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FINAL

FEASIBILITY STUDY REPORT
OPERABLE UNIT NO. 7
SITE 28

MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA
VOLUME II OF II

CONTRACT TASK ORDER 0231

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LIST OF ACRONYMS AND ABBREVIATIONS

ADL	administrative deadline lot
AOCs	areas of concern
ARARs	applicable or relevant and appropriate requirements
AWQC	Ambient Water Quality Criteria
Baker	Baker Environmental, Inc.
bgs	below ground surface
BEHP	bis (2-ethyl hexyl) phthalate
BRA	baseline human health risk assessment
CAA	Clean Air Act
CAMA	Coastal Area Management Act
Carc.	carcinogenic effects
CFR	Code of Federal Regulations
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CLEAN	Comprehensive Long-Term Environmental Action Navy
CLEJ	Camp Lejeune
CLP	contract laboratory program
COD	chemical oxygen demand
COCs	contaminants of concern
COPC	contaminants of potential concern
CSA	Comprehensive Site Assessment
CSF	carcinogenic slope factor
CWA	Clean Water Act
1,2-DCE	1,2-dichloroethene
DOD	Department of the Defense
DoN	Department of the Navy
DOT	Department of Transportation
DQO	data quality objective
EMD	Environmental Management Division (Camp Lejeune)
EPIC	Environmental Photographic Interpretation Center
ERA	ecological risk assessment
ER-L	effects range-low
ESE	Environmental Science and Engineering, Inc.
F	degrees Fahrenheit
FAWQC	Federal Ambient Water Quality Criteria
FFA	Federal Facilities Agreement
FSAP	Field Sampling and Analysis Plan
ft	feet
ft/ft	foot per foot

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

gpm	gallons per minute
GW	groundwater well
HA	health advisories
HI	Hazard Index
HPIA	Hadnot Point Industrial Area
HQ	hazard quotient
HQW	high quality water
i	hydraulic gradient
IAS	Initial Assessment Study
IAS	in situ air sparging
ICRs	incremental lifetime cancer risks
IDW	investigative derived wastes
IR	ingestion rate
IRA	interim remedial action
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
K	hydraulic conductivity
kg	kilograms
LANTDIV	Naval Facilities Engineering Command, Atlantic Division
LAW	Law Engineering
MCB	Marine Corps Base
MCL	maximum contaminant level
mgd	million gallons per day
mg/kg	milligram per kilogram
mg/L	milligram per liter
ml	milliliter
msl	mean sea level
MTBE	methyl-tertiary-butyl-ether
MW	monitoring well
NAAQS	National Ambient Air Quality Standards
NCAC	North Carolina Administrative Code
NC DOT	North Carolina Department of Transportation
NC DEHNR	North Carolina Department of Environment, Health, and Natural Resources
NCMFC	North Carolina Marine Fisheries Commission
NCP	National Contingency Plan
NCWP	Near Coastal Waters Program
NCWQC	North Carolina Water Quality Criteria
NCWQS	North Carolina Water Quality Standards
NCWRC	North Carolina Wildlife Resources Commission

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

ND	nondetect
NEESA	Naval Energy and Environmental Support Activity
NOAA	National Oceanic Atmosphere Administration
NOAEL	no-observed-adverse-effect-level
NEP	National Estuary Program
NPL	National Priorities List
NPW	net present worth
O&G	oil and grease
O&M	operations and maintanence
OU	operable unit
PAH	polynuclear aromatic hydrocarbons
PCB	polychlorinated biphenyls
PCE	tetrachloroethene
PEF	particulate emissions factor
POLs	petroleum, oil, lubricants
POTW	publicly owned treatment works
ppb	parts per billion
ppm	parts per million
PRAP	Proposed Remdial Action Plan
PRGs	preliminary remediation goals
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
QI	quotient index
RA	risk assessment
RAAs	remedial action alternatives
RBCs	region III risk-based concentrations
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RG	remediation goals
RGO	remediation goal options
RI/FS	Remedial Investigation/Feasibilty Study
RL	remediation levels
RME	responsible maximum exposure
ROD	Record of Decision
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SMCL	secondary maximum contaminant level
SOP	standard operating procedure
SQC	sediment quality criteria
SSV	sediment screening value

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

SVE	soil vapor extraction
SVOCs	semivolatile organic compounds
TAL	target analyte list
TBC	to be considered
TCE	trichloroethene
TCL	target compound list
TCLP	toxicity characteristics leaching procedure
TDS	total dissolved solids
TICs	tentatively identified compounds
TPH	total petroleum hydrocarbons
trans-1,2-DCE	trans-1,2-dichloroethene
TRV	terrestial residential value
TSS	total suspended solids
UCL	upper confidence level
UF	uncertainty factor
µg/L	micrograms per liter
µg/kg	micrograms per kilogram
USC	United States Code
USCS	Unified Soils Classification System
USDI	United States Department of the Interior
USEPA	United States Enviromemtal Protection Agency
USGS	United States Geological Survey
UST	underground storage tank
VOCs	volatile organic compounds
WOE	weight-of-evidence
WS	Wilderness Society
WQS	water quality standards
WQSV	water quality screening values

7.0 INTRODUCTION TO SITE 28 - HADNOT POINT BURN DUMP

Section 7.0 marks the beginning of the Site 28 portion of the FS. This section presents the organization of the Site 28 report and the following background information: a site description, a site history, previous investigations, surface water hydrology and drainage features, geology, hydrogeology, extent of site contamination, a summary of the human health risk assessment, and a summary of the ecological risk assessment. More extensive Site 28 background information is provided in the RI report (Baker, 1995).

7.1 Report Organization

The Site 28 portion of the FS is organized into five main sections: (1) an introduction to the site, (2) the development of remediation goal options, remediation levels, and remedial action objectives, (3) the identification and preliminary screening of remedial action technologies, (4) the development and screening of remedial action alternatives, and (5) the detailed analysis of remedial action alternatives.

7.2 Site Description

Site 28, the Hadnot Point Burn Dump, is located along the eastern bank of the New River. The site is within the Hadnot Point development area, approximately one mile south of HPIA on the Mainside portion of MCB, Camp Lejeune.

Figure 7-1 presents a site map. As shown, the site is surrounded by the Hadnot Point Sewage Treatment Plant (STP), to the north, wooded areas to the east and south, and the New River to the west. Cogdels Creek flows into the New River at Site 28 and forms a natural divide between the eastern and western portions of the site. Vehicle access to the site is via Julian C. Smith Boulevard near its intersection with O Street, and the eastern and western portions of the site are served by an improved gravel road.

A majority of the estimated 23 acres that constitute the site are used for recreation and physical training exercises. The site is predominantly comprised of two lawn and recreation areas, known collectively as the Orde Pond Recreation Area, that are separated by Cogdels Creek. Picnic pavilions, playground equipment, and a stocked fish pond (Orde Pond) are located within this recreation area and they are regularly used by base personnel and their families. In addition, field exercises and physical training activities frequently take place at the recreation area.

The STP is located on and adjacent to Site 28. A portion of the STP facility extends across Cogdels Creek, from west to east. The STP operates a number of clarifying, settling, and aeration ponds that are located on either side of Cogdels Creek. Both operational areas of the STP are fenced with six-foot chain link. The treated water from the STP discharges into the New River via an outfall pipe approximately 400 feet from the shoreline.

7.3 Site History

Site 28 operated from 1946 to 1971 as a burn area for a variety of solid wastes generated on base. Reportedly, industrial waste, trash, oil-based paint, and construction debris were burned then covered with soil. In 1971, the burn dump ceased operations, and was graded and seeded with grass.

The approximate extent of this burn dump is identified in Figure 7-1. The total volume of fill within the dump is estimated to be between 185,000 and 375,000 cubic yards. This estimate was based upon a surface area of 23 acres and a depth ranging from five to ten feet (Water and Air Research, 1983).

7.4 Previous Investigations

This section presents a summary of previous investigations conducted at Site 28. These investigations include an Initial Assessment Study, a Confirmation Study, additional investigations for scoping a Remedial Investigation, an Aerial Photographic Investigation, and a Remedial Investigation.

7.4.1 Initial Assessment Study

An IAS was conducted by Water and Air Research, Inc. in 1983. The IAS identified a number of sites at MCB, Camp Lejeune as potential sources of contamination, including Site 28. The IAS reviewed historical records and aerial photographs, performed field inspections, and conducted personnel interviews to evaluate potential hazards at various sites on MCB, Camp Lejeune. The IAS recommended performing a confirmation study at Site 28 to evaluate the necessity of conducting mitigating actions or cleanup operations.

7.4.2 Confirmation Study

A two part confirmation study was conducted by Environmental Science and Engineering, Inc. from 1984 through 1987. The Confirmation Study was executed in two separate stages: a Verification Step performed in 1984 and a Confirmation Step performed in 1986 and 1987. The purpose of the Confirmation Study was to investigate potential contaminant source areas identified in the IAS Report. At Site 28, the study focused on the presence of potential contaminants in groundwater, surface water, sediment, and fish tissue.

Metals were the most prevalent contaminant group encountered during both rounds of the investigation. Groundwater, surface water, and sediment samples suggested that metal contaminants, with the exception of mercury in surface water, originated from the disposal area at the site. Concentrations of metals in groundwater generally decreased from one sampling round to the next, during 1984 and 1986. Metal concentrations in sediment, however, increased from the first to the second sampling round. Surface water samples obtained from Cogdels Creek identified cadmium and mercury at concentrations that, in certain cases, exceeded state surface water standards. Lead was also detected at concentrations exceeding regulatory limits in sediment samples collected from Cogdels Creek and shallow groundwater samples collected during both the 1984 and 1986 investigations. In addition, mercury was detected in surface water and shallow groundwater samples. The distribution of mercury throughout the site suggests that the contaminant was present at the site, but most likely migrated from an upstream location.

VOCs were detected in groundwater samples collected from monitoring well 28-GW01 during both rounds of the investigation; the sample exceeded regulatory limits for TCE and vinyl chloride. Volatile contaminants were not detected in groundwater samples from any of the other three wells. Results indicated that O&G were consistent in groundwater and sediment samples obtained during both rounds of sampling.

Upon completion of the Confirmation Study, a Site Summary Report was written to summarize the result of the study. The report recommended that further characterization of groundwater and surface water quality be implemented to complete the RI/FS process. Additional surface water and sediment investigations of Cogdels Creek, between Site 28 and HPIA, were also recommended to evaluate possible upstream sources of contamination. Following the characterization of potentially impacted environmental media, a risk assessment was recommended to identify unacceptable risks to human health and the environment.

7.4.3 Additional Investigations

Additional investigations conducted by Baker included groundwater sampling in April 1993 to support future RI scoping activities, and a surface water and sediment investigation of Cogdels Creek in 1993.

Based on analytical results from these additional investigations, the most prevalent contaminants found in environmental media at Site 28 were PAH compounds, pesticides, and metals. PAH compounds were detected in sediment samples from both Cogdels Creek and the New River. A number of maximum PAH concentrations were detected in a sediment sample from the New River, downstream of Site 28. PAH compounds were also detected upstream of the site, in sediments collected from Cogdels Creek. Three PAH compounds were also identified, at low concentrations, in a groundwater sample collected from well 28-GW02, adjacent to the western disposal area and the mouth of Cogdels Creek.

Pesticides were detected in both surface water and sediments from Cogdels Creek and the New River. The proportional concentrations and widespread occurrence of detected pesticides, particularly in sediments, suggests that their presence was most likely the result of spraying activities rather than disposal. Positive detections of pesticides in sediments were not exceptionally high or concentrated in any one area. Pesticide concentrations of this magnitude have historically been encountered throughout MCB, Camp Lejeune.

Inorganic analytes such as cadmium, chromium, and lead were, in general, found throughout the various environmental media at Site 28. Total metals were frequently detected at concentrations in excess of both NCWQS, National Oceanographic and Aeronautic Administration (NOAA) criteria, and MCL criteria in surface water, sediment, and groundwater samples.

7.4.4 Aerial Photographic Investigation

In August of 1992, an interim aerial photographic investigation report was completed by the USEPA's Environmental Photographic Interpretation Center (EPIC). The investigation was performed at the request of the Superfund Support Section of USEPA Region IV.

Aerial photographs, which depict surface conditions over time at Site 28, were used to identify areas of concern (AOCs) and verify the occurrence of waste disposal activities. Where possible, disposal activities were noted in the EPIC report and annotated on aerial photographs.

7.4.5 Remedial Investigation

Baker conducted an RI at OU No. 7 from late March through early May 1994. As part of the RI, additional groundwater sampling was conducted in December 1994. The purpose of the RI was to evaluate the nature and extent of the threat to public health and the environment caused by the release of hazardous substances, pollutants, or contaminants and to support the Feasibility Study documented in this report.

At Site 28, soil, groundwater, surface water, sediment, benthic, and aquatic investigations were conducted. Figure 7-2 depicts the locations of environmental samples collected during the RI.

The field investigation focused on areas which were potentially impacted by previous disposal practices. The potential areas of concern were identified from record searches and interviews with base personnel, review of historical aerial photographs, previous investigation data, and information obtained during the pre-investigation scoping. Consequently, the sampling programs for each media were developed based on these findings.

As part of the RI, field data related to the physical characteristics (e.g., hydrologic, geologic, and hydrogeological conditions) of Site 28 were analyzed and interpreted to assist in determining contaminant movement. Sections 7.5, 7.6, and 7.7 of this FS summarize the physical characteristics at the site. Data collected from Site 28 were also analyzed and interpreted to evaluate the extent of contamination for each media investigated. Section 7.8 of this FS summarizes the results of laboratory analyses and describes the extent of contamination at the site. Human health and ecological risk assessments were also conducted as part of the RI to determine potential site risks. Sections 7.9 and 7.10 summarize the results of the risk assessments.

7.5 Surface Water Hydrology and Drainage Features

Cogdels Creek, the New River, and Orde Pond serve as the main surface water bodies in the vicinity of Site 28. Of these bodies, the New River and Cogdels Creek have the most influence on surface drainage in the area. Drainage within the central and eastern portions of the site are influenced by Cogdels Creek and drainage within the western portion of the site is influenced by the New River. Based on surface water and groundwater elevation data from the RI, Cogdels Creek appears to receive groundwater recharge from the Site 28 area. Areas along the New River and Cogdels Creek where the elevations are below 10 feet are within the 100-year flood plain.

7.6 Geology

Based on the RI, shallow soils (less than 30 feet) underlying Site 28 consist of predominantly fill material/debris, sand, and silty-sand, with minor amounts of silt (5 to 20 percent) and clay (5 to 10 percent). The appearance of the soils encountered at Site 28 are generally consistent with soils described for Site 1 ("undifferentiated" Formation). Based on the USCS, the shallow soils at Site 28 classify as SM. Results from the standard penetration tests indicated relative densities ranging from very loose to dense.

Deeper soils at Site 28 consisted of sand and sand-shell mixtures to a depth of 94 to 112 feet bgs. A layer of sand and marl, marking the top of the River Bend Formation, was also encountered between 40 and 65 feet in well boring 28-GW01DW. A thin layer of sandy-clay was encountered at approximately 92 to 94 feet bgs. A s noted for Site 1, the soil appeared visually to have a permeability high enough to permit vertical groundwater movement into the deeper aquifer.

7.7 Hydrogeology

The hydrogeologic setting was evaluated during the RI by installing a network of shallow and deep monitoring wells throughout the eastern and western areas of the site, and by installing staff gauges in Cogdels Creek and Orde Pond. Additionally, information on the hydraulic characteristics of the surficial aquifer near Site 28 were evaluated during a pump test conducted by Baker at a UST site located adjacent to the HPIA sewage treatment plant.

The hydrogeologic setting in the vicinity of Site 28 consists of several aquifer system. For this study, the most upper two aquifer systems were investigated, the surficial and Castle Hayne. The surficial aquifer lies within the "undifferentiated" deposits of sand, silt, and clay. The thickness of the surficial aquifer in the vicinity of Site 28 is approximately 40 feet, based on the occurrence of the sand and marl mixtures which mark the upper portion of the River Bend Formation. The underlying Castle Hayne aquifer consists of sand, silty clay, shell hash, and during the test borings, there does not appear to be a significant hydraulic separation of the aquifers since no distinct groundwater retarding unit was encountered.

The hydrogeologic conditions were evaluated by installing a network of shallow and deep monitoring wells throughout eastern and western areas of Site 28 and installing staff gauges in Cogdels Creek and Orde Pond. Additionally, information on aquifer characteristics for the surficial aquifer was obtained from a pump test conducted by Baker at a UST site located adjacent to the HPIA sewage treatment plant.

Two rounds of groundwater and surface water level measurements were collected (groundwater contour maps are provided in the RI report). The initial round of measurements (March 19, 1994) were collected prior to the investigation and, therefore, only include the existing wells. Groundwater elevations measured in the shallow wells on May 10, 1994 varied from 1.00 to 3.53 feet above msl. In the existing monitoring wells where two rounds of measurements were collected (March 19 and May 10, 1994), the water levels declined between 0.16 and 0.38 feet. This slight decline in the water table appears to be the result of normal daily and/or seasonal fluctuations. Groundwater elevations measured in the deep wells on May 10, 1994 varied from 1.36 to 2.47 feet above msl. Slightly different groundwater elevations between the surficial and deeper aquifers were measured. The elevation differentials between the surfical and deep aquifers have created a slight vertical gradient which is noteworthy since this may contribute to the vertical migration of contaminants.

An estimate of the horizontal groundwater gradient for the surficial and Castle Hayne aquifers was calculated from the May 10, 1994 elevation data. Based on the May 10, 1994 data, the estimated horizontal gradients for the surficial (toward Cogdels Creek) and deep (toward the New River) aquifers are 0.004 and 0.0013, respectively. Both values indicate a relatively flat water table surface. Groundwater flow velocity within the surficial aquifer was estimated at 4.1×10^{-2} feet/day (15 feet/year).

7.7.1 Potable Water Supply Wells

Based on information obtained from a USGS publication (Harned, et al., 1989) and interviews with Base personnel, no potable water supply wells were identified within a one-mile radius of Site 28.

7.8 Extent of Contamination

This section addresses the extent of contamination at Site 28. The extent of contamination is based on analytical findings from the sampling of soil, groundwater, surface water, sediment, and aquatic organisms during the RI. All sampling locations that are referred to in this section are identified on Figure 7-2. Please note that concentrations denoted with a "J" are estimated analytical results.

7.8.1 Soil

VOCs were found in one surface soil sample and two subsurface samples at very low concentrations. The VOCs benzene, tetrachloroethene, and 1,1,1-trichloroethane were each detected once within the 72 soil samples collected at Site 28. Based upon their wide dispersion, infrequent detection, and low concentration, the occurrence of VOCs in soils at Site 28 did not appear to be the result of past disposal practices.

VOCs, SVOCs, pesticides, PCBs, and inorganics were detected in surface and/or subsurface soil samples at Site 28.

SVOCs within soil samples at Site 28 appeared to be the most directly linked, among organic compounds, to past disposal practices. Several SVOCs were identified in both surface and subsurface soil samples, primarily from the western disposal area. A majority of SVOCs detected in soil samples were PAH compounds, most probably resulting from combustion of waste material or refuse. Several of the SVOCs were detected at concentrations greater than 1,000 µg/kg.

The pesticides dieldrin, 4,4'-DDE, 4,4'-DDD, 4,4'-DDT, alpha-chlordane, and gamma-chlordane appeared to be the most widely scattered contaminants within soils at Site 28. Each of the five pesticides were detected in at least 15 of the 72 soil samples. The pesticide 4,4'-DDE was the most prevalent, with 44 positive detections ranging from 3.1 J to 1,600 µg/kg. The highest pesticide concentration was that of 4,4'-DDT at 7,300 µg/kg. In general, higher concentrations of those pesticides more frequently detected, were limited to the western portion of the study area, and in particular among borings 28-GW01, 28-GW01DW, and SB12.

Three PCB contaminants, aroclor 1242, aroclor 1254, and aroclor 1260, were detected in soil samples obtained from borings at Site 28. The maximum PCB concentration was 1,300 µg/kg from the pilot test boring SB15.

Inorganic elements were detected in both surface and subsurface soil samples from the western portion of the study area at concentrations greater than one order of magnitude above of base-specific background levels. In general, elevated metal concentrations were limited to soils obtained from the western portion of the study area. The metals copper, lead, manganese, and zinc were observed at maximum concentrations greater than two orders of magnitude above base-specific background levels. The same four metals had several positive detections in excess of the one order of magnitude level.

7.8.2 Groundwater

VOCs, SVOCs, pesticides, and inorganics were detected in the groundwater at Site 28.

Positive detections of VOCs in groundwater were limited to the central western portion of the study area. The VOCs chloroform, ethylbenzene, and xylenes were detected in a single shallow groundwater sample obtained from temporary well 28-TGWPA.

SVOCs were detected in five of ten shallow groundwater samples obtained during the first sampling round from the western portion of the study area but no specific SVOC was detected in more than two wells. The maximum SVOC concentration, 99 μg/L, was detected within the sample from temporary monitoring well 28-TGWPA, located in the central western portion of the study area. SVOC analyses of groundwater samples were not performed as part of the second sampling round.

The organic pesticide compounds 4,4'-DDE, 4,4'-DDD, 4,4'-DDT, and gamma-chlordane were each detected at least once within samples obtained from six shallow monitoring wells located on the western portion of Site 28, during the first sampling round. Pesticides 4,4'-DDE and 4,4'-DDD were detected within five and six shallow groundwater samples, respectively. The highest pesticide concentration detected was 9 μg/L of 4,4'-DDD, within the sample obtained from monitoring well 28-GW07. A second round of groundwater samples was obtained from those monitoring wells which presented evidence of pesticide contamination during the first sampling round. However, groundwater samples obtained during the second sampling round did not exhibit pesticides.

Inorganic elements were the most prevalent and widely distributed contaminants in groundwater and were found throughout the site. Concentrations of TAL total metals, in samples obtained during both sampling rounds, were generally higher in shallow groundwater samples than in samples collected from the deeper aquifer. Lead was detected, and confirmed by the second sampling round, within only one (28-GW08) of the shallow and deep groundwater samples at a concentration which exceeded the NCWQS and federal action level. Lead was also detected during the first sampling round in a sample retained from temporary well 28-TGWPA at a concentration which exceeded the NCWQS and federal action level. Iron and manganese were the most prevalent inorganic elements detected during both sampling rounds. Concentrations of iron and manganese were confirmed by the second sampling round to have exceeded either federal or state standards within 7 groundwater samples.

7.8.3 Surface Water

7.8.3.1 Orde Pond

Organic compounds (VOCs, SVOCs, pesticides, and PCBs) were not detected in the two samples collected at Orde Pond. Fourteen of 23 TAL total metals were positively identified in these samples. The thallium concentration in sample 28-OP-SW02, obtained from the eastern end of Orde Pond, exceeded the NOAA chronic screening value of 4.0 μg/L by only 0.7 μg/L. No other total metal concentrations were in excess of chronic screening values.

7.8.3.2 Cogdels Creek

Organic compounds (VOCs, SVOCs, pesticides, and PCBs) were not detected in the seven samples collected at Cogdels Creek. Laboratory analyses of the samples indicate that 14 of 23 possible total metals were positively detected. Lead was the only metal identified at a concentration in excess of the NOAA chronic screening values. Lead was detected within each of the seven surface water samples in excess of the 1.32 μg/L screening value. The maximum concentration of lead, 4.2 μg/L, was observed in a sample collected upstream of the study area. None of the positive lead detections exceeded the maximum base-specific surface water background concentration of 10.4 µg/L. No other total metal concentrations in the seven surface water samples exceeded chronic screening values.

7.8.3.3 New River

A positive detection of one SVOC was observed among the five New River surface water samples. The SVOC phenanthrene was detected at a trace concentration of 1 µg/L in sample 28-NR-SW02, located slightly upstream of the study area. The pesticide organic compounds 4,4'-DDE and 4-4'-DDD were detected in surface water sample 28-NR-SW03, located adjacent to the western disposal area, at estimated concentrations of 0.04 J and 0.05 J µg/L, respectively.

Sixteen of 23 TAL total metals were positively identified in the five surface water samples collected from the New River. Copper, lead, thallium, and zinc were each identified at concentrations in excess of NOAA chronic screening values. Thallium and zinc were detected in excess of surface water screening values in one sample each. Copper and lead each exceeded screening values in a total of three surface water samples. The thallium concentration in sample 28-NR-SW04, located at the mouth of Cogdels Creek, exceeded the NOAA chronic screening value of 4.0 µg/L by 1.6 µg/L. Copper and lead were detected, among the five New River surface water samples, at maximum concentrations of 181 and 23.4 µg/L, respectively. Both maximum detections of copper and lead were observed in sample 28-NR-SW01, located approximately 100 yards upstream of the study area. The sample 28-NR-SW03, collected adjacent to the western disposal area, had copper, lead, and zinc concentrations of 6.6, 3.1, and 363 µg/L, respectively. Each of these three detections were in excess of the established chronic surface water screening values for copper, lead, and zinc (6.5, 1.32, and 58.9 µg/L, respectively). No other total metal concentrations in the seven surface water samples exceeded chronic screening values.

7.8.4 Sediment

7.8.4.1 Orde Pond

VOCs and SVOCs were not detected among the samples retained for analysis from Orde Pond. The pesticide 4,4'-DDD was detected at an estimated concentration of 8.3 J µg/kg within sample 28-OP-SD01, located near the western bank of Orde Pond. The positive detection of 4,4'-DDD at this location is in excess of the NOAA Effects Range - Low (ER-L) screening criteria of 2 µg/kg. No total metal concentrations in any of the Orde Pond samples exceeded NOAA screening values.

7.8.4.2 Cogdels Creek

Carbon disulfide was the only VOC detected among the 14 Cogdels Creek sediment samples. The maximum detection of carbon disulfide, 13 J µg/kg, was identified within sample 28-CC-SD07, collected upstream of the study area. The other detection of carbon disulfide was from a sample located downstream of the site, near the mouth of Cogdels Creek.

A number of SVOCs were identified within Cogdels Creek sediment samples. A total of 12 SVOCs were detected in the 14 Cogdels Creek samples. Nine of the 12 detected SVOCs were identified exclusively in samples 28-CC-SD03 and 28-CC-SD02, located adjacent to and downstream of the disposal area. The maximum semivolatile concentration, 1,700 µg/kg, was that of both BEHP and the PAH benzo(a)pyrene. Benzo(a)pyrene was positively detected within nine of the 14 samples submitted for laboratory analysis. Five of those nine positive benzo(a)pyrene detections exceeded the NOAA screening value of 400 µg/kg, all within samples collected upstream of the study area. The phenanthrene concentration in sample 28-CC-SD03, located adjacent to the study area, exceeded the NOAA screening value of 225 µg/kg by 35 µg/kg.

The organic pesticides 4,4'-DDE and 4,4'-DDD were detected within nine and seven of the 14 Cogdels Creek sediment samples, respectively. Each of the detections found upstream and downstream of the study area were in excess of NOAA screening values. Both 4,4'-DDE and 4,4'-DDD were detected at their respective maximum concentrations at sample station 28-CC-SD01, located at the mouth of Cogdels Creek. The positive 4,4'-DDE and 4,4'-DDD detections of 200 J and 450 J µg/kg, respectively, exceeded the NOAA screening value for both pesticide contaminants of 2 µg/kg. The pesticides 4,4'-DDT, alpha-chlordane, and gamma-chlordane were also detected at concentrations which, in each case, exceeded screening values. The three pesticides were observed in only two samples retained from upstream locations. The estimated maximum concentrations of 4,4'-DDT, alpha-chlordane, and gamma-chlordane were 50 J, 5.9 NJ, and 8.4 J µg/kg, respectively.

Twenty-two of 23 TAL total metals were positively identified in the 14 sediment samples retained from Cogdels Creek (selenium was not detected). Lead, mercury, silver, and zinc were each identified at concentrations in excess of NOAA ER-L screening values. Silver and zinc were detected in excess of sediment screening values within one and two Cogdels Creek sediment samples, respectively. Lead and mercury exceeded screening values in seven and four of the 14 Cogdels Creek sediment samples. The silver concentration of 2 mg/kg in sample 28-CC-SD04, located adjacent to the disposal area, exceeded the NOAA screening value for of 1.0 mg/kg. Lead and mercury were detected, among the 14 Cogdels Creek sediment samples, at maximum concentrations of 202 and 0.41 mg/kg, respectively. The maximum detection of lead was observed in sample 28-CC-SD04, located adjacent to the study area. Mercury was observed at a maximum concentration at sample station 28-CC-SD01, located near the mouth of Cogdels Creek. No other total metal concentrations among the 14 Cogdels Creek sediment samples exceeded screening values.

7.8.4.3 New River

Carbon disulfide was the only VOC detected among the ten sediment samples collected from the New River. The only detection of carbon disulfide, 2 J µg/kg, was identified within sample 28-NR-SD02, located slightly upstream of the study area. No other VOCs were detected.

A number of SVOCs were identified within sediment samples retained from the New River. A total of 17 SVOCs, 13 of which were PAHs, were detected in the ten New River sediment samples. Twelve of the 17 positively detected SVOCs were identified at their respective maximum concentrations in sample 28-NR-SD01, located approximately 100 yards upstream of the study area. The maximum PAH concentration, 2,100 µg/kg, was that of chrysene. Chrysene was positively detected within five of the sediment samples submitted for laboratory analysis from the New River. Three of those five positive chrysene detections exceeded the NOAA screening value of 400 µg/kg. Phenanthrene, anthracene, fluoranthene, pyrene, benzo(a)anthracene, and benzo(a)pyrene were also detected within sediment samples in excess of sediment screening values. In general, concentrations of SVOCs in the two samples obtained adjacent to the western disposal area were lower than those detections observed both upstream and downstream of the study area.

The organic pesticides 4,4'-DDE, 4,4'-DDD, 4,4'-DDT, alpha-chlordane, and gamma-chlordane were each detected in either two or three of the ten New River sediment samples. Each of the detections were in excess of NOAA screening values. Both 4,4'-DDE and 4,4'-DDD were detected at their respective maximum concentrations at sample station 28-NR-SD01, located upstream of the study area. The positive 4,4'-DDE and 4,4'-DDD detections of 8.5 and 15 µg/kg, respectively, exceeded the NOAA screening value for both pesticide contaminants of 2 µg/kg. The pesticides 4,4'-DDT, alpha-chlordane, and gamma-chlordane were also detected at concentrations which, in each case, exceeded screening values. Alpha- and gamma-chlordane were observed in only two samples retained from the New River, located adjacent to and downstream of the site. The maximum concentrations of 4,4'-DDT, alpha-chlordane, and gamma-chlordane were 300, 6.6 J, and 4.6 J µg/kg, respectively.

Nineteen of 23 TAL total metals were positively identified in the ten New River sediment samples (beryllium, cadmium, selenium, and thallium were not detected). Antimony, copper, lead, and silver were each identified at concentrations in excess of NOAA ER-L screening values. Each of the four metal contaminants were detected in excess of sediment screening values within two samples retained from the New River. Antimony, copper, and lead were each detected at their respective maximum concentrations among the ten New River samples at station 28-NR-SD01, located upstream of the study area. The copper concentration of 1,340 mg/kg in sample 28-NR-SD01 exceeded the NOAA screening value of 70 mg/kg. Antimony and lead were detected at maximum concentrations of 263 and 38,800 mg/kg, respectively. The NOAA screening values for antimony and lead are 2 and 35 mg/kg, respectively. Concentrations of silver in samples 28-NR-SD03, 3.4 J mg/kg, and 28-NR-SD05, 3.1 J mg/kg, slightly exceeded the NOAA value of 1 mg/kg. No other total metal concentrations among the ten New River sediment samples exceeded screening values.

7.8.5 Aquatic Organisms

7.8.5.1 Orde Pond

The pesticides 4,4'-DDE and alpha-chlordane were detected among the whole body tissue samples collected in Orde Pond. The maximum pesticide concentration was that of 4,4'-DDE at 38 µg/kg. Positive detections of VOCs and SVOCs in whole body tissue samples were rejected due to laboratory contamination. Total xylenes were detected in the American eel tissue sample at an estimated concentration of 8 J µg/kg.

Sixteen metals were detected in the whole body tissue samples collected from Orde Pond. The metals antimony, arsenic, chromium, copper, mercury, selenium, and zinc were found in Orde Pond biotic samples at maximum concentrations of 0.17 J, 0.10 J, 10.7 J, 1.2 J, 0.18 J, 0.45 J, and 26.3 J µg/kg, respectively.

The majority of VOC and SVOC analyses from Orde Pond fillet samples were rejected due to laboratory interference. Therefore, the results of those analyses are inconclusive. There were no pesticides or PCBs detected in the fillet tissue samples, however.

Thirteen metals were detected in the fillet tissue samples collected from Orde Pond. The priority pollutant metals arsenic, chromium, copper, mercury, selenium, and zinc were detected in Orde Pond fillet samples at maximum concentrations of 0.1 J, 0.63 J, 0.22 J, 0.23 J, 0.32 J, and 22.9 µg/kg, respectively. The maximum tissue levels of metals in fillet tissue samples were found in the largemouth bass, blue gill, and redear sunfish.

7.8.5.2 New River

The pesticides beta BHC, 4,4'-DDE, 4,4'-DDD, endrin aldehyde, and alpha-chlordane were detected among the whole body stripped mullet, summer flounder, and Atlantic menhaden in New River tissue samples. Positive detections of VOCs and SVOCs were considered common laboratory contaminants.

Twenty of 23 TAL metals were detected in New River whole body tissue samples that were obtained from stripped mullet, summer flounder, and Atlantic menhaden. The metals antimony, arsenic, beryllium, cadmium, chromium, copper, mercury, selenium, silver, and zinc were detected in New River whole body samples at maximum concentrations of 0.23 J, 1.2 J, 0.007 J, 0.02 J, 5.4 J, 4.6 J, 0.014 J, 0.41 J, 0.10 J, and 1.8 J µg/kg, respectively.

The pesticides detected in the fillet tissue samples were identical to the pesticides found in the whole body samples. The VOCs and SVOCs detected in the whole body samples were considered common laboratory contaminants.

Fillet tissue samples, as with whole body samples, from the stripped mullet, summer flounder, spotted sea trout and black drum contained metals. Similar concentrations of metals were found in both fillet and whole body samples. Although metals were detected in all species, not all species contained the same metals.

7.9 Human Health Risk Assessment

As part of the RI, a human health risk assessment was conducted to assess potential risks associated with contaminants at Site 28. The results indicated that metals in groundwater, subsurface soil, and sediment were driving the potential noncarcinogenic and carcinogenic risks at the site. These metals were manganese in groundwater, antimony, arsenic, copper, and zinc in subsurface soil, and antimony in the sediment of the New River.

In the current case, potential noncarcinogenic and carcinogenic risks to the military personnel, recreational adult, and fisherman were within acceptable risk levels. For the current recreational child receptor , there was a potential noncarcinogenic risk from New River sediment. The noncarcinogenic risk from the ingestion pathway was 1.2, which is slightly greater than the acceptable risk level of one. The COPC driving this noncarcinogenic risk was antimony.

In the future case, the total potential noncarcinogenic risk to the child receptor, 23, exceeded the acceptable risk level of one. This risk was attributed to exposure to groundwater, subsurface soil, and sediment from the New River. For the adult receptor, there were noncarcinogenic and carcinogenic risks from exposure to groundwater. The risks to the construction worker were within acceptable risk levels.

It is important to note that due to the segregation of the soil noncarcinogenic risks based on the effects on different target organs, the soil noncarcinogenic risk may be an overestimate. It also is important to note that the future exposure scenario was based on potential residential development of Site 28. At present, the site is a recreational/picnic area located within training areas on the base. It is highly unlikely that a residence will be implemented on-site in the foreseeable future. Consequently, exposure to subsurface soil and groundwater under a residential scenario is highly conservative and unlikely given the present site conditions. It follows that the potential risks associated with this exposure scenario are conservative and may be overestimated values.

In terms of lead health impacts, use of the lead uptake biokinetic (UBK) model indicated that exposure to surface soil, subsurface soil and groundwater at this site generated blood lead levels in children that were within acceptable levels.

7.10 Ecological Risk Assessment

In addition to the human health RA, an ecological RA was also conducted during the RI to assess potential ecological impacts associated with contaminants at Site 28. Metals and pesticides appeared to be the most significant site related COPCs that could have the potential to affect the integrity of the aquatic receptors at Site 28. For the terrestrial receptors at Site 28, metals appeared to be the most significant site related COPC that could have the potential to affect their integrity. Although the American Alligator had been observed at Site 28, potential adverse impacts to this threatened or endangered species was low due to the low levels of most contaminants in its critical habitat.

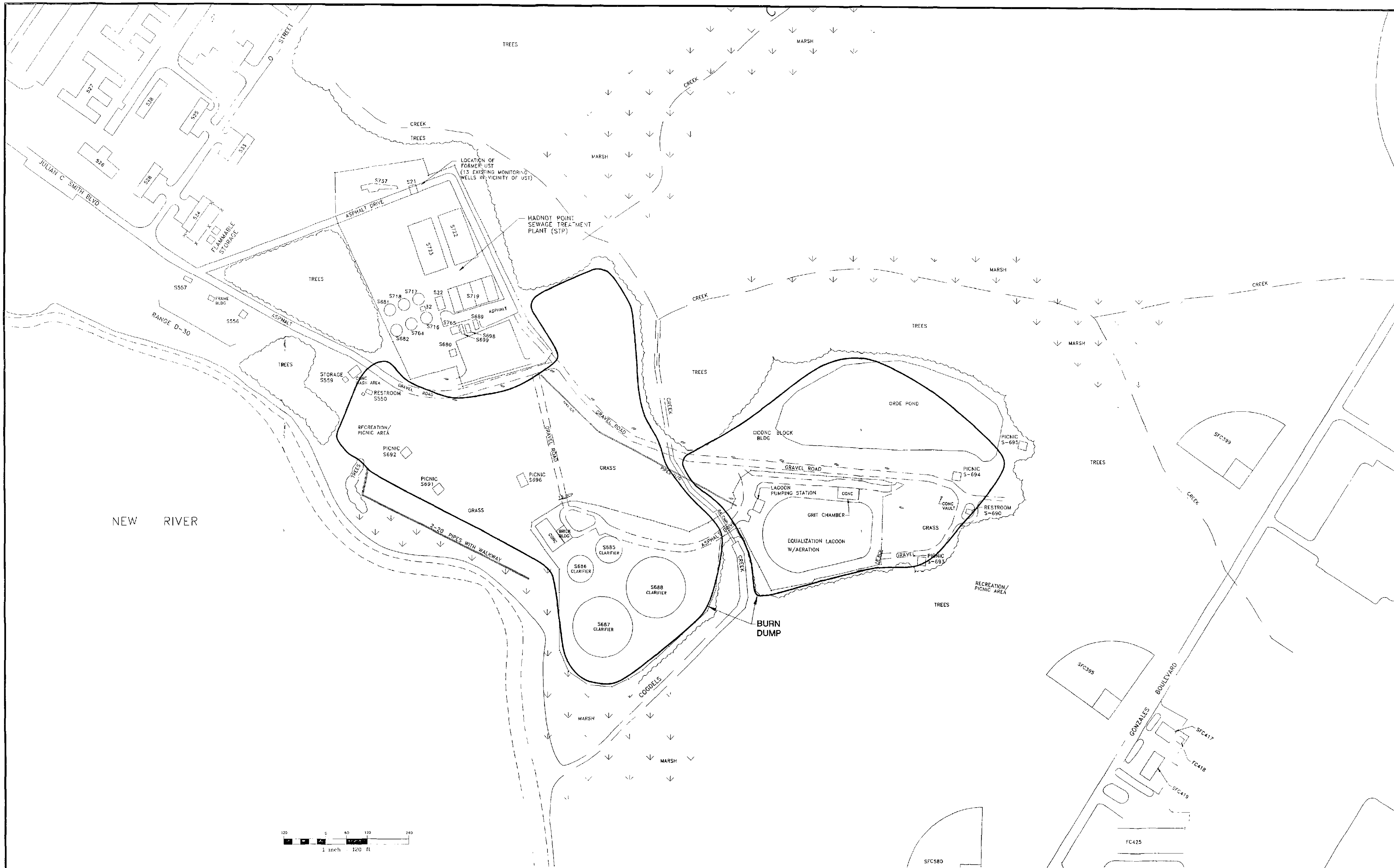
In the New River surface water, copper exceeded aquatic reference values but at levels that were indicative of a low potential for risk. Lead and zinc only exceeded unity slightly at a single station. Copper exceeded the surface water reference values in Cogdels Creek, and aluminum exceeded the surface water reference values in Orde Pond. However, these exceedences were only slightly above the reference values.

In the sediment, lead exceeded the sediment aquatic reference values only once in Cogdels Creek at a low level but exceeded its sediment aquatic reference values significantly in the New River at one station. Antimony exceeded its sediment aquatic reference values moderately at the same station in the New River. This station may be associated with runoff from the active firing range. Pesticides exceeded the sediment aquatic reference values throughout Cogdels Creek with the highest exceedences in the lower reach of the creek near the confluence with the New River. These exceedences represent a moderate potential for risk to aquatic receptors. The levels detected in the sediment may be a result of routine application in the general vicinity of Site 28, especially near the sewage treatment plant and recreational area.

Results of the analysis of benthic macroinvertebrates and fish populations indicated that Cogdels Creek and this reach of the New River support an aquatic community that is representative of a tidally-influenced freshwater and estuarine ecosystem with both freshwater and marine species. The absence of pathologies observed in the fish sampled from Cogdels Creek and the New River indicated that the surface water and sediment quality does not adversely impact the fish community. The benthic community demonstrated the typical tidal/freshwater species trend of primarily chironomids and oligochaetes in the upper reaches of Cogdels Creek and polychaetes and amphipods in the lower reaches of Cogdels Creek and in the New River. Species representative of both tolerant and intolerant taxa were present, and the overall community composition did not indicate a benthic community adversely impacted by surface water and sediment quality.

During the habitat evaluation, no areas of vegetation stress or gross impacts from site contaminants were noted. Based on the soil toxicity data for several metals (cadmium, chromium, copper, manganese, nickel, and zinc), these contaminants at Site 28 may decrease the integrity of terrestrial invertebrates or plants at the site. Based on the evaluation of the deer, rabbit, fox, raccoon, and quail receptors, there did appear to be an ecological risk to terrestrial vertebrate receptors. This risk is expected to be significant if greater exposure to these contaminants results.

SECTION 7.0 FIGURES



LEGEND
VEGETATION
FENCE
CREEK/DRAINAGE
MARSH

SOURCE: LANTDIV, FEBRUARY 1992

DATE	NOVEMBER 1994
SCALE	1" = 120'
DRAWN	REL
REVIEWED	TFT
S.O. #	62470-231-0000
CADD #	231138FS

NORTH

FEASIBILITY STUDY CTO-0231
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

BAKER ENVIRONMENTAL, Inc
Coraopolis, Pennsylvania

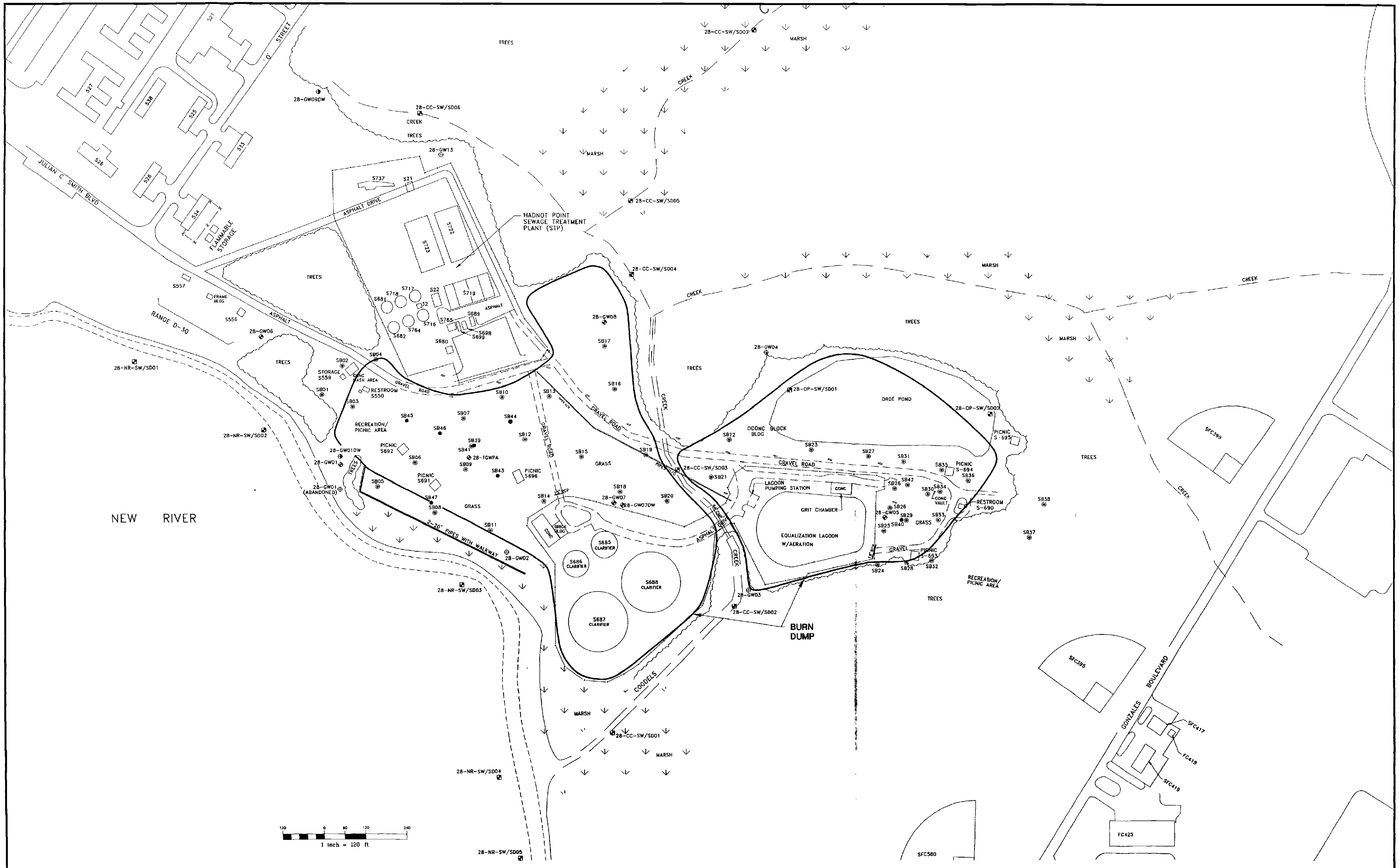
Baker Environmental, Inc

SITE MAP
SITE 28 – HADNOT POINT BURN DUMP

SCALE 1" = 120'   DATE NOVEMBER 1994

FIGURE No
7-1

01476DDB1X



LEGEND

- 28-GW02 EXISTING SHALLOW MONITORING WELL
- 28GW01 NEWLY INSTALLED SHALLOW MONITORING WELL (BAKER, 1994)
- 28GW01DW NEWLY INSTALLED DEEP MONITORING WELL (BAKER, 1994)
- 28-CC-SW/SD01 SURFACE WATER/SEDIMENT SAMPLING LOCATION
- SB1 SOIL BORING LOCATION
- SB40 EXPLORATORY TEST BORING
- VEGETATION
- CREEK/DRAINAGE
- FENCE
- MARSH

SOURCE. LANTDIV, FEBRJARY 1992

DATE	FEBRUARY 1995
SCALE	1" = 120'
DRAWN	REL
REVIEWED	TFT
S O #	62470-231
CADD#	231102FS

NORTH

FEASIBILITY STUDY CTO-0231
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.

REMEDIAL INVESTIGATION
SAMPLING LOCATIONS
SITE 28 – HADNOT POINT BURN DUMP

SCALE 1" = 120'   DATE FEBRUARY 1995

FIGURE No
7-2

8.0 REMEDIATION GOAL OPTIONS, REMEDIATION LEVELS, AND REMEDIAL ACTION OBJECTIVES - SITE 28

This section presents the remediation goal options, remediation goals, and remedial action objectives for Site 28 in Operable Unit No. 7. Before determining remediation goal options, media and contaminants of concern are identified in Section 8.1, and exposure routes and receptors are identified in Section 8.2. In Section 8.3, remediation goal options and final remediation levels are developed. Section 8.3 also includes a final set of contaminants of concern (COCs) for the FS. Based on the remediation levels, areas of concern (AOCs) are identified in Section 8.4. Finally, the remedial action objectives are presented in Section 8.5.

8.1 Media of Concern/Contaminants of Concern

As previously mentioned the results of the RAs (baseline human health and ecological risk assessments) presented in the RI Report (Baker, 1995) indicated that groundwater was the media of concern, with respect to potential carcinogenic and noncarcinogenic risks. The other media (i.e., soil, sediment, surface water, and biota) had incremental cancer risks (ICRs) less than 1.0×10^{-4} and hazard indices (HIs) less than 1.0. Therefore, the primary focus of this FS is groundwater remediation.

Soil, surface water, sediments, and biota (i.e., fish tissue) do not appear to be media of concern, based on the conclusions drawn by the human health and ecological risk assessments. Although contaminants were present in these media, they will not be directly remediated. In addition, please note that lead detected in a sediment sample from the New River was not addressed in this FS because it does not appear to be site related. Instead, this detection of lead may be the result of current on-going activities at the nearby pistol range. Although this detection of lead is not addressed in this FS, it may be addressed in future investigations.

The set of groundwater COPCs evaluated during the RA is listed in Table 8-1. These COPCs are considered preliminary COCs for the FS. The detected concentrations of the preliminary COCs will be compared to the remediation levels that will be developed in Section 8.3 to generate a final list of COCs for the FS. Any preliminary COC that does not exceed the applicable regulatory or health based remediation level will be eliminated from the final set of COCs thus eliminating it from consideration in the FS. In addition, an evaluation will be conducted on the remaining set of contaminants to determine areas of concern for the site. The final set of COCs will become the basis for a set of remedial action objectives applicable to the site.

8.2 Routes of Exposure and Receptors

The results of the human health and the ecological RAs indicated that the exposure route of concern for groundwater is ingestion. Current receptors include military personnel (i.e., surface soil exposure) and wildlife (i.e., terrestrial and aquatic). Future receptors include adult and child residents (i.e., groundwater exposure).

8.3 Remediation Goal Options and Remediation Levels

Remediation goal options are established based on information, such as federal and state criteria and risk-based action levels. Section 8.3.1 presents the definition of applicable or relevant and appropriate federal and state requirements (ARARs) and "to be considered" (TBC) requirements.

Section 8.3.2 is the identification and evaluation of site specific federal and state criteria for COCs at Site 28. Site specific risk-based action levels for the COCs at Site 28 will be developed in Section 8.3.3. The federal and state criteria and risk-based action levels developed for each COC are considered remediation goal options. One remediation goal option is chosen for each COC to develop a final set of remediation levels for the FS.

8.3.1 Definition of Applicable or Relevant and Appropriate Federal and State Requirements and "To Be Considered" Requirements

Under Section 121(d)(1) of CERCLA, remedial actions must attain a degree of cleanup which assures protection of human health and the environment. Additionally, CERCLA remedial actions that leave any hazardous substances, pollutants, or contaminants on site must meet, upon completion of the remedial action, a level or standard of control that at least attains standards, requirements, limitations, or criteria that are "applicable or relevant and appropriate" under the circumstances of the release. These requirements are known as "ARARs" or applicable or relevant and appropriate requirements. ARARs are derived from both federal and state laws. USEPA Interim Guidance (52 Fed. Reg. 32496, 1987) provides a definition of "Applicable Requirements"s:

> ...cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site.

Drinking water criteria may be an applicable requirement for a site with contaminated groundwater that is used as a drinking water source. The definition of "Relevant and Appropriate Requirements" is:

> ...cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site.

There are three types of ARARs. The first type, chemical-specific ARARs, are requirements which set health or risk-based concentration limits or ranges for specific hazardous substances, pollutants, or contaminants. Maximum Contaminant Levels (MCLs) established under the Safe Drinking Water Act (SDWA) are examples of chemical-specific ARARs.

The second type of ARAR, location-specific, sets restrictions on activities based upon the characteristics of the site and/or the nearby suburbs. Examples of this type of ARAR include federal and state siting laws for hazardous waste facilities and sites on the National Register of Historic Places.

The third classification of ARAR, action-specific, refers to the requirements that set controls or restrictions on particular activities related to the management of hazardous substances, pollutants, or contaminants. RCRA regulations for closure of hazardous waste storage units, RCRA incineration standards, and pretreatment standards under the Clean Water Act (CWA) for discharges to publicly owned treatment works (POTWs) are examples of action-specific ARARs.

Subsection 121(d) of CERCLA requires that the remedial action meet a level or standard which at least attains federal and state substantive requirements that qualify as ARARs. Federal, state, or local permits do not need to be obtained for removal or remedial actions implemented on site, but their substantive requirements must be met. "On-site" is interpreted by the USEPA to include the areal extent of contamination and all suitable areas in reasonable proximity to the contamination necessary for implementation of the response action.

ARARs can be identified only on a site-specific basis. They depend on the detected contaminants at a site, specific site characteristics, and particular remedial actions proposed for the site. Potential ARARs identified for Site 28 are presented in the following section.

The preamble to the proposed rule in 40 CFR Part 300.400(g)(3) states that "advisories, criteria, or guidance to-be-considered (TBC) that do not meet the definition of ARAR may be necessary to determine what is protective or may be useful in developing Superfund remedies. The ARAR preamble described three types of TBCs: health effects information with a high degree of credibility, technical information on how to perform or evaluate site investigations or remedial actions, and policy" (USEPA, 1990a).

8.3.2 Potential ARARs and TBCs Identified for Site 28

A set of chemical-specific, location-specific, and action-specific ARARs were identified and evaluated for Site 28 and are discussed below.

8.3.2.1 <u>Chemical-Specific ARARs</u>

Potential chemical-specific ARARs and TBCs identified for the preliminary COCs at Site 28 are listed on Table 8-2. These ARARs/TBCs were based on the following: the federal MCLs, NCWQSs applicable to groundwater, and federal risk-based health advisories (Has) for adults and children. A brief description of each these standards is presented below.

Federal Maximum Contaminant Levels - MCLs are enforceable standards for public water supplies promulgated under the SDWA and are designed for the protection of human health. MCLs are based on laboratory or epidemiological studies and apply to drinking water supplies consumed by a minimum of 25 persons. These standards are designed for prevention of human health effects associated with a lifetime exposure (70-year lifetime) of an average adult (70 kg) consuming 2 liters of water per day. MCLs also consider the technical feasibility of removing the contaminant from the public water supply. As shown in Table 8-2, MCLs have been established for 5 of the 10 groundwater COCs. The federal MCLs will be considered ARARs for Site 28.

North Carolina Water Quality Standards (Groundwater) - Under the North Carolina Administrative Code (NCAC), Title 15A, Subchapter 2L, Section .0200, (15A NCAC 2L.0200) the North Carolina Department of Environment, Health, and Natural Resources (NC DEHNR) has established groundwater standards (NCWQSs) for three classifications of groundwater within the state: GA, GSA, and GC. Class GA waters are those groundwaters in the state naturally containing 250 milligram per liter (mg/L) or less of chloride. These waters are an existing or potential source of drinking water supply for humans. Class GSA waters are those groundwaters in the state naturally containing greater than 250 mg/L of chloride. These waters are an existing or potential source of water supply for potable mineral water and conversion to fresh water. Class GC water is defined as a source of water supply for purposes other than drinking. The NCAC T15A:02L.0300 has established sixteen river basins within the state as Class GC groundwaters (15A NCAC 2L.0201 and 2L.0300).

The water quality standards for the groundwaters are the maximum allowable concentrations resulting from any discharge of contaminants to the land or water of the state, which may be tolerated without creating a threat to human health or which would otherwise render the groundwater unsuitable for its intended best usage. If the water quality standard of a substance is less than the limit of detectability, the substance shall not be permitted in detectable concentrations. If naturally occurring substances exceed the established standard, the standard will be the naturally occurring concentration, as determined by the state. Substances which are not naturally occurring and for which no standard is specified are not permitted in detectable concentrations for Class GA or Class GSA groundwaters (15A NCAC 2L.0202).
The NCWQSs for substances in Class GA and Class GSA groundwaters are established as the lesser of:

- Systemic threshold concentration (based on reference dose and average consumption)
- Concentration which corresponds to an incremental lifetime cancer risk of $1.0x10^{-6}$
- Taste threshold limit value
- Odor threshold limit value
- MCL
- National Secondary Drinking Water Standard

Note that the water quality standards for Class GA and Class GSA groundwaters are the same except for chloride and total dissolved solids concentrations (15A NCAC 2L.0202).

The Class GA groundwater NCWQSs for the groundwater COCs for Site 28 are listed on Table 8-2. As shown on the table, the majority of the state standards are the same or more stringent than the federal MCLs. The NCWQSs will be considered ARARs for Site 28.

Federal Health Advisories (HAs) - Federal HAs are guidelines developed by the USEPA Office of Drinking Water for nonregulated constituents in drinking water. These guidelines are designed to consider both acute and chronic toxic effects in children (assumed body weight 10 kg) who consume 1 liter of water per day or in adults (assumed body weight 70 kg) who consume 2 liters of water per day. HAs are generally available for acute (1 day), subchronic (10 days), and chronic (longer-term) exposure scenarios. These guidelines are designed to consider only threshold effects and, as such, are not used to set acceptable levels of potential human carcinogens. The federal HAs will be considered TBCs for Site 28 since they are not enforceable regulations.

Long-term HAs for the groundwater COCs listed in Table 8-2 are included for both a child (10 kg) and an adult (70 kg).

8.3.2.2 <u>Location-Specific ARARs</u>

Potential location-specific ARARs identified for Site 28 are listed on Table 8-3. An evaluation determining the applicability of these location-specific ARARs with respect to Site 28 is also presented and summarized on Table 8-3. Based on this evaluation, specific sections of the following location-specific ARARs may be applicable to Site 28:

- Fish and Wildlife Coordination Act
- Federal Endangered Species Act
- North Carolina Endangered Species Act
- Executive Order 11990 on Protection of Wetlands
- Executive Order 11988 on Floodplain Management
- RCRA Location Requirements

It should be noted that the citations listed on Table 8-3 should not be interpreted to indicate that the entire citation is an ARAR. The citation listing is provided on the table as a general reference.

8.3.2.3 Action-Specific ARARs

Action-specific ARARs are typically evaluated following the development of alternatives since they are dependent on the type of action being considered. Therefore, at this step in the FS process, potential action-specific ARARs have only been identified and not evaluated for Site 28. A set of potential action-specific ARARs are listed on Table 8-4. These ARARs are based on RCRA, CWA, SDWA, and Department of Transportation (DOT) requirements. Note that the citations listed on Table 8-4 should not be interpreted to indicate that the entire citation is an ARAR. The citation listing is provided on the table as a general reference.

These ARARs will be evaluated after the remedial action alternatives have been identified for Site 28. Additional action-specific ARARs may also be identified and evaluated at that time.

8.3.3 Site-Specific Risk-Based Action Levels

In this section of the FS, site-specific risk-based action levels are developed for the preliminary COCs. The determination of derived action levels for Site 28 involves establishing acceptable human health risk criteria, determining allowable risk to COCs, and back calculating media-specific concentrations for the established risk levels.

The methodology used for the derived action levels is in accordance with USEPA risk assessment guidance (USEPA, 1989a; USEPA, 1991). For noncarcinogenic effects, concentrations that corresponds to an HI of 1.0, 0.1, and 0.01 were calculated. At these levels of contaminant exposure via all significant exposure pathways in a given medium, even sensitive populations are unlikely to experience health effects. A 1.0 risk level was used as an end point for determining action levels for remediation. For carcinogenic effects, concentrations were calculated that correspond to 1.0×10^{-4} (one in ten thousand), 1.0×10^{-5} (one in one hundred thousand), and 1.0×10^{-6} (one in one million) ICR over a lifetime as a result of exposure to the potential carcinogen from all significant exposure pathways for a given medium. A 1.0×10^{-4} risk level was used as an end point for determining action levels for remediation. Based on the National contingency Plan (NCP) (40 CFR 300.430), for known or suspected carcinogens, acceptable exposure levels are generally concentrations that represent an ICR between 1.0×10^{-4} and 1.0×10^{-6}. Action levels are representative of acceptable incremental risks at the evaluated site based on current and probable future use of the area.

Three steps are involved in estimating the risk-based action levels for the preliminary COCs. These steps involved identifying the most significant: (1) exposure pathways and routes, (2) exposure parameters, and (3) equations. The equations included calculations of total intake from a given medium and were based on identified exposure pathways and associated parameters.

8.3.3.1 Risk Evaluation Assessment

The determination of medium-specific risk-based action levels was performed in accordance with USEPA guidance (USEPA, 1989a). Reference doses (RfDs) were used to evaluate noncarcinogenic action levels, while cancer slope factors (CSFs) were used to evaluate carcinogenic action levels.

Potential exposure pathways and receptors used to determine action levels are site-specific. They consider the current and future land use of a site. Ingestion of groundwater was the exposure scenario used to determine risk-based action levels for Site 28.

Consistent with USEPA guidance, noncarcinogenic health effects were estimated using an average annual exposure. The action level incorporates the exposure time and/or frequency that represents the number of hours per day and the number of days per year that exposure occurs. The exposure variables are used with a term known as the averaging time, which converts the daily exposure to an annual exposure. Carcinogenic health effects were calculated as an incremental lifetime cancer risk, which represented the exposure duration (years) over the lifetime (70 years) of a potentially exposed individual.

Estimation methods and models used in this section were consistent with current USEPA risk assessment guidance (USEPA, 1989a; USEPA, 1991). Exposure estimates associated with the exposure route are presented below. Carcinogenic action levels for the future residential land use (i.e., ingestion of groundwater) were based on and exposure duration of 6 years for a child (weighing 15 kg on average) and 24 years for an adult (weighing 70 kg on average), for a total exposure duration of 30 years (i.e., the 90th percentile at one residence). Carcinogenic action levels for the military personnel in the current scenario were based on an exposure duration of 4 years. The following sections present the equations and inputs used in the estimation of action levels developed for Site 28.

Ingestion of Groundwater

Currently, there are no receptors exposed to groundwater contamination in this area. Groundwater is obtained from noncontaminated MCB Camp Lejeune supply wells and pumped to water treatment plants. The treated water is distributed via the base water system. However, for the purposes of calculating action levels, it is assumed that the site wells are potable and supply groundwater for public consumption. Groundwater ingestion action levels can be characterized using the following equation:

$$Cs = \frac{TR \text{ or } THI * BW * ATc \text{ or } ATnc * DY}{CSF \text{ or } 1/RfD * EF * ED * IR}$$

Where:

Cw	=	contaminant concentration in groundwater (mg/L)
TR	=	total lifetime risk
THI	=	total hazard index
BW	=	adult body weight (kg)
ATc	=	averaging time carcinogens (yr)
ATnc	=	averaging time noncarcinogens (yr)
DY	=	days per year (day/year)

CSF	=	cancer slope factor $(mg/kg-day)^{-1}$
RfD	=	reference dose (mg/kg-day)
EF	=	exposure frequency (day/year)
ED	=	exposure duration (yr)
IR	=	ingestion rate (L/day)

Under the military personnel scenario, the following input parameters were used to determine the action levels: military personnel are assumed to ingest 2 liters of water per day, for 250 days per year, over a 4 year period (USEPA, 1989a). Under the residential use scenario, the following input parameters were used to estimate action levels: adult residents are assumed to ingest 2 liters of water per day, for 350 days per year over a 30 year exposure duration; and child residents are assumed to ingest 1 liter of water per day, for 350 days per year for an exposure period of 6 years (USEPA, 1989a). Table 8-5 summarizes the input parameters used to estimate the groundwater ingestion action levels.

8.3.3.2 Summary of Site-Specific Risk-Based Action Levels

Site-specific risk-based action levels were calculated from the risk evaluation assessment. These action levels represent the risk-based cleanup levels for specific medium, and are used in determining remediation levels.

Risk-based action levels were only generated for contaminants with available toxicity data. A summary of the action levels calculated for the potential exposure scenarios is presented below. Separate action levels for military personnel, future adult residents, and future child residents have been calculated for the groundwater ingestion scenario discussed below. In addition, both carcinogenic and noncarcinogenic action levels have been calculated. Calculations are provided in Appendix A of this report.

Groundwater ingestion action levels were estimated for the groundwater within the entire operable unit. Currently, there are no known receptors of the groundwater. Military personnel receive potable water from the base distribution system. Consequently, a hypothetical future ingestion action level was estimated for the COCs. In order to estimate conservative action levels for subpopulations, (i.e., military personnel, adult resident, and child resident), specific input variables were developed for each subpopulation. Tables 8-6 through 8-11 present the risk-based action levels calculated for the carcinogenic and noncarcinogenic COCs in the groundwater.

8.3.3.3 Comparison of Risk-Based Action Levels to Maximum Contaminant Levels

Generally, risk-based action levels are not required for any contaminants in a medium with a cumulative cancer risk of less than 1.0×10^{-6}, where an HI is less than or equal to 1.0 or where the action levels are clearly defined by ARARs. However, there may be cases where a medium or contaminant appears to meet the protectiveness criterion, but also contributes to the risk of another medium. In some cases, contamination may be unevenly distributed across the site resulting in hot spots (i.e., areas of high contamination relative to other areas of the site). Therefore, if the hot spot is located in an area which is visited or used more frequently, exposure to the spot should be assessed separately.

In order to decrease uncertainties in estimating the reasonable maximum exposure (RME) (i.e., the maximum exposure that is reasonably expected to occur at the site), the maximum concentration of a contaminant in a medium can be compared to the estimated action level, instead of using the concentration term (i.e., the 95th percent upper confidence limit), which is used to estimate the RME. To assess hot spot contaminants, a more protective approach is followed. This maximum value is usually compared to the estimated risk-based action level, because, in most situations, assuming long-term contact with the maximum contaminant concentration is not reasonable.

Conclusions of the human health RA indicate that cumulative current and future baseline cancer risks associated with groundwater are not within the USEPA's acceptable risk range of $1.0x10^{-4}$ to $1.0x10^{-6}$. A comparison between the risk-based action levels previously estimated to the maximum concentrations of groundwater COCs has been conducted.

These risk-based action levels and chemical-specific ARARs were compared to maximum contaminant concentrations in Table 8-12. As shown on the table, the maximum concentrations of lead and manganese exceeded the action levels for groundwater for the future potential scenario.

Identification of remedial alternatives should not be placed solely on the estimation of risk-based action levels, especially in the event of hot spot contamination. Comparison of maximum contaminant concentrations to risk-based action levels provides an upper-bound (i.e., worst case), protective estimation, and aids in screening and identifying remedial alternatives. Risk-based action levels are not to be used in making final remedial decisions.

8.3.3.4 Uncertainty Analysis

Uncertainties associated with calculating risk-based action levels are summarized below. The action level estimates presented in the previous section are quantitative in nature, and are highly dependent upon the accuracy of the input. The accuracy with which input values can be quantified is critical to the degree of confidence that the decision maker has in the action levels.

Most scientific computation involves a limited number of input variables, tied together by a scenario to provide a desired output. Some action level inputs are based on literature values rather than measured values. In such cases, the degree of certainty may be expressed in terms of whether the estimate was based on literature values or measured values, and not by how well-defined the distribution. Some action levels are based on estimated parameters; the qualitative statement that the action level was based on estimated inputs defines the certainty in a qualitative manner.

The toxicity factors (i.e., CSFs and RfDs), have uncertainties built into the assumptions used to calculate these values. Because the toxicity factors are determined from high doses administered to experimental animals and extrapolated to low doses to which humans may be exposed, uncertainties exist. Thus, toxicity factors could either overestimate or underestimate potential effects on humans. However, because human data exists for very few chemicals, risks are based on these conservative values obtained primarily from animal studies.

In order to estimate an intake, certain assumptions must be made about exposure events, exposure durations, and the corresponding assimilation of contaminants by the receptor. Exposure factors have been generated by the scientific community and have undergone review by the USEPA. Regardless of the validity of these exposure factors, they have been derived from a range of values generated by studies of a limited number of individuals. In all instances, values used in the risk assessment, scientific judgements, and conservative assumptions agree with those of the USEPA. Conservative assumptions designed not to underestimate daily intakes were employed throughout this section and should error conservatively, thus adequately protecting human health and allowing the establishment of reasonable clean-up goals.

8.3.4 Summary of Remediation Levels and Final COCs

Remediation levels (RLs) associated with the preliminary COCs at Site 28 are presented on Table 8-13. This list was based on a comparison of chemical-specific ARARs and the site-specific risk based action levels identified throughout Section 8.3.3.4 of the FS. If a COC had an ARAR, the most limiting (or protective) ARAR was selected as the RL for that contaminant. If a COC did not have an ARAR, the most conservative risk-based action level was selected for the RL. The basis for each of the RLs is also presented in Table 8-13.

In order to determine the final set of COCs, the maximum contaminant concentrations detected in the groundwater were compared to the RLs presented on Table 8-13. The contaminants which exceeded at least one of the RLs were retained as COCs. The contaminants that did not exceed any of the remediation levels were no longer be considered to be COCs with respect to this FS. Based on this comparison, the following COCs exceeded a remediation level and were retained as COCs for Site 28:

- Lead
- Manganese

The final set of COCs and their RLs are presented on Table 8-14.

8.4 Areas of Concern

Areas of concern (AOCs) are locations within a specific medium that require a remedial action evaluation. These areas are determined based on RA results and the location of COCs that exceeded RLs.

Figure 8-1 shows the location of monitoring wells where lead and manganese exceeded remediation levels in both the shallow and deep aquifers. Lead exceeded its remediation level in one well, 28GW08. The detected concentration of lead was 126 µg/L; the remediation level is 15 µg/L. Manganese exceeded its remediation level at six shallow wells: 28GW01, 28GW02, 28GW04, 28GW7, 28GW08, and 28GW13, and one deep well, 28GW01DW. The detected manganese concentrations were 225 µg/L, 185 µg/L, 55.6 µg/L, 694 µg/L, 1,450 µg/L, 347 µg/L, and 65.8 µg/L, respectively; the remediation level for manganese is 50 µg/L. Because they tend to sorb to solid particles, metals in groundwater do not travel in a plume formation. As a result, the wells where high manganese and lead concentrations were detected will be considered individual AOCs at the site.

8.5 Remedial Action Objectives

The following remedial action objective has been identified for groundwater at Site 28:

- Mitigate the potential for direct exposure to the groundwater COCs.

No other remedial action objectives, such as preventing the COC migration or remediating the aquifer, were developed because the risks associated with the groundwater COCs are minimal. Manganese and lead at Site 28 do not pose substantial risks for the following reasons:

- Manganese concentrations (i.e., both total and filtered) in groundwater at MCB, Camp Lejeune often exceed the NCWQS and federal secondary MCL of 50 µg/L (Baker, 1994a). Elevated manganese levels, at concentrations above the NCWQS, were reported in samples collected from a number of base potable water supply wells (Greenhorne and O'Mara, 1992). Manganese concentrations at several Site 28 wells exceeded the NCWQS, and all but one sample fell within the range of concentrations for samples collected elsewhere at MCB, Camp Lejeune. As a result, manganese does not appear to be a site related contaminant. Instead, manganese appears to naturally occur at concentrations exceeding the RL in groundwater throughout the Base.

- Lead was detected above its remediation level at only one well, 28-GW08. This well, which is situated in an area of loosely compacted fill material, exhibited high turbidity (above 10 turbidity units) and total suspended solids (111 mg/L). In addition, lead was only detected in the total metals sample, not the dissolved metals sample, taken at this well. All of this information suggests that the high lead concentration detected at 28-GW08 may be the result of suspended solids, and the total metals analysis is indicative of lead in the soil and groundwater, not just the amount of lead that is dissolved in the groundwater. As a result, lead does not appear to be a site related contaminant.

Based on this information, the case can be made that an FS for groundwater at Site 28 is not necessary. It is pointless to remediate or prevent the migration of a metal that naturally exists at high levels throughout the Base and a metal that was not detected in the dissolved phase. However, since the site is used as a public recreation area, an FS will be conducted ensuring an overly conservative approach to the protection of human health and the environment. The FS will be focused with only one remedial action objective that accounts for the minimal risks associated with the groundwater COCs.

SECTION 8.0 TABLES

TABLE 8-1

PRELIMINARY CONTAMINANTS OF CONCERN FOR THE FS
SITE 28 - HADNOT POINT BURN DUMP
FEASIBILITY STUDY CTO-231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Contaminant of Potential Concern Evaluated in the RA (1)	Preliminary Contaminant of Concern for the FS (2)
Groundwater	4,4'-DDE	X
	4,4'-DDD	X
	4,4'-DDT	X
	Chloroform	X
	2,4-Dimethylphenol	X
	2-Methylnaphthalene	X
	4-Methylphenol	X
	Acenaphthene	X
	Phenanthrene	X
	Arsenic	X
	Barium	X
	Lead	X
	Manganese	X
	Mercury	X

(1) This list includes all of the contaminants of potential concern evaluated in the Risk Assessment (Baker, 1995)
(2) The determination of the set of preliminary contaminants of concern for the FS was based on two criteria: (1) the contaminant was found to be a contaminant of concern from the results of the RA, or (2) standards and/or criteria are established for the contaminant.

TABLE 8-2

POTENTIAL CHEMICAL-SPECIFIC ARARs AND TBCs
SITE 28 - HADNOT POINT BURN DUMP
FEASIBILTIY STUDY CTO-231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant	NCWQS[1]	Federal MCL [2]	Federal Health Advisories[3]	
			Adult	Child
Chloroform	190	100	0.4	0.1
2,4-Dimethylphenol	NE	NE	NE	NE
2-Methylnaphthalene	NE	NE	NE	NE
4-Methylphenol	NE	NE	NE	NE
Acenaphthene	NE	NE	NE	NE
Phenanthrene	210	NE	NE	NE
4,4'-DDE	NE	NE	NE	NE
4,4'-DDD	NE	NE	NE	NE
4,4'-DDT	NE	NE	NE	NE
Arsenic	50	50	NE	NE
Barium	2,000	2,000	NE	NE
Lead	15	15[4]	NE	NE
Manganese	50	NE	NE	NE
Mercury	1.1	2	NE	2

Notes: Concentrations expressed in microgram per liter (ug/L)
- [1] NCWQS = North Carolina Water Quality Standards for Groundwater
- [2] MCL = Safe Drinking Water Act Maximum Contaminant Level
- [3] Health Advisories - Nonenforceable guidelines, therefore, a TBC
- [4] The MCL for this compounds is an action level only.
- NE = No Criteria Established

TABLE 8-3

EVALUATION OF POTENTIAL LOCATION-SPECIFIC ARARs
SITE 28 - HADNOT POINT BURN DUMP
FEASIBLITY STUDY CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Potential Location-Specific ARAR	General Citation	ARAR Evaluation
National Historic Preservation Act of 1966 - requires action to take into account effects on properties included in or eligible for the National Register of Historic Places and to minimize harm to National Historic Landmarks.	16 USC 470, 40-CFR-6.301(b), and 36 CFR 800	No known historic properties are within or near Site 28, therefore, this act will not be considered as an ARAR
Archeological and Historic Preservation Act - establishes procedures to provide for preservation of historical and archeological data which might be destroyed through alteration of terrain.	16 USC 469, and 40 CFR 6.301(c)	No known historical or archeological data is known to be present at the sites, therefore, this act will not be considered as an ARAR.
Historic Sites, Buildings and Antiquities Act - requires action to avoid undesirable impacts on landmarks on the National Registry of Natural Landmarks.	16-USC 461467, and 40 CFR 6.301(a)	No known historic sites, buildings or antiquities are within or near Site 28, therefore, this act will not be considered as an ARAR.
Fish and Wildlife Coordination Act - requires action to protect fish and wildlife from actions modifying streams or areas affecting streams.	16 USC 661-666	The New River, Cogdels Creek and Orde Pond are located near and/or within the operable unit boundaries. If remedial actions are implemented that modify these creeks, this will be an applicable ARAR.
Federal Endangered Species Act - requires action to avoid jeopardizing the continued existence of listed endangered species or modification of their habitat.	16-USC 1531, 50 CFR 200, and 50 CFR 402	Many protected species have been sited near and on MCB Camp Lejeune such as the American alligator, the Bachmans sparrow, the Black skimmer, the Green turtle, the Loggerhead turtle, the piping plover, the Red-cockaded woodpecker, and the rough-leaf loosestrife (LeBlond, 1991),(Fussell, 1991),(Walters, 1991). In addition, the alligator has been sighted on Base (in Orde Pond). Therefore, this will be considered as an ARAR.
North Carolina Endangered Species Act - per the North Carolina Wildlife Resources Commission. Similar to the Federal Endangered Species Act, but also includes State special concern species, State significantly rate species, and the State watch list.	GS 113-331 to 113-337	Since the American alligator has been sighted within MCB Camp Lejeune (in Orde Pond), this will be considered as an ARAR.
Rivers and Harbors Act of 1899 (Section 10 Permit) - requires permit for structures or work in or affecting navigable waters.	33 USC 403	No remedial actions will affect the navigable waters of the New River. Therefore, this act will not be considered as an ARAR.

TABLE 8-3 (Continued)

EVALUATION OF POTENTIAL LOCATION-SPECIFIC ARARs
SITE 28 - HADNOT POINT BURN DUMP
FEASIBLITY STUDY CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Potential Location-Specific ARAR	General Citation	ARAR Evaluation
Executive Order 11990 on Protection of Wetlands - establishes special requirements for Federal agencies to avoid the adverse impacts associated with the destruction or loss of wetlands and to avoid support of new construction in wetlands if a practicable alternative exists.	Executive Order Number 11990, and 40-CFR-6	Based on a review of Wetland Inventory Maps, The New River and Cogdels Creek have areas of wetlands. Therefore, this will be an applicable ARAR.
Executive Order 11988 on Floodplain Management - establishes special requirements for Federal agencies to evaluate the adverse impacts associated with direct and indirect development of a floodplain.	Executive Order Number 11988, and 40 CFR 6	Based on the Federal Emergency Management Agency's Flood Insurance Rate Map for Onslow County, OU No. 1 is primarily within a minimal flooding zone (outside the 500-year floodplain). The immediate areas around The New River and Cogdels Creek are within the 100-year floodplain (FEMA, 1987). Therefore, this may be an ARAR for the operable unit.
Wilderness Act - requires that federally owned wilderness area are not impacted. Establishes nondegradation, maximum restoration, and protection of wilderness areas as primary management principles.	16-USC-1131, and 50-CFR-35.1	No known federally owned wilderness areas near the operable unit, therefore, this act will not be considered as an ARAR.
National Wildlife Refuge System - restricts activities within a National Wildlife Refuge.	16 USC 668, and 50 CFR 27	No known National Wildlife Refuge areas near the operable unit, therefore, this will not be considered as an ARAR.
Scenic Rivers Act - requires action to avoid adverse effects on designated wild or scenic rivers.	16 USC 1271, and 40 CFR 6.302(e)	No known wild or scenic rivers near the operable unit, therefore, this act will not be considered as an ARAR.
Coastal Zone Management Act - requires activities affecting land or water uses in a coastal zone to certify noninterference with coastal zone management.	16-USC 1451	No activities will affect land or water uses in a coastal zone, therefore, this act will not be considered as an ARAR.
Clean Water Act (Section 404) - prohibits discharge of dredged or fill material into wetland without a permit.	33 USC 404	No actions to discharge dredged or fill material into wetlands will be considered for the operable unit, therefore, this act will not be considered as an ARAR.

TABLE 8-3 (Continued)

EVALUATION OF POTENTIAL LOCATION-SPECIFIC ARARs
SITE 28 - HADNOT POINT BURN DUMP
FEASIBLITY STUDY CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Potential Location-Specific ARAR	General Citation	ARAR Evaluation
RCRA Location Requirements - limitations on where on-site storage, treatment, or disposal of RCRA hazardous waste may occur.	40 CFR 264.18	These requirements may be applicable if the remedial actions for the operable unit includes the on-site storage, treatment, or disposal of RCRA hazardous waste. Therefore, these requirements may be an applicable ARAR for the operable unit.

TABLE 8-4

POTENTIAL ACTION-SPECIFIC ARARs
SITE 28 - HADNOT POINT BURN DUMP
FEASIBILITY STUDY CTO-0231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Standard [1]	Action	General Citation
RCRA	Capping	40 CFR 264
	Closure	40 CFR 264, 244
	Container Storage	40 CFR 264, 268
	New Landfill	40 CFR 264
	New Surface Impoundment	40 CFR 264
	Dike Stabilization	40 CFR 264
	Excavation, Groundwater Diversion	40 CFR 264, 268
	Incineration	40 CFR 264, 761
	Land Treatment	40 CFR 264
	Land Disposal	40 CFR 264, 268
	Slurry Wall	40 CFR 264, 268
	Tank Storage	40 CFR 264, 268
	Treatment	40 CFR 264, 265, 268; 42 USC 6924; 51 FR 40641; 52 FR 25760
	Waste Pile	40 CFR 264, 268
CWA	Discharge to Water of United States	40 CFR 122, 125, 136
	Direct Discharge to Ocean	40 CFR 125
	Discharge to POTW	40 CFR 403, 270
	Dredge/Fill	40 CFR 264; 33 CFR 320-330; 33 USC 403
SDWA	Underground Injection Control	40 CFR 144, 146, 147, 268
DOT	DOT Rules for Transportation	49 CFR 107

TABLE 8-5

SUMMARY OF EXPOSURE DOSE INPUT PARAMETERS
SITE 28 - HADNOT POINT BURN DUMP
FEASIBILITY STUDY CTO-231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Input Parameter	Units	Receptor		
		Future Child	Future Adult	Current Military Personnel
Groundwater (mg/L)				
Ingestion Rate, IR	L/d	1	2	2
Exposure Frequency, EF	d/y	350	350	250
Exposure Duration, ED	y	6	30	4
Exposure Time, ET	h/d	0.25	0.25	0.25
Averaging Time, Noncarc., ATnc	d	2,190	10,950	1,460
Averaging Time, Carc., ATcarc	d	25,550	25,550	25,550
Conversion Factor, CF	L/cm^3	0.001	0.001	0.001
Body Weight, BW	kg	15	70	70

References:

USEPA Risk Assessment for Superfund Volume I. Human Health Manual (Part A) Interim Final, December, 1989

USEPA Exposure Factors Handbook, July, 1989

USEPA Risk Assessment for Superfund Volume I. Human Health Evaluation Manual Supplemental Guidance. "Standard Default Exposure Factors" Interim Final. March 25, 1991

USEPA Dermal Exposure Assessment: Principles and Applications. Interim Report. January, 1992

USEPA Region IV Guidance for Soil Absorbance

TABLE 8-6

GROUNDWATER INGESTION ACTION LEVELS
BASED ON CARCINOGENIC RISK
FUTURE ADULT RESIDENT
SITE 28 - HADNOT POINT BURN DUMP
FEASIBILITY STUDY CTO-231
MCB, CAMP LEJEUNE, NORTH CAROLINA

	Carcinogenic Risk-Based Action Levels Future Adult Resident		
Contaminant of Concern	Carcinogenic Target Risk Level 1.0×10^{-04}	Carcinogenic Target Risk Level 1.0×10^{-05}	Carcinogenic Target Risk Level 1.0×10^{-06}
4,4'-DDE	25	2.5	0.25
4,4'-DDD	35	3.5	0.35
4,4'-DDT	25	2.5	0.25
Chloroform	1,396	139.6	13.96
Arsenic	5	0.5	0.05

Note: Action level concentrations expressed as ug/L

TABLE 8-7

GROUNDWATER INGESTION ACTION LEVELS
BASED ON CARCINOGENIC RISK
FUTURE CHILD RESIDENT
SITE 28 - HADNOT POINT BURN DUMP
FEASIBILITY STUDY CTO-231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Concern	Carcinogenic Risk-Based Action Levels - Future Child Resident		
	Carcinogenic Target Risk Level 1.0×10^{-04}	Carcinogenic Target Risk Level 1.0×10^{-05}	Carcinogenic Target Risk Level 1.0×10^{-06}
4,4'-DDE	54	5.4	0.54
4,4'-DDD	76	7.6	0.76
4,4'-DDT	54	5.4	0.54
Chloroform	2992	299.2	29.92
Arsenic	10	1.0	0.1

Note: Action level concentrations expressed as ug/L

TABLE 8-8

GROUNDWATER INGESTION ACTION LEVELS
BASED ON CARCINOGENIC RISK
CURRENT MILITARY PERSONNEL
SITE 28 - HADNOT POINT BURN DUMP
FEASIBILITY STUDY CTO-231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Concern	Carcinogenic Risk-Based Action Levels - Current Military Personnel		
	Carcinogenic Target Risk Level 1.0×10^{-04}	Carcinogenic Target Risk Level 1.0×10^{-05}	Carcinogenic Target Risk Level 1.0×10^{-06}
4,4'-DDE	263	26.3	2.63
4,4'-DDD	373	37.3	3.73
4,4'-DDT	263	26.3	2.63
Chloroform	14,660	1466	146.6
Arsenic	51	5.1	0.51

Note: Action level concentrations expressed as ug/L

TABLE 8-9

GROUNDWATER INGESTION ACTION LEVELS BASED ON NONCARCINOGENIC RISK
FUTURE ADULT RESIDENT
SITE 28 - HADNOT POINT BURN DUMP
FEASIBILITY STUDY CTO-231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Concern	Noncarcinogenic Risk-Based Action Levels - Future Adult Resident		
	Noncarcinogenic Target Risk Level 1.0 x 10^{-04}	Noncarcinogenic Target Risk Level 1.0 x 10^{-05}	Noncarcinogenic Target Risk Level 1.0 x 10^{-06}
4,4'-DDT	18	1.8	0.18
2,4'-Dimethylphenol	730	73	7.3
4-Methylphenol	183	18.3	1.83
Acenaphthene	2,190	219	21.9
Chloroform	365	36.5	3.65
2-Methylnaphthalene	1,460	146	14.6
Phenanthrene	1,095	109.5	10.95
Arsenic	11	1.1	0.11
Barium	2,555	255.5	25.55
Manganese	183	18.3	1.83
Mercury	11	1.1	0.11

Note: Action level concentrations expressed as ug/L

TABLE 8-10

GROUNDWATER INGESTION ACTION LEVELS BASED ON NONCARCINOGENIC RISK FUTURE CHILD RESIDENT SITE 28 - HADNOT POINT BURN DUMP FEASIBILITY STUDY CTO-231 MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Concern	Noncarcinogenic Risk-Based Action Levels - Future Child Resident		
	Noncarcinogenic Target Risk Level 1.0×10^{-04}	Noncarcinogenic Target Risk Level 1.0×10^{-05}	Noncarcinogenic Target Risk Level 1.0×10^{-06}
4,4'-DDT	8	0.8	0.08
2,4-Dimethylphenol	313	31.3	3.13
4-Methylphenol	78	7.8	0.78
Acenaphthene	939	93.9	9.39
Chloroform	156	15.6	1.56
2-Methylnaphthalene	626	62.6	6.26
Phenanthrene	469	46.9	4.69
Arsenic	5	0.5	0.05
Barium	1,095	109.5	10.95
Manganese	78	7.8	0.78
Mercury	5	0.5	0.05

Note: Action level concentrations expressed as ug/L

TABLE 8-11

GROUNDWATER INGESTION ACTION LEVELS BASED ON
NONCARCINOGENIC RISK
CURRENT MILITARY PERSONNEL
SITE 28 - HADNOT POINT BURN DUMP
FEASIBILITY STUDY CTO-231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Concern	Noncarcinogenic Risk-Based Action Levels - Current Military Personnel		
	Noncarcinogenic Target Risk Level 1.0×10^{-04}	Noncarcinogenic Target Risk Level 1.0×10^{-05}	Noncarcinogenic Target Risk Level 1.0×10^{-06}
4,4'-DDT	26	2.6	0.26
2,4-Dimethylphenol	1,022	102.2	10.22
4-Methylphenol	256	25.6	2.56
Acenaphthene	3,066	306.6	30.66
Chloroform	511	51.1	5.11
2-Methylnaphthalene	2,044	204.4	20.44
Phenanthrene	1,533	153.3	15.33
Arsenic	15	1.5	0.15
Barium	3,577	357.7	35.77
Manganese	256	25.6	2.56
Mercury	15	1.5	0.15

Note: Action level concentrations expressed as ug/L

TABLE 8-12

COMPARISON OF GROUNDWATER ARARs AND RISK-BASED ACTION LEVELS TO MAXIMUM CONTAMINANT CONCENTRATIONS
SITE 28 - HADNOT POINT BURN DUMP
FEASIBILTIY STUDY CTO-231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant	ARAR		Groundwater Ingestion Risk		Maximum Detected Concentration
	NCWQS[(1)]	Federal MCL [(2)]	Carcinogenic	Noncarcinogenic	
Chloroform	190	100	1,396	156	2
2,4-Dimethylphenol	NE	NE	NA	313	2
4-Methylphenol	NE	NE	NA	78	9.3
Acenaphthene	NE	NE	NA	939	31
2-Methylnaphthalene	NE	NE	NA	626	33
Phenanthrene	210	NE	NA	469	14
4,4'-DDE	NE	NE	25	NA	6.6
4,4'-DDD	NE	NE	35	NA	9
4,4'-DDT	NE	NE	25	8	0.37
Arsenic	50	50	5	5	4.7
Barium	2,000	2,000	NA	1,095	759
Lead	15	15[(4)]	NE	NE	126
Manganese	50	NE	NA	78	1,450
Mercury	1.1	2	NA	5	0.58

Notes: Concentrations expressed in microgram per liter (µg/L)
[(1)] NCWQS = North Carolina Water Quality Standards for Groundwater
[(2)] MCL = Safe Drinking Water Act Maximum Contaminant Level
[(4)] The MCL for this compounds is an action level only.
NE = No Criteria Established
NA = Not Applicable

TABLE 8-13

REMEDIATION LEVELS
SITE 28 - HADNOT POINT BURN DUMP
FEASIBILITY STUDY CTO-231
MCB, CAMP LEJEUNE, NORTH CAROLINA

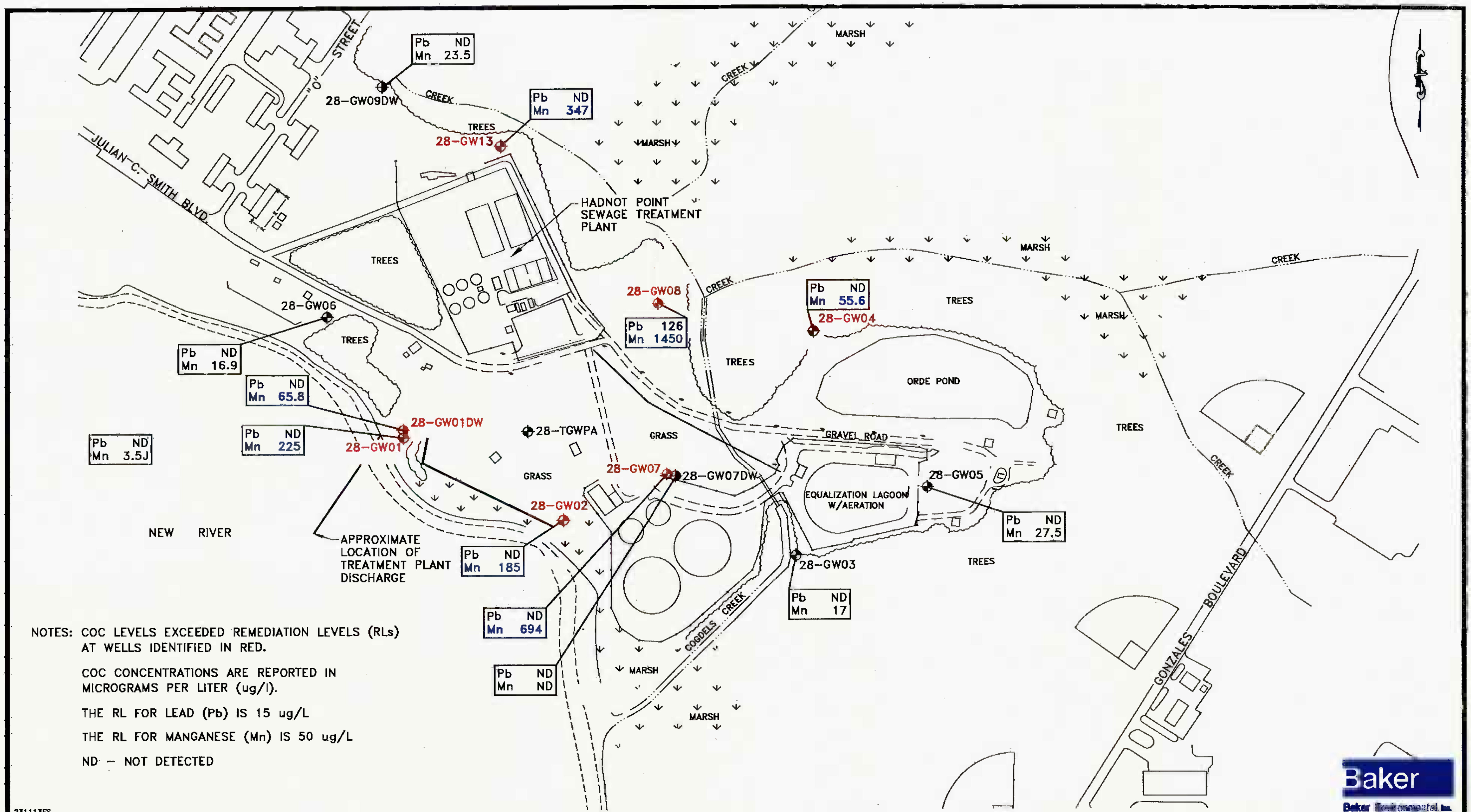
Medium	Contaminat of Concern	Remediation Level	Unit	Basis of Remediation Level	Corresponding Risk	
					Carcinogenic	Noncarcinogenic
Groundwater	2,4-Dimethylphenol	313	µg/L	Risk-Ingestion		HI=1.0
	4-Methylphenol	78	µg/L	Risk-Ingestion		HI=1.0
	Acenaphthene	939	µg/L	Risk-Ingestion		HI=1.0
	2-Methylnaphthalene	626	µg/L	Risk-Ingestion		HI=1.0
	Phenanthrene	210	µg/L	NCWQS		
	Chloroform	100	µg/L	Federal MCL		
	4,4'-DDE	25	µg/L	Risk-Ingestion	ICR=1.0E-4	
	4,4'-DDD	35	µg/L	Risk-Ingestion	ICR=1.0E-4	
	4,4'-DDT	8	µg/L	Risk-Ingestion		HI=1.0
	Arsenic	50	µg/L	NCWQS		
	Barium	2,000	µg/L	NCWQS		
	Lead	15	µg/L	NCWQS		
	Manganese	50	µg/L	NCWQS		
	Mercury	1.1	µg/L	NCWQS		

TABLE 8-14

FINAL SET OF COCs
SITE 28 - HADNOT POINT BURN DUMP
FEASIBILITY STUDY CTO-231
MCB, CAMP LEJEUNE, NORTH CAROLINA

Medium	Contaminat of Concern	Remediation Level	Unit	Basis of Level
Groundwater	Lead	15	µg/L	NCWQS
	Manganese	50	µg/L	NCWQS

SECTION 8.0 FIGURES



NOTES: COC LEVELS EXCEEDED REMEDIATION LEVELS (RLs) AT WELLS IDENTIFIED IN RED.

COC CONCENTRATIONS ARE REPORTED IN MICROGRAMS PER LITER (ug/l).

THE RL FOR LEAD (Pb) IS 15 ug/L

THE RL FOR MANGANESE (Mn) IS 50 ug/L

ND - NOT DETECTED

LEGEND

28-GW01 — SHALLOW MONITORING WELL

28-GW01DW — DEEP MONITORING WELL

Pb 126 — CONCENTRATION EXCEEDING THE LEAD RL

Mn 1450 — CONCENTRATION EXCEEDING THE MANGANESE RL

SOURCE: LANTDIV, FEBRUARY 1992 AND W.K. DICKSON, JUNE 1994

300 0 150 300 600

1 inch = 300 ft.

FIGURE 8-1
AREAS OF CONCERN
SITE 28 - HADNOT POINT BURN DUMP
FEASIBILITY STUDY CTO-0231

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01496DD01Y

9.0 IDENTIFICATION AND PRELIMINARY SCREENING OF REMEDIAL ACTION TECHNOLOGIES - SITE 28

Section 9.0 includes the identification and preliminary screening of remedial action technologies and process options that may be applicable to the remediation of groundwater at Site 28. More specifically, Section 9.1 identifies a set of general response actions, Section 9.2 identifies remedial action technologies and process options for each general response action, and Section 9.3 presents the preliminary screening of remedial action technologies and process options. After this preliminary screening, the remaining technologies/process options undergo a process option evaluation in Section 9.4. A brief description of the technologies/process options that passed the process option evaluation is presented in Section 9.5.

9.1 General Response Actions

General response actions are broad-based medium-specific categories of actions that can be identified to satisfy the remedial action objectives of an FS. Table 9-1 lists the general response actions that will satisfy the remedial action objectives identified for Site 28. As shown in Table 9-1, four general response actions have been identified for the groundwater objectives: no action, institutional controls, containment/collection actions, and treatment/discharge actions. Brief descriptions of the general response actions are presented below.

9.1.1 No Action

The NCP requires the evaluation of the no action response action as part of the FS process. A no action response provides a baseline assessment for comparisons involving other remedial alternatives that have a greater level of response. A no action alternative may be considered appropriate when there are no adverse or unacceptable risks to human health or the environment, or when a response action may cause a greater environmental or health danger than the no action alternative itself.

9.1.2 Institutional Controls

Institutional controls are various "institutional" actions that can be implemented at a site as part of a complete remedial action alternative to minimize exposure to potential hazards at the site. With respect to groundwater, institutional controls may include monitoring programs, ordinances, and access restrictions.

9.1.3 Containment/Collection Actions

This general response action combines containment actions and collection actions. Containment actions include technologies which contain and/or isolate contaminants by covering, sealing, chemically stabilizing, or providing an effective barrier against specific areas of concern. These actions also provide isolation and prevent direct exposure with or migration of the contaminated media without disturbing or removing the waste from the site. Collection actions include technologies that collect contaminants via withdrawal techniques such as pumping or interceptor trenches.

9.1.4 Treatment/Discharge Actions

Treatment actions for contaminated groundwater include chemical, biological, and thermal treatment, physical removal systems, and in situ treatment systems. Discharge actions include on-site and off-site discharge.

9.2 Identification of Remedial Action Technologies and Process Options

In this step, an extensive set of potentially applicable technologies and process options will be identified for each of the general response actions. The term "technology type" will refer to general categories of technologies such as physical/chemical treatment, thermal treatment, biological treatment, and in situ treatment. The term "process option" will refer to specific processes, or technologies, within each generalized technology type. For example, air stripping, carbon adsorption, and reverse osmosis are process options that fall under the technology type known as physical/chemical treatment. Several technology types may be identified for each general response action, and numerous process options may exist within each generalized technology type.

Remedial action technology types that are potentially applicable to Site 28 are listed in Table 9-2 with respect to their corresponding general response action. (These technology types are listed in the column titled "Remedial Action Technology".) Also identified on the table are applicable process options associated with each of the listed technology types.

9.3 Preliminary Screening of Remedial Action Technologies and Process Options

In this step, the set of remedial action technologies and process options identified in the previous section will be screened (or reduced) by evaluating the technologies with respect to technical implementability and site-specific factors. This screening step will be accomplished by using readily available information from the RI (with respect to contaminant types, contaminant concentrations, and on-site characteristics) to screen out technologies and process options that cannot be effectively implemented at the site (USEPA, 1988). In general, all technologies and process options which appear to be applicable to the site contaminants and to the site conditions will be retained for further evaluation. The preliminary screening is presented on Table 9-3. Following the preliminary screening, each of the process options remaining will be evaluated in Section 9.4.

As shown on Table 9-3, several technologies and/or process options were eliminated from further evaluation because they were determined to be inappropriate for the site and/or the contaminants present at the site. The specific reasons for retaining or eliminating process options are provided in the column titled "Site-Specific Applicability". The technologies/process options that were eliminated include:

- Fencing
- Capping
- Vertical Barriers
- Horizontal Barriers
- Extraction/Injection Wells
- Hydrofracturing
- Biological Treatment
- Air/Steam Stripping
- Carbon Adsorption
- Chemical Dechlorination
- Ultraviolet (UV) Oxidation
- Chemical Reduction
- Ion Exchange
- Distillation
- Oil/Water Separation
- Thermal Treatment
- Engineered Wetland Treatment
- Treatment at POTW

- Treatment at RCRA Facility
- In Situ Biodegradation
- Air Sparging
- Groundwater Circulation Wells
- Dual Phase Extraction
- Discharge by Reinjection
- POTW Discharge

The technologies and process options that passed this preliminary screening are listed in Table 9-4.

9.4 Process Option Evaluation

The objective of the process option evaluation is to select only one process option for each applicable remedial technology type to simplify the subsequent development and evaluation of alternatives without limiting flexibility during remedial design. More than one process option may be selected for a technology type if the processes are sufficiently different in their performance that one would not adequately represent the other. The representative process provides a basis for developing performance specifications during preliminary design. However, the specific process option used to implement the remedial action may not be selected until the remedial design phase.

The process options listed in Table 9-4 were evaluated based on three criteria: effectiveness, implementability, and relative cost. The effectiveness evaluation focused on: the potential effectiveness of process options in meeting the remedial action objectives; the potential impacts to human health and the environment during the construction and implementation phase; and how reliable the process is with respect to the contaminants of concern. The implementability evaluation focused on the administrative feasibility of implementing a technology (e.g., obtaining permits), since the technical implementability was previously considered in the preliminary screening. The cost evaluation played a limited role in this screening. Only relative capital and operating and maintenance (O&M) costs were used instead of detailed estimates. As per the USEPA guidance, the relative cost analysis was made on the basis of engineering judgment.

A summary of the process options evaluation is presented on Table 9-5. It is important to note that the elimination of a process option does not mean that the process option/technology can never be reconsidered for the site. As previously stated, the purpose of this part of the FS process is to simplify the development and evaluation of potential alternatives.

9.5 Final Set of Remedial Action Technologies/Process Options

Table 9-6 identifies the final set of feasible technologies/process options that will be used to develop remedial action alternatives in Section 10.0. Brief descriptions of the final technologies/process options are presented below.

9.5.1 No Action

The no action response (or passive remediation) provides a baseline for comparison with other response actions. Under the no action response, groundwater at Site 28 will be left in place, and passive remediation can occur. Passive remediation involves natural attenuation processes, such as biodegradation, volatilization, photolysis, leaching, and adsorption, that over time destroy contaminants of concern. Factors that influence these natural processes include: water content in soil, soil porosity/permeability, clay content, adsorption site density, pH, oxidation/reduction potential, temperature, wind, evaporation, precipitation, microbial community, chemical composition and concentration, depth of incorporation, irrigation management, soil management, and availability of nutrients.

9.5.2 Groundwater Monitoring

A long-term groundwater monitoring program could be implemented at Site 28 as an institutional control. This program would continue to provide information regarding the effectiveness of any remedial activities conducted on site.

9.5.3 Aquifer-Use Restrictions

An ordinance restricting the use of the deep aquifer (i.e., the Castle Hayne Aquifer) at Site 28 as a drinking water source could be implemented as an institutional control. This restriction would help reduce the risk to both human and ecological populations from ingestion and direct contact with the contaminants that could possibly migrate into the aquifer.

9.5.4 Deed Restrictions

Deed restrictions or land use restrictions may be used as an institutional control measure. Selected areas within a site may be subject to a deed restriction thereby limiting the future use of that land. A typical example of such a restriction is a RCRA landfill. After a landfill has been closed, that area of land becomes subject to a deed restriction providing that no future disturbance (development, excavation, etc.) is permitted.

SECTION 9.0 TABLES

TABLE 9-1

GENERAL RESPONSE ACTIONS FOR SITE 28
FEASIBILITY STUDY, CTO-0231
SITE 28, HADNOT POINT BURN DUMP
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media of Concern	Remedial Action Objective	General Response Action
Groundwater	• Mitigate the potential for direct exposure to the groundwater COCs.	• No Action • Institutional Controls • Containment/Collection Actions • Treatment/Discharge Actions

TABLE 9-2

POTENTIAL SET OF REMEDIAL ACTION TECHNOLOGIES AND PROCESS OPTIONS
FEASIBILITY STUDY CTO-0231
SITE 28, HADNOT POINT BURN DUMP
MCB CAMP LEJEUNE, NORTH CAROLINA

Media of Concern	General Response Action	Remedial Action Technology	Process Option
Groundwater	No Action	No Action	Not Applicable
	Institutional Controls	Monitoring	Groundwater Monitoring
		Ordinances	Aquifer-Use Restrictions
		Access Restrictions	Deed Restrictions
			Fencing
	Containment/Collection Actions	Capping	Clay/Soil Cap
			Asphalt/Concrete Cap
			Soil Cover
			Multilayered Cap
		Vertical Barriers	Grout Curtain
			Slurry Wall
			Sheet Piling
			Rock Grouting
		Horizontal Barriers	Grout Injection
			Block Displacement
		Extraction	Extraction Wells
			Extraction/Injection Wells
			Hydrofracturing
		Subsurface Drains	Interceptor Trenches
	Treatment/Discharge Actions	Biological Treatment	Aerobic • Aerated Lagoon • Activated Sludge • Powdered Activated Carbon Treatment • Trickling Filter • Rotating Biological Contactor
			Anaerobic
		Physical/Chemical Treatment	Air Stripping
			Steam Stripping
			Carbon Adsorption
			Chemical Dechlorination
			Ultraviolet (UV) Oxidation
			Chemical Oxidation •Hydrogen Peroxide •Chlorine •Potassium Permanganate •Ozonation
			Chemical Reduction
			Reverse Osmosis

TABLE 9-2 (Continued)

POTENTIAL SET OF REMEDIAL ACTION TECHNOLOGIES AND PROCESS OPTIONS
FEASIBILITY STUDY CTO-0231
SITE 28, HADNOT POINT BURN DUMP
MCB CAMP LEJEUNE, NORTH CAROLINA

Media of Concern	General Response Action	Remedial Action Technology	Process Option
Groundwater (Continued)	Treatment/Discharge Actions (Continued)	Physical/Chemical Treatment (Continued)	Ion Exchange
			Electrodialysis
			Electrochemical Ion Generation
			Distillation
			Neutralization
			Precipitation
			Filtration
			Flocculation
			Sedimentation
			Oil/Water Separation
		Thermal Treatment	Incineration ● Liquid Injection ● Rotary Kiln ● Fluidized Bed ● Multiple Hearth
			Molten Salt
			Plasma Arc Torch
			Pyrolysis
			Wet Air Oxidation
		Engineered Wetland Treatment	Constructed Wetlands
		Off-Site Treatment	POTW
			RCRA Facility
			Sewage Treatment Plant
		In-Situ Treatment	Biodegradation
			Air Sparging
			Groundwater Circulation Wells
			Dual Phase Extraction
			Passive Treatment Wall
		On-Site Discharge	Surface Water
			Reinjection ● Injection Wells ● Infiltration Galleries
		Off-Site Discharge	POTW
			Pipeline to River
			Sewage Treatment Plant
			Deep Well Injection

TABLE 9-3

PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS
FEASIBILITY STUDY, CTO-0231
SITE 28, HADNOT POINT BURN DUMP
MCB, CAMP LEJEUNE, NORTH CAROLINA

General Response	Remedial Action Technology	Process Option	Description	Site-Specific Applicability	Screening Results
No Action	No Action	Not Applicable	No action - contaminated groundwater remains as is.	Potentially applicable to any site; required by the NCP.	Retained
Institutional Controls	Monitoring	Groundwater Monitoring	Ongoing monitoring of existing wells.	Potentially applicable.	Retained
	Ordinances	Aquifer-Use Restrictions	Prohibit use of the contaminated aquifer as a potable water source.	Potentially applicable.	Retained
	Access Restrictions	Deed Restrictions	Limit the future use of land including placement of wells.	Potentially applicable.	Retained
		Fencing	Limit access by installing a fence around contaminated area.	A fence alone will not prevent contaminant migration.	Eliminated
Containment/Collection Actions	Capping	Clay/Soil Cap Asphalt/Concrete Cap Soil Cover Multilayered Cap	Capping material placed over areas of contamination.	Typically used in conjunction with vertical barriers which are not technically feasible at Site 28. A cap alone will not meet the remedial objectives.	Eliminated
	Vertical Barriers	Grout Curtain	Pressure injection of grout in a regular pattern of drilled holes to contain contamination.	No continuous confining layer under the site for the wall to adjoin to.	Eliminated
		Slurry Wall	Trench around areas of contamination. The trench is filled with a soil bentonite slurry to limit migration of contaminants.	No continuous confining layer under the site for the wall to adjoin to.	Eliminated
		Sheet Piling	Interlocking sheet pilings installed via drop hammer around areas of contamination.	No continuous confining layer under the site for the wall to adjoin to.	Eliminated
		Rock Grouting	Specialty operation for sealing fractures, fissures, solution cavities, or other voids in rock to control flow of groundwater.	No bedrock underlies the site.	Eliminated

TABLE 9-3 (Continued)

PRELIMINARY SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS
FEASIBILITY STUDY, CTO-0231
SITE 28, HADNOT POINT BURN DUMP
MCB, CAMP LEJEUNE, NORTH CAROLINA

General Response	Remedial Action Technology	Process Option	Description	Site-Specific Applicability	Screening Results
Containment/Collection Actions (Continued)	Horizontal Barriers	Grout Injection	Pressure injection of grout to form a bottom seal across a site at a specific depth.	Technique is in the experimental stage.	Eliminated
		Block Displacement	Continued pumping of grout into specially notched holes causing displacement of a block of contaminated earth.	Technique is in the experimental stage.	Eliminated
	Extraction	Extraction Wells	Series of wells used to extract contaminated groundwater.	Potentially applicable.	Retained
		Extraction/Injection Wells	Injection wells inject uncontaminated groundwater to enhance collection of contaminated groundwater via the extraction wells. Injection wells can also inject material into an aquifer to remediate groundwater.	Based on the low permeability of soils at the site, injected liquid may mound in the subsurface formations rather than flowing through.	Eliminated
		Hydrofracturing	Pressurized water is injected to create fractures in the formation, thus improving permeability. Used to enhance pump and treat systems.	Pilot scale technology.	Eliminated
	Subsurface Drains	Interceptor Trenches	Perforated pipe installed in trenches backfilled with porous media to collect contaminated groundwater. Generally limited to shallow depths.	Potentially applicable.	Retained
Treatment/Discharge Actions	Biological Treatment	Aerobic • Aerated Lagoon • Activated Sludge • Powered Activated Carbon Treatment • Trickling Filter • Rotating Biological Contactor	Degradation of organics using microorganisms in an aerobic environment.	Not applicable to the inorganic contaminants of concern.	Eliminated

TABLE 9-3 (Continued)

PRELIMINARY SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS
FEASIBILITY STUDY, CTO-0231
SITE 28, HADNOT POINT BURN DUMP
MCB, CAMP LEJEUNE, NORTH CAROLINA

General Response	Remedial Action Technology	Process Option	Description	Site-Specific Applicability	Screening Results
Treatment/Discharge Actions (Continued)	Biological Tretment (Continued)	Anaerobic	Degradation of organics using microorganisms in an anaerobic environment.	Not applicable to the contaminants of concern.	Eliminated
	Physical/Chemical Treatment	Air Stripping	Mixing large volumes of air with water in a packed volume to promote transfer of VOCs to air. Applicable to VOCs and some SVOCs.	Not applicable to the contaminants of concern.	Eliminated
		Steam Stripping	Mixing large volumes of steam with water in a packed column to promote transfer of VOCs to air. Applicable to a wide range of organics.	Not applicable to the contaminants of concern.	Eliminated
		Carbon Adsorption	Adsorption of contaminants onto activated carbon by passing water through carbon column. Applicable to wide range of organics.	Not applicable to the contaminants of concern.	Eliminated
		Chemical Dechlorination	Process which uses specially synthesized chemical reagents to destroy hazardous chlorinated molecules or to detoxify them to form other less harmful compounds. Applicable to PCBs, chlorinated hydrocarbons and dioxins.	Not applicable to the contaminants of concern.	Eliminated
		Ultraviolet (UV) Oxidation	Ultraviolet radiation used to destroy organic contaminants as water flows into a treatment tank; an azone destruction unit treats off-gases from the treatment tank.	Not applicable to the contaminants of concern.	Eliminated
		Chemical Oxidation • Hydrogen Peroxide • Chlorine • Potassium Permanganate • Ozonation	Addition of an oxidizing agent to raise the oxidation state of a substance. Applicable to organics and some metals, primarily iron and manganese.	Potentially applicable to manganese in the groundwater.	Retained

TABLE 9-3 (Continued)

PRELIMINARY SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS
FEASIBILITY STUDY, CTO-0231
SITE 28, HADNOT POINT BURN DUMP
MCB, CAMP LEJEUNE, NORTH CAROLINA

General Response	Remedial Action Technology	Process Option	Description	Site-Specific Applicability	Screening Results
Treatment/Discharge Actions (Continued)	Physical/Chemical Treatment (Continued)	Chemical Reduction	Addition of a reducing agent to lower the oxidation state of a substance to reduce toxicity/solubility. Applicable to chromium, mercury and lead.	The small amount of lead in the groundwater does not warrant the use of this technology.	Eliminated
		Reverse Osmosis	Using high pressure to force water through carbon column. Applicable to wide range of inorganics.	Potentially applicable.	Retained
		Ion Exchange	Contaminated water is passed through a resin bed where ions are exchanged between resin and water. Effective for inorganics, but not iron and manganese.	Not applicable to manganese in the groundwater; the small amount of lead in the groundwaater does not warrant the use of this technology.	Eliminated
		Electrodialysis	Metal ions are removed when an electric current drives contaminated water through ion exchangers in membrane form.	Potentially applicable.	Retained
		Electrochemical Ion Generation	Electrical currents are used to put ferrous and hydroxyl ions into solution for subsequent removal via precipitation. Applicable to metals removal.	Potentially applicable.	Retained
		Distillation	Contaminated water is heated so it evaporates leaving contaminants behind. The water vapor is then cooled resulting in condensate of purified water. Highly energy intensive.	Because it is highly energy intensive, this method is inappropriate for treating groundwater with low contaminant concentrations such as the groundwater at Site 28.	Eliminated
		Neutralization	Addition of an acid or base to a waste in order to adjust its pH. Applicable to acidic or basic waste streams.	Although pH is not a concern at the site, neutralization may be applicable in a treatment train with precipitation.	Retained
		Precipitation	Materials in solution are transferred into a solid phase for removal. Applicable to particulates and metals.	Potentially applicable.	Retained

TABLE 9-3 (Continued)

PRELIMINARY SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS
FEASIBILITY STUDY, CTO-0231
SITE 28, HADNOT POINT BURN DUMP
MCB, CAMP LEJEUNE, NORTH CAROLINA

General Response	Remedial Action Technology	Process Option	Description	Site-Specific Applicability	Screening Results
Treatment/Discharge Actions (Continued)	Physical/Chemical Treatment (Continued)	Filtration	Removal of suspended solids from solution by forcing the liquid through a porous medium. Applicable to suspended solids.	Potentially applicable.	Retained
		Flocculation	Small, unsettleable particles suspended in a liquid medium are made to agglomerate into large particles by the addition of flocculating agents. Applicable to particulates and inorganics.	Potentially applicable.	Retained
		Sedimentation	Removal of suspended solids in an aqueous waste stream via gravity separation. Applicable to suspended solids.	Potentially applicable.	Retained
		Oil/Water Separation	Materials in solution are transferred into a separate phase for removal. Applicable to petroleum hydrocarbons.	Not applicable to the contaminants of concern.	Eliminated
	Thermal Treatment	Incineration • Liquid Injection • Rotary Kiln • Fluidized Bed • Multiple Hearth	Combustion of waste at high temperatures. Different incinerator types can be applicable to pumpable organic wastes, combustible liquids, soils, slurries, or sludges.	Incineration is relatively expensive when there are low contaminant concentrations; extensive dewatering may be required.	Eliminated
		Molten Salt	Advanced incineration; waste contacts hot molten salt to undergo catalytic destruction. Applicable for hazardous liquids, low ash, high chlorine wastes.	Incineration is relatively expensive when there are low contaminant concentrations; extensive dewatering may be required.	Eliminated
		Plasma Arc Torch	Advanced incineration; pyrolyzing wastes into combustible gases in contact with a gas which has been energized to its plasma state by an electrical discharge. Applicable for liquid organic waste.	Incineration is relatively expensive when there are low contaminant concentrations; extensive dewatering may be required.	Eliminated

TABLE 9-3 (Continued)

PRELIMINARY SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS
FEASIBILITY STUDY, CTO-0231
SITE 28, HADNOT POINT BURN DUMP
MCB, CAMP LEJEUNE, NORTH CAROLINA

General Response	Remedial Action Technology	Process Option	Description	Site-Specific Applicability	Screening Results
Treatment/Discharge Actions (Continued)	Thermal Treatment (Continued)	Pyrolysis	Advanced incineration; thermal conversion of organic material into solid, liquid, and gaseous components; takes place in an oxygen-deficient atmosphere. Applicable for organics and inorganics.	Incineration is relatively expensive when there are low contaminant concentrations; extensive dewatering may be required.	Eliminated
		Wet Air Oxidation	Advanced incineration; aqueous phase oxidation of dissolved or suspended organic substances at elevated temperatures and pressures. Applicable for organics with high COD, high strength wastes, and for oxidizable inorganics.	Incineration is relatively expensive when there are low contaminant concentrations; extensive dewatering may be required.	Eliminated
	Engineered Wetland Treatment	Constructed Wetlands	An engineered complex of plants, substrates, water, and microbial populations. Contaminants are removed via plant uptake, biodegradation (organics only), precipitation, and sorption processes.	Too extensive for groundwater that is primarily contaminated with inorganics; based on land use at Site 28, wetlands construction may be difficult.	Eliminated
	Off-site Treatment	POTW	Extracted groundwater discharged to Jacksonville POTW for treatment.	Distance to POTW makes this option impractical.	Eliminated
		RCRA Facility	Extracted groundwater transported to licensed RCRA facility for treatment and/or disposal.	Distance to nearest RCRA facility makes this option impractical.	Eliminated
		Sewage Treatment Plant	Extracted groundwater discharged to Hadnot Point STP for treatment.	Potentially applicable.	Retained
	In Situ Treatment	Biodegradation	System of introducing nutrients and oxygen to waste for the stimulation or augmentation of microbial activity to degrade contamination. Applicable to a wide range of organic compounds.	Not applicable to the contaminants of concern.	Eliminated

TABLE 9-3 (Continued)

PRELIMINARY SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS
FEASIBILITY STUDY, CTO-0231
SITE 28, HADNOT POINT BURN DUMP
MCB, CAMP LEJEUNE, NORTH CAROLINA

General Response	Remedial Action Technology	Process Option	Description	Site-Specific Applicability	Screening Results
Treatment/Discharge Actions (Continued)	In Situ Treatment (Continued)	Air Sparging	"In Situ Air Stripping". Used in combination with treatment of soils in the unsaturated zone. Applicable to volatile organics.	Not applicable to the contaminants of concern.	Eliminated
		Groundwater Circulation Wells	Groundwater pumped from the aquifer passes through an in-well separation plate, passes through an on-site treatment installation, then is reinjected into the aquifer; applicable to dissolved heavy metals.	Shallow aquifers may limit effectiveness.	Eliminated
		Dual Phase Extraction	A high vacuum placed in a well removes liquid and gas; applicable to VOCs in low permeability or heterogeneous formations.	Not applicable to the contaminants of concern.	Eliminated
		Passive Treatment Wall	A permeable reaction wall is installed across the flow path of a contaminant plume, allowing the plume to passively move through the wall.	Potentially applicable.	Retained
	On-Site Discharge	Surface Water	Treated water discharged to stream on the site (i.e., Cogdels Creek, Orde Pond).	Potentially applicable.	Retained
		Reinjection • Injection Wells • Infiltration Galleries	Treated water reinjection into the site aquifer via use of shallow infiltration galleries (trenches) or via deep injection wells.	Based on the low permeability of soils at the site, injected liquid may mound in the subsurface formations rather than flowing through.	Eliminated
	Off-Site Discharge	POTW	Treated water discharged to Jacksonville POTW.	Distance to POTW makes this option impractical.	Eliminated
		Pipeline to Stream	Treated water discharged to stream off site (i.e., New River).	Potentially applicable.	Retained
		Sewage Treatment Plant	Treated water discharged to Hadnot Point STP.	Potentially applicable.	Retained

TABLE 9-3 (Continued)

PRELIMINARY SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS
FEASIBILITY STUDY, CTO-0231
SITE 28, HADNOT POINT BURN DUMP
MCB, CAMP LEJEUNE, NORTH CAROLINA

General Response	Remedial Action Technology	Process Option	Description	Site-Specific Applicability	Screening Results
Treatment/Discharge Actions (Continued)	Off-Site Discharge (Continued)	Deep Well Injection	Treated water is reinjected into the brine aquifer located under the Castle Hayne aquifer.	Potentially applicable.	Retained

TABLE 9-4

SET OF POTENTIAL TECHNOLOGIES/PROCESS OPTIONS THAT PASSED THE PRELIMINARY SCREENING SITE 28, HADNOT POINT BURN DUMP FEASIBILITY STUDY CTO-0231 MCB CAMP LEJEUNE, NORTH CAROLINA

Media of Concern	General Response Action	Remedial Action Technology	Process Option
Groundwater	No Action	No Action	Not Applicable
	Institutional Controls	Monitoring	Groundwater Monitoring
		Ordinances	Aquifer-Use Restrictions
		Access Restrictions	Deed Restrictions
	Containment/Collection Actions	Extraction	Extraction Wells
		Subsurface Drains	Interceptor Trenches
	Treatment/Discharge Actions	Physical/Chemical Treatment	Chemical Oxidation ●Hydrogen Peroxide ●Chlorine ●Potassium Permanganate ●Ozonation
			Reverse Osmosis
			Electrodialysis
			Electrochemical Ion Generation
			Neutralization
			Precipitation
			Filtration
			Flocculation
			Sedimentation
		Off-Site Treatment	Sewage Treatment Plant
		In Situ Treatmen	Passive Treatment Wall
		On-Site Discharge	Surface Water
		Off-Site Discharge	Pipeline to Stream
			Sewage Treatment Plant
			Deep Well Injection

TABLE 9-5

SUMMARY OF PROCESS OPTION EVALUATION
FEASIBILITY STUDY, CTO-0231
SITE 28, HADNOT POINT BURN DUMP
MCB, CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Evaluation: Effectiveness	Evaluation: Implementability	Evaluation: Relative Cost	Evaluation Results
No Action	No Action	Not Applicable	• Effectiveness depends on contaminant concentrations, risks associated with the contaminants, and/or the effects of natural attenuation	• Easily implemented	• No cost	Retained as per the requirements of the NCP
Institutional Controls	Monitoring	Groundwater Monitoring	• Will effectively detect contaminant increases so that exposure can be avoided	• Easily implemented	• Low capital • Low O&M	Retained because of its effectiveness and low cost
	Ordinances	Aquifer-Use Restrictions	• Effective at preventing future exposure to groundwater • Effectiveness dependent on continued future implementation	• Easily implemented	• Negligible Cost	Retained because of its effectiveness and negligible cost
	Access Restrictions	Deed Restrictions	• Effective at preventing future exposure to groundwater • Effectiveness dependent on continued future implementation	• Easily implemented • Legal requirements	• Negligible cost	Retained because of its effectiveness and negligible cost
Containment/ Collection Actions	Extraction	Extraction Wells	• Because inorganics sorb to solid particles, extraction wells may not be highly effective • Potential exposures during implementation	• Easily implemented • Equipment readily available • Metals (i.e., the groundwater COCs) will precipitate and clog well screens; this necessitates frequent maintenance and equipment replacement	• Moderate capital • Low O&M	Eliminated because it may not be effective for collecting inorganics in groundwater; also, the COCs may clog the well screens

TABLE 9-5 (Continued)

SUMMARY OF GROUNDWATER PROCESS OPTION EVALUATION
FEASIBILITY STUDY, CTO-0231
SITE 28, HADNOT POINT BURN DUMP
MCB, CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Evaluation			Evaluation Results
			Effectiveness	Implementability	Relative Cost	
Containment/ Collection Actions (Continued)	Subsurface Drains	Interceptor Trenches	• Commercial track record for collecting and/or containing a contaminated groundwater plume • Applicable only for shallow groundwater plumes • Slower recovery than extraction wells • Potential exposures during installation	• Requires an experienced specialty contractor • Requires extensive excavation trenching • Requires more area than extraction wells • May limit the recreational use of land at Site 28	• Low to moderate to high capital • Low to moderate O&M	Eliminated because it requires extensive excavation.
Treatment/ Discharge Actions	Physical/ Chemical Treatment	Chemical Oxidation • Hydrogen Peroxide • Chlorine • Potassium Permanganate • Ozonation	• Used in conjunction with collection technologies which are considered inappropriate for the COCs • Reliable and proven on industrial wastewaters for iron and manganese treatment • Can be used alone or in conjunction with precipitation	• Well-demonstrated at hazardous waste sites in pilot- and full-scale • Readily available, conventional equipment required • Bench scale testing normally required	• Low to moderate capital • Moderate to high O&M	Eliminated because it is used in conjunction with collection technologies which are considered inappropriate for the COCs

TABLE 9-5 (Continued)

SUMMARY OF GROUNDWATER PROCESS OPTION EVALUATION
FEASIBILITY STUDY, CTO-0231
SITE 28, HADNOT POINT BURN DUMP
MCB, CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Evaluation			Evaluation Results
			Effectiveness	Implementability	Relative Cost	
Treatment/ Discharge Actions (Continued)	Physical/ Chemical Treatment (Continued)	Reverse Osmosis	• Used in conjunction with collection technologies which are considered inappropriate for the COCs • Membrane is sensitive to fouling • Membranes must be replaced approximately once every five years • Membrane selection is critical	• Readily available technology	• Low capital • Moderate to high O&M	Eliminated because it is used in conjunction with collection technologies which are considered inappropriate for the COCs
		Electrodialysis	• Used in conjunction with collection technologies which are considered inappropriate for the COCs • Membrane is sensitive to fouling so pretreatment is necessary • Membrane selection is critical	• Commercially available technology	• Low capital • Moderate to high O&M	Eliminated because it is used in conjunction with collection technologies which are considered inappropriate for the COCs
		Electrochemical Ion Generation	• Used in conjunction with collection technologies which are considered inappropriate for the COCs • Not significantly impacted by varying concentrations • Less sludge may be produced	• Emerging technology-bench or pilot testing required • Used in combination with precipitation	• Low to moderate capital • Moderate O&M	Eliminated because it is used in conjunction with collection technologies which are considered inappropriate for the COCs

TABLE 9-5 (Continued)

SUMMARY OF GROUNDWATER PROCESS OPTION EVALUATION
FEASIBILITY STUDY, CTO-0231
SITE 28, HADNOT POINT BURN DUMP
MCB, CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Evaluation: Effectiveness	Evaluation: Implementability	Evaluation: Relative Cost	Evaluation Results
Treatment/ Discharge Actions (Continued)	Physical/ Chemical Treatment (Continued)	Neutralization	• Used in conjunction with collection technologies which are considered inappropriate for the COCs • Can be used in a treatment train for pH adjustment	• Widely used and well-demonstrated • Simple and readily available equipment/materials • Bench-scale studies may be required	• Low capital • Low to moderate O&M	Eliminated because it is used in conjunction with collection technologies which are considered inappropriate for the COCs
		Precipitation	• Used in conjunction with collection technologies which are considered inappropriate for the COCs • Effective, reliable, permanent, and conventional technology • Typically used for removal of heavy metals, like lead • Followed by solids-separation method • Generates sludge which can be voluminous, difficult to dewater, and may require treatment	• Widely used and well demonstrated • Equipment is basic and easily designed • Compact, single units that are deliverable to the site • Requires bench- or pilot-scale tests	• Low capital • Moderate O&M	Eliminated because it is used in conjunction with collection technologies which are considered inappropriate for the COCs
		Filtration	• Used in conjunction with collection technologies which are considered inappropriate for the COCs • Conventional, proven method of removing suspended solids from wastewater • Does not remove other contaminants • Generates a sludge which requires proper handling	• Equipment is relatively simple to install and no chemicals are required • Pilot study is required • Package units available	• Low capital • Low O&M	Eliminated because it is used in conjunction with collection technologies which are considered inappropriate for the COCs

TABLE 9-5 (Continued)

SUMMARY OF GROUNDWATER PROCESS OPTION EVALUATION
FEASIBILITY STUDY, CTO-0231
SITE 28, HADNOT POINT BURN DUMP
MCB, CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Evaluation			Evaluation Results
			Effectiveness	Implementability	Relative Cost	
Treatment/ Discharge Actions (Continued)	Physical/ Chemical Treatment (Continued)	Flocculation	• Used in conjunction with collection technologies which are considered inappropriate for the COCs • Well established technology • Applicable to any aqueous waste stream where particles must be agglomerated into larger more settleable particles prior to other types of treatment • Performance depends on the variability of the composition of the waste being treated	• Equipment is readily available and easy to operate • Can be easily integrated into more complex treatment systems	• Low capital • Moderate O&M	Eliminated because it is used in conjunction with collection technologies which are considered inappropriate for the COCs
		Sedimentation	• Used in conjunction with collection technologies which are considered inappropriate for the COCs • Effective for removing suspended solids and precipitated materials from wastewater • Performance depends on density and particle size of the solids, effective charge on the suspended particles, types of chemicals used in pretreatment, surface loading, upflow rate, and rejection time • Feasible for large volumes of water to be treated	• Sedimentation tanks demonstrated and proven successful at hazardous waste sites • Effluent streams include the effluent water, scum, and settled solids	• Moderate capital • Moderate O&M	Eliminated because it is used in conjunction with collection technologies which are considered inappropriate for the COCs

TABLE 9-5 (Continued)

SUMMARY OF GROUNDWATER PROCESS OPTION EVALUATION
FEASIBILITY STUDY, CTO-0231
SITE 28, HADNOT POINT BURN DUMP
MCB, CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Evaluation			Evaluation Results
			Effectiveness	Implementability	Relative Cost	
Treatment/ Discharge Actions (Continued)	Off-Site Treatment	Sewage Treatment Plant	• Used in conjunction with collection technologies which are considered inappropriate for the COCs • Effectiveness and reliability require pilot test to determine	• Readily implementable if STP will accept waste; gaining STP acceptance may be difficult • Modifications to permits may be required	• Moderate capital • Low O&M	Eliminated because it is used in conjunction with collection technologies which are considered inappropriate for the COCs
	In Situ Treatment	Passive Treatment Wall	• New and innovative technology; not widely demonstrated • Inorganics precipitation and biofouling could occur resulting in a reduction of permeability through the wall	• Does not create contaminated residue, sludge, or other materials requiring disposal • No external energy source is required for the treatment process • Trenching is required	• Moderate to high capital • Low O&M	Eliminated because it has not been well demonstrated
	On-Site Discharge	Surface Water	• Used in conjunction with collection technologies which are considered inappropriate for the COCs • Effective and reliable discharge method	• Based on the low pumping rates expected, the drainage ditch on the southern portion of Site 1 (which ultimately flows into Cogdels Creek) should have the capacity to handle discharge from a pump and treat system	• Low to moderate capital • Low to moderate O&M	Eliminated because it is used in conjunction with collection technologies which are considered inappropriate for the COCs

TABLE 9-5 (Continued)

SUMMARY OF GROUNDWATER PROCESS OPTION EVALUATION
FEASIBILITY STUDY, CTO-0231
SITE 28, HADNOT POINT BURN DUMP
MCB, CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Evaluation			Evaluation Results
			Effectiveness	Implementability	Relative Cost	
Treatment/ Discharge Actions (Continued)	Off-Site Discharge	Pipeline to Stream	• Used in conjunction with collection technologies which are considered inappropriate for the COCs • Effective and reliable discharge method	• Discharge permits required • Distance from the contaminated plume to the New River makes this process option more difficult to implement	• Moderate to high capital • Low O&M	Eliminated because it is used in conjunction with collection technologies which are considered inappropriate for the COCs
		Sewage Treatment Plant	• Used in conjunction with collection technologies which are considered inappropriate for the COCs • Effective and reliable discharge method	• Discharge permit may need modified • Capacity of the Hadnot Point STP may not be able to accept the flow	• Low capital • Low O&M	Eliminated because it is used in conjunction with collection technologies which are considered inappropriate for the COCs
		Deep Well Injection	• Used in conjunction with collection technologies which are considered inappropriate for the COCs • Injection wells effectiveness is highly dependent on site geology/hydrogeology • Wells may clog in time due to inorganics precipitation	• Discharge permit required • Injection wells must be installed	• Moderate Capital • Moderate O&M	Eliminated because it is used in conjunction with collection technologies which are considered inappropriate for the COCs; also, the COCs may clog the well screens

TABLE 9-6

FINAL SET OF POTENTIAL REMEDIAL ACTION TECHNOLOGIES AND PROCESS OPTIONS
FEASIBILITY STUDY CTO-0231
SITE 28, HADNOT POINT BURN DUMP
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media of Concern	General Response Action	Remedial Action Technology	Process Option
Groundwater	No Action	No Action	Not Applicable
	Institutional Controls	Monitoring	Groundwater Monitoring
		Ordinances	Aquifer-Use Restrictions
		Access Restrictions	Deed Restrictions

10.0 DEVELOPMENT AND SCREENING OF REMEDIAL ACTION ALTERNATIVES - SITE 28

In this section, remedial action technologies and process options chosen for Site 28 will be combined to form remedial action alternatives (RAAs). Following the development of these RAAs (Section 10.1), each RAA may be evaluated against the short-term and long-term aspects of three criteria: effectiveness, implementability, and cost (Section 10.2). The RAAs with the most favorable evaluation are then retained for further consideration during the detailed analysis (Section 11.0). Note that the screening evaluation at this step of the FS is optional. It will only be conducted if too many RAAs are initially developed.

10.1 Development of Remedial Action Alternatives

RAAs were developed by combining the general response actions, remedial action technologies, and process options that are listed in Table 9-6. Two RAAs were developed for the groundwater: no action and institutional controls. A description of these RAAs is presented in the following subsections.

10.1.1 RAA No. 1: No Action

Under the no action RAA, no additional remedial actions will be performed to reduce the toxicity, mobility, or volume of contaminants identified in the groundwater. The no action alternative is required by the NCP to provide a baseline for comparison with other remedial action alternatives that provide a greater level of response.

Since contaminants will remain at the site under this RAA, the NCP [40 CFR 300.430(f)(4)] requires the lead agency to review the effects of this alternative no less often than once every five years.

10.1.2 RAA No. 2: Institutional Controls

Under RAA No. 2, no remedial actions will be performed to reduce the toxicity, mobility, or volume of groundwater contaminants at Site 28. Instead, the following institutional controls (or technologies/process options) will be implemented: continued groundwater monitoring, aquifer-use restrictions, and deed restrictions.

Figure 10-1 identifies the well locations where groundwater will be monitored under RAA No. 2. As shown, four samples will be collected from the surficial aquifer and two samples will be collected from the Castle Hayne aquifer. Groundwater samples, collected semiannually, will be analyzed for lead and manganese to monitor their concentrations over time. Additional wells may be added to the monitoring plan, if necessary.

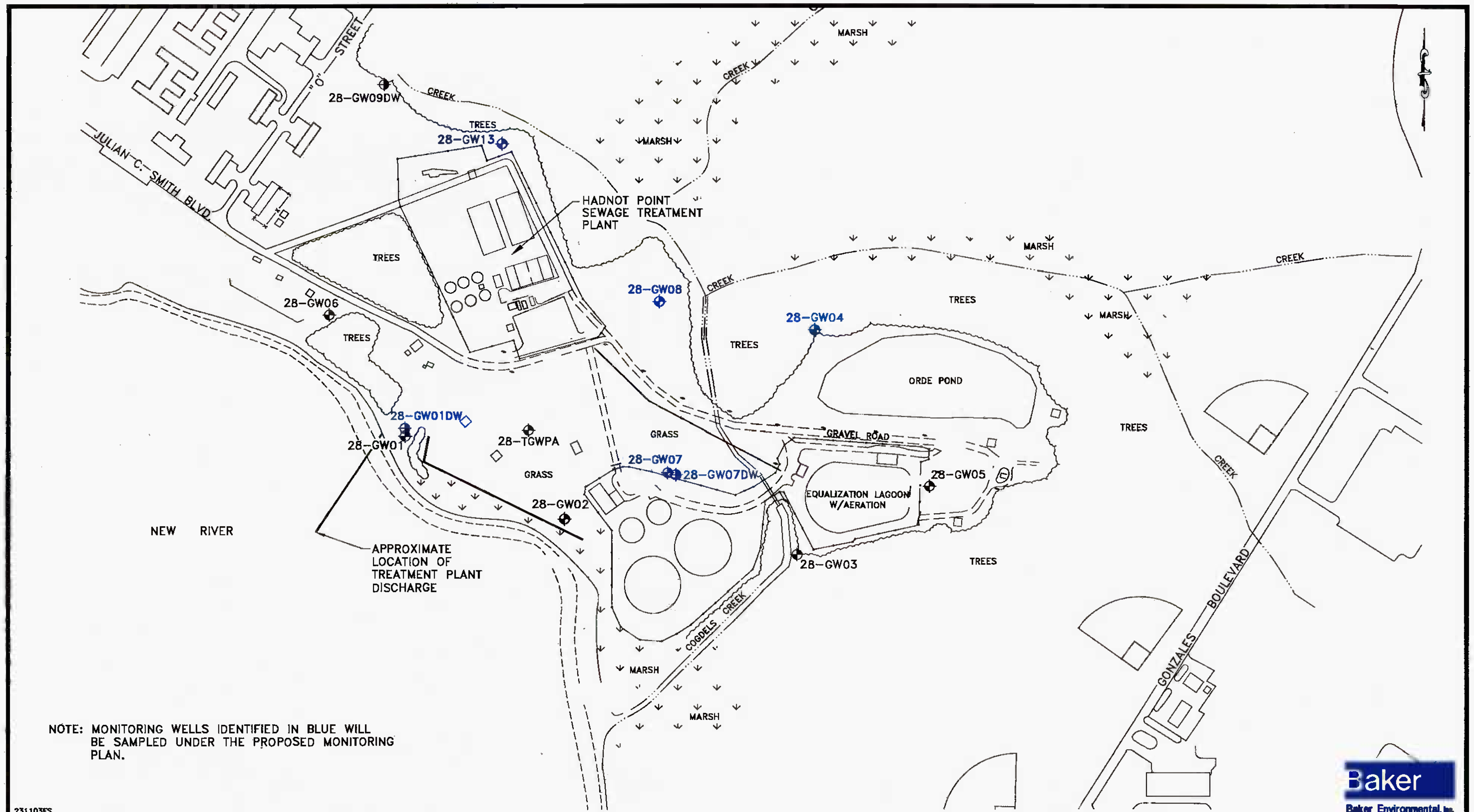
In addition to groundwater monitoring, the Base Master Plan will be modified to include aquifer-use restrictions which will prohibit future use of the aquifer as a potable water source. Also, deed restrictions will be implemented to limit the future use of land at the site, including placement of wells.

Since contaminants will remain at the site under this RAA, the NCP [40 CFR 300.430(f)(4)] requires the lead agency to review the effects of this alternative no less often than once every five years.

10.2 Screening of Alternatives

Typically, this section of the FS presents the initial screening of the potential RAAs. The objective of this screening is to make comparisons between similar alternatives so that only the most promising ones are carried forward for further evaluation (USEPA, 1988). This screening is an optional step in the FS process, and is usually conducted if there are too many RAAs to perform the detailed evaluation on. For Site 28, the decision was made not to conduct this preliminary RAA screening step. Therefore, all of the developed RAAs will undergo the detailed analysis presented in Section 11.0.

SECTION 10.0 FIGURES



LEGEND

28-GW01	SHALLOW MONITORING WELL
28-GW01DW	DEEP MONITORING WELL

300 0 150 300 600

1 inch = 300 ft.

FIGURE 10-1
RAA No. 2: INSTITUTIONAL CONTROLS – MONITORING PLAN
SITE 28 – HADNOT POINT BURN DUMP
FEASIBILITY STUDY CTO-0231
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

SOURCE: LANTDIV, FEBRUARY 1992 AND W.K. DICKSON, JUNE 1994

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11.0 DETAILED ANALYSIS OF REMEDIAL ACTION ALTERNATIVES - SITE 28

This section contains a detailed analysis of the Site 28 groundwater RAAs that were developed in Section 10.0. More specifically, Sections 11.1 and 11.2 present the two parts of the detailed analysis: the individual analysis of remedial action alternatives, and a comparative analysis of remedial action alternatives.

This detailed analysis has been conducted to provide sufficient information to adequately compare the alternatives, select an appropriate remedy for the site, and demonstrate satisfaction of the CERCLA remedy selection requirements in the ROD. The extent to which alternatives are assessed during the detailed analysis is influenced by the available data, the number and types of alternatives being analyzed, and the degree to which alternatives were previously analyzed during their development and screening (USEPA, 1988). (There was no initial screening of alternatives for Site 28).

The detailed analysis of alternatives was conducted in accordance with the "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (USEPA, 1988) and the NCP, including the February 1990 revisions. In conformance with the NCP, seven of the following nine criteria were used for the detailed analysis:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost
- State acceptance (not evaluated at this time)
- Community acceptance (not evaluated at this time)

State acceptance and community acceptance will be evaluated in the ROD by addressing comments received after the FS and Proposed Remedial Action Plan (PRAP) have been reviewed by the Technical Review Committee (TRC), which includes participants from the State of North Carolina Department of Environmental, Health, and Natural Resources (NC DEHNR), USEPA Region IV, and the public.

Section 6.0 of this FS presents an overview of the nine evaluation criteria, and cost estimates for the Site 28 RAAs are provided in Appendix B of Volume II.

11.1 <u>Individual Analysis of Alternatives</u>

The following subsections present the detailed analysis of groundwater RAAs on an individual basis. This individual analysis includes a brief description of each RAA and an assessment of how well the RAA performs against the evaluation criteria. Table 11-1 summarizes the individual, detailed analysis.

11.1.1 RAA No. 1: No Action

Description

Under the no action alternative, groundwater at Site 28 will remain as is. No remedial actions will be implemented.

Assessment

Overall Protection of Human Health and the Environment: Because no remedial actions will be implemented, the potential risks associated with human exposure will remain under this RAA. Similarly, the potential risks associated with ecological receptor exposure will remain under this RAA.

Compliance With ARARs: Under the no action alternative, manganese in the groundwater is expected to exceed chemical-specific ARARs. However, manganese levels exceeding ARARs have been detected in groundwater throughout MCB, Camp Lejeune (Baker, 1994b). Therefore, it appears that manganese levels exceeding ARARs are a natural occurrence at MCB, Camp Lejeune.

Lead is not expected to exceed its chemical-specific ARARs because its high detection was most likely the result of suspended solids in the total metals sample. Lead was detected in only one well and that well exhibited high turbidity and total suspended solids readings. Also, lead was only detected in the total metals sample, not the dissolved metals sample, at that well. As a result, the lead concentration detected may not accurately represent dissolved lead in the groundwater, and the actual concentration of dissolved lead may not exceed chemical-specific ARARs.

No action-specific or location-specific ARARs apply to this no action alternative.

Long-Term Effectiveness and Permanence: Residual risks to human health will remain at the site under the no action alternative. Residual risks include use of the groundwater as a potable water source. However, it is highly unlikely that this scenarios will occur because the surficial aquifer is not used as a potable water source (Harned, et. al., 1989). Thus, the magnitude of residual risk is minimal.

The no action alternative does not include any type of controls for managing untreated COCs that will remain at the site. Since COCs will not be removed from the aquifer, RAA No. 1 will require 5-year reviews to ensure that adequate protection of human health and the environment is maintained.

Reduction of Toxicity, Mobility, or Volume Through Treatment: The no action alternative does not provide a means for toxicity, mobility, or volume reduction of lead and manganese in the groundwater. Additionally, RAA No. 1 does not satisfy the statutory preference for treatment.

Short-Term Effectiveness: Since there are no remedial action activities associated with RAA No. 1, implementation of this alternative does not increase risks to the community or to workers. Implementation also does not create any additional environmental impacts. The time required to meet the remedial response objectives cannot be estimated.

Implementability: With respect to technical implementability, the no action alternative will be easy to implement since no additional construction or operation activities will be conducted. However, this alternative does not include a monitoring plan so there is no way of determining the alternative's effectiveness. If increases in COC levels are not detected, ingestion of contaminated groundwater could possibly occur in the future.

In terms of administrative feasibility, RAA No. 1 should not require additional coordination with other agencies. In addition, the availability of services, materials, and/or technologies is not applicable to this alternative.

Cost: There are no capital costs or O&M costs associated with this alternative. Therefore, the NPW is $0.

11.1.2 RAA No. 2: Institutional Controls

<u>Description</u>

RAA No. 2 differs from the no action alternative by including the following institutional controls: continued groundwater monitoring, aquifer-use restrictions, and deed restrictions. Under this alternative, six existing monitoring wells will be sampled on a semiannual basis and the samples will be analyzed for lead and manganese. Additional wells may be added to the monitoring program, if necessary. In addition, aquifer-use restrictions and deed restrictions will be implemented at the site.

<u>*Assessment*</u>

Overall Protection of Human Health and the Environment: Under RAA No. 2, institutional controls will reduce the potential risks associated with human exposure to the groundwater. This RAA will also reduce potential risks associated with exposure to ecological receptors.

Compliance With ARARs: Under the no action alternative, manganese in the groundwater is expected to exceed ARARs. However, manganese levels exceeding ARARs have been detected in groundwater throughout MCB, Camp Lejeune (Baker, 1994b). Therefore, it appears that manganese levels exceeding chemical-specific ARARs are a natural occurrence at MCB, Camp Lejeune.

Lead is not expected to exceed its chemical-specific ARARs because its high detection was most likely the result of suspended solids in the total metals sample. Lead was detected in only one well and that well exhibited high turbidity and total suspended solids readings. Also, lead was only detected in the total metals sample, not the dissolved metals sample, at that well. As a result, the lead concentration detected may not accurately represent dissolved lead in the groundwater, and the actual concentration of dissolved lead may not exceed chemical-specific ARARs.

No action-specific or location-specific ARARs apply to this alternative.

Long-Term Effectiveness and Permanence: The residual risk from leaving the COCs untreated at the site will be minimal. However, RAA No. 2 will reduce any residual risk that may exist because: (1) the aquifer-use restrictions will restrict groundwater from being used as a potable water source, (2) the deed restrictions will limit future use of land at Site 28, and (3) the monitoring plan will detect any improvement or deterioration in groundwater quality.

RAA No. 2 is based on adequate and reliable controls that will help to manage the untreated COCs. For example, the monitoring plan will be an adequate and reliable control for assessing the effectiveness of the remedial action alternative. Similarly, aquifer-use and deed restrictions will be adequate and reliable controls for preventing human exposure to the groundwater.

Because COCs will remain untreated, RAA No. 2 requires 5-year reviews to ensure that adequate protection of human health and the environment is maintained.

Reduction of Toxicity, Mobility, or Volume Through Treatment: RAA No. 2 does not provide a means for toxicity, mobility, or volume reduction of lead and manganese in the groundwater. Additionally, RAA No. 2 does not satisfy the statutory preference for treatment.

Short-Term Effectiveness: Implementation of the institutional controls associated with RAA No. 2 will not increase risks to the community. In addition, implementation does not pose any significant risks to workers although worker protection will be required during groundwater sampling. Implementation also does not create any environmental impacts.

Under RAA No. 2, the time required to meet the remedial response objectives has been assumed to be 30 years.

Implementability: With respect to technical implementability, RAA No. 2 will be easy to implement since sampling monitoring wells and procuring aquifer-use and deed restrictions have been easily implemented in the past. In addition, the effectiveness of this RAA can be adequately monitored since the RAA includes a monitoring plan. If groundwater quality is deteriorating, the monitoring plan will provide notification before significant exposure can occur. Additional remedial actions could then be implemented along with RAA No. 2.

In terms of administrative feasibility, this alternative will not require additional coordination with other agencies. However, semiannual reports must be submitted to document sampling. In addition, all required services, materials, and/or technologies should be readily available.

Cost: The estimated net present worth associated with RAA No. 2 is approximately $500,000. O&M costs of approximately $30,000 annually are projected for this RAA; there are no capital costs.

11.2 Comparative Analysis

This section presents a comparative analysis of the groundwater RAAs. The purpose of this comparative analysis is to identify the relative advantages and disadvantages of each RAA with respect to the evaluation criteria.

11.2.1 Overall Protection of Human Health and the Environment

RAA No. 1, the no action alternative, does not reduce potential risks to human health and the environment. On the other hand, RAA No. 2 does reduce potential risks because it involves institutional controls that can prevent future exposure to the groundwater.

Regardless, the magnitude of residual risks is considered to be minimal. The groundwater COCs, lead and manganese, do not pose substantial risks to human health or the environment for the following reasons:

- Manganese concentrations (i.e., both total and filtered) in groundwater at MCB, Camp Lejeune often exceed the NCWQS and federal secondary MCL of 50 µg/L (Baker, 1994b). Elevated manganese levels, at concentrations above the NCWQS, were reported in samples collected from a number of base potable water supply wells (Greenhorne and O'Mara, 1992). Manganese concentrations at several Site 28 wells exceeded the NCWQS, and all but one sample fell within the range of concentrations for samples collected elsewhere at MCB, Camp Lejeune.

- Lead was detected above its remediation level at only one well, 28-GW08. This well, which is situated in an area of loosely compacted fill material, exhibited high turbidity (above 10 turbidity units) and total suspended solids (111 mg/L). In addition, lead was only detected in the total metals sample, not the dissolved metals sample, taken at this well. All of this information suggests that the high lead concentration detected at 28-GW08 may be the result of suspended solids, and the total metals analysis is indicative of lead in the soil and groundwater, not just the amount of lead that is dissolved in the groundwater.

Considering the minimal risks associated with lead and manganese in the groundwater, institutional controls (RAA No.2) will be adequate for protecting human health and the environment. No action, however, provides no protection.

11.2.2 Compliance with ARARs

Under RAA Nos. 1 and 2, manganese levels are expected to exceed their chemical-specific ARARs. However, this is not a great concern because manganese at the Base appears to naturally exceed its ARARs. Lead, however, is not expected to exceed ARARs because the high lead detection is believed to be the result of suspended solids in the total metals sample.

No location- or action-specific ARARs apply to RAA Nos. 1 and 2.

11.2.3 Long-Term Effectiveness and Permanence

RAA No. 1 allows the most residual risk, and RAA No. 2 allows less residual risk. Regardless, the magnitude of any residual risk will be minimal for the two reasons stated in Section 11.2.1.

RAA No. 2 involves monitoring, aquifer-use restrictions, and deed restrictions, which are all adequate and reliable controls; RAA No. 1 involves no controls. As a result, RAA No. 2 can mitigate the potential for groundwater exposure, but RAA No. 1 cannot. Also, the effectiveness of RAA No. 2 can be determined more often than the effectiveness of RAA No. 1.

Both RAAs require 5-year reviews to ensure that adequate protection of human health and the environment is maintained.

11.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

RAA Nos. 1 and 2 do not involve active treatment processes so these alternatives will not reduce toxicity, mobility, or volume of the groundwater COCs. Additionally, neither RAA satisfies the statutory preference for treatment.

11.2.5 Short-Term Effectiveness

Implementation of RAA Nos. 1 and 2 will not increase risks to the community. RAA No. 1 will not increase risks to workers, but RAA No. 2 will. RAA No. 2, however, will not significantly increase worker risks because worker protection will be utilized during groundwater sampling. In addition, groundwater sampling has been successfully implemented in the past with minimal worker risks.

No additional environmental impacts are expected under RAA Nos. 1 and 2.

11.2.6 Implementability

RAA No. 1 is the most implementable, if not the most effective, alternative. RAA No. 2 is not as implementable as RAA No. 1, but it is still easily implementable. RAA No. 2 involves conventional, well-demonstrated, and commercially available technologies, and it has been easily implemented in the past.

Despite its implementability, RAA No. 1 does not have adequate monitoring to determine its effectiveness. As a result, failure to detect increases in COC levels could result in potential exposure to the groundwater COCs. RAA No. 2 involves a monitoring plan so there will be notice of contaminant increases in COC levels before significant groundwater exposure can occur.

Unlike RAA No. 1, RAA No. 2 requires the submission of semiannual sampling reports. RAA No. 1 requires no coordination with agencies.

11.2.7 Cost

In terms of NPW, the No Action Alternative (RAA No. 1) would be the least expensive RAA to implement, followed by RAA No. 2. The estimated NPW values in increasing order are $0 (RAA No. 1) and $500,000 (RAA No. 2).

SECTION 11.0 TABLES

TABLE 11-1

SUMMARY OF DETAILED ANALYSIS
FEASIBILITY STUDY, CTO-0231
SITE 28, HADNOT POINT BURN DUMP
MCB, CAMP LEJEUNE, NORTH CAROLINA

Evaluation Criteria	RAA No. 1 No Action	RAA No. 2 Institutional Controls
OVERALL PROTECTIVENESS • Human Health	No reduction in potential human health risks.	Institutional controls reduce potential human health risks.
• Environmental Protection	No reduction in potential risks to ecological receptors.	Institutional controls reduce potential risks to ecological receptors.
COMPLIANCE WITH ARARS • Chemical-Specific ARARs	Manganese is expected to exceed chemical-specific ARARs, but it appears to naturally exceed ARARs in groundwater throughout MCB, Camp Lejeune. Lead is believed to be the result of suspended solids so it is not expected to exceed ARARs.	Manganese is expected to exceed chemical-specific ARARs, but it appears to naturally exceed ARARs in groundwater throughout MCB, Camp Lejeune. Lead is believed to be the result of suspended solids so it is not expected to exceed ARARs.
• Location-Specific ARARs	Not applicable.	Not applicable.
• Action-Specific ARARs	Not applicable.	Not applicable.
LONG-TERM EFFECTIVENESS AND PERMANENCE • Magnitude of Residual Risk	The residual risk from untreated lead and manganese will be minimal.	The residual risk from untreated lead and manganese will be minimal; institutional controls will mitigate any residual risk that may exist.
• Adequacy and Reliability of Controls	Not applicable-no controls.	The monitoring plan is adequate and reliable for determining effectiveness; aquifer-use and deed restrictions are adequate and reliable for preventing human health exposure.
• Need for 5-year Review	Review will be required to ensure adequate protection of human health and the environment.	Review will be required to ensure adequate protection of human health and the environment.
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT • Treatment Process Used	No treatment process.	No treatment process.
• Amount Destroyed or Treated	None.	None.
• Reduction of Toxicity, Mobility, or Volume	None.	None.
• Residuals Remaining After Treatment	Not applicable-no treatment.	Not applicable-no treatment.
• Statutory Preference for Treatment	Not satisfied.	Not satisfied.
SHORT-TERM EFFECTIVENESS • Community Protection	Potential risks to the community will not be increased.	Potential risks to the community will not be increased.
• Worker Protection	No risks to workers.	No significant risks to workers.

TABLE 11-1 (Continued)

SUMMARY OF DETAILED ANALYSIS
FEASIBILITY STUDY, CTO-0231
SITE 28, HADNOT POINT BURN DUMP
MCB, CAMP LEJEUNE, NORTH CAROLINA

Evaluation Criteria	RAA No. 1 No Action	RAA No. 2 Institutional Controls
• Environmental Impact	No additional environmental impacts; current impacts will continue.	No additional environmental impacts; current impacts will continue.
• Time Until Action is Complete	Not applicable.	Estimated 30 years.
IMPLEMENTABILITY • Ability to Construct and Operate	No construction or operation activities.	No construction or operation activities; institutional controls have been easily implemented in the past.
• Ability to Monitor Effectiveness	No monitoring plan; failure to detect increases in COC levels could result in potential ingestion of groundwater.	Proposed monitoring plan will detect increases in COC levels before significant exposure can occur.
• Availability of Services and Capacities; Equipment	No services or equipment required.	No special services or equipment required.
• Requirements for Agency Coordinations	None required.	Must submit semiannual reports to document sampling.
COST (Net Present Worth)	$0	$500,000

12.0 REFERENCES

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APPENDIX A - RISK-BASED ACTION LEVEL CALCULATIONS - SITE 28

INGESTION OF GROUNDWATER ACTION LEVEL, revised 5/30/95
FEASABILITY STUDY
CTO-0231, SITE 28
MCB CAMP LEJEUNE
FUTURE ADULT RESIDENT

C = TR or THI * BW * ATc or ATnc * DY / IRw * EF * ED * CSF or 1/RfD

Where:	INPUTS
C = contaminant concentration in water ((ug/L)	
TR = total lifetime risk	1E-04
THI = total hazard index	1
CSF = carcinogenic slope factor	specific
RfD = reference dose	specific
IRw = daily water ingestion rate (L/Day)	2
EF = exposure frequency (days/yr)	350
ED = exposure duration (yr)	30
BW = body weight (kg)	70
ATc = averaging time for carcinogen (yr)	70
ATnc = averaging time for noncarcinogen (yr)	30
DY = days per year (day/year)	365

Note: Inputs are scenario and site specific

Contaminant	Concentration Carcinogen (ug/l)	Ingestion Rate (L/day)	Exposure Frequency (day/year)	Exposure Duration (year)	Body Weight (kg)	Average Carc Time (years)	Days per year (day/yr)	Slope Factor (mg/kg-day)-1	Target Excess Risk
4,4'-DDE	25	2	350	30	70	70	365	3.40E-01	1.0E-04
4,4'-DDD	35	2	350	30	70	70	365	2.40E-01	1.0E-04
4,4'-DDT	25	2	350	30	70	70	365	3.40E-01	1.0E-04
2,4-Dimethylphenol	0	2	350	30	70	70	365		1.0E-04
4-Methylphenol	0	2	350	30	70	70	365		1.0E-04
Acenaphthene	0	2	350	30	70	70	365		1.0E-04
Chloroform	1396	2	350	30	70	70	365	6.10E-03	1.0E-04
2-Methylnaphthalene	0	2	350	30	70	70	365		1.0E-04
Phenanthrene	0	2	350	30	70	70	365		1.0E-04
Arsenic	5	2	350	30	70	70	365	1.75E+00	1.0E-04
Barium	0	2	350	30	70	70	365		1.0E-04
Lead	0	2	350	30	70	70	365		1.0E-04
Manganese	0	2	350	30	70	70	365		1.0E-04
Mercury	0	2	350	30	70	70	365		1.0E-04

Contaminant	Concentration Noncarcinogen (ug/L)	Ingestion Rate (L/day)	Exposure Frequency (day/year)	Exposure Duration (year)	Body Weight (kg)	Average Noncarc Time (years)	Days per year (day/yr)	Reference Dose (mg/kg-day)	Target Hazard Index
4,4'-DDE	0	2	350	30	70	30	365		1
4,4'-DDD	0	2	350	30	70	30	365		1
4,4'-DDT	18	2	350	30	70	30	365	5.00E-04	1
2,4-Dimethylphenol	730	2	350	30	70	30	365	2.00E-02	1
4-Methylphenol	183	2	350	30	70	30	365	5.00E-03	1
Acenaphthene	2190	2	350	30	70	30	365	6.00E-02	1
Chloroform	365	2	350	30	70	30	365	1.00E-02	1
2-Methylnaphthalene	1460	2	350	30	70	30	365	4.00E-02	1
Phenanthrene	1095	2	350	30	70	30	365	3.00E-02	1
Arsenic	11	2	350	30	70	30	365	3.00E-04	1
Barium	2555	2	350	30	70	30	365	7.00E-02	1
Lead	0	2	350	30	70	30	365		1
Manganese	183	2	350	30	70	30	365	5.00E-03	1
Mercury	11	2	350	30	70	30	365	3.00E-04	1

INGESTION OF GROUNDWATER ACTION LEVEL, revised 5/30/95
FEASABILITY STUDY
CTO-0231, SITE 28
MCB CAMP LEJEUNE
FUTURE CHILD RESIDENT

C = TR or THI * BW * ATc or ATnc * DY / IRw * EF * ED * CSF or 1/RfD

Where:	INPUTS
C = contaminant concentration in water ((ug/L)	
TR = total lifetime risk	1E-04
THI = total hazard index	1
CSF = carcinogenic slope factor	specific
RfD = reference dose	specific
IRw = daily water ingestion rate (L/Day)	1
EF = exposure frequency (days/yr)	350
ED = exposure duration (yr)	6
BW = body weight (kg)	15
ATc = averaging time for carcinogen (yr)	70
ATnc = averaging time for noncarcinogen (yr)	6
DY = days per year (day/year)	365

Note: Inputs are scenario and site specific

Contaminant	Concentration Carcinogen (ug/l)	Ingestion Rate (L/day)	Exposure Frequency (day/year)	Exposure Duration (year)	Body Weight (kg)	Average Carc Time (years)	Days per year (day/yr)	Slope Factor (mg/kg-day)-1	Target Excess Risk
4,4'-DDE	54	1	350	6	15	70	365	3.40E-01	1.0E-04
4,4'-DDD	76	1	350	6	15	70	365	2.40E-01	1.0E-04
4,4'-DDT	54	1	350	6	15	70	365	3.40E-01	1.0E-04
2,4-Dimethylphenol	0	1	350	6	15	70	365		1.0E-04
4-Methylphenol	0	1	350	6	15	70	365		1.0E-04
Acenaphthene	0	1	350	6	15	70	365		1.0E-04
Chloroform	2992	1	350	6	15	70	365	6.10E-03	1.0E-04
2-Methylnaphthalene	0	1	350	6	15	70	365		1.0E-04
Phenanthrene	0	1	350	6	15	70	365		1.0E-04
Arsenic	10	1	350	6	15	70	365	1.75E+00	1.0E-04
Barium	0	1	350	6	15	70	365		1.0E-04
Lead	0	1	350	6	15	70	365		1.0E-04
Manganese	0	1	350	6	15	70	365		1.0E-04
Mercury	0	1	350	6	15	70	365		1.0E-04

Contaminant	Concentration Noncarcinogen (ug/L)	Ingestion Rate (L/day)	Exposure Frequency (day/year)	Exposure Duration (year)	Body Weight (kg)	Average Noncarc Time (years)	Days per year (day/yr)	Reference Dose (mg/kg-day)	Target Hazard Index
4,4'-DDE	0	1	350	6	15	6	365		1
4,4'-DDD	0	1	350	6	15	6	365		1
4,4'-DDT	8	1	350	6	15	6	365	5.00E-04	1
2,4-Dimethylphenol	313	1	350	6	15	6	365	2.00E-02	1
4-Methylphenol	78	1	350	6	15	6	365	5.00E-03	1
Acenaphthene	939	1	350	6	15	6	365	6.00E-02	1
Chloroform	156	1	350	6	15	6	365	1.00E-02	1
2-Methylnaphthalene	626	1	350	6	15	6	365	4.00E-02	1
Phenanthrene	469	1	350	6	15	6	365	3.00E-02	1
Arsenic	5	1	350	6	15	6	365	3.00E-04	1
Barium	1095	1	350	6	15	6	365	7.00E-02	1
Lead	0	1	350	6	15	6	365		1
Manganese	78	1	350	6	15	6	365	5.00E-03	1
Mercury	5	1	350	6	15	6	365	3.00E-04	1

INGESTION OF GROUNDWATER ACTION LEVEL, revised 5/30/95
FEASABILITY STUDY
CTO-0231, SITE 28
MCB CAMP LEJEUNE
MILITARY PERSONNEL

C = TR or THI * BW * ATc or ATnc * DY / IRw * EF * ED * CSF or 1/RfD

Where:	INPUTS
C = contaminant concentration in water ((ug/L)	
TR = total lifetime risk	1E-04
THI = total hazard index	1
CSF = carcinogenic slope factor	specific
RfD = reference dose	specific
IRw = daily water ingestion rate (L/Day)	2
EF = exposure frequency (days/yr)	250
ED = exposure duration (yr)	4
BW = body weight (kg)	70
ATc = averaging time for carcinogen (yr)	70
ATnc = averaging time for noncarcinogen (yr)	4
DY = days per year (day/year)	365

Note: Inputs are scenario and site specific

Contaminant	Concentration Carcinogen (ug/l)	Ingestion Rate (L/day)	Exposure Frequency (day/year)	Exposure Duration (year)	Body Weight (kg)	Average Carc Time (years)	Days per year (day/yr)	Slope Factor (mg/kg-day)-1	Target Excess Risk
4,4'-DDE	263	2	250	4	70	70	365	3.40E-01	1.0E-04
4,4'-DDD	373	2	250	4	70	70	365	2.40E-01	1.0E-04
4,4'-DDT	263	2	250	4	70	70	365	3.40E-01	1.0E-04
2,4-Dimethylphenol	0	2	250	4	70	70	365		1.0E-04
4-Methylphenol	0	2	250	4	70	70	365		1.0E-04
Acenaphthene	0	2	250	4	70	70	365		1.0E-04
Chloroform	0	2	250	4	70	70	365		1.0E-04
2-Methylnaphthalene	14660	2	250	4	70	70	365	6.10E-03	1.0E-04
Phenanthrene	0	2	250	4	70	70	365		1.0E-04
Arsenic	51	2	250	4	70	70	365	1.75E+00	1.0E-04
Barium	0	2	250	4	70	70	365		1.0E-04
Lead	0	2	250	4	70	70	365		1.0E-04
Manganese	0	2	250	4	70	70	365		1.0E-04
Mercury	0	2	250	4	70	70	365		1.0E-04

Contaminant	Concentration Noncarcinogen (ug/L)	Ingestion Rate (L/day)	Exposure Frequency (day/year)	Exposure Duration (year)	Body Weight (kg)	Average Noncarc Time (years)	Days per year (day/yr)	Reference Dose (mg/kg-day)	Target Hazard Index
4,4'-DDE	0	2	250	4	70	4	365		1
4,4'-DDD	0	2	250	4	70	4	365		1
4,4'-DDT	26	2	250	4	70	4	365	5.00E-04	1
2,4-Dimethylphenol	1022	2	250	4	70	4	365	2.00E-02	1
4-Methylphenol	256	2	250	4	70	4	365	5.00E-03	1
Acenaphthene	3066	2	250	4	70	4	365	6.00E-02	1
Chloroform	511	2	250	4	70	4	365	1.00E-02	1
2-Methylnaphthalene	2044	2	250	4	70	4	365	4.00E-02	1
Phenanthrene	1533	2	250	4	70	4	365	3.00E-02	1
Arsenic	15	2	250	4	70	4	365	3.00E-04	1
Barium	3577	2	250	4	70	4	365	7.00E-02	1
Lead	0	2	250	4	70	4	365		1
Manganese	256	2	250	4	70	4	365	5.00E-03	1
Mercury	15	2	250	4	70	4	365	3.00E-04	1

APPENDIX B - COST ESTIMATES - SITE 28

TABLE B-1
ESTIMATED COSTS FOR RAA No. 2

RAA No. 2: INSTITUTIONAL CONTROLS
SITE 28 - HADNOT POINT BURN DUMP
MCB, CAMP LEJEUNE, NC

MONITORING 6 EXISTING WELLS

ANNUAL O&M COSTS

Jul-95

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	ASSUMPTIONS/COMMENTS	UNIT COST SOURCE
GROUNDWATER MONITORING O&M (Based on semiannual sampling for 30 years)							
Labor	Hours	240	$40	$9,600		2 sampling events/yr, 5 days/event, 12 hrs/day/person, 2 people	Engineering Estimate - Previous Projects
Travel	Sample Event	2	$1,437	$2,874		Includes car rental and airfare for 2 people	Engineering Estimate - Previous Projects
Per Diem	Sample Event	2	$686	$1,372		Includes meals and lodging for 2 people	Engineering Estimate - Previous Projects
Laboratory Analyses:							
Lead (Total and Dissolved)	Sample	38	$50	$1,900		Cost includes both laboratory analysis & data validation	Basic Ordering Agreement
Manganese (Total and Dissolved)	Sample	38	$40	$1,520		Cost includes both laboratory analysis & data validation	Basic Ordering Agreement
Equipment	Sample Event	2	$1,300	$2,600		Ice, DI water, expendables, etc.	Engineering Estimate - Previous Projects
Sample Shipping	Sample Event	2	$370	$740		2 coolers per day for 2 days, $183/cooler	Engineering Estimate - Previous Projects
Reporting	Sample Event	2	$3,000	$6,000		Laboratory reports, administration, etc.	Engineering Estimate - Previous Projects
Well Replacement	Year	1	$5,500	$5,500		*Equal annual cost of replacing 5 wells every 5 years for 30 years*	Engineering Estimate - Previous Projects
Total Groundwater Monitoring O&M Costs					$32,000		

SUMMARY OF TOTAL CAPITAL AND O&M COSTS

TOTAL DIRECT AND INDIRECT CAPITAL COSTS	**$0**	
TOTAL ANNUAL O&M COSTS	**$32,000**	Assuming 30 Years of Monitoring
PRESENT WORTH VALUE	**$500,000**	

S.O. No. 62470-231

Subject: Cost Estimate Assumptions for Groundwater Monitoring O&M - Site 28

Sheet No. 1 of 4

Drawing No.

Computed by TLB Checked By MAS Date 7-5-95

Baker

GENERAL ASSUMPTIONS:

- Groundwater will be sampled semiannually for 30 years.
- The discount rate is 5%
- 6 Wells will be sampled for lead and manganese (as shown on Figure 10-1 of the FS)

LABOR:

2 people × 12 hrs/day × 5 days/sampling event × 2 events/yr
= 240 hrs/yr

TRAVEL:

Car rental: 5 days @ $65/day = $325
Air Fare: $556/round trip × 2 people = $1112
Total = $1437/event

PER DIEM:

Lodging - 5 nights @ $40/night × 2 people = $400
Meals - 5.5 days @ $26/day × 2 people = $286
$686/event

S.O. No. 62470-231

Subject: Cost Estimate Assumptions for Groundwater Monitoring O&M - Site 28

Sheet No. 2 of 4

Drawing No.

Computed by TLB Checked By MDS Date 7.5.95

Baker

GROUNDWATER MONITORING O&M

LABORATORY ANALYSES & DATA VALIDATION (QUANTITY CALCULATIONS):

① VOCs →
6 samples (1 at each well targeted for Mn & Pb)
5 rinsates (1/day)
1 duplicates (1 for every 10 samples collected)
1 trip 1 ms/msd (1 for every 20 samples collected)
5 trip blanks (1/day)
1 field blank (1/sampling event)

19 Mn & Pb analyses/6 mos. → 38/yr.

EQUIPMENT:

Per event... (Costs are estimates based on previous projects)

Assume $50/day for meters, HNu, bailers, etc:

5 days × $50/day = $250/event

Assume $25/day/person for health & safety equipment

5 days × $25/day/person × 2 people = $250/event

Assume $225/event for sampling expendables

Assume $275/event for decon expendables

Assume $300/event for ice, DI water

Total = $1300/event

S.O. No. 62470-231

Subject: Cost Estimate Back-Up for Groundwater Monitoring/ O&M - SITE 28

Sheet No. 3 of 4

Drawing No.

Computed by MOS Checked By TLB Date 6·26·95

Baker

WELL REPLACEMENT:

ASSUMPTIONS:

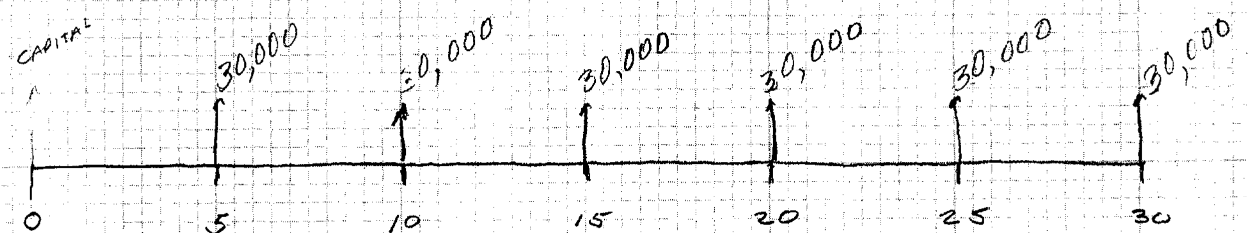
AT SITE 1 REPLACE 4 SHALLOW WELLS (on average, 20' deep) AND 1 DEEP WELL (120' DEEP) EVERY 5 YRS

$n = 30$ $i = 5\%$

FIND: EQUAL ANNUAL COST

COST FOR SINGLE EPISODE

DAY ITEM	UNIT COST	UNITS	TOTAL
MOBILIZATION	$1500/EVENT	1 EVENT	1500
WELLS DEEP	$60/LF	120 LF	7200
WELLS SHALLOW	$48/LF	80 LF	3840
COVERS	$400/EA	6 EACH	2400
DEVELOPMENT	$200/EA	6 EACH	1200
PER DIEM	$180/CREW/DAY	10 DAYS	1800
STAND BY	$140/HR	10 HRS	1400
DRUMS	$42/DRUM	20 DRUMS	840
IDW	$140/HR	20 HRS	2800
GEOLOGIST	$40/HR	120 HRS	4800
ABANDONMENT	$10/LF	220	2200
			29,980
			≈ $30,000 per EVENT



{(P/F, 5%, 5) + (P/F, 5%, 10) + (P/F, 5%, 15) +
{(.7835) + .6139
(P/F, 5%, 20) + (P/F, 5%, 25) + (P/F, 5% 30)} 30,0

S.O. No. 62470-231

Subject: Cost Estimate Back-Up for Groundwater Monitoring O & M - SITE 28

Sheet No. 4 of 4

Drawing No.

Computed by MDS Checked By

Date TLB 6·26·95

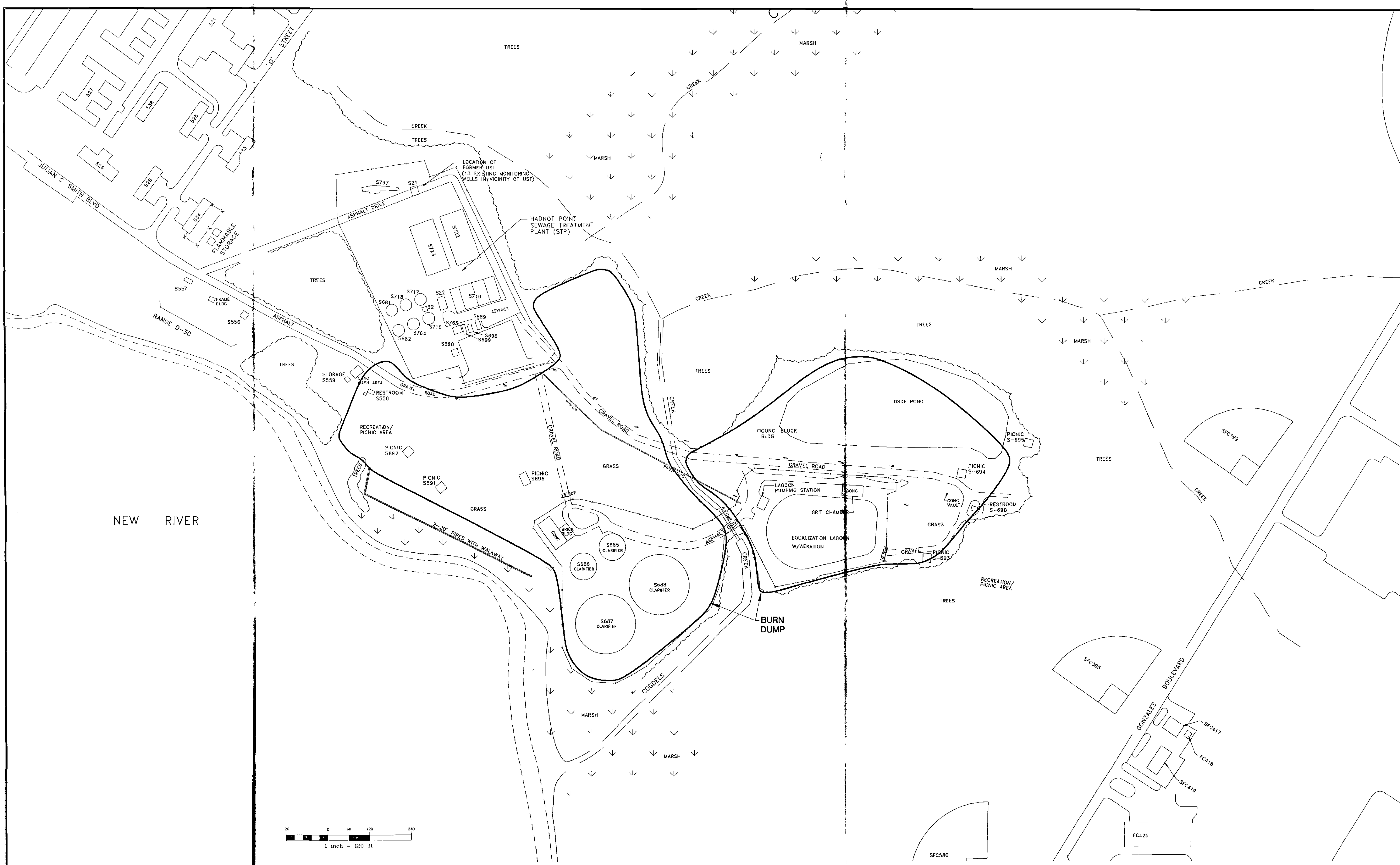
WELL REPLACEMENT (CONTINUED):

{(.7835) + (.6139) + (.4810) + (.3769) + (.2953) + (.2314)} × 30,000

= $ 83,460 PW

(A/P, 5% 30) $ 83,460 =

.0651 × $ 83,460 = $ 5,433 ≈ $5500



LEGEND
VEGETATION
—x— FENCE
— — CREEK/DRAINAGE
MARSH

SOURCE LANTDIV. FEBRUARY 1992

DATE	NOVEMBER 1994
SCALE	1" = 120'
DRAWN	REL
REVIEWED	TFT
S O #	62470-231-0000
C #	231138FS

NORTH

FEASIBILITY STUDY CTO-0231
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

BAKER ENVIRONMENTAL,Inc
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc

SITE MAP
SITE 28 – HADNOT POINT BURN DUMP

SCALE 1" = 120'

DATE NOVEMBER 1994

FIGURE No
7-1

01496DDB2X

LEGEND	
28-GW02	EXISTING SHALLOW MONITORING WELL
28GW01	NEWLY INSTALLED SHALLOW MONITORING WELL (BAKER, 1994)
28GW01DW	NEWLY INSTALLED DEEP MONITORING WELL (BAKER, 1994)
28-CC-SW/SD01	SURFACE WATER/SEDIMENT SAMPLING LOCATION
SB1	SOIL BORING LOCATION
SB40	EXPLORATORY TEST BORING
	VEGETATION
	CREEK/DRAINAGE
—X—	FENCE
	MARSH

SOURCE LANTDIV, FEBRUARY 1992

DATE	FEBRUARY 1995
SCALE	1" = 120'
DRAWN	REL
REVIEWED	TFT
S O #	62470-231
CADD#	231102FS

NORTH

FEASIBILITY STUDY CTO-0231
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

Baker Environmental, Inc

REMEDIAL INVESTIGATION
SAMPLING LOCATIONS
SITE 28 - HADNOT POINT BURN DUMP

SCALE 1" = 120' DATE FEBRUARY 1995

FIGURE No
7-2