/1997	3.18E+03	J	2.35E+02	9.17E+03	1.10E+04	NA
	694GW00602b	K694GW006	7/18/1997	5.24E+03		2.35E+02	9.17E+03	1.10E+04	NA
	694GW00603	K694GW006	12/19/1997	3.36E+03	J	2.35E+02	9.17E+03	1.10E+04	NA
	694GW00604	K694GW006	3/19/1998	1.99E+03		2.35E+02	9.17E+03	1.10E+04	NA
	694GW00701c	K694GW007	5/14/1997	3.63E+03	J	2.35E+02	9.17E+03	1.10E+04	NA
	694GW00702	K694GW007	7/17/1997	5.40E+03		2.35E+02	9.17E+03	1.10E+04	NA
	694GW00703	K694GW007	12/18/1997	3.18E+03	J	2.35E+02	9.17E+03	1.10E+04	NA
694GW00704	K694GW007	3/18/1998	3.52E+03		2.35E+02	9.17E+03	1.10E+04	NA	
694GW00801	K694GW008	12/10/1999	2.66E+03		2.35E+02	9.17E+03	1.10E+04	NA	
694GW00802	K694GW008	1/13/2000	8.04E+02		2.35E+02	9.17E+03	1.10E+04	NA	

TABLE 2-6

HISTORICAL EXCEEDANCES OF INORGANICS IN GROUNDWATER
AOCs 693 and 694
CHARLESTON NAVAL COMPLEX, NORTH CHARLESTON, SOUTH CAROLINA
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Parameter	Sample ID	Sample Location	Sample Date	Concentration	RFI 2X MEAN BG ¹	2001 2X MEAN BG ²	TAP WATER RBC ³	MCL/TT ACTION LEVEL ⁴	
Inorganic Elements (UG/L)									
	694GW00901	K694GW009	12/10/1999	1.57E+04		2.35E+02	9.17E+03	1.10E+04	NA
	694GW00902	K694GW009	1/13/2000	1.90E+04		2.35E+02	9.17E+03	1.10E+04	NA
	694GW00903	K694GW009	4/19/2002	2.32E+04		2.35E+02	9.17E+03	1.10E+04	NA
	694GW009F3	K694GW009	4/19/2002	2.28E+04		2.35E+02	9.17E+03	1.10E+04	NA
	694GW01101	K694GW011	12/10/1999	1.27E+04		2.35E+02	9.17E+03	1.10E+04	NA
	694GW01102	K694GW011	1/13/2000	1.16E+04		2.35E+02	9.17E+03	1.10E+04	NA
	694GW01201	K694GW012	12/10/1999	2.31E+03		2.35E+02	9.17E+03	1.10E+04	NA
	694GW01202	K694GW012	1/13/2000	1.25E+03		2.35E+02	9.17E+03	1.10E+04	NA
	694GW01301	K694GW013	12/10/1999	9.23E+03		2.35E+02	9.17E+03	1.10E+04	NA
	694GW01302	K694GW013	1/13/2000	8.72E+03		2.35E+02	9.17E+03	1.10E+04	NA
	694GW01303	K694GW013	4/22/2002	1.52E+03		2.35E+02	9.17E+03	1.10E+04	NA
	694GW013F3	K694GW013	4/22/2002	1.36E+03		2.35E+02	9.17E+03	1.10E+04	NA
	694GW01401	K694GW014	12/10/1999	5.73E+03		2.35E+02	9.17E+03	1.10E+04	NA
	694GW01402	K694GW014	1/13/2000	9.94E+03		2.35E+02	9.17E+03	1.10E+04	NA
	694GW01501	K694GW015	4/19/2002	1.73E+03		2.35E+02	9.17E+03	1.10E+04	NA
	694GW015F1	K694GW015	4/19/2002	6.94E+02		2.35E+02	9.17E+03	1.10E+04	NA
	694GW01601	K694GW016	4/19/2002	1.56E+03		2.35E+02	9.17E+03	1.10E+04	NA
	694GW016F1	K694GW016	4/19/2002	5.21E+02		2.35E+02	9.17E+03	1.10E+04	NA
MANGANESE	694GW00201	K694GW002	5/16/1997	2.60E+03	J	1.21E+01	1.21E+03	3.20E+02	NA
	694GW00202	K694GW002	7/17/1997	2.67E+03		1.21E+01	1.21E+03	3.20E+02	NA
	694GW00203	K694GW002	12/17/1997	2.02E+03	J	1.21E+01	1.21E+03	3.20E+02	NA
	694GW00204	K694GW002	3/16/1998	1.83E+03		1.21E+01	1.21E+03	3.20E+02	NA
	694GW00301	K694GW003	5/16/1997	1.57E+03	J	1.21E+01	1.21E+03	3.20E+02	NA
	694GW00302	K694GW003	7/17/1997	1.28E+03		1.21E+01	1.21E+03	3.20E+02	NA
	694GW00303	K694GW003	12/17/1997	1.28E+03	J	1.21E+01	1.21E+03	3.20E+02	NA
	694GW00304	K694GW003	3/17/1998	1.35E+03		1.21E+01	1.21E+03	3.20E+02	NA
	694GW00401b	K694GW004	5/15/1997	7.59E+01	J	1.21E+01	1.21E+03	3.20E+02	NA
	694GW00402	K694GW004	7/21/1997	8.73E+02		1.21E+01	1.21E+03	3.20E+02	NA
	694GW00403	K694GW004	1/12/1998	1.25E+03		1.21E+01	1.21E+03	3.20E+02	NA
	694GW00404	K694GW004	3/17/1998	1.20E+03		1.21E+01	1.21E+03	3.20E+02	NA
	694GW00501b	K694GW005	5/15/1997	2.54E+02	J	1.21E+01	1.21E+03	3.20E+02	NA
	694GW00502	K694GW005	7/17/1997	2.70E+02		1.21E+01	1.21E+03	3.20E+02	NA
	694GW00503	K694GW005	12/18/1997	3.07E+02	J	1.21E+01	1.21E+03	3.20E+02	NA
	694GW00504	K694GW005	3/19/1998	2.18E+02		1.21E+01	1.21E+03	3.20E+02	NA
	694GW00601b	K694GW006	5/15/1997	1.61E+03	J	1.21E+01	1.21E+03	3.20E+02	NA
	694GW00602b	K694GW006	7/18/1997	1.66E+03		1.21E+01	1.21E+03	3.20E+02	NA
	694GW00603	K694GW006	12/19/1997	1.36E+03	J	1.21E+01	1.21E+03	3.20E+02	NA
	694GW00604	K694GW006	3/19/1998	9.36E+02		1.21E+01	1.21E+03	3.20E+02	NA
694GW00701c	K694GW007	5/14/1997	1.32E+03	J	1.21E+01	1.21E+03	3.20E+02	NA	
694GW00702	K694GW007	7/17/1997	1.46E+03		1.21E+01	1.21E+03	3.20E+02	NA	

TABLE 2-6

HISTORICAL EXCEEDANCES OF INORGANICS IN GROUNDWATER
AOCs 693 and 694
CHARLESTON NAVAL COMPLEX, NORTH CHARLESTON, SOUTH CAROLINA
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Parameter	Sample ID	Sample Location	Sample Date	Concentration	RFI 2X MEAN BG ¹	2001 2X MEAN BG ²	TAP WATER RBC ³	MCL/TT ACTION LEVEL ⁴	
Inorganic Elements (UG/L)									
	694GW00703	K694GW007	12/18/1997	9.48E+02	J	1.21E+01	1.21E+03	3.20E+02	NA
	694GW00704	K694GW007	3/18/1998	1.09E+03		1.21E+01	1.21E+03	3.20E+02	NA
	694GW00801	K694GW008	12/10/1999	5.18E+02		1.21E+01	1.21E+03	3.20E+02	NA
	694GW00802	K694GW008	1/13/2000	1.18E+02		1.21E+01	1.21E+03	3.20E+02	NA
	694GW00901	K694GW009	12/10/1999	3.57E+03		1.21E+01	1.21E+03	3.20E+02	NA
	694GW00902	K694GW009	1/13/2000	2.98E+03		1.21E+01	1.21E+03	3.20E+02	NA
	694GW009F3	K694GW009	4/19/2002	4.00E+03	J	1.21E+01	1.21E+03	3.20E+02	NA
	694GW00903	K694GW009	4/19/2002	4.02E+03	J	1.21E+01	1.21E+03	3.20E+02	NA
	694GW01101	K694GW011	12/10/1999	2.01E+03		1.21E+01	1.21E+03	3.20E+02	NA
	694GW01102	K694GW011	1/13/2000	1.70E+03		1.21E+01	1.21E+03	3.20E+02	NA
	694GW01201	K694GW012	12/10/1999	1.84E+03		1.21E+01	1.21E+03	3.20E+02	NA
	694GW01202	K694GW012	1/13/2000	1.42E+03		1.21E+01	1.21E+03	3.20E+02	NA
	694GW01301	K694GW013	12/10/1999	1.46E+03		1.21E+01	1.21E+03	3.20E+02	NA
	694GW01302	K694GW013	1/13/2000	1.16E+03		1.21E+01	1.21E+03	3.20E+02	NA
	694GW013F3	K694GW013	4/22/2002	5.73E+02	J	1.21E+01	1.21E+03	3.20E+02	NA
	694GW01303	K694GW013	4/22/2002	5.36E+02	J	1.21E+01	1.21E+03	3.20E+02	NA
	694GW01401	K694GW014	12/10/1999	1.80E+03		1.21E+01	1.21E+03	3.20E+02	NA
	694GW01402	K694GW014	1/13/2000	1.29E+03		1.21E+01	1.21E+03	3.20E+02	NA
	694GW015F1	K694GW015	4/19/2002	9.24E+02	J	1.21E+01	1.21E+03	3.20E+02	NA
	694GW01501	K694GW015	4/19/2002	8.34E+02	J	1.21E+01	1.21E+03	3.20E+02	NA
694GW016F1	K694GW016	4/19/2002	2.17E+02	J	1.21E+01	1.21E+03	3.20E+02	NA	
694GW01601	K694GW016	4/19/2002	2.31E+02	J	1.21E+01	1.21E+03	3.20E+02	NA	
MERCURY	694GW00202	K694GW002	7/17/1997	1.60E+00		NA	NA	6.30E-01	2.00E+00
	694GW00304	K694GW003	3/17/1998	7.60E+00	J	NA	NA	6.30E-01	2.00E+00
	694GW01102	K694GW011	1/13/2000	2.00E-01	J	NA	NA	6.30E-01	2.00E+00
	694GW01201	K694GW012	12/10/1999	1.20E-01	J	NA	NA	6.30E-01	2.00E+00
	694GW01202	K694GW012	1/13/2000	1.10E-01	J	NA	NA	6.30E-01	2.00E+00
THALLIUM	694GW00903	K694GW009	4/19/2002	9.90E+00	J	NA	NA	1.60E-01	2.00E+00
	694GW009F3	K694GW009	4/19/2002	9.20E+00	J	NA	NA	1.60E-01	2.00E+00
	694GW01303	K694GW013	4/22/2002	4.80E+00	U	NA	NA	1.60E-01	2.00E+00
	694GW013F3	K694GW013	4/22/2002	5.30E+00	J	NA	NA	1.60E-01	2.00E+00
	694GW01501	K694GW015	4/19/2002	4.90E+00	J	NA	NA	1.60E-01	2.00E+00
	694GW015F1	K694GW015	4/19/2002	4.80E+00	U	NA	NA	1.60E-01	2.00E+00
	694GW01601	K694GW016	4/19/2002	7.00E+00	J	NA	NA	1.60E-01	2.00E+00
694GW016F1	K694GW016	4/19/2002	7.50E+00	J	NA	NA	1.60E-01	2.00E+00	

1 Site-specific background concentrations developed and presented in the Final Zone K RFI Report, Charleston Naval Complex. June 1999. (EnSafe, 1999).

2 Site-specific background concentrations developed and presented in the Technical Memorandum: A Summary of Inorganic Chemical Concentrations in Background Soil and Groundwater at the CNC, CH2M Hill, 2001.

3 Risk Based Concentration (RBC) - USEPA Tapwater Screening Level, USEPA Regional Screening Levels Table, May 2013.

4 Maximum Contaminant Level (MCL) -USEPA Maximum Contaminant Levels, USEPA Regional Screening Levels Table, May 2013.

Shading indicates that the detected concentration exceeds 2001 2X mean background and one or more screening criteria.

TT - Treatment Technique

UG/L - microgram per liter

TABLE 2-7

SUMMARY OF RISKS
 AOCS 693 and 694
 CHARLESTON NAVAL COMPLEX, NORTH CHARLESTON, SOUTH CAROLINA
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Receptor	Media	Chemical of Potential Concern	ILCR			HIs		
			Inhalation	Ingestion	Dermal	Inhalation	Ingestion	Dermal
Child Residents	Surface Soil	Aluminum	--	--	--	2.00E-02	0.30	0.04
		Antimony	--	--	--	--	0.10	0.01
		Chromium	--	--	--	--	0.001	3.00E-03
		Copper	--	--	--	--	0.03	0.002
		Iron	--	--	--	--	1.00	0.1
		Lead	--	--	--	--	--	--
		Manganese	--	--	--	2.00E-02	0.10	0.05
		Vandadium	--	--	--	--	0.10	0.1
		BEQs	--	--	--	--	--	--
		Chemical Total	--	--	--	4.E-02	1.63	3.E-01
	Medium Total				--			2.E+00
	Groundwater	Arsenic	--	--	--	--	6.99	--
		Cadmium	--	--	--	--	0.54	--
		Chromium	--	--	--	--	0.18	--
		Iron	--	--	--	--	1.67	--
		Manganese	--	--	--	--	3.65	--
		Mercury	--	--	--	--	0.33	--
		Silver	--	--	--	--	0.13	--
		Thallium	--	--	--	--	6.65	--
	Chemical Total	--	--	--	--	20	--	
Medium Total				--			20	
Receptor Total				--			22	

TABLE 2-7

SUMMARY OF RISKS
 AOCS 693 and 694
 CHARLESTON NAVAL COMPLEX, NORTH CHARLESTON, SOUTH CAROLINA
 PAGE 2 OF 3

Receptor	Media	Chemical of Potential Concern	ILCR			HIs		
			Inhalation	Ingestion	Dermal	Inhalation	Ingestion	Dermal
Adult Residents	Surface Soil	Aluminum	--	--	--	0.005	0.03	0.01
		Antimony	--	--	--	--	0.02	0.003
		Chromium	--	--	--	--	0.0001	0.0009
		Copper	--	--	--	--	0.004	0.0005
		Iron	--	--	--	--	0.1	0.03
		Lead	--	--	--	--	--	--
		Manganese	--	--	--	0.007	0.01	0.01
		Vandadium	--	--	--	--	0.01	0.04
		BEQs	--	--	--	--	--	--
		Chemical Total	--	--	--	0.012	0.2	0.09
	Medium Total				--			0.3
	Groundwater	Arsenic	--	--	--	--	3	--
		Cadmium	--	--	--	--	0.2	--
		Chromium	--	--	--	--	0.08	--
		Iron	--	--	--	--	0.7	--
		Manganese	--	--	--	--	2	--
		Mercury	--	--	--	--	0.1	--
		Silver	--	--	--	--	0.05	--
		Thallium	--	--	--	--	3	--
	Chemical Total	--	--	--	--	9	--	
Medium Total				--			17	
Receptor Total				--			18	

TABLE 2-7

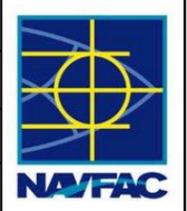
SUMMARY OF RISKS
 AOCS 693 and 694
 CHARLESTON NAVAL COMPLEX, NORTH CHARLESTON, SOUTH CAROLINA
 PAGE 3 OF 3

Receptor	Media	Chemical of Potential Concern	ILCR			HIs		
			Inhalation	Ingestion	Dermal	Inhalation	Ingestion	Dermal
Residential Lifetime Weighted Average	Surface Soil	Aluminum	--	--	--	--	--	--
		Antimony	--	--	--	--	--	--
		Chromium	--	--	--	--	--	--
		Copper	--	--	--	--	--	--
		Iron	--	--	--	--	--	--
		Lead	--	--	--	--	--	--
		Manganese	--	--	--	--	--	--
		Vandadium	--	--	--	--	--	--
		BEQs	1.00E-08	6.00E-06	4.E-06	--	--	--
		Chemical Total	1.00E-08	6.00E-06	4.E-06	--	--	--
	Medium Total				1.E-05			--
	Groundwater	Arsenic	--	8.E-04	--	--	--	--
		Cadmium	--	--	--	--	--	--
		Chromium	--	--	--	--	--	--
		Iron	--	--	--	--	--	--
		Manganese	--	--	--	--	--	--
		Mercury	--	--	--	--	--	--
		Silver	--	--	--	--	--	--
		Thallium	--	--	--	--	--	--
Chemical Total	--	8.E-04	--	--	--	--		
Medium Total				8.E-04			--	
Receptor Total				8.E-04			--	
Industrial Worker	Groundwater	Arsenic	2.E-04	--	--	--	1.11	--
		Cadmium	--	--	--	--	0.09	--
		Chromium	--	--	--	--	0.03	--
		Iron	--	--	--	--	0.27	--
		Manganese	--	--	--	--	0.58	--
		Mercury	--	--	--	--	0.05	--
		Silver	--	--	--	--	0.02	--
		Thallium	--	--	--	--	1.06	--
	Chemical Total	2.E-04	--	--	--	--	--	
Medium Total				2.E-04			3	
Receptor Total				2.E-04			3	



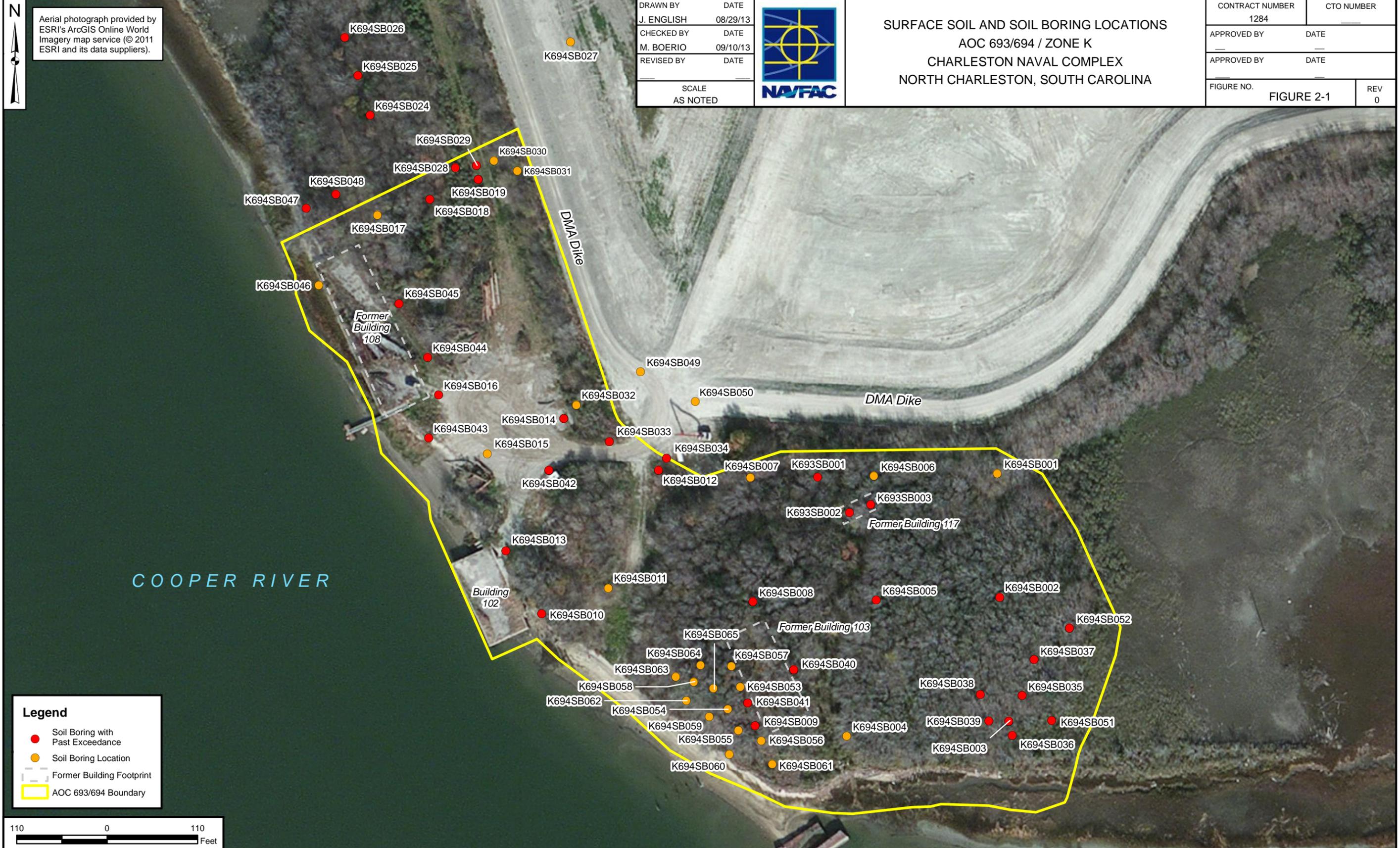
Aerial photograph provided by ESRI's ArcGIS Online World Imagery map service (© 2011 ESRI and its data suppliers).

DRAWN BY J. ENGLISH	DATE 08/29/13
CHECKED BY M. BOERIO	DATE 09/10/13
REVISOR BY	DATE
SCALE AS NOTED	



SURFACE SOIL AND SOIL BORING LOCATIONS
AOC 693/694 / ZONE K
CHARLESTON NAVAL COMPLEX
NORTH CHARLESTON, SOUTH CAROLINA

CONTRACT NUMBER 1284	CTO NUMBER
APPROVED BY	DATE
APPROVED BY	DATE
FIGURE NO. FIGURE 2-1	REV 0



Legend

- Soil Boring with Past Exceedance
- Soil Boring Location
- - - Former Building Footprint
- ▭ AOC 693/694 Boundary





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DRAWN BY	DATE
J. ENGLISH	08/29/13
CHECKED BY	DATE
M. BOERIO	09/11/13
REVISED BY	DATE
SCALE	AS NOTED



GROUNDWATER SAMPLE LOCATIONS
AOC 693/694 / ZONE K
CHARLESTON NAVAL COMPLEX
NORTH CHARLESTON, SOUTH CAROLINA

CONTRACT NUMBER	CTO NUMBER
1284	
APPROVED BY	DATE
APPROVED BY	DATE
FIGURE NO.	REV
FIGURE 2-2	0



Legend

- Monitoring Well with Past Exceedance
- Monitoring Well
- - - Former Building Footprint
- ▭ AOC 693/694 Boundary



3.0 DEVELOPMENT OF CORRECTIVE MEASURES OBJECTIVES

3.1 INTRODUCTION

The purpose of this section is to develop CMOs and identify MCSs for soil and groundwater at AOCs 693/694. The CMOs are based on risk assessment and compliance with risk-based MCSs.

3.2 CORRECTIVE MEASURES OBJECTIVES AND MEDIA CLEANUP STANDARDS

CMOs are developed in this section to address the contaminants in soil and groundwater at AOCs 693/694. CMOs generally identify COCs, receptors, pathways, and MCSs. Medium-specific CMOs and corresponding cleanup levels are presented in the following sections.

3.2.1 Corrective Measures Objectives

The CMOs for soil and groundwater at AOCs 693/694 are as follows:

1. Prevent unacceptable risks to current human exposure (onsite worker) to contaminants in surface soil at AOCs 693/694.
2. Prevent unacceptable risks to potential future human exposure (hypothetical adult and adolescent residents) to contaminants in surface soil and groundwater at AOCs 693/694.
3. Attain MCSs, to the extent possible.

3.2.2 Media Cleanup Standards for Soil

The soil cleanup levels were determined based on concentrations that present unacceptable human health risks through direct contact exposure and incidental ingestion. The following paragraphs identify the soil cleanup standards to which site concentrations must be reduced to prevent unacceptable direct contact or ingestion risk.

Preliminary cleanup levels were determined for direct contact exposures to soil where the total ILCRs were greater than the middle range of the USEPA acceptable risk range of 1E-04 to 1E-06 and/or total HIs were greater than 1.

For AOCs 693/694 during the Zone K RFI, arsenic was the primary contributor to ILCR projections and BEQs were secondary for the residential scenario. Aluminum and arsenic were primary contributors to

hazard estimates exceeding unity and secondary contributors were antimony, chromium, copper, and vanadium in the residential scenario. Arsenic and BEQs were identified for the industrial surface soil pathway. The ILCR for site workers exposed to arsenic in surface soil range from 1E-07 to 1E-05, which is less than or within USEPA's acceptable range of 1E-06 and 1E-04. Hazard estimates ranged from 0.00001 to 0.06. The ILCR for BEQs was 1E-06, the maximum detected concentration of BEQs was less than its industrial risk-based concentration, and so BEQs were considered to be borderline COCs for the industrial scenario (EnSafe, 1999).

During the Clouter Island RFI Report Addendum, additional soil and groundwater samples were collected to address data gaps. Aluminum, antimony, manganese, vanadium, and BEQs were identified as COCs in the upper soil interval. Because the 1999 risk assessment did not identify unacceptable site worker risks or hazards due to soil exposure, the future site worker exposed to soil was not addressed in the 2002 evaluation. The cumulative soil pathway residential exposure ILCR risk was 1E-05. This risk estimate is less than 1E-04, which is the upper bound of USEPA's risk range. For the residential scenario, the HI for soil was 2 for the child, with iron contributing 82 percent of the total risk. However, the iron intake from incidental ingestion would be less than the recommended daily intake from an iron supplement. The HI for the adult resident was 0.3 (EnSafe, 2002).

No cleanup levels were developed for ecological and human exposure because of the negligible risk to receptors.

3.2.3 Media Cleanup Standards for Groundwater

During the Zone K RFI, arsenic was the sole contributor to ILCR projections for both the residential and industrial scenarios. Arsenic, cadmium, and manganese were contributors to hazard projections for both scenarios (EnSafe, 1999).

During the Clouter Island RFI Report Addendum, the projected ILCR for the future residential groundwater ingestion pathway was 8E-04 and the estimated risk for the future worker groundwater ingestion pathway was 2E-04. Both risk values exceed USEPA's acceptable range of 1E-06 to 1E-04. Arsenic was the sole contributor to the ILCR values for both the residential and worker groundwater pathways (EnSafe, 2002).

The HI for the adult resident was 9, and the HI for the child resident was 20. Arsenic, iron, manganese, and thallium were primary contributors to the projected HIs for the groundwater ingestion pathway. Cadmium, chromium, mercury, and silver were secondary contributors. The HI for the future worker for the groundwater pathway was 3; arsenic and thallium were primary contributors to the HI.

3.2.4 Remedial Goal Options

In accordance with USEPA Region 4 guidance, Remedial Goal Options (RGOs) were developed for those exposures with ILCRs greater than 1E-04 and total HIs greater than 1.0. RGOs were derived for the COCs that contribute significantly to the cancer risk and/or HI for each exposure pathway in a land use scenario for a receptor group. Chemicals were not considered significant contributors to risk and therefore were not included as COCs if their individual carcinogenic risk contribution was less than 1E-06 or their non-carcinogenic Hazard Quotient (HQ) was less than 0.1. HIs for children and adults exposed to arsenic in groundwater exceeded the acceptable level of 1, and ILCRs for site worker and adult residents exposed to arsenic in groundwater exceeded USEPA's target risk range of 1E-04 to 1E-06. In addition to arsenic, cadmium, chromium, iron, manganese, mercury, silver, and thallium were also contributors to the HQ. Consequently, RGOs were developed for these receptors and chemicals. RGOs for AOCs 693/694 were developed according to guidance provided in the Region 4 Human Health Risk Assessment Bulletins, and calculated using the following equation:

$$\text{RGO}[\text{chemical } i] = \text{EPC}[\text{chemical } i] \times \text{Target Risk} / \text{Calculated Risk}[\text{chemical } i]$$

Where:

- RGO [chemical i] = chemical specific RGO
- EPC [chemical i] = exposure point concentration (EPC) for chemical i
- Target Risk = target ILCR for carcinogens or target HQ for non-carcinogens
- Calculated Risk [chemical i] = total risk calculated for a chemical i

In accordance with Region 4 guidance, the target cancer risks used were 1E-06 , 1E-05, and 1E-04, and the target HQs were 0.1, 1, and 3 (EnSafe, 2002). The chemical-specific RGOs for groundwater are presented in Table 3-1.

TABLE 3-1

REMEDIAL GOAL OPTIONS
AOCS 693/694 - FUSE AND PRIMER HOUSE, FORMER BUILDING 117 AND FORMER NAVAL AMMUNITION DEPOT
CHARLESTON NAVAL COMPLEX, NORTH CHARLESTON, SOUTH CAROLINA

Residential Land Use										
Media	Chemical	EPC	Estimated Cancer Risk	Estimated Hazard Index Risk	Remedial Goal Options (µg/L)					
					Target Cancer Risk Level			Target Hazard Index		
					1.0E-06	1.0E-05	1.0E-04	0.1	1	3
Groundwater	Arsenic	3.3E-02	8.0E-07	6.99	4.0E-05	4.0E-05	4.0E-03	5.0E-04	5.0E-03	1.0E-02
	Cadmium	4.2E-03	NA	0.54	NA	NA	NA	8.0E-04	8.0E-03	2.0E-02
	Chromium	8.4E-03	NA	0.18	NA	NA	NA	5.0E-03	5.0E-02	1.0E-01
	Iron	7.8E+00	NA	1.67	NA	NA	NA	5.0E-01	5.0E+00	1.0E+01
	Manganese	1.4E+00	NA	3.65	NA	NA	NA	4.0E-02	4.0E-01	1.0E+00
	Mercury	1.6E-03	NA	0.33	NA	NA	NA	5.0E-04	5.0E-03	1.0E-02
	Silver	9.9E-03	NA	0.13	NA	NA	NA	8.0E-03	8.0E-02	2.0E-01
Thallium	7.3E-03	NA	6.65	NA	NA	NA	1.0E-04	1.0E-03	3.0E-03	
Soil	Aluminum	2.3E+04	NA	0.2872	NA	NA	NA	8.0E+03	8.0E+04	2.0E+05
	Antimony	4.4E+00	NA	0.1412	NA	NA	NA	3.0E+00	3.0E+01	9.0E+01
	Manganese	4.6E+02	NA	0.1251	NA	NA	NA	4.0E+02	4.0E+03	1.0E+04
	Vanadium	5.3E+01	NA	0.1389	NA	NA	NA	4.0E+01	4.0E+02	1.0E+03
	BEQs	4.8E-01	1.0E-08	NA	5.0E-02	5.0E-01	5.0E+00	NA	NA	NA
Industrial Land Use										
Media	Chemical	EPC	Estimated Cancer Risk	Estimated Hazard Index Risk	Remedial Goal Options (µg/L)					
					Target Cancer Risk Level			Target Hazard Index		
					1.0E-06	1.0E-05	1.0E-04	0.1	1	3
Groundwater	Arsenic	3.3E-02	2.0E-04	3.0E+00	2.0E-04	2.0E-03	2.0E-02	1.1E-03	1.0E-02	3.3E-02
	Cadmium	4.2E-03	NA	2.3E-01	NA	NA	NA	1.8E-03	1.8E-02	5.5E-02
	Iron	7.8E+00	NA	7.1E-01	NA	NA	NA	1.1E+00	1.1E+01	3.3E+01
	Manganese	1.4E+00	NA	1.6E+00	NA	NA	NA	8.8E-02	8.8E-01	2.6E+00
	Mercury	1.6E-03	NA	1.4E-01	NA	NA	NA	1.1E-03	1.1E-02	3.3E-02
	Thallium	7.3E-03	NA	2.9E+00	NA	NA	NA	2.6E-04	2.6E-03	7.7E-03

Notes:

EPC= exposure point concentration

mg/L= milligram per liter

NA= not applicable

4.0 IDENTIFICATION AND SCREENING OF CORRECTIVE MEASURES TECHNOLOGIES

4.1 INTRODUCTION

This section presents the identification and screening of remedial alternatives formulated to achieve the CMOs for AOCs 693/694.

4.2 IDENTIFICATION AND SCREENING OF CORRECTIVE MEASURES TECHNOLOGIES AND PROCESS OPTIONS FOR SOIL

This section identifies and screens technologies and process options for soil at a preliminary stage based on implementation with respect to site conditions. Table 4-1 summarizes the preliminary screening of technologies and process options applicable to AOCs 693/694 soil. Technologies and process options are grouped according to General Response Actions (GRAs). Alternatives are then formulated by combining the GRAs to address the CMOs. The technologies evaluated under each GRA are evaluated as primary or secondary technologies. Primary technologies consist of the main technology to be implemented during the remedial action, such as covering. Secondary technologies are those technologies that are an integral part of a primary technology, such as land use controls (LUCs). The GRA categories include the following:

- No Action
- Limited Action
- Containment
- Removal
- Ex-Situ Treatment
- In-Situ Treatment

The evaluation criteria used for detailed screening of technologies and process options that have been retained after the preliminary screening are effectiveness, implementability, and cost. The following are descriptions of the evaluation criteria:

- Effectiveness
 - Protection of human health and environment; reduction in toxicity, mobility, and volume; and permanence of solution.
 - Ability of the technology to address the estimated areas or volumes of contaminated media.

- Ability of the technology to meet the remediation goals identified in the CMOs.
- Technical reliability (innovative versus well-proven) with respect to contaminants and site conditions.

- Implementability
 - Overall technical feasibility at the site.
 - Availability of vendors, mobile units, storage and disposal services, etc.
 - Administrative feasibility.
 - Special long-term maintenance and operation requirements.

- Cost (Qualitative)
 - Capital cost.
 - Operation and maintenance (O&M) costs.

The items listed above may not apply directly to each technology and, therefore, will be addressed only as appropriate. Screening evaluations at this stage generally focus on effectiveness and implementability, with less emphasis on cost evaluations. Technologies that would be precluded by waste characteristics and inapplicability based on AOCs 693/694 conditions are screened and eliminated from further consideration. Each technology presented in this section is not necessarily intended to be implemented alone and may be combined with other technologies into remedial alternatives.

The following are the technologies and process options that were retained for detailed screening.

General Response Action	Remedial Technology	Process Options (Primary/Secondary)
No Action	None	None
Limited Action	Use Restrictions	LUCs (primary)

The process options presented above for use at AOCs 693/694 are evaluated in the following sections. The “No Action” option is used as a baseline for comparison with other corrective action alternatives; therefore, it has been retained but is not evaluated further because there are insignificant costs associated with it and because no action is implementable by definition.

Limited Action

This action would consist of formulating and implementing LUCs to require the property owner to follow the CNC dig permit process for construction activities when disturbing soil within the limits of AOCs 693/694. This would ensure the property owner is notified of the potential for encountering contaminated dredge spoils and/or munitions.

Effectiveness

LUCs are effective in restricting the type of activities that can be performed in the future at identified areas. However, the effectiveness of LUCs is dependent on the system utilized to communicate the locations and restrictions associated with LUCs. The property was transferred from the Navy property inventory to the USACE property inventory in 1996 for continued use as a dredge spoils area. There was no deed involved in this transfer, thus no deed restrictions. Should the USACE transfer the property by deed to a non-Federal entity, particularly for a use(s) other than dredge spoil disposal, the transfer deed should include a requirement that the new owner follow the CNC dig permit process for construction activities when working within the limits of AOCs 693/694, a notification that the area was previously a munitions storage area, and a requirement for inspections to ensure compliance with and long-term effectiveness of LUCs. Currently, there is no reason to anticipate transfer of the AOCs 693/694 area to the public (i.e., AOCs 693/694 will be owned by the USACE in the near and extended future).

Implementability

Federal facilities typically ensure the long-term effectiveness of LUCs by making use of LUC implementation plans. The Navy could develop and implement LUCs to specify activities or controls necessary to limit the potential for encountering contaminated dredge spoils and/or munitions at AOCs 693/694.

Cost

Costs of preparing LUC implementation plans and implementing LUCs would be relatively low.

Conclusion

LUCs are retained as a primary technology for the development of corrective measures alternatives.

4.3 IDENTIFICATION AND SCREENING OF CORRECTIVE MEASURES TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER

This section identifies and screens technologies and process options for groundwater at a preliminary stage based on implementation with respect to site conditions and contamination. Table 4-2 summarizes the preliminary screening of technologies and process options applicable to groundwater. Technologies and process options are grouped according to GRAs. Alternatives are then formulated by combining the GRAs to address the CMOs. The technologies evaluated under each GRA are evaluated as primary or secondary technologies. Primary technologies consist of the main technology to be implemented during

the remedial action, such as in-situ chemical oxidation. Secondary technologies are those technologies that are an integral part of a primary technology, such as granular activated carbon to remove vapor contaminants from a vapor extraction system.

The evaluation criteria used for detailed screening of technologies and process options that have been retained after the preliminary screening are effectiveness, implementability, and cost. The following are descriptions of the evaluation criteria:

- Effectiveness
 - Protection of human health and environment.
 - Reduction in toxicity, mobility, and volume.
 - Permanence of solution.
 - Ability of the technology to address the estimated areas or volumes of contaminated media.
 - Ability of the technology to meet the remediation goals identified in the CMOs.
 - Technical reliability (innovative versus well proven) with respect to contaminants and site conditions.

- Implementability
 - Overall technical feasibility at the site.
 - Availability of vendors, mobile units, storage and disposal services, etc.
 - Administrative feasibility.
 - Special long-term maintenance and operation requirements.

- Cost (Qualitative)
 - Capital cost.
 - O&M costs.

The items listed above may not apply directly to each technology and, therefore, will be addressed only as appropriate. Screening evaluations at this stage generally focus on effectiveness and implementability, with less emphasis on cost evaluations. Technologies that would be precluded by waste characteristics and inapplicability under the given site conditions are screened and eliminated from further consideration. Each technology presented in this section is not necessarily intended to be implemented alone and may be combined with other technologies into remedial alternatives.

The categories of GRAs that are retained to be implemented, based on the screening summarized in Table 4-1, to achieve or address the CMOs include the following:

- No Action
- Limited Action

The following are the groundwater technologies and process options that were retained for detailed final screening.

General Response Action	Remedial Technology	Process Options
No Action	None	None
Limited Action	Use Restrictions	LUCs (primary)

Limited Action

LUCs would include a prohibition on the installation of wells to restrict the use of groundwater for drinking purposes, a requirement the property owner follow the CNC dig permit process for construction activities within the limits of AOCs 693/694, and a notification that the area was previously a munitions storage area. This would ensure the property owner is notified of the potential for encountering contaminated groundwater and/or munitions. The LUCs would also be incorporated into the CNC wide LUC program.

Effectiveness

LUCs alone would not reduce the toxicity, mobility, or volume of contaminants in groundwater. Contaminants would remain in groundwater although they may degrade through natural processes over time. Restrictions on site use would effectively prevent the occurrence of unacceptable risks to human receptors through direct exposure to contaminated groundwater. The property was transferred from the Navy property inventory to the USACE property inventory in 1996 for continued use as a dredge spoil area. There was no deed involved in this transfer, thus no deed restrictions. Should the USACE transfer the property by deed to a non-Federal entity, particularly for a use(s) other than dredge spoil disposal, the transfer deed should include a restriction prohibiting the installation of wells, a requirement that the new owner follow the CNC dig permit process for construction activities when working within the limits of AOCs 693/694, a notification that the area was previously a munitions storage area, and a requirement for inspections to ensure compliance with and long-term effectiveness of LUCs. Currently, there is no reason to anticipate transfer of the AOCs 693/694 area to the public (i.e., AOCs 693/694 will be owned by the USACE in the near and extended future).

Implementability

Federal facilities typically ensure the long-term effectiveness of LUCs by making use of LUC implementation plans. The Navy could develop and implement LUCs to specify activities or controls necessary to limit exposure to contaminants in groundwater at AOCs 693/694.

Cost

Costs of institutional controls would be low.

Conclusion

Institutional controls are retained as a primary process option or in combination with other process options for the development of remedial alternatives.

TABLE 4-1

**PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR SOIL
AOCS 693/694 - FUSE AND PRIMER HOUSE, FORMER BUILDING 117 AND FORMER NAVAL AMMUNITION DEPOT
CORRECTIVE MEASURES STUDY
CHARLESTON NAVAL COMPLEX, NORTH CHARLESTON, SOUTH CAROLINA
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General Response Action	Technology	Process Options	Description	Screening Comment
No Action	None	Not Applicable	No activities would be conducted at the site to address contamination.	Retain. No action is retained as a baseline for comparison with other technologies.
Limited Action	Monitoring	Soil Sampling	Periodic sampling and analysis to determine if contamination is spreading	Eliminate. Monitoring is eliminated because the current use as a dredge spoils area prevents monitoring the current surface soils due to heterogeneous backfill created from the spoils that would be continuously replaced around the site. The ability to evaluate the migration of contamination would be ineffective.
	Access/Use Restrictions	Land Use Controls	Land use controls include both physical and administrative controls. Physical controls include fencing and signage. Administrative controls include dig restriction and future use restrictions	Retain. Administrative Land use controls are retained to limit exposure to contaminated soil. Physical controls not needed as long as USACE continues its operations on the property.
Containment	Capping	Soil Cover or Asphalt Cover	Use of soil cover or asphalt cover to minimize exposure to contaminants and migration of contaminants.	Eliminate. Capping (soil or asphalt cover) is eliminated because the current use as a dredge spoils area and the heterogeneous backfill created from the spoils would be continuously replaced around the site which would prevent clean soil from covering areas and would be inefficient and ineffective.

TABLE 4-1

PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR SOIL
 AOCS 693/694 - FUSE AND PRIMER HOUSE, FORMER BUILDING 117 AND FORMER NAVAL AMMUNITION DEPOT
 CORRECTIVE MEASURES STUDY
 CHARLESTON NAVAL COMPLEX, NORTH CHARLESTON, SOUTH CAROLINA
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General Response Action	Technology	Process Options	Description	Screening Comment
Removal	Excavation	Excavation	Means for removal of waste and contaminated soil.	Eliminate. Excavation is eliminated based on the same basis as capping. Also, based on the results of previous investigations, the high detections of contaminants are not indicative of soil concentrations to which a receptor might be exposed such as a site worker because such receptors are more likely to traverse the site rather than remain at one location, these receptors would be exposed to an average concentration in soil. The contaminant level at AOCs 693/694 was below the industrial screening level.
In-Situ Treatment	Thermal	Vitrification/ Radiofrequency Heating	Use of high temperature to fuse inorganic contaminants into a glass matrix or the use of moderate temperature to volatilize contaminants and remove them from the vadose zone.	Eliminate. Vitrification is eliminated because this technology is not proven effective with the heterogeneous material found in AOCs 693/694. The cost is not justified based on the very low concentrations and very low risk.
	Physical/ Chemical	Soil Flushing	Use of water or solvents to remove contaminants from the vadose zone by leaching and collecting contaminated wastewater in the saturated zone followed by aboveground treatment.	Eliminate. Soil flushing is eliminated because of questionable effectiveness with heterogeneous material (tight clayey soils) found in AOCs 693/694 and the current use would render this treatment ineffective due to the continuous replacement of spoils in the area. The cost is not justified based on the very low concentrations and very low risk.

TABLE 4-1

PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR SOIL
 AOCs 693/694 - FUSE AND PRIMER HOUSE, FORMER BUILDING 117 AND FORMER NAVAL AMMUNITION DEPOT
 CORRECTIVE MEASURES STUDY
 CHARLESTON NAVAL COMPLEX, NORTH CHARLESTON, SOUTH CAROLINA
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General Response Action	Technology	Process Options	Description	Screening Comment
In-Situ Treatment (continued)	Physical/ Chemical	Soil Vapor Extraction	Use of a vacuum and possibly air sparging to volatilize and remove contaminants from the vadose zone.	Eliminate. Soil vapor extraction is eliminated due to the tight clayey soil types that would prevent adequate air circulation. The cost is not justified based on the very low concentrations and very low risk.
		Solidification	Use of pozzolanic materials in the vadose zone to chemically fix inorganics and solidify the matrix to reduce leachability.	Eliminate. Solidification is eliminated because of questionable effectiveness with the heterogeneous material found at AOCs 693/694. Also, the current and projected land use as a dredge spoil area would prevent the treatment from being effective.
Ex-Situ Treatment	Physical/ Chemical	Soil Washing/ Solvent Extraction	Use of water and solvents to remove contaminants from solid materials.	Eliminate. Soil washing/solvent extraction is eliminated because of questionable effectiveness with the heterogeneous material found at AOCs 693/694 and based on types of contaminants present. Also, the current and projected land use as a dredge spoil area would prevent the treatment from being effective. The cost is not justified based on the very low concentrations and very low risk.

TABLE 4-1

PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR SOIL
 AOCs 693/694 - FUSE AND PRIMER HOUSE, FORMER BUILDING 117 AND FORMER NAVAL AMMUNITION DEPOT
 CORRECTIVE MEASURES STUDY
 CHARLESTON NAVAL COMPLEX, NORTH CHARLESTON, SOUTH CAROLINA
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General Response Action	Technology	Process Options	Description	Screening Comment
Ex-Situ Treatment (continued)		Solidification	Use of pozzolanic materials to chemically fix inorganics and solidify the matrix to reduce leachability	Eliminate. Solidification is eliminated because of questionable effectiveness and implementation with heterogeneous material found in AOCs 693/694. Also, the current and projected land use as a dredge spoil area would prevent the treatment from being effective. The cost is not justified based on the very low concentrations and very low risk.
	Biological	Landfarming	Tilling of contaminated soil and waste in layers to remove volatile organic compounds and biodegrade organics.	Eliminate. Landfarming is eliminated because the type of soil at the site would make aerating the soil difficult. In addition, landfarming becomes a potential option with larger volumes of soil where costs for system enclosures are offset by large disposal costs. Also, the current and projected land use as a dredge spoil area would prevent the treatment from being effective. The cost is not justified based on the very low concentrations and very low risk.

TABLE 4-1

PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR SOIL
 AOCS 693/694 - FUSE AND PRIMER HOUSE, FORMER BUILDING 117 AND FORMER NAVAL AMMUNITION DEPOT
 CORRECTIVE MEASURES STUDY
 CHARLESTON NAVAL COMPLEX, NORTH CHARLESTON, SOUTH CAROLINA
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General Response Action	Technology	Process Options	Description	Screening Comment
Ex-Situ Treatment (continued)		Bioslurry Treatment	Treatment of soil in a slurry reactor under controlled conditions using natural or cultured microorganisms to biodegrade organics.	Eliminate. Bioslurry treatment is eliminated because of questionable effectiveness with the heterogeneous material found at AOCs 693/694. Also, the current and projected land use as a dredge spoil area would prevent the treatment from being effective. The cost is not justified based on the very low concentrations and very low risk.
	Thermal	Low-Temperature Thermal Desorption	Use of low to moderate temperature to volatilize contaminants.	Eliminate. Low-temperature thermal desorption is eliminated because of questionable effectiveness with the heterogeneous material found at AOCs 693/694 and cost associated with low volumes. Also, the current and projected land use as a dredge spoil area would prevent the treatment from being effective. The cost is not justified based on the very low concentrations and very low risk.

TABLE 4-2

**PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER
AOCS 693/694 - FUSE AND PRIMER HOUSE, FORMER BUILDING 117 AND FORMER NAVAL AMMUNITION DEPOT
CORRECTIVE MEASURES STUDY
CHARLESTON NAVAL COMPLEX, NORTH CHARLESTON, SOUTH CAROLINA
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General Response Action	Technology	Process Options	Description	Screening Comment
No Action	None	Not Applicable	No activities would be conducted at the site to address contamination.	Retain. No action is retained as a baseline for comparison with other technologies.
Limited Action	Access/Use Restrictions	Active Controls: Physical Barriers/ Security Guards	Fencing, markers, and warning signs to restrict site access.	Eliminate. Not necessary as long as USACE continues its operations on the property.
		Passive Controls: Restrictions on Groundwater use	Administrative action, such as land use controls, used to restrict the use of groundwater as a source of drinking water.	Retain to limit future human exposure to groundwater.
	Monitoring	Monitoring	Monitoring groundwater to assess migration and changes in concentrations	Eliminate. The current and projected land use as a dredge spoil area would prevent the treatment from being effective.
Containment	Vertical Barriers	Slurry Wall	Use of a low-permeability wall to restrict horizontal migration of groundwater or to redirect groundwater flow.	Eliminate. The current and projected land use as a dredge spoil area would prevent the treatment from being effective. The cost is not justified based on the very low concentrations and very low risk.
		Grout Curtain	Pressure injection of grout to form a low-permeability perimeter wall to restrict horizontal migration of groundwater.	Eliminate. The current and projected land use as a dredge spoil area would prevent the treatment from being effective. The cost is not justified based on the very low concentrations and very low risk.
	Hydraulic Barriers	Sheet Piling	Metal sheet piling driven into the ground to restrict horizontal migration of groundwater or to redirect groundwater flow.	Eliminate. The current and projected land use as a dredge spoil area would prevent the treatment from being effective. The cost is not justified based on the very low concentrations and very low risk.

TABLE 4-2

**PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER
AOCs 693/694 - FUSE AND PRIMER HOUSE, FORMER BUILDING 117 AND FORMER NAVAL AMMUNITION DEPOT
CORRECTIVE MEASURES STUDY
CHARLESTON NAVAL COMPLEX, NORTH CHARLESTON, SOUTH CAROLINA
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General Response Action	Technology	Process Options	Description	Screening Comment
Contaminant (continued)	Horizontal Barriers	Physical Barrier	Injection of bottom-sealing slurry beneath source to minimize vertical migration of groundwater.	Eliminate. Site geology already includes a low permeability clay layer that minimizes vertical migration.
Removal	Groundwater Extraction	Excavation of Saturated Soil	Excavation of saturated soil with high concentrations that would not be adequately addressed via treatment. This process would be followed by extraction of contaminated groundwater from the resulting excavation. A typical application of this technology would be to remove contaminated soil acting as a source area.	Eliminate. Costs would likely be high due to the large volume of material (both soil and groundwater) to be removed and disposed. Workers would be exposed to contaminated soil and groundwater during removal actions. In addition, COC concentrations do not warrant this technology. The cost is not justified based on the very low concentrations and very low risk.
In-Situ Treatment	Biological	Monitored Natural Attenuation	Monitoring groundwater to assess contaminant dilution or degradation through natural processes.	Eliminate. The current and projected land use as a dredge spoil area would prevent the treatment from being effective.
		Phytoremediation	Use of green plants and their associated microorganisms to stabilize or reduce contamination.	Eliminate. Information as to the rate and extent of remediation achievable is lacking. Documented examples of successful implementation of this technology are also minimal. In addition, plants that accumulate contaminants may pose a risk of spreading the contamination through the food chain if the plants are consumed. The cost is not justified based on the very low concentrations and very low risk.

TABLE 4-2

**PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER
AOCs 693/694 - FUSE AND PRIMER HOUSE, FORMER BUILDING 117 AND FORMER NAVAL AMMUNITION DEPOT
CORRECTIVE MEASURES STUDY
CHARLESTON NAVAL COMPLEX, NORTH CHARLESTON, SOUTH CAROLINA
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General Response Action	Technology	Process Options	Description	Screening Comment
In-Situ Treatment (Continued)	Biological	Bioaugmentation	Introducing natural microbial strains or laboratory-enriched variants to the contaminant plume to enhance bioremediation.	Eliminate. The current and projected land use as a dredge spoil area would prevent the treatment from being effective. The cost is not justified based on the very low concentrations and very low risk.
	Physical/ Chemical	Air Sparging/ Soil Vapor Extraction	Volatilization and enhancement of biodegradation of organics by supply of air and extraction of organic compounds.	Eliminate. This technology would have limited effectiveness because of nitrification of the metals and the aquifer has a low permeability and the water table is extremely shallow. This would limit the ability of the injected air to permeate through the aquifer and the effectiveness of the extraction system. The relatively thin silty sand layer would make it difficult to distribute the air. Similarly, the clay layer below the silty sand would limit the ability to distribute the air throughout the silty sand.
		Permeable Reactive Barrier (PRB)	Use of a PRB allows the passage of groundwater and acts to remove or destroy the contaminants.	Eliminate. Groundwater flow direction is variable. Low gradient would limit movement through a PRB. The cost is not justified based on the very low concentrations and very low risk.

TABLE 4-2

**PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER
AOCs 693/694 - FUSE AND PRIMER HOUSE, FORMER BUILDING 117 AND FORMER NAVAL AMMUNITION DEPOT
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General Response Action	Technology	Process Options	Description	Screening Comment
Ex-situ Treatment	Thermal	Dynamic Underground Stripping	Steam injection at the periphery of the contaminated area resulting in the volatilization of chlorinated volatile organic compounds bound to soil and movement of contaminants to a centrally located extraction well.	Eliminate. This process would add significant amounts of water to the subsurface resulting in an increase in the water table. The water table is approximately 3-5 feet bgs, and therefore the water table would be elevated to above the ground surface. A horizontal extraction system in the vadose zone would be required to remove the volatilized VOCs; however, this would not be implementable because the vadose zone would be saturated. Also, the process is not effective for metal contamination. The cost is not justified based on the very low concentrations and very low risk.
	Physical	Filtration	Separation of suspended solids from water via entrapment in a bed of granular media or membrane.	Eliminate. Groundwater will not be extracted due to close proximity with the river. The cost is not justified based on the very low concentrations and very low risk.
		Reverse Osmosis	Use of high pressure and membranes to separate dissolved materials from water.	
		Air Stripping	Contact of water with air to remove volatile organics.	
		Solvent Extraction	Separation of contaminants from a solution by contact with an immiscible liquid with a higher affinity for the contaminants of concern.	

TABLE 4-2

PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER
 AOCs 693/694 - FUSE AND PRIMER HOUSE, FORMER BUILDING 117 AND FORMER NAVAL AMMUNITION DEPOT
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General Response Action	Technology	Process Options	Description	Screening Comment
Ex-Situ Treatment (Continued)	Physical	Enhanced Oxidation	Use of oxidizers such as air, ozone, peroxide, chlorine, or permanganate to destroy organic compounds.	Eliminate. Groundwater will not be extracted due to close proximity with the river. The cost is not justified based on the very low concentrations and very low risk.
		Distillation	Vaporization of a liquid following by condensation of the vapors to concentrate various constituents.	
		Sedimentation	Separation of solids from water via gravity settling.	
		Electrodialysis	Recovery of anions or cations using special membranes under the influence of an electric current.	
		Flotation/Density Separation	Separation of oils and suspended solids less dense than water.	
		Dewatering	Process for removing the free water content from excavated soil.	
	Chemical	Ion Exchange	Process in which ions, held by electrostatic forces to charged functional groups on a resin surface, are exchanged for ions of similar charge in a water stream.	
		Electrolytic Recovery	Passage of an electric current through a solution with resultant ion recovery on positive and negative electrodes.	

TABLE 4-2

PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER
 AOCs 693/694 - FUSE AND PRIMER HOUSE, FORMER BUILDING 117 AND FORMER NAVAL AMMUNITION DEPOT
 CORRECTIVE MEASURES STUDY
 CHARLESTON NAVAL COMPLEX, NORTH CHARLESTON, SOUTH CAROLINA
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General Response Action	Technology	Process Options	Description	Screening Comment
Ex-Situ Treatment (Continued)		Reduction	Use of reducers such as sulfur dioxide, sulfite compounds, or ferrous iron compounds to decrease the oxidation state of organic and inorganic compounds.	Eliminate. Groundwater will not be extracted due to close proximity with the river. The cost is not justified based on the very low concentrations and very low risk.
	Chemical	Chemical Precipitation	Use of reagents to convert soluble constituents into insoluble constituents.	
		Catalytic Oxidation	Use of a metal catalyst to oxidize contaminants, resulting in the formation of carbon dioxide, water, and hydrochloric gas.	
		Coagulation/ Flocculation	Use of chemicals to neutralize surface charges and promote attraction of colloidal particles to facilitate settling.	
		Neutralization/pH Adjustment	Use of acids or bases to counteract excess pH.	
	Biological	Aerobic	Natural degradation of organic contaminants via microorganisms in an aerobic (oxygen-rich) environment.	
		Anaerobic	Natural degradation of organic contaminants via microorganisms in an anaerobic (oxygen-deficient) environment.	

5.0 DEVELOPMENT OF CORRECTIVE MEASURES ALTERNATIVES

Corrective measures alternatives for soil and groundwater at AOCs 693/694 are described in this section.

5.1 DEVELOPMENT OF CORRECTIVE MEASURES ALTERNATIVES FOR AOCs 693/694 SOIL

The following two alternatives were developed using the retained technologies identified in Section 4.0 to address AOCs 693/694 soil contamination:

- Alternative S-1 – No Action
- Alternative S-2 – Limited Action - LUCs

Based on the results of the RFI, the soil contamination was delineated and covers approximately 43,560 square yards (yd²). The depth of contamination is estimated to be 8.5 ft. This area encompasses soil contamination originating from the original operations and dredge depositing activities at AOCs 693/694. The dredge spoil area limits were determined by historical maps and clear boundaries of the separate parcels of land during site reconnaissance that was performed during the RFI.

The following subsections describe the corrective measures alternatives to address the soil contamination at AOCs 693/694.

5.1.1 Alternative S-1 – No Action

No action would consist of maintaining the status quo at the site. The No Action alternative is included to provide a baseline for comparison to other alternatives and their effectiveness in mitigating risks posed by site contaminants. Because no remedial actions would be taken under this alternative, there would be no reductions in risk through exposure control or treatment and no associated costs. Contaminant concentrations may eventually be reduced by natural attenuation processes, but this would not be monitored.

5.1.2 Alternative S-2 – Limited Action - LUCs

Alternative S-2 would include maintaining current site operations which is consistent with existing site conditions to minimize exposure to contaminants and migration of contaminants and the implementation of LUCs to require the property owner to follow the CNC dig permit process for construction activities when disturbing soil within the limits of AOCs 693/694. This would ensure the property owner is notified

of the potential for encountering contaminated dredge spoils and/or munitions. The limits of the proposed LUCs are identified by the current boundary.

In addition, should the USACE transfer the property by deed to a non-Federal entity, particularly for a use(s) other than dredge spoil disposal, the transfer deed should include a requirement that the new owner follow the CNC dig permit process for construction activities when working within the limits of AOCs 693/694., a notification that the area was previously a munitions storage area, and a requirement for inspections to ensure compliance with and long-term effectiveness of LUCs. Currently, there is no reason to anticipate transfer of the AOCs 693/694 area to the public (i.e., AOCs 693/694 will be owned by the USACE in the near and extended future).

5.2 DEVELOPMENT OF CORRECTIVE MEASURES ALTERNATIVES FOR GROUNDWATER

The following two alternatives were developed to address groundwater contamination at AOCs 693/694:

- Alternative G-1 – No Action
- Alternative G-2 – Limited Action - LUCs

The following subsections describe the corrective measures alternatives to address the groundwater contamination at AOCs 693/694.

5.2.1 Alternative G-1 – No Action

No action would consist of maintaining the status-quo at the site. The No Action alternative is included to provide a baseline for comparison to other alternatives and their effectiveness in mitigating risks posed by site contaminants. Because no remedial actions would be taken under this alternative, there would be no reductions in risk through exposure control or treatment and no associated costs. Concentrations of contaminants would eventually be reduced by natural attenuation processes, but this would not be monitored.

5.2.2 Alternative G-2 – Limited Action - LUCs

LUCs would restrict the use of groundwater for drinking purposes, require the property owner to follow the CNC dig permit process for construction activities within the limits of AOCs 693/694, and notify the property owner that the area was previously a munitions storage area.

In addition, should the USACE transfer the property by deed to a non-Federal entity, particularly for a use(s) other than dredge spoil disposal, the transfer deed should include a restriction prohibiting the

installation of wells, a requirement that the new owner follow the CNC dig permit process for construction activities when working within the limits of AOCs 693/694., a notification that the area was previously a munitions storage area, and a requirement for inspections to ensure compliance with and long-term effectiveness of LUCs. Currently, there is no reason to anticipate transfer of the AOCs 693/694 area to the public (i.e., AOCs 693/694 will be owned by the USACE in the near and extended future).

A formal request would also be made to the South Carolina Department of Health and Environmental Control (SCDHEC) (as part of the Corrective Action Plan) to not issue permits for installation of drinking water wells at AOCs 693/694 that would draw groundwater from the surficial aquifer. The limits of the proposed LUCs are identified by the current boundary (See Figure 2-1).

6.0 EVALUATION OF CORRECTIVE MEASURES ALTERNATIVES

The corrective measures alternatives described in Section 5.0 are evaluated in this section.

6.1 CORRECTIVE MEASURES EVALUATION CRITERIA

The alternatives are evaluated against the standards and factors described in Appendix C of the CNC RCRA Permit. In particular, the remedy must meet the following standards:

- Protection of human health and the environment.
- Attainment of MCSs.
- Control of the source of releases so as to reduce or eliminate, to the extent practicable, further releases that may pose a threat to human health and the environment.
- Compliance with applicable standards for management of wastes.

The following five additional factors are considered in the selection of a remedy:

- Long-term reliability and effectiveness
- Reduction in the toxicity, mobility, or volume of wastes
- Short-term effectiveness
- Implementability
- Cost

Descriptions of these standards and factors, summarized from the RCRA Permit, are provided below.

6.1.1 Protection of Human Health and the Environment

Corrective action remedies must be protective of human health and the environment. Remedies may include those measures that are needed to be protective but are not directly related to media cleanup, source control, or management of wastes.

6.1.2 Attainment of MCSs

Remedies will be required to attain MCSs. The ability of a potential remedy to achieve the remediation goals will be addressed. An estimate of the time frame to achieve the goals will be included. Contingent remedies may also be proposed.

6.1.3 Control Source of Releases

The type of source control actions are to be described, including the anticipated success and track record of the technology.

6.1.4 Compliance with Applicable Standards for Management of Wastes

Compliance with all applicable state and federal regulations during waste management activities will be described.

6.1.5 Long-Term Reliability and Effectiveness

Each alternative must be considered regarding effective application under analogous conditions, immediate impacts on receptors if the technology fails, and flexibility to deal with uncontrollable changes at the site. Frequency and complexity of O&M activities are to be considered. The projected useful life of the mechanical and structural components of the alternative must also be considered.

6.1.6 Reduction in the Toxicity, Mobility, or Volume of Wastes

Remedies that employ techniques that are capable of eliminating or substantially reducing the potential for the wastes and/or contaminated media to be released in the future are preferred. Estimates of reductions in toxicity, mobility, and volume are to be included.

6.1.7 Short-Term Effectiveness

Short-term factors include potential for fire and explosions, exposure to hazardous constituents, and potential threats associated with treatment, excavation, transportation, and disposal.

6.1.8 Implementability

Implementability considerations include administrative activities (such as permitting), constructability, availability of disposal capacity and technical services, and availability of the proposed technology.

6.1.9 Cost

Capital costs and O&M costs are to be estimated, and a net present worth (NPW) value of the capital and O&M costs will be calculated.

6.2 DETAILED ANALYSIS OF SOIL CORRECTIVE MEASURES ALTERNATIVES FOR AOCs 693/694

The following is the evaluation of the alternatives developed for the AOCs 693/694 soils. The evaluation is summarized in Table 6-1.

6.2.1 Alternative S-1 – No Action

6.2.1.1 Protection of Human Health and the Environment

Alternative S-1 would not provide protection of human health and the environment. Under current and future land use, there could be unacceptable risks to human health and ecological receptors exposed to subsurface soil.

6.2.1.2 Attainment of MCSs

There are no MCSs identified for the soil that need to be attained. Soil contamination might eventually be attenuated through long-term natural processes but no monitoring would be conducted to verify this.

6.2.1.3 Control Source of Releases

Alternative S-1 would not control releases from contaminated soil.

6.2.1.4 Compliance with Applicable Standards for Management of Wastes

Since no contaminated material is being removed from the site, Alternative S-1 would not require the management of wastes, and there are no state and/or federal regulations to comply with.

6.2.1.5 Long-Term Reliability and Effectiveness

Alternative S-1 would have no long-term reliability and effectiveness because no action would occur and the contaminated soil would remain on site. Because there would be no LUCs to restrict use of the site, the potential would also exist for unacceptable risk to develop for human receptors during construction activities. Although contaminant concentrations might eventually be attenuated through natural processes, no monitoring would verify this.

6.2.1.6 Reduction in the Toxicity, Mobility, or Volume of Wastes

Alternative S-1 would not reduce toxicity, mobility, or volume of contaminants because no treatment would occur. Some reduction in the toxicity and volume of contaminants might occur through natural dispersion, dilution, or other attenuation processes, but no monitoring would be performed to verify this.

6.2.1.7 Short-Term Effectiveness

Because no action would occur, implementation of Alternative S-1 would not pose any risks to on site workers or result in short-term adverse impact to the local community and the environment.

6.2.1.8 Implementability

Because no action would occur, Alternative S-1 would be readily implementable. Implementability of administrative measures is not applicable because no such measures would be taken. Constructability and technology issues are not applicable.

6.2.1.9 Cost

There would be no costs associated with the No Action alternative.

6.2.2 Alternative S-2 – Limited Action - LUCs

6.2.2.1 Protection of Human Health and the Environment

Implementation of Alternative S-2 is protective of human health because it would include maintenance of the existing conditions and implementation of LUCs that would require the property owner to follow the CNC dig permit process for construction activities within the limits of AOCs 693/694, and notify the property owner that the area was previously a munitions storage area. This would ensure the property owner is aware of the potential for encountering contaminated dredge spoils and/or munitions. The implementation of this alternative would not address potential impacts to the environment; however, the ecological risk assessment in the approved 1999 RFI Report concluded that the identified ecological contaminants of potential concern pose minimal risk to the representative receptors.

6.2.2.2 Attainment of MCSs

There are no MCSs identified for the soil that need to be attained. Soil contamination might eventually be further attenuated through long-term natural processes but no monitoring would be conducted to verify this.

6.2.2.3 Control Source of Releases

Alternative S-2 would not control releases from contaminated soil.

6.2.2.4 Compliance with Applicable Standards for Management of Wastes

Since no contaminated material is being removed from the site, Alternative S-2 would not require the management of wastes during normal operations, and there are no state and/or federal regulations to comply with.

6.2.2.5 Long-Term Reliability and Effectiveness

Implementation of Alternative S-2 would provide long-term reliability and effectiveness if adequately maintained and implemented. Maintaining the dig permit process would alert human receptors of the potential from coming into contact with soil contaminants or munitions.

6.2.2.6 Reduction in the Toxicity, Mobility, or Volume of Wastes

Alternative S-2 would not reduce toxicity, mobility, or volume of contaminants because no treatment would occur. Some reduction in the toxicity and volume of contaminants might occur through natural dispersion, dilution, or other attenuation processes, but no monitoring would be performed to verify this.

6.2.2.7 Short-Term Effectiveness

Short-term impacts are very limited under Alternative S-2. Implementation of this alternative would not adversely impact the surrounding community or the environment. Exposure of workers to contamination would be minimized by compliance with Occupational Safety and Health Administration (OSHA) requirements, including wearing of appropriate personal protective equipment (PPE) and adherence to site-specific health and safety procedures.

6.2.2.8 Implementability

Alternative S-2 would be relatively simple to implement because the necessary resources, equipment, and materials are available for all of the proposed tasks. The administrative and permitting aspects of Alternative S-2 would be relatively simple to implement. The LUCs would be incorporated into the CNC LUC program that is currently being implemented under the RCRA Permit.

6.2.2.9 Cost

The implementation of Alternative S-2 includes both capital and O&M costs. These costs are summarized below. Detailed cost estimates including the cost of annual LUC inspections should the property be transferred to a non-Federal entity, are provided in Appendix A.

Capital Cost	\$ 20,000
Average Yearly O&M	\$ 46,000
30-Year NPW	\$ 66,000

6.3 DETAILED ANALYSIS OF GROUNDWATER CORRECTIVE MEASURES ALTERNATIVES

The following is the evaluation of the alternatives developed for the AOCs 693/694 groundwater. The evaluation is summarized in Table 6-2.

6.3.1 Alternative G-1 – No Action

6.3.1.1 Protection of Human Health and the Environment

Alternative G-1 would not provide protection of human health and the environment. Under current and future land use, there could be unacceptable risks to human health from exposure to contaminated groundwater during construction activities. Because no monitoring would be performed, potential migration of contaminants would not be detected.

6.3.1.2 Attainment of MCSs

Alternative G-1 would not comply with MCSs because no action would be taken to reduce contaminant concentrations. Compliance with any MCSs would be purely incidental.

6.3.1.3 Control Source of Releases

Alternative G-1 would not control releases from contaminated soil.

6.3.1.4 Compliance with Applicable Standards for Management of Wastes

Since no contaminated material is being removed from the site, Alternative G-1 would not require the management of wastes, and there are no state and/or federal regulations to comply with.

6.3.1.5 Long-Term Reliability and Effectiveness

Alternative G-1 would have no long-term reliability and effectiveness because no action would occur and the contaminated soil would remain on site. Because there would be no LUCs to restrict the use of the groundwater, the potential would also exist for unacceptable risk to develop for human receptors during construction activities. Although contaminant concentrations might eventually be attenuated through natural processes, no monitoring would verify this.

6.3.1.6 Reduction in the Toxicity, Mobility, or Volume of Wastes

Alternative G-1 would not reduce toxicity, mobility, or volume of contaminants because no treatment would occur. Some reduction in the toxicity and volume of contaminants might occur through natural dispersion, dilution, or other attenuation processes, but no monitoring would be performed to verify this.

6.3.1.7 Short-Term Effectiveness

Because no action would occur, implementation of Alternative G-1 would not pose any risks to on site workers or result in short-term adverse impact to the local community and the environment.

6.3.1.8 Implementability

Because no action would occur, Alternative G-1 would be readily implementable. Implementability of administrative measures is not applicable because no such measures would be taken. Constructability and technology issues are not applicable.

6.3.1.9 Cost

There would be no costs associated with the No Action alternative.

6.3.2 Alternative G-2 – LUCs

6.3.2.1 Protection of Human Health and the Environment

This alternative would be protective of human health and the environment. LUCs would be protective of human health and the environment until MCSs are met. Restricting the use of groundwater would be protective of human health and the environment by avoiding unacceptable risks of exposure to contaminated groundwater.

6.3.2.2 Attainment of MCSs

Although there is no treatment, exposure to COCs at concentration greater than MCSs would be controlled by LUCs. By eliminating the exposure and risk, the MCSs are met. The natural attenuation in alternative G-2 would eventually reduce the concentration of the COCs and would meet identified MCSs.

6.3.2.3 Control Source of Releases

Alternative G-2 would not control releases from contaminated soil.

6.3.2.4 Compliance with Applicable Standards for Management of Wastes

Since no contaminated material is being removed from the site, Alternative G-2 would not require the management of wastes and there would be no state and/or federal regulations requiring compliance.

6.3.2.5 Long-Term Reliability and Effectiveness

Implementation of Alternative G-2 would provide long-term reliability and effectiveness if adequately implemented. Groundwater use would be restricted through LUCs. Although contaminant concentrations might eventually be attenuated through natural processes, no monitoring would verify this.

6.3.2.6 Reduction in the Toxicity, Mobility, or Volume of Wastes

Alternative G-2 would not reduce toxicity, mobility, or volume of contaminants because no treatment would occur. Some reduction in the toxicity and volume of contaminants might occur through natural dispersion, dilution, or other attenuation processes, but no monitoring would be performed to verify this.

6.3.2.7 Short-Term Effectiveness

Short-term impacts are very limited under Alternative G-2. Site workers might be exposed to contaminated soils or groundwater, but the risk would be minimized by compliance with OSHA requirements including wearing of appropriate PPE and adherence to site-specific health and safety procedures.

6.3.2.8 Implementability

Alternative G-2 would be relatively simple to implement because the necessary resources, equipment, and materials are available for the proposed tasks. The administrative and permitting aspects of Alternative G-2 would be relatively simple to implement. The LUCs would be incorporated in the LUC program that is required by the RCRA Permit.

6.3.2.9 Cost

Implementation of Alternative G-2 would include both capital and O&M costs. These costs are summarized below. Detailed cost estimates, including the cost of annual LUC inspections should the property be transferred to a non-Federal entity, are provided in Appendix A.

Capital (\$)	\$ 20,000
Average Yearly O&M	\$ 46,000
30-Year NPW	\$ 66,000

TABLE 6-1

**SUMMARY OF COMPARATIVE ANALYSIS OF SOIL ALTERNATIVES
AOCS 693/694 - FUSE AND PRIMER HOUSE, FORMER BUILDING 117 AND FORMER NAVAL AMMUNITION DEPOT
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Evaluation Criterion	Alternative S-1: No Action	Alternative S-2: Limited Action - Land Use Controls
Protection of Human Health and the Environment	Would not be protective of human health and the environment because no action would occur.	Would be protective of human health and would not be protective of the environment.
Attainment of MCSs	Would not attain MCSs.	Would eventually attain MCSs through natural attenuation.
Control of Source Releases	Would not control source releases.	Would not control source releases.
Comply with Applicable Standards for Management of Wastes	No state or federal regulations apply to this alternative.	No state or federal regulations apply to this alternative.
Long-Term Reliability and Effectiveness	Would not be effective or reliable because contaminants would remain.	AOCs 693/694 are located within a secure area; the long-term reliability and effectiveness of implemented land use controls is certain.
Reduction of Contaminant Toxicity, Mobility, or Volume	Would not reduce contaminant toxicity, mobility, or volume.	Would not reduce contaminant toxicity, mobility or volume.
Short-Term Effectiveness	Would not result in any short-term risks because no action would occur.	Proper usage and oversight of personal protective equipment would mitigate risks associated with potential worker exposure to contamination.
Implementability	Technical and administrative implementation would be extremely simple because there would be no action to implement.	Alternative S-2 would be easily implementable. The methods used to implement land use controls are standard practice, a program is in place, and personnel needed to implement the alternative are readily available.
Costs:		
Capital	\$0	\$20,000
Average Yearly O&M	\$0	\$46,000
30-Year NPW	\$0	\$66,000 (30-Year)

COCs Chemicals of Concern
MCSs Media Cleanup Standards
NPW Net Present Worth
O&M Operation and Maintenance

TABLE 6-2

**SUMMARY OF COMPARATIVE ANALYSIS OF GROUNDWATER ALTERNATIVES
AOC 693/694 - FUSE AND PRIMER HOUSE, FORMER BUILDING 117 AND FORMER NAVAL AMMUNITION DEPOT
CORRECTIVE MEASURES STUDY
CHARLESTON NAVAL COMPLEX, NORTH CHARLESTON, SOUTH CAROLINA**

Evaluation Criterion	Alternative G-1: No Action	Alternative G-2: Limited Action - Land Use Controls
Protection of Human Health and Environment	Would not be protective of human health and the environment because no action would occur.	Would be protective of human health and the environment.
Attainment of MCSs	Would not attain MCSs.	Would attain MCSs eventually through natural attenuation.
Control of Source Releases	Would not control source releases.	Would not control source releases.
Compliance with Applicable Standards for Management of Wastes	No applicable waste management standards with which to comply.	No applicable waste management standards with which to comply.
Long-Term Reliability and Effectiveness	Would not be effective because contaminants would remain.	AOCs 693/694 are located within a secure area ; the long-term reliability and effectiveness of implemented land use controls is certain
Reduction of Contaminant Toxicity, Mobility, or Volume	Would not reduce contaminant toxicity, mobility or volume.	Some reduction in the toxicity and volume of contaminants might occur through natural dispersion, dilution, or other attenuation processes.
Short-Term Effectiveness	Would not result in any short-term risks because no action would occur.	Would not result in any short-term risks because no action would occur.
Implementability	Technical and administrative implementation would be extremely simple because there would be no action to implement.	Technical implementability would be simple. Administrative implementation of the LUCs through the RCRA Permit LUC program would be simple. No major permits would be needed.
Costs:		
Capital	\$0	\$20,000
O&M	\$0	\$46,000
NPW	\$0	\$66,000 (30-Year)

COCs Chemicals Of Concern
LUC Land use control
NPW Net present worth
O&M Operation and maintenance
LTM Long-term monitoring
MNA Monitored natural attenuation

7.0 JUSTIFICATION AND RECOMMENDATION OF CORRECTIVE MEASURE

7.1 SOIL ALTERNATIVES

7.1.1 Comparison of Soil Corrective Measures Alternatives for AOCs 693/694

This section provides a comparative analysis of soil alternatives for AOCs 693/694. The criteria for comparison are identical to those used for the detailed analysis of individual alternatives. These comparisons are summarized in Table 6-1. The alternatives compared in this section include the following:

- Alternative S-1 – No Action
- Alternative S-2 – Limited Action - LUCs

7.1.1.1 Protection of Human Health and the Environment

Alternative S-1 would not protect human health and the environment because nothing would prevent exposure to contaminated soil that could result in unacceptable risk to human and ecological receptors. Also under this alternative, no warning would be provided of the potential future migration of contaminants because no monitoring would be performed.

Alternative S-2 would be protective of human health. The long-term LUCs would prevent unauthorized contact with contaminated soil.

7.1.1.2 Attainment of MCSs

There are no MCSs identified for the soil that need to be attained. Soil contamination might eventually be attenuated through long-term natural processes but no monitoring would be conducted to verify this under any of the soil alternatives.

7.1.1.3 Control Source of Releases

Alternatives S-1 and S-2 provide no controls to prevent release of contamination. However, due to the nature of this site being used as a dredge spoil area, there is difficulty in distinguishing the source of the contamination and possible future sources due to continued dredging disposal activities, such as typical excavation and diking activities that may contribute to the site by uncovering or exposing contaminants from deeper soils rather than past operations of AOCs 693/694.

7.1.1.4 Compliance with Applicable Standards for Management of Wastes

In Alternatives S-1 and S-2, no waste is being handled, so there are no state and/or federal waste regulations to comply with.

7.1.1.5 Long-Term Reliability and Effectiveness

Alternative S-1 would have no long-term reliability or effectiveness. Because there would be no restriction on land use, human and ecological receptors could be exposed to contaminated soil.

Alternative S-2 would provide long-term reliability and effectiveness. Requiring the property owner to follow the CNC dig permit process would make human receptors aware of the potential for coming into contact with soil contaminants and/or munitions.

Because there would be no groundwater monitoring under either of the two alternatives, potential off-site migration of contaminants would not be detected. Although contaminant concentrations might eventually be attenuated through natural processes, no monitoring would verify this.

7.1.1.6 Reduction in the Toxicity, Mobility, or Volume of Wastes

Alternatives S-1 and S-2 would provide no mechanisms to reduce the toxicity, mobility, or volume of waste associated with AOCs 693/694. Some reduction in the toxicity and volume of COCs might occur through natural dispersion, dilution, or other attenuation processes, but no monitoring would be performed to verify this under either of the two alternatives.

7.1.1.7 Short-Term Effectiveness

Implementation of Alternative S-1 would not result in risks to site workers or adversely impact the surrounding community or environment because no actions would be performed.

Implementation of Alternative S-2 would result in a slight possibility of exposing site workers to contaminated soil. For Alternative S-2, risks could be mitigated through the use of appropriate PPE.

7.1.1.8 Implementability

Alternative S-1 would entail no activities to implement.

For Alternative S-2, the methods used to implement LUCs are standard practice and the equipment and personnel needed to implement the alternative are readily available. The LUCs would be incorporated in

the CNC LUC program that is required by the RCRA Permit. Therefore, Alternative S-2 would be easily implemented.

7.1.1.9 Cost

The capital and O&M costs and NPW of the alternatives are as follows.

Alternative	Capital	O&M	NPW
S-1	\$0	\$0	\$0
S-2	\$20,000	\$46,000	\$66,000 (30 Years)

Detailed cost estimates, including the cost of annual LUC inspections should the property be transferred to a non-Federal entity, are provided in Appendix A.

7.1.1.10 Recommendation of AOCs 693/694 Corrective Measure

Alternative S-1 is eliminated because it would not meet the standards for protection of human health and the environment.

Based on the future use of the land and the extent of contamination at the site, Alternative S-2 is recommended as the AOCs 693/694 corrective measures for soil.

7.1.1.11 Contingency Remedies

If Alternative S-2 is implemented, provisions in the LUC program would address the possible need for new remedies if the area changes operational purpose.

7.2 GROUNDWATER ALTERNATIVES

7.2.1 Comparison of Groundwater Corrective Measures Alternatives for AOCs 693/694

This section provides a comparative analysis of the following groundwater alternatives:

- Alternative G-1 – No Action
- Alternative G-2 – Limited Action - LUCs

The criteria for comparison are identical to those used for the detailed analysis of individual alternatives. These comparisons are summarized in Table 6-2.

7.2.1.1 Protection of Human Health and the Environment

Alternative G-1 would not protect human health and the environment because nothing would prevent exposure to contaminated groundwater that could result in unacceptable risk to human receptors

Alternative G-2 would be protective of both human health and the environment. The LUC component of the alternatives would be protective because it would prevent exposure to contaminated groundwater by prohibiting installation of wells and requiring use of the CNC dig permit process for construction activities at the site.

7.2.1.2 Attainment of Media Cleanup Standards

Alternative G-1 would not attain MCSs but Alternative G-2 would eventually comply with MCSs through natural attenuation.

7.2.1.3 Control the Source of Releases

Neither of the two groundwater alternatives provides control of releases from the contaminated soil. However, groundwater use would be restricted through LUCs under Alternative G-2.

7.2.1.4 Compliance with Applicable Standards for Management of Wastes

In Alternative G-1 and Alternative G-2, no waste would be handled, so there are no state and/or federal waste regulations to comply with.

7.2.1.5 Long-Term Reliability and Effectiveness

Alternative G-1 would have no long-term reliability and effectiveness. Because there would be no restriction of groundwater or requirement for following the CNC dig permit process, human receptors could be exposed to contaminated groundwater during operational activities. Because there would be no monitoring, the progress of natural attenuation would not be evaluated.

Alternative G-2 would provide long-term reliability and effectiveness. The LUC component of Alternative G-2 would effectively prevent exposure to contaminated groundwater.

7.2.1.6 Reduction in the Toxicity, Mobility, or Volume of Wastes

Neither of the two groundwater alternatives would achieve any reduction of toxicity, mobility, or volume of contaminants. There would be some reduction of contaminant toxicity and volume through natural attenuation; however, this reduction would neither be verified nor quantified.

7.2.1.7 Short-Term Effectiveness

Implementation of Alternative G-1 would not result in risks to site workers or adversely impact the surrounding community or environment because no actions would be performed.

Implementation of Alternative G-2 would result in a slight possibility of exposing site workers to contaminated groundwater during construction activities. Such risks would be minimized by compliance with OSHA requirements including wearing of appropriate PPE and adherence to site-specific health and safety procedures.

7.2.1.8 Implementability

Alternative G-1 would entail no activities to implement.

The technical implementation of the LUCs under Alternative G-2 would not be difficult. Administrative and permitting aspects of LUCs would be relatively simple to implement. The LUCs would be incorporated in the CNC LUC program that is required by the RCRA Permit.

7.2.1.9 Cost

The capital and O&M costs and NPW of the alternatives are as follows.

Alternative	Capital	NPW of O&M	NPW
G-1	\$0	\$0	\$0
G-2	\$20,000	\$46,000	\$66,000 (30 Years)

Detailed cost estimates, including the cost of annual LUC inspections should the property be transferred to a non-Federal entity, are provided in Appendix A.

7.2.2 Recommendation of Groundwater Corrective Measure

Alternative G-1 is eliminated because it would not meet the standards for protection of human health and the environment, and would not control releases from the source. Based on the future use of the land

and the extent of contamination at the site, Alternative G-2 is recommended as the AOCs 693/694 corrective measure for groundwater.

7.2.3 Contingency Remedies

If Alternative G-2 is implemented, provisions in the CNC LUC program would address the possible need for new remedies if the area changes operational purpose.

REFERENCES

EnSafe, 1999. Final Zone K RFI Report, Charleston Naval Complex. June 1999.

EnSafe, 2002. Clouter Island RFI Report Addendum, Charleston Naval Complex. September 2002.

USACE (U.S. Army Corps of Engineers), 2006. Final Environmental Impact Statement, Proposed Marine Container Terminal at the Charleston Naval Complex, North Charleston, South Carolina. Charleston District, Charleston, South Carolina, December.

Van Dolah, R. F., P.H. Wendt, and E.L. Wenner, eds., 1990. A Physical and Ecological Characterization of the Charleston Harbor Estuarine System. Marine Resources Division, South Carolina Wildlife and Marine Resources Department, cited in USACE (U.S. Army Corps of Engineers), 2006. Final Environmental Impact Statement, Proposed Marine Container Terminal at the Charleston Naval Complex, North Charleston, South Carolina. Charleston District, Charleston, South Carolina, December.

APPENDIX A

CALCULATIONS

CHARLESTON NAVAL COMPLEX
North Charleston, South Carolina
AOC 693/694 CMS
Alternative G-2: Land Use Controls
Capital Cost

10/1/2012 10:24 AM

Item	Quantity	Unit	Subcontract	Unit Cost			Extended Cost			Subtotal	
				Material	Labor	Equipment	Subcontract	Material	Labor		Equipment
1 PROJECT PLANNING & DOCUMENTS											
1.1 Prepare LUC RD Documents	300	hr			\$39.00		\$0	\$0	\$11,700	\$0	\$11,700
Subtotal							\$0	\$0	\$11,700	\$0	\$11,700
Overhead on Labor Cost @ 30%									\$3,510		\$3,510
G & A on Labor, Material, Equipment, & Subs Cost @ 10%							\$0	\$0	\$1,170	\$0	\$1,170
Tax on Materials and Equipment Cost @ 6%								\$0	\$0	\$0	\$0
Total Direct Cost							\$0	\$0	\$16,380	\$0	\$16,380
Indirects on Total Direct Cost @ 0%											\$0
Profit on Total Direct Cost @ 10%											\$1,638
Subtotal											\$18,018
Health & Safety Monitoring @ 0%											\$0
Total Field Cost											\$18,018
Contingency on Total Field Costs @ 10%											\$1,802
Engineering on Total Field Cost @ 0%											\$0
TOTAL CAPITAL COST											\$19,820

CHARLESTON NAVAL COMPLEX
North Charleston, South Carolina
AOC 693/694 CMS
Alternative G-2: Land Use Controls
Annual Cost

10/1/2012 10:24 AM

Item	Item Cost years 1 - 30	Notes
Site Inspection: Visit	\$1,150	One-day visit to verify LUC RD
Site Inspection: Report	<u>\$800</u>	
Subtotal	\$1,950	
Contingency @ 10%	<u>\$195</u>	
TOTAL	\$2,145	

CHARLESTON NAVAL COMPLEX
North Charleston, South Carolina
AOC 693/694 CMS
Alternative G-2: Land Use Controls
Present Worth Analysis

10/1/2012 10:24 AM

Year	Capital Cost	Annual Cost	Total Year Cost	Annual Discount Rate 2.3%	Present Worth
0	\$19,820		\$19,820	1.000	\$19,820
1		\$2,145	\$2,145	0.978	\$2,097
2		\$2,145	\$2,145	0.956	\$2,050
3		\$2,145	\$2,145	0.934	\$2,004
4		\$2,145	\$2,145	0.913	\$1,959
5		\$2,145	\$2,145	0.893	\$1,914
6		\$2,145	\$2,145	0.872	\$1,871
7		\$2,145	\$2,145	0.853	\$1,829
8		\$2,145	\$2,145	0.834	\$1,788
9		\$2,145	\$2,145	0.815	\$1,748
10		\$2,145	\$2,145	0.797	\$1,709
11		\$2,145	\$2,145	0.779	\$1,670
12		\$2,145	\$2,145	0.761	\$1,633
13		\$2,145	\$2,145	0.744	\$1,596
14		\$2,145	\$2,145	0.727	\$1,560
15		\$2,145	\$2,145	0.711	\$1,525
16		\$2,145	\$2,145	0.695	\$1,491
17		\$2,145	\$2,145	0.679	\$1,457
18		\$2,145	\$2,145	0.664	\$1,425
19		\$2,145	\$2,145	0.649	\$1,392
20		\$2,145	\$2,145	0.635	\$1,361
21		\$2,145	\$2,145	0.620	\$1,331
22		\$2,145	\$2,145	0.606	\$1,301
23		\$2,145	\$2,145	0.593	\$1,271
24		\$2,145	\$2,145	0.579	\$1,243
25		\$2,145	\$2,145	0.566	\$1,215
26		\$2,145	\$2,145	0.554	\$1,188
27		\$2,145	\$2,145	0.541	\$1,161
28		\$2,145	\$2,145	0.529	\$1,135
29		\$2,145	\$2,145	0.517	\$1,109
30		\$2,145	\$2,145	0.506	\$1,084
TOTAL PRESENT WORTH					\$65,936

CHARLESTON NAVAL COMPLEX
North Charleston, South Carolina
AOC 693/694 CMS
Alternative S-2: Limited Action - LUCs
Capital Cost

10/1/2012 10:22 AM

Item	Quantity	Unit	Subcontract	Unit Cost			Extended Cost			Subtotal	
				Material	Labor	Equipment	Subcontract	Material	Labor		Equipment
1 PROJECT PLANNING & DOCUMENTS											
1.1 Prepare LUC RD Documents	300	hr			\$39.00		\$0	\$0	\$11,700	\$0	\$11,700
Subtotal							\$0	\$0	\$11,700	\$0	\$11,700
Overhead on Labor Cost @ 30%									\$3,510		\$3,510
G & A on Labor, Material, Equipment, & Subs Cost @ 10%							\$0	\$0	\$1,170	\$0	\$1,170
Tax on Materials and Equipment Cost @ 6%								\$0	\$0	\$0	\$0
Total Direct Cost							\$0	\$0	\$16,380	\$0	\$16,380
Indirects on Total Direct Cost @ 0%											\$0
Profit on Total Direct Cost @ 10%											\$1,638
Subtotal											\$18,018
Health & Safety Monitoring @ 0%											\$0
Total Field Cost											\$18,018
Contingency on Total Field Costs @ 10%											\$1,802
Engineering on Total Field Cost @ 0%											\$0
TOTAL CAPITAL COST											\$19,820

CHARLESTON NAVAL COMPLEX
North Charleston, South Carolina
AOC 693/694 CMS
Alternative S-2: Limited Action - LUCs
Annual Cost

10/1/2012 10:22 AM

Item	Item Cost years 1 - 30	Notes
Site Inspection: Visit	\$1,150	One-day visit to verify LUC RD
Site Inspection: Report	\$800	
Subtotal	<hr/> \$1,950	
Contingency @ 10%	<hr/> \$195	
TOTAL	<hr/> \$2,145	

CHARLESTON NAVAL COMPLEX
North Charleston, South Carolina
AOC 693/694 CMS
Alternative S-2: Limited Action - LUCs
Present Worth Analysis

10/1/2012 10:22 AM

Year	Capital Cost	Annual Cost	Total Year Cost	Annual Discount Rate 2.3%	Present Worth
0	\$19,820		\$19,820	1.000	\$19,820
1		\$2,145	\$2,145	0.978	\$2,097
2		\$2,145	\$2,145	0.956	\$2,050
3		\$2,145	\$2,145	0.934	\$2,004
4		\$2,145	\$2,145	0.913	\$1,959
5		\$2,145	\$2,145	0.893	\$1,914
6		\$2,145	\$2,145	0.872	\$1,871
7		\$2,145	\$2,145	0.853	\$1,829
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9		\$2,145	\$2,145	0.815	\$1,748
10		\$2,145	\$2,145	0.797	\$1,709
11		\$2,145	\$2,145	0.779	\$1,670
12		\$2,145	\$2,145	0.761	\$1,633
13		\$2,145	\$2,145	0.744	\$1,596
14		\$2,145	\$2,145	0.727	\$1,560
15		\$2,145	\$2,145	0.711	\$1,525
16		\$2,145	\$2,145	0.695	\$1,491
17		\$2,145	\$2,145	0.679	\$1,457
18		\$2,145	\$2,145	0.664	\$1,425
19		\$2,145	\$2,145	0.649	\$1,392
20		\$2,145	\$2,145	0.635	\$1,361
21		\$2,145	\$2,145	0.620	\$1,331
22		\$2,145	\$2,145	0.606	\$1,301
23		\$2,145	\$2,145	0.593	\$1,271
24		\$2,145	\$2,145	0.579	\$1,243
25		\$2,145	\$2,145	0.566	\$1,215
26		\$2,145	\$2,145	0.554	\$1,188
27		\$2,145	\$2,145	0.541	\$1,161
28		\$2,145	\$2,145	0.529	\$1,135
29		\$2,145	\$2,145	0.517	\$1,109
30		\$2,145	\$2,145	0.506	\$1,084
TOTAL PRESENT WORTH					\$65,936

APPENDIX B

COMMENTS AND RESPONSES

BOARD:
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Mark S. Lutz
Vice Chairman



Catherine B. Templeton, Director
Promoting and protecting the health of the public and the environment

BOARD:
R. Kenyon Wells
L. Clarence Batts, Jr.
Ann B. Kirol, DDS
John O. Hutto, Sr., MD

MEMORANDUM

TO: Meredith Amick, P.E., Engineering Associate
Corrective Action Engineering Section
Division of Waste Management
Bureau of Land and Waste Management

FROM: Annie M. Gerry, Hydrogeologist
Federal Facilities Groundwater Section
Division of Waste Management
Bureau of Land and Waste Management

DATE: December 7, 2012

RE: Charleston Naval Complex
SC0 170 022 5

Review of Corrective Measures Study for AOC 693- Fuse and Primer House,
Former Building 117 and AOC 694- Former Naval Ammunition Depot at
Charleston Naval Complex (CNC), North Charleston, SC, dated October 2012

The above referenced document has been reviewed with respect to R.61-79 of the South Carolina Hazardous Waste Management Regulations and conditions of RCRA Unilateral Administrative Order 94-04-R. Area of Concern (AOC) 693 and 694 are located on Clouter Island which consists of four dredge spoil areas. AOC 693 consists of Building 117 (fuse and primer house) which is still intact, and AOC 694 includes the former Naval Ammunition Depot. Both AOCs are located outside of the bermed area used for depositing dredged spoils from surrounding rivers. Constituents of concern identified in past investigations include metals and explosives in soil and groundwater. The purpose of this document is to discuss contamination caused by operations on the Naval facility and to propose corrective measure alternatives for AOC 693/694.

Based on review of this document, the following comments have been generated.

COMMENTS

1. Please include a table that presents the historical data collected at this site. Figure 2-2 was useful, but provides no collection dates.
2. **Section 5.2- Development of Corrective Measures Alternatives for Groundwater-** Two groundwater alternatives were selected after screening and include *Alternative G-1: No Action*, and *Alternative G-2: Limited Action with Land Use Controls (LUCs)* which

File # 50484

would be implemented to restrict the use of groundwater for drinking purposes and would restrict residential development within AOCs 693/694.

The Department disagrees with Alternative G-1 and G-2 and will require long term monitoring (LTM) at this site since contamination is present at the site at concentrations above the established cleanup goals. Therefore, a third alternative should be listed and selected which will include LUCs with LTM. Please update the text as necessary.

In addition, since LTM is required, the Navy should have the wells surveyed (to establish Top of Casing elevations) so that potentiometric maps can be prepared using potentiometric data collected during future groundwater monitoring events and presented in future groundwater monitoring reports (See Section 2.3.4.2. Groundwater Flow Direction)

Should you have any questions regarding this memo, please contact me via email at GerryAM@dhec.sc.gov or by phone at (803) 896-4018



Catherine B. Templeton, Director

Promoting and protecting the health of the public and the environment

MEMORANDUM

TO: Meredith Amick, P.E., Environmental Engineering Associate
Corrective Action Engineering Section
Division of Waste Management
Bureau of Land and Waste Management

FROM: Kent Krieg, Risk Assessor
Corrective Action Engineering Section
Division of Waste Management
Bureau of Land and Waste Management

KMK

DATE: December 19, 2012

RE: Charleston Naval Complex (CNC)
Charleston, South Carolina

Document: Corrective Measure Study for AOC 693 – Fuse and Primer House
and AOC 694 – Former Naval Ammunition Depot
Dated October 2012

The above referenced document by TetraTech, NUS has been reviewed. The Department has the following risk related comments.

Specific Comments:

Table 3-1 does not match the RFI Addendum Table 7.34 (see attached page from RFI Addendum, EnSafe 2002). Specifically, the Residential Land Use estimated cancer risks and remedial goal options' units are inconsistent. Please correct the table as necessary.

3.2.4 Remedial Goal Options pg. 3-3.

The text is confusing as it only references arsenic as the exceeded risk levels contaminant for groundwater. Although arsenic is the only ILCR exceedances, cadmium, chromium, iron, manganese, mercury, silver, and thallium are contributors to the elevated HQ. Please add these chemicals into the discussion regarding the HQ exceeding the acceptable level of 1.

6.2.2.1 Protection of Human Health and the Environment, pg. 6-4.

As presented in the RFI, the potential risks to the environmental receptors were found to be acceptable by the Project Risk Managers based upon document approval. From this decision, protections for the potential environmental receptors are not necessary. Please clarify the last sentence.

If you need any further information, feel free to contact me at (803) 896-4262.

**Navy Responses to
ENGINEERING COMMENTS
Prepared by Meredith Amick
Charleston Naval Complex
November 30, 2012**

1. Proof must be provided that the current property owner (USACE) will accept Land Use Controls for property associated with AOCs 693 and 694 prior to the Department approving the remedy.

Navy Response: The Navy will ensure that the current property owner for AOCs 693 and 694 (USACE) will accept the Land Use Controls proposed for the property as part of the approved remedy.

2. If LUCs are chosen as the remedy, the Department feels that no LUC inspections will be needed as long as the USACE continues to operate the land as a dredge spoil area as stipulated in the 1996 transfer agreement between the Department of the Navy and the Department of the Army.

Navy Response: Comment noted. The Navy concurs.

3. Additionally, as long as the USACE continues to operate the land as a dredge spoil area, the Department does not feel that signage is necessary because of the limited entrance to the property. Additionally, if any work is to be performed on the property, following the process to construct on property subject to LUCs would notify the USACE as well as any subcontractors of the potential for contamination due to dredge spoils as well as the potential for encountering munitions because of the past use as a munitions storage facility.

Navy Response: Comment noted. The Navy concurs.

4. Page 2-1 discusses a survey conducted of the AOCs for unexploded ordnance from 0-5 ft bgs. Please clarify the timing of this survey (i.e., before or after dredge spoil was placed on top of the AOCs). Additionally, please discuss if anything was found during the survey.

Navy Response: Dredge spoils were deposited in the area of AOCs 693 and 694 after use of the depot was discontinued in the 1940s. Significant use of the island for dredge disposal began in the late 1950s/early 1960s. The Cooper River side of the island was noted to be bermed in a 1966 USACE report and the entire perimeter of the island was bermed by the late 1960s/early 1970s. The AOCs are located outside of the bermed dredge spoil disposal area(s). The text has been clarified to note that the purpose of the UXO survey was to assess selected soil sampling locations and temporary monitoring well locations for UXO potential, and to screen access routes to and from these locations in order to avoid potential UXO sites. The UXO avoidance screening was performed concurrently with the first round of RFI sampling in January 1997; thus, the UXO "survey" would have been both after spoils were placed on the AOCs and after the area was no longer used for dredge disposal. Screening of sample locations did not result in the discovery of UXO.

5. Please provide both a table and a map of soil analytical data exceedances of soil screening values. Additionally, discuss the current depth (under new dredge fill) of these samples.

Navy Response: Tables 2-1 through 2-6 which summarize historical analytical data exceedances of soil and groundwater screening values have been added to the CMS along with soil and groundwater sample location maps. No new dredge fill has been placed within the sample collection areas since the samples were collected between 1996 and 2002 as the AOCs are not located within the bermed dredge spoil disposal cells. The text has been clarified to note this.

6. The background values discussed for both soil and groundwater do not appear to match the approved CH2M Hill's background data for Zone K Clouter Island from 2001.

Navy Response: These BG values are actually the "the two times the mean" screening values used in both the 1999 Zone K RFI Report and the 2002 Clouter Island RFI Report Addendum. The text will be clarified to note this and the November 2001 values will be provided as well.

7. Figure 3-2 is labeled Soil Concentrations; however, the data appears to be groundwater data. Please correct.

Navy Response: It appears the reviewer is referring to Figure 2-2. Former Figures 2-1 (Monitoring Well and Soil Boring Sampling Locations) and 2-2 (Soil Concentrations) have been replaced with a new Figure 2-1 (Surface Soil and Soil Boring Locations) and Figure 2-2 (Groundwater Sample Locations), as discussed on July 3, 2013 (telephone conversation between Meredith Amick, SCDHEC and Lawson Anderson, Tetra Tech).

8. A table summarizing risks to each receptor (i.e., ICLRs and HIs) would be beneficial.

Navy Response: The requested table has been added to the report.

9. It appears that the major risk driver to the residential receptors is from drinking the groundwater. Because a groundwater use restriction is recommended, if no unacceptable risk to the residential receptors exists from soil, the Department feels that a residential use restriction may not be necessary. However, deed restrictions including no installation of wells, as well as notification that the area was previously used as a munitions storage area would be necessary.

Navy Response: Comment noted. The Navy concurs with the suggested land use control and notification. The property was transferred from the Navy property inventory to the USACE property inventory in 1996 for continued use as a dredge spoil area. Should the USACE transfer the property by deed to a non-Federal entity, particularly for a use(s) other than dredge spoil disposal, the transfer deed should include a restriction prohibiting installation of wells, and a notification that the area was previously used as a munitions storage area.

10. The document appears to be contradictory in several places. It appears that LUCs (groundwater use restrictions, etc.) are recommended as the remedy for AOCs 693 and 694; however, page 4-3 and page 4-5 state, "Therefore, deed restrictions are not needed for AOCs 693/694". Additionally, notification is needed to denote that the property was previously used as a munitions storage area. Finally, the Department understands that since the transfer of the property associated with AOC 693 and 694 was between two federal agencies, it is possible that no deed exists for the property. Please correct and clarify the discrepancies.

Navy Response: The text has been clarified to state that LUCs are needed, but not in the form of deed restrictions because the property was not transferred by deed.

11. Please clarify why LUCs are being chosen if as stated on page 6-4, "However, the implementation of this alternative [LUCs] would not be protective of the environment."

Navy Response: The text has been clarified to note that while the LUCs would not address potential impacts to the environment, the ecological risk assessment in the approved 1999 RFI Report concluded that the identified ecological contaminants of potential concern pose minimal risks to the representative receptors.

**Navy Responses to
RISK-RELATED COMMENTS
Prepared by Kent Krieg
Charleston Naval Complex
December 19, 2012**

The above referenced document by Tetra Tech NUS, Inc., has been reviewed. The Department has the following risk related comments.

Specific Comments:

Table 3-1 does not match the RFI Addendum Table 7.34 (see attached page from RFI Addendum, EnSafe 2002). Specifically, the Residential Land Use estimated cancer risks and remedial goal options' units are inconsistent. Please correct the table as necessary.

Navy Response: The requested corrections have been made.

3.2.4 Remedial Goal Options pg. 3-3.

The text is confusing as it only references arsenic as the exceeded risk levels contaminant for groundwater. Although arsenic is the only ILCR exceedances, cadmium, chromium, iron, manganese, mercury, silver, and thallium are contributors to the elevated HQ. Please add these chemicals into the discussion regarding the HQ exceeding the acceptable level of 1.

Navy Response: The HQ discussion has been edited as requested.

6.2.2.1 Protection of Human Health and the Environment, pg. 6-4.

As presented in the RFI, the potential risks to the environmental receptors were found to be acceptable by the Project Risk Managers based upon document approval. From this decision, protections for the potential environmental receptors are not necessary. Please clarify the last sentence.

Navy Response: The text has been clarified to note that while the LUCs would not address potential impacts to the environment, the ecological risk assessment in the approved 1999 RFI Report concluded that the identified ecological contaminants of potential concern pose minimal risks to the representative receptors.



Catherine B. Templeton, Director

Promoting and protecting the health of the public and the environment.

December 21, 2012

David Criswell, P.E.
BRAC PMO SE
4130 Faber Place Drive
Suite 202
N. Charleston, SC 29405

RE: Review of *CMS for AOC 693 and 694*
Charleston Naval Complex (CNC)
SC0 170 022 560

Dear Mr. Criswell:

The Corrective Action Engineering and the Hydrogeology Sections of the South Carolina Department of Health and Environmental Control (Department) received the above referenced report on October 2, 2012. The Department reviewed the documents and provides the following engineering, risk assessment and hydrogeology comments.

The response to the review of these comments should be included in the next report. If you have any questions regarding this issue, please contact me at (803) 896-4218.

Sincerely,

Meredith Amick, P.E., Environmental Engineer
Corrective Action Engineering Section
Division of Waste Management
Bureau of Land and Waste Management

cc: Gary Foster, CH2MHill
Geoff Pope, Tetra Tech
Christine Sanford-Coker, EQC Region 7, Charleston

Annie Gerry, Hydrogeology

Engineering Comments *MDS*
November 30, 2012

1. Proof must be provided that the current property owner (USACE) will accept Land Use Controls for property associated with AOCs 693 and 694 prior to the Department approving the remedy.
2. If LUCs are chosen as the remedy, the Department feels that no LUC inspections will be needed as long as the USACE continues to operate the land as a dredge spoil area as stipulated in the 1996 transfer agreement between the Department of the Navy and the Department of the Army.
3. Additionally as long as the USACE continues to operate the land as a dredge spoil area, the Department does not feel that signage is necessary because of the limited entrance to the property. Additionally if any work is to be performed on the property, following the process to construct on property subject to LUCs would notify the USACE as well as any subcontractors of the potential for contamination due to dredge spoils as well as the potential for encountering munitions because of the past use as a munitions storage facility.
4. Page 2-1 discusses a survey conducted of the AOCs for unexploded ordnance from 0-5 ft bgs. Please clarify the timing of this survey (ie before or after dredge spoil was placed on top of the AOCs). Additionally please discuss if anything was found during the survey.
5. Please provide both a table and a map of soil analytical data exceedances of soil screening values. Additionally discuss the current depth (under new dredge fill) of these samples.
6. The background values discussed for both soil and groundwater do not appear to match the approved CH2M Hill's background data for Zone K Clouter Island from 2001.
7. Figure 3-2 is labeled Soil Concentrations; however, the data appears to be groundwater data. Please correct.
8. A Table summarizing risks to each receptor (ie ICLRs and HIs) would be beneficial.
9. It appears that the major risk driver to the residential receptors is from drinking the groundwater. Because a groundwater use restriction is recommended, if no unacceptable risk to the residential receptors exists from soil, the Department feels that a residential use restriction may not be necessary. However, deed restrictions including no installation of wells, as well as notification that the area was previously used as a munitions storage area would be necessary.
10. The document appears to be contradictory in several places. It appears that LUCs (groundwater use restrictions, etc.) are recommended as the remedy for AOCs 693 and 694; however, page 4-3 and page 4-5 states, "Therefore, deed restrictions are not needed for AOCs 693/694". Additionally notification is needed to denote that the property was previously used as a munitions storage area. Finally the Department understands that since the transfer of the property associated with AOC 693 and 694 was between two federal agencies, it is possible that no deed exists for the property. Please correct and clarify the discrepancies.
11. Please clarify why LUCs are being chosen if as stated on page 6-4, "However, the implementation of this alternative [LUCs] would not be protective of the environment."

**Navy Response to
HYDROGEOLOGY COMMENTS
Prepared by Annie Gerry
Charleston Naval Complex
December 7, 2012**

COMMENTS

1. Please include a table that presents the historical data collected at this site. Figure 2-2 was useful, but provides no collection dates.

Navy Response: Tables 2-1 through 2-6 which summarize historical analytical data exceedances of soil and groundwater screening values have been added to the CMS along with soil and groundwater sample location maps.

2. Section 5.2 - Development of Corrective Measures Alternatives for Groundwater - Two groundwater alternatives were selected after screening and include *Alternative G-1: No Action*, and *Alternative G-2: Limited Action with Land Use Controls (LUCs)* which would be implemented to restrict the use of groundwater for drinking purposes and would restrict residential development within AOCs 693/694.

The Department disagrees with Alternative G-1 and G-2 and will require long term monitoring (LTM) at this site since contamination is present at the site at concentrations above the established cleanup goals. Therefore, a third alternative should be listed and selected which will include LUCs with LTM. Please update the text as necessary.

In addition, since LTM is required, the Navy should have the wells surveyed (to establish Top of Casing elevations) so that potentiometric maps can be prepared using potentiometric data collected during future groundwater monitoring events and presented in future groundwater monitoring reports (See Section 2.3.4.2. Groundwater Flow Direction).

Navy Response: Because there is no reason to anticipate a change in land use, or a transfer of the land to a private entity that might result in a change in land use, the potential for human exposure to groundwater contamination is very low with implementation of a groundwater use restriction. The current and projected land use as a dredge spoil area would prevent active treatment alternatives from being effective given the shallow groundwater table and recharge of brackish water through dredge spoil materials containing naturally occurring elements. Long-term groundwater monitoring will not result in a reduction in groundwater contaminant concentrations, nor a reduction in exposure potential. Thus, the Navy believes the use of limited financial resources for long-term monitoring is not justified based on the very low concentrations and very low risk.