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DRAFT ZONE C CORRECTIVE MEASURES STUDY WORK PLAN CNC CHARLESTON SC
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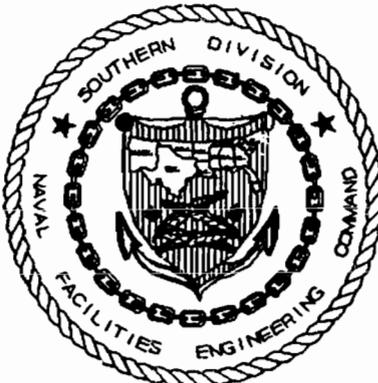
**DRAFT ZONE C CORRECTIVE MEASURES
STUDY WORK PLAN
NAVAL BASE CHARLESTON
CHARLESTON, SOUTH CAROLINA**



Prepared for:

**Department of the Navy
Southern Division
Naval Facilities Engineering Command
North Charleston, South Carolina**

**Contract Number:
N62467-89-D-0318**



Prepared by:

**EnSafe Inc.
5724 Summer Trees Drive
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December 18, 1998



DEPARTMENT OF THE NAVY
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NAVAL FACILITIES ENGINEERING COMMAND
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5090/11
Code 1877
23 December, 1998

Mr. John Litton, P.E.
Director, Division of Hazardous and Infectious Waste Management
Bureau of Land and Waste Management
South Carolina Department of Health and Environmental Control
2600 Bull Street
Columbia, SC 29201

Subj: SUBMITTAL OF ZONE C CORRECTIVE MEASURE STUDY WORKPLANS

Dear Mr. Litton,

The purpose of this letter is to submit the enclosed Zone C Draft Corrective Measure Study (CMS) Work Plan page changes for Naval Base Charleston. The work plan is submitted to fulfill the requirements of condition IV.E.2 of the RCRA Part B permit issued to the Navy by the South Carolina Department of Health and Environmental Control and the U.S. Environmental Protection Agency (USEPA).

The revised workplan contains responses to comments received from the Department and the USEPA. These responses have been previously discussed with Department personnel. The Navy requests that the Department and the USEPA review and provide comment or approval whichever is appropriate. If you should have any questions please contact Billy Drawdy or myself at (843) 743-9985 and (843) 820-5525 respectively.

Sincerely,

A handwritten signature in black ink that reads "M.A. Hunt".

M.A.HUNT, P.E.
Remedial Project Manager
Installation Restoration III

Enclosure: (1) Zone C Corrective Measure Study Workplan, dated 18 December, 1998

Copy to:
SCDHEC (Paul Bergstrand, Johnny Tapia), USEPA (Dann Spariosu)
CSO Naval Base Charleston (Billy Drawdy), SOUTHNAVFACENGCOM (Dodds)



DEPARTMENT OF THE NAVY

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5090/11
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1 July, 1998

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Sincerely,

H.N. SHEPARD II, P.E.
Caretaker Site Officer
by direction

Copy to:
SCDHEC (Paul Bergstrand, Johnny Tapia)
USEPA (Dann Spariosu)
CSO Naval Base Charleston (Billy Drawdy, Daryle Fontenot)
SPORTENVDETCNASN (Bobby Dearhart)

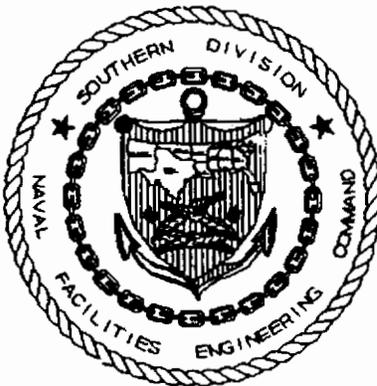
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December 18, 1998

FILING INSTRUCTIONS

The following is a list of pages in the *Draft Zone C Corrective Measures Study Work Plan* dated *June 23, 1998*, that have been revised. The obsolete pages presently in your binders are listed in the column headed "Remove." New and replacement pages are listed in the column headed "Replace." Please file this instruction cover sheet preceding the Table of Content of *Draft Corrective Measures Study Work Plan for Zone C*.

If you have any questions, please call 843-884-0029.

| List of Changes/Revisions | Remove | Replace |
|---|---|--|
| | <u>Pages</u> | <u>Pages</u> |
| Table of Contents - updated. | i - v | i - vi |
| Section 2.0 | 2-3 and 2-4 | 2-3 and 2-4 |
| Section 3.0 | 3-3 | 3-3 |
| Section 4.0 <i>(Please keep the color drawings except for those listed:)</i> | 4-2, 4-4 to 4-6, Figure 4.4, 4-12, Figure 4.7, Figure 4.8, 4-15 to 4-17 | 4-2, 4-4 to 4-6, Figure 4.4 4-12, Figure 4.7, Figure 4.8, 4-15 to 4-18 |
| Section 5.0 | 5-4 to 5-13, Figures 5.2, 5.3, 5.4 5-17 to 5-21 | 5-4 to 5-13 Figures 5.2, 5.3, 5.4 5-17 to 5-24 |
| Section 6.0 | 6-3, 6-5 to 6-8, 6-12 to 6-14 | 6-3, 6-5 to 6-9, 6-13 to 6-16, New Figure 6.6 |
| Section 7.0 | Figure 7-1 7-4 to 7-5, 7-8 to 7-9 | Figure 7-1 7-4 to 7-5, 7-8 to 7-10 New Figure 7.4 |
| Section 8.0 | 8-3 to 8-5, Figure 8.3, 8-8 to 8-9 | 8-3 to 8-5, not replaced 8-7 to 8-8 |

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|--------------|----------------------------|---|
| Section 9.0 | 9-3 to 9-5, 9-8 to 9-9, | 9-3 to 9-6, 9-9 to 9-10, New Figure 9.4 |
| Section 10.0 | 10-3 to 10-5 | 10-3 to 10-6 New Figure 10.2 |
| Section 11.0 | Entire Section | Entire Section |
| Section 13.0 | 13-3 to 13-7 | 13-3 to 13-7 |
| Appendix A | | New Appendix A |

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|----------------------------------|--------------------------------|---------------------------------|
| Section 4.6 | Figure 4.4 | Figure 4.4 |
| Section 9.0 | Figures 9.1 through 9.4 | Figures 9.1 through 9.4 |
| Appendix A | | New Appendix A |

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1.0 DESCRIPTION OF THE RCRA CAP PROCESS

The Resource Conservation and Recovery Act (RCRA) Corrective Action Program (CAP) consists of a series of actions typically required at permitted facilities at which a release has occurred from a solid waste management unit (SWMU) or area of concern (AOC). Consent orders issued by an authorizing agency can also require that a facility establish and begin a RCRA CAP.

The environmental investigation and remediation at the former Charleston Naval Base and Shipyard are required by the Hazardous and Solid Waste Amendments section of the facility's RCRA Part B permit. This work plan describes the corrective measures study portion of the RCRA CAP for Zone C at the former military base.

1.1 Components of the RCRA CAP

A RCRA CAP may consist of the following five actions, as well as other actions not listed:

- Action 1 — RCRA Facility Assessment (RFA)
- Action 2 — RCRA Facility Investigation (RFI)
- Action 3 — Interim Stabilization Measures (ISM)
- Action 4 — Corrective Measures Study (CMS)
- Action 5 — Corrective Measures Implementation (CMI)

The RFA is the initial assessment and investigation of releases at the subject facility. This step is noninvasive (e.g., no environmental media are sampled) and it primarily reviews the facility's history of releases. Should there be sufficient evidence of a release, the facility usually proceeds to the next stage of the program, an RFI, which is used to evaluate the nature and extent of the release and provide additional information to support a CMS, if warranted.

The CMS identifies and evaluates potential remedial alternatives for selected sites at the facility and is usually followed by the implementation of the one selected. This subsequent step (e.g., remedial alternative implementation) is referred to as the CMI.

ISMs are intended to control or abate immediate and extreme threats to human health and/or the environment from the release(s) and/or to prevent or reduce the further spread of contamination while long-term remedies are being developed. Per definition, this stabilization effort is not required for all sites. However, if emergency stabilization efforts are required, they generally occur during the first stage of corrective action, though they may also be conducted at any time during the process. The level of present threat and/or likelihood of potential threat to either human health or the environment from releases at the subject facility determines the time and the scope of ISM, if required.

1.2 Sequencing of the RCRA CAP

It is not necessary for the RCRA CAP to occur in the sequence indicated by the steps listed. Nor are all the steps required to satisfy the RCRA CAP. Every facility and every associated site release is unique. Therefore, the remedial action evaluation and cleanup process needs to be tailored to each facility and it should be directly related to the complexity of facility operations and the severity of its associated release(s).

In summary, the level of detail, and thus ensuing effort, of a corrective action program at a RCRA-regulated facility needs to be proportional to the actual risk to human health and/or the environment posed by facility-related contaminants.

2.0 DESCRIPTION OF THE CMS PROCESS

The CMS essentially starts with the selection of candidate sites for remedial alternative evaluation. As part of a risk management decision, the project team selects sites for inclusion into the CMS process. The decision is primarily based on applicable site conditions and the information obtained during the RFI process, such as risk level and the main risk drivers.

2.1 Objective

The CMS' overall objective is to identify, screen, evaluate, and rank potential remedial alternatives for sites that have been elevated into the CMS stage from the RFI.

This objective will be met by screening and evaluating potential alternatives against four threshold criteria and five balancing criteria. If more than one viable alternative is identified for the subject site, a matrix of ranked alternatives will be presented in the CMS report.

2.2 Inclusion Criteria

Sites with the following characteristics were included in the CMS process. However, as stated previously, final CMS site selection occurs as a result of risk management decisions made by the project team.

- Inclusion Criteria 1 — Sites at which surface soil posed an incremental lifetime excess cancer risk (ILCR) exceeding 1E-6, based on a maximum unrestricted reuse scenario (e.g., residential reuse).

- Inclusion Criteria 2 — Sites at which groundwater contaminants exceeded applicable maximum contaminant levels (MCLs) or other promulgated standards, as defined by the project team, and/or groundwater with residential risk exceeding 1E-6.

- Inclusion Criteria 3 — Sites recommended for further consideration by the project team.

2.3 Threshold Criteria

Potential remedial technologies or alternatives have been listed for each site based on information from the current RFI, other field or support documents, professional experience, and project team input. During the CMS each potential remedial technology or alternative will be screened against four threshold criteria to determine its viability. Threshold criteria are considered primary criteria that must be met by the screened alternative for the alternative to be further considered as a viable candidate.

- Threshold Criteria 1 — Protection of human health and the environment
- Threshold Criteria 2 — Attainment of cleanup standards
- Threshold Criteria 3 — Source control
- Threshold Criteria 4 — Compliance with applicable waste management standards

Technologies or alternatives that pass this initial screening will be retained for further evaluation and comparison. In addition, ranking the alternatives may be required if more than one remedial option passes the initial screening. Formal, or secondary, screening typically requires engineering calculation, parameter estimation, or treatability/pilot study to determine technology effectiveness.

2.4 Balancing Criteria

If more than one remedial option is identified for the site, they are further evaluated against five balancing criteria. These secondary criteria can act as a tie-breaker for remedial alternatives that have met all four of the threshold criteria previously described.

- Balancing Criteria 1 — Long-term reliability and effectiveness
- Balancing Criteria 2 — Reduction in toxicity, mobility, or volume of wastes
- Balancing Criteria 3 — Short-term effectiveness
- Balancing Criteria 4 — Implementability
- Balancing Criteria 5 — Cost

The remedial alternative eventually selected for the site is usually the one that presents favorable overall balancing characteristics. However, it is important that the evaluation process consider site-specific constraints and remain flexible. It is possible that technology limitations, or other yet to-be-determined limitations, could drive the selection of a viable remedial alternative rather than media-specific cleanup goals driving remedy selection. Property reuse consideration is an example of a potential limiting factor.

2.5 Ranking of Alternatives

Alternatives will then be compared to each other and ranked, based on their ability to satisfy the nine criteria. The proposed alternative for the site's final remedy typically will consist of the alternative, or group of alternatives, that present the most cost-effective and technically feasible approach that can protect human health and the environment while obtaining ~~realistic cleanup goals in a timely fashion, considering property reuse potential:~~ **Bureau of Solid and Hazardous Waste Management (BSHWM) cleanup goals in a timely fashion considering both residential and industrial re-use scenarios.**

2.6 Public Participation

Public involvement and input regarding remedial alternative selection will be solicited during the CMS. However, public participation can also be solicited at anytime throughout the RCRA CAP. It is important to provide open communication to all stakeholders at the former Charleston Naval Base and Shipyard. The practice of early, and frequent, public involvement activities usually

leads to informed and sincere public support of the project rather than public opposition through misunderstanding.

The CMS process is further described in *Volume I of the Comprehensive Corrective Measures Study Project Management Plan, EnSafe/Allen & Hoshall, June 1997.*

2.7 Final Remedy Selection

The United States Navy and the South Carolina Department of Health and Environmental Control (SCDHEC) will jointly lead the effort to select the final remedy for each site. The United States Environmental Protection Agency (USEPA) will assist the joint leaders during the selection process. Selection of the final remedy will consist of developing a statement of basis and an associated public involvement plan. Public feedback and input will be considered during final remedy selection.

3.0 DESCRIPTION OF THE CMS WORK PLAN

This Draft Zone C CMS Work Plan describes the components of the proposed CMS for this site at the former Charleston Naval Base and Shipyard. Zone C is one of the twelve investigative zones (A through L) that make up the former base. The designation of twelve separate investigative zones was necessary to effectively manage and expedite the environmental investigation of a large and multi-functional military facility.

The draft work plan consists of the following sections:

- Section 1 — Description of the RCRA CAP Process
- Section 2 — Description of the CMS Process
- Section 3 — Description of the CMS Work Plan
- Section 4 — CMS Site Selection
- Section 5 — Site-Specific Overview (SWMU 44)
- Section 6 — Site-Specific Overview (SWMU 47 and AOC 516)
- Section 7 — Site-Specific Overview (AOC 508 and AOC 511)
- Section 8 — Site-Specific Overview (AOC 512)
- Section 9 — Site-Specific Overview (AOC 518)
- Section 10 — Site-Specific Overview (AOC 700)
- Section 11 — Zone-Wide Groundwater
- Section 12 — CMS Schedule and Report Outline
- Section 13 — References
- Section 14 — Signatory Requirement

3.1 Reference to the Comprehensive CMS Work Plan

A comprehensive CMS operational plan was written and finalized in June 1997 by EnSafe/Allen & Hoshall (E/A&H): *Final Comprehensive Corrective Measures Study Project Management and Work Plans (Volumes I and II)* EnSafe/Allen & Hoshall, 1997. These two volumes make up the comprehensive CMS work plan and contain detailed information and specifics outlining the proposed approach to the overall CMS effort and its objective for the Charleston Naval Base Complex.

It is not the intent of this zone-specific CMS work plan to restate the information presented in the comprehensive CMS work plan. Rather, it outlines brief approaches to the CMS efforts for the Zone C applicable sites. Applicable sites are defined as those designated by the project team as warranting a CMS under the RCRA CAP. Section 4, *CMS Site Selection*, describes how sites are selected for the CMS. By using the comprehensive and zone-specific CMS work plans together, a more efficient and cost-effective CMS will be realized.

The comprehensive CMS work plan should be referenced for the following general plans:

- Sampling and analysis plan (SAP)
- Quality assurance plan (QAP)
- Health and safety plan (HASP)
- Data management plan (DMP)
- Community relations plan (CRP)

These general plans have previously been developed and approved for use during the RCRA Facility Investigation of the former naval base and shipyard. The comprehensive CMS work plan also presents the *overall* technical approach to the CMS effort as well as project management details (e.g., typical project work elements, overall project schedule, and project management

typical project work elements, overall project schedule, and project management responsibilities). Zone-specific information is provided in the zone-specific CMS work plans such as this one.

3.2 Objective of Zone- or Site-Specific CMS Work Plans

The primary goal of this zone-specific work plan is to present the CMS process and objectives proposed for Zone C only. The CMS Work Plan also states supplemental data needs (e.g., additional site-specific field investigations, additional sampling and analysis, treatability studies) required to fully complete the CMS effort for each applicable Zone C site. This data will supplement the information previously obtained during the Zone C RCRA Facility Investigation. The site-specific work plan will present remedial objectives consistent with ~~property reuse plans as currently identified by the Charleston Naval Complex Re-Development Authority.~~ **SCDHEC BSHWM cleanup goals considering both residential and industrial re-use.**

4.0 CMS SITE SELECTION

This section describes how Zone C sites were selected for the CMS process. The project team included a site in the CMS process based primarily on whether residential risk exceeded $1E-6$. The inclusion process did not directly consider contaminant extent, frequency, type, or property reuse plans.

4.1 The Use of Risk Management

Risk management decisions were made by project team consensus based primarily on RFI risk assessment results. This allowed the project team to categorize each Zone C site into one of the three following categories.

- Category I — No further action (NFA) sites
- Category II — CMS sites
- Category III — Petroleum storage tank (PST) sites

4.2 Category I — NFA Sites

Based on RFI results, the project team designated some sites for no further investigative or remedial action under the RCRA Subtitle C program. Therefore, these sites will not be addressed in the CMS. However, some of these sites may require further action under the Navy's PST program or other applicable regulatory programs such as RCRA Subtitle I. The Navy PST program sites are classified as Category III sites discussed in Section 4.4.

The eight Zone C sites listed in Table 4.1 have been designated for NFA. Based on limited monitoring data for each AOC, groundwater for AOCs 510, 512, 513,517, 520, and 523 will be addressed as a single unit as discussed in Section 4.7. Section 11.0 includes the proposed CMS activities for this zone-wide groundwater analysis.

**Table 4.1
 Zone C Sites Designated for NFA**

| | |
|--------------------|--|
| AOC 510 | Former geotechnical laboratory, warehouse, washroom, paint shop and storage room |
| AOC 513 | Former morgue |
| AOC 515 | Former incinerator |
| AOC 517 | Former indoor small arms firing range |
| AOC 519 | Former boiler house |
| AOC 520 | Former garbage storage house |
| AOC 522 | Former grease and wash building (former Building 1252) |
| AOC 523 | Former gas station |

4.3 Category II – CMS Sites

Sites designated for the CMS warrant a corrective measures study as directed by the project team. Figure 4.1, *Zone C CMS Site Location Map*, shows the location of each CMS-designated site in Zone C. The six Zone C investigated areas listed in Table 4.2 have been designated for a CMS. However, four RFI investigation areas have been combined into two separate CMS-designated sites. SWMU 47 and AOC 516 are considered a single CMS area, and AOC 508 and AOC 511 are also considered a single CMS area.

4.4 Category III – PST Sites

PST-designated sites are those identified by the project team as requiring additional studies or field work under the Navy's PST program or, if applicable, under the RCRA Subtitle I program for underground storage tanks. **PST sites will be addressed or managed by the South Carolina Underground Storage Tank Program.** ~~These sites do not require further action under Subtitle C (hazardous waste provision) of the RCRA CAP.~~ None of the Zone C sites are designated Category III. However, AOC 508/AOC 511 did contain a heating fuel oil UST that was

Table 4.2
Zone C Sites Designated for CMS

| | |
|---------------------|--|
| SWMU 44 | Former coal storage yard |
| SWMU 47 and AOC 516 | Former burning dump site (SWMU 47) and former vehicle/equipment spray-washing area and lead-acid battery recharging area (AOC 516); co-located |
| AOC 508 and AOC 511 | Former incinerator and former oil storage house; close proximity |
| AOC 512 | Former incinerator |
| AOC 517 | Former indoor small arms firing range (decision pending) |
| AOC 518 | Former coal storage bins |
| AOC 523 | Former gas station (decision pending) |
| AOC 700 | Former golf course maintenance building |

* - Taken from SCDHEC correspondence dated May 5, 1998.

removed by the Navy Environmental Detachment (DET) in 1998. As stated in Section 7.4, the results of the ISM will be considered during the CMS.

4.5 — Pending Risk Management Tool

Presently, the project team is developing a "risk management decision tool" for the RCRA CAP at the Charleston Naval Base. The purpose of this tool is to assist the project team in determining which RFI sites should undergo a CMS, thus focusing resources on those sites at the former naval base that pose unacceptable risks to human health or the environment. It is expected that this tool should be available to the project team by the middle to latter part of 1998.

The risk management process will evaluate the RFI, supplemental sampling data, and ISM results to evaluate current status. Current and projected land use scenarios, contaminant distributions and frequency of detection, and various other criteria will be evaluated to determine if site risks are acceptable. The project team will then develop a list of sites within each zone which require CMS.

4.6 Zone C RFI Summary

Zone C is comprised of administrative areas, former military housing areas, warehouses, and the former base coal storage yard. The zone is on the western edge of the northern portion of the former naval base. The zone is bounded by McMillian Avenue on the south, Hobson Avenue on the east, Avenue "D" on the northeast, and base property on the west and north. Zone C contains properties identified in the *Final Environmental Impact Statement for Disposal and Reuse of the Charleston Naval Base* (Ecology and Environment, Inc., June 1995) to be used for housing, open space/buffer, community support, and office/training.

The objectives of the RFI were to characterize the nature and extent of contaminants associated with releases from SWMUs and AOCs, to evaluate contaminant migration pathways, and to identify both actual and potential receptors. Twenty-four sites were identified in Zone C through the RFA process, 16 of which advanced to the RFI. **Six Eight** sites advanced to the CMS.

Zone C Groundwater Physical Setting

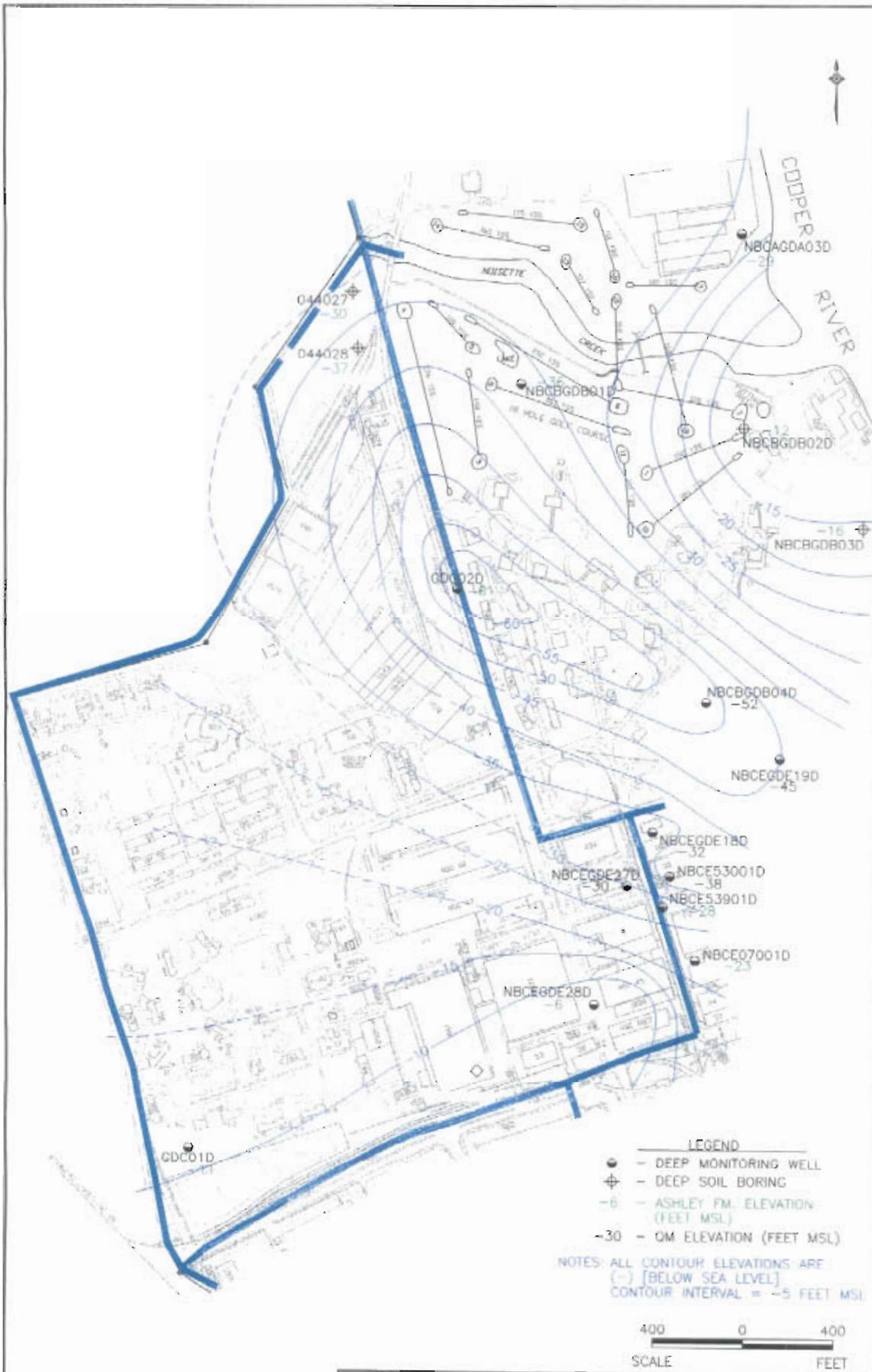
Groundwater occurs under water table or poorly confined conditions overlying a confining unit comprised predominantly of the Ashley Formation and including a marsh clay. The Ashley Formation has a high clay and silt content and acts as a confining unit between the lower members of the Cooper Group/Eocene-age Santee Limestone and the overlying water-bearing Quaternary-age sediments (Park, 1985). Park identifies the Cooper Unit, of which the Ashley Formation is a member and hydrogeologically similar, as being approximately 300 feet thick. A more detailed discussion of and investigation into the geology of Zone C is presented in Sections 2.1 and 2.2 of the *Zone C RFI Report* (EnSafe, 1997).

Borehole lithologic information in Zone C is limited to the upper 85 feet of the subsurface. During the RFI, boring data from Zone C wells and from Zones A, B, and E deep well locations were used to construct a contour map of the elevation of the top of the confining unit (Figure 4.2). A lithologic cross-section was developed from Zone C well information and is presented in Figure 4.3.

Shallow Zone C groundwater elevations measured during the RFI, along with water table data from Zone B and E wells, were used to develop the water table elevations and groundwater flow directions. shown in Figure 4.4. Groundwater elevations are highest in the western and southwestern portions of Zone C. A groundwater divide trends roughly southwest to northeast and separates the northwestern and southeastern portion of the zone. Groundwater northwest of the divide flows off the former naval base property or toward SWMU 44. Southeast of the divide, groundwater flows east toward Zones B and E. Six groundwater flowpaths were constructed from shallow groundwater elevations (shown in Figure 4.4). Flowpaths A and C provide gradient estimates across SWMUs 44 and 47, respectively. The remaining flowpaths estimate generalized gradients across the zone. Groundwater level measurements were collected base-wide in January 1998. The results of the measurements showing groundwater flow directions in and around Zone C are presented in Figure 4.4.

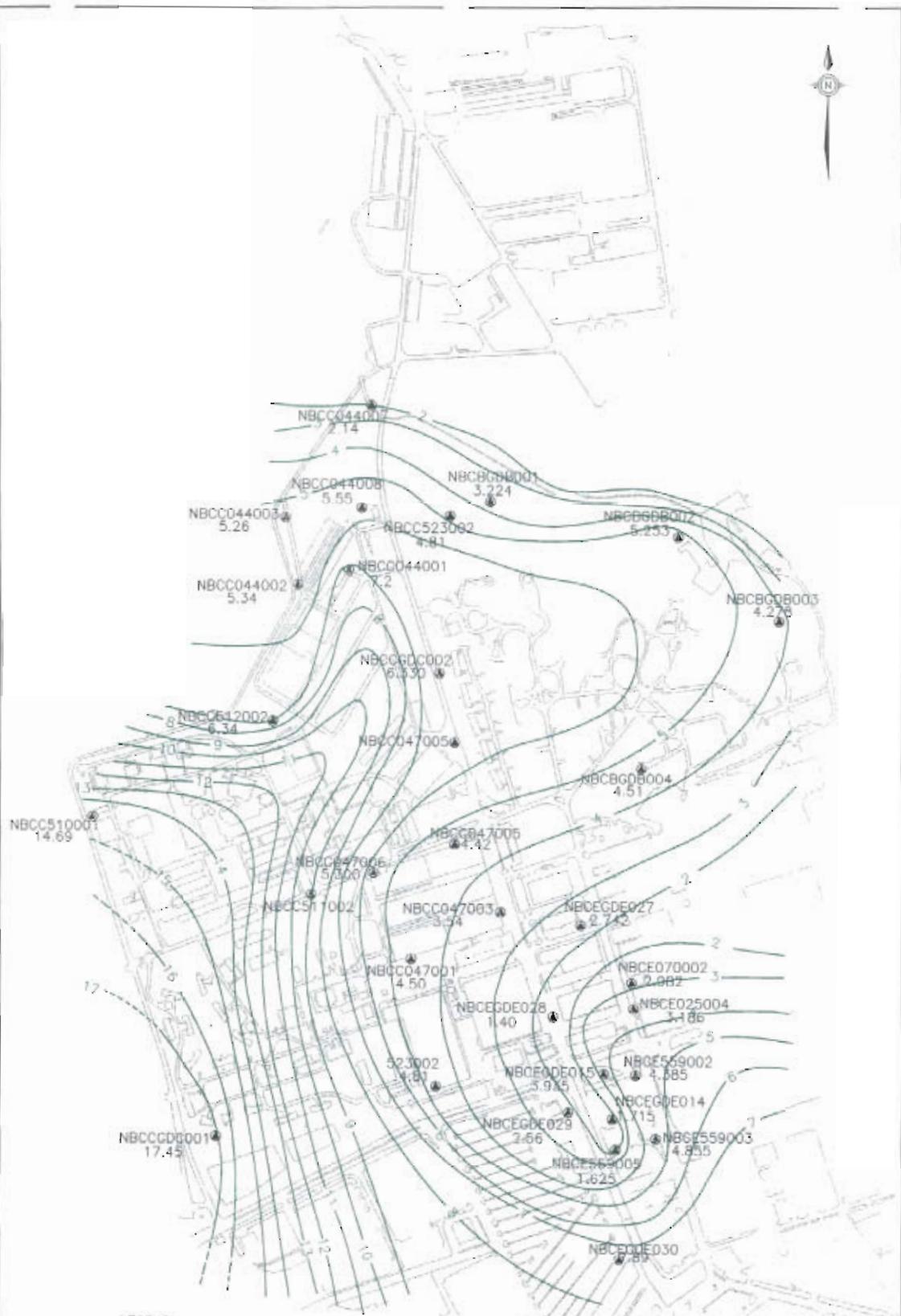
Measurement of vertical hydraulic gradient in the two Zone C shallow/deep well pairs resulted in a downward hydraulic gradient in well pair NBC-GDC-001/NBC-GDC-01D, and an upward hydraulic gradient in well pair NBC-GDC-002/NBC-GDC-02D. The vertical hydraulic gradients are shown in Figure 4.5.

The geometric means of hydraulic conductivity (Figure 4.6) based on rising and falling head slug tests ranged from 0.66 to 10.7 feet/day for shallow wells and 0.96 to 3.41 feet/day for deep wells. An effective conductivity value of 4.38 feet/day was calculated as the geometric mean for shallow



ZONE C
RCRA CMS WORK PLAN
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 4.2
ZONE C
TOP OF CONFINING UNIT
ELEVATION CONTOUR MAP



LEGEND

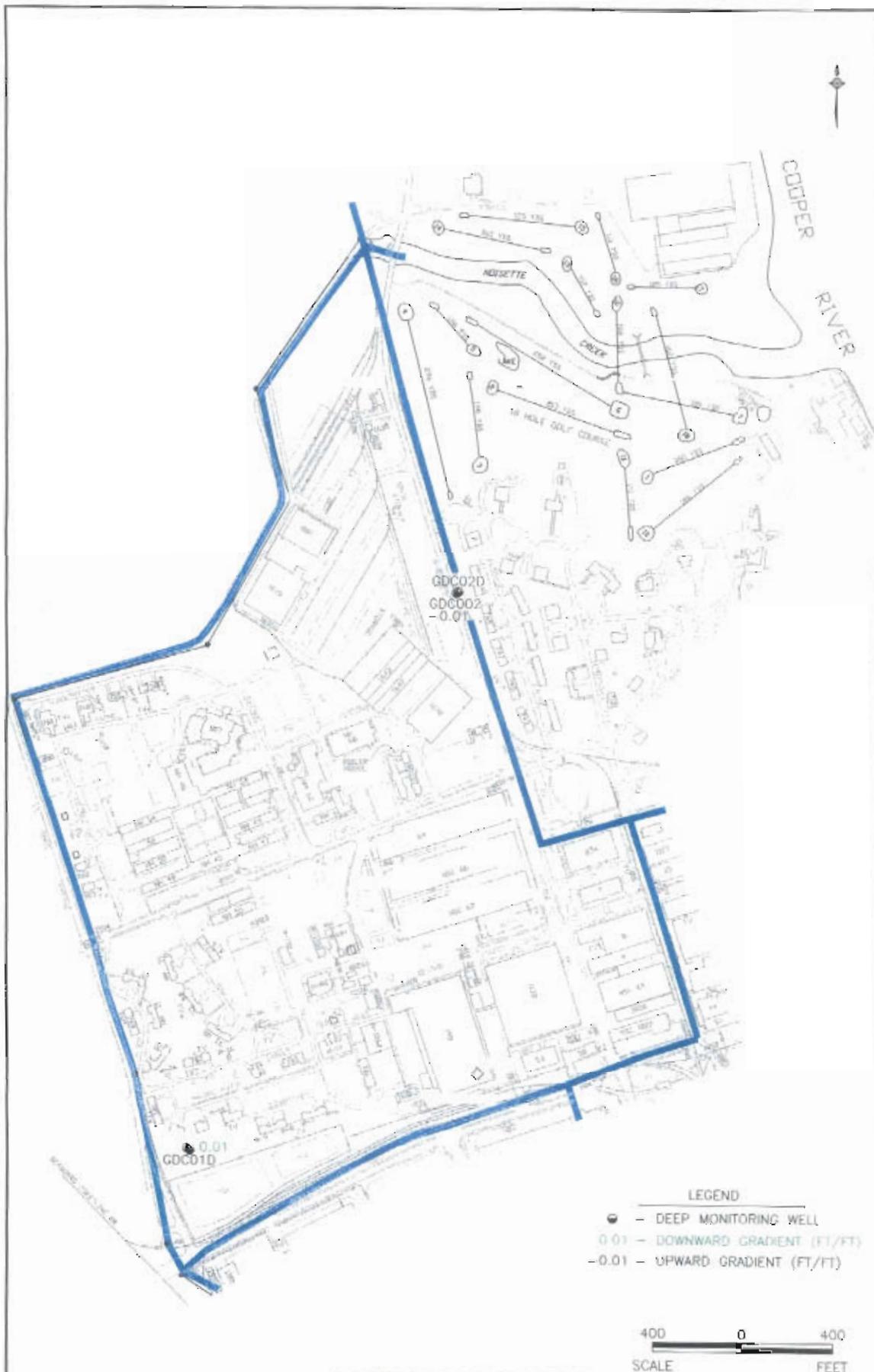
- - SHALLOW MONITORING WELL
- 1 — - ELEVATION CONTOUR

NOTES: ELEVATION IN FEET MSL
ND - NO DATA
CONTOUR INTERVAL = 1 FEET



 ZONE C
RCRA CMS WORK PLAN
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 4.4
ZONE C
SHALLOW GROUNDWATER ELEVATION
MAP - JANUARY, 1998



ZONE C
RCRA CMS WORK PLAN
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

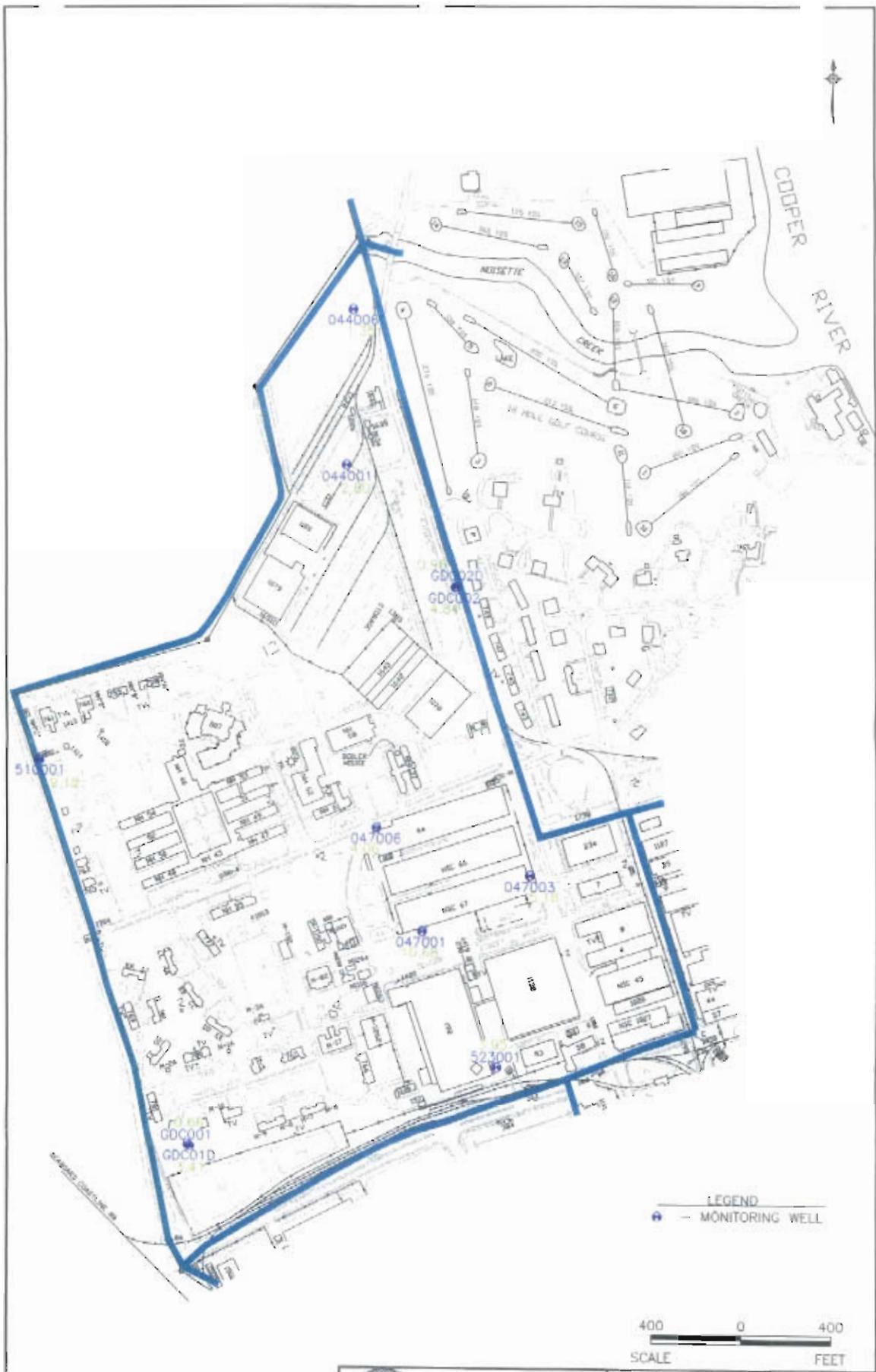
FIGURE 4.5
ZONE C
VERTICAL HYDRAULIC GRADIENTS

Shallow Zone C groundwater elevations measured during the RFI, along with water table data from Zone B and E wells, were used to develop the water table elevations and groundwater flow directions shown in Figure 4.4. Groundwater elevations are highest in the western and southwestern portions of Zone C. A groundwater divide trends roughly southwest to northeast and separates the northwestern and southeastern portion of the zone. Groundwater northwest of the divide flows off the former naval base property or toward SWMU 44. Southeast of the divide, groundwater flows east toward Zones B and E. Six groundwater flowpaths were constructed from shallow groundwater elevations (shown in Figure 4.4). Flowpaths A and C provide gradient estimates across SWMUs 44 and 47, respectively. The remaining flowpaths estimate generalized gradients across the zone.

Measurement of vertical hydraulic gradient in the two Zone C shallow/deep well pairs resulted in a downward hydraulic gradient in well pair NBC-GDC-001/NBC-GDC-01D, and an upward hydraulic gradient in well pair NBC-GDC-002/NBC-GDC-02D. The vertical hydraulic gradients are shown in Figure 4.5.

The geometric means of hydraulic conductivity (Figure 4.6) based on rising and falling head slug tests ranged from 0.66 to 10.7 feet/day for shallow wells and 0.96 to 3.41 feet/day for deep wells. An effective conductivity value of 4.38 feet/day was calculated as the geometric mean for shallow wells, exclusive of SWMU 44. The SWMU 44 effective conductivity was calculated at 1.94 feet/day. The deep well geometric mean conductivity is 1.81 feet/day.

Groundwater velocities were calculated for the six flowpaths in Figure 4.4 based on the effective hydraulic conductivity. Velocity results ranged from 0.0089 feet/day (flowpath D) to 0.1206 feet/day (flowpath E).



NOTE: RESULTS ARE IN FEET/DAY



ZONE C
RCRA CMS WORK PLAN
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

LEGEND
● - MONITORING WELL

400 0 400
SCALE FEET

FIGURE 4.6
ZONE C
HYDRAULIC CONDUCTIVITY
GEOMETRIC MEANS

DWG DATE: 06/19/98 DWG NAME: 29ZNCMW2

wells, exclusive of SWMU 44. The SWMU 44 effective conductivity was calculated at 1.94 feet/day. The deep well geometric mean conductivity is 1.81 feet/day.

Groundwater velocities were calculated for the six flowpaths in Figure 4.4 based on the effective hydraulic conductivity. Velocity results ranged from 0.0089 feet/day (flowpath D) to 0.1206 feet/day (flowpath E).

Zone C Chemicals of Concern

Chemicals of concern (COCs) in groundwater were selected based primarily on their presence in concentrations above MCLs determined through multiple rounds of sampling. Groundwater COCs identified during the RFI include acetophenone, aluminum, antimony, arsenic, bis(2-ethylhexyl)phthalate, beryllium, lead, manganese, thallium, and tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) equivalents. Figures 4.7 and 4.8 show organic and inorganic detections exceeding threshold concentrations (i.e., risk-based concentration [RBC], background reference value [BRV], or maximum contaminant level [MCL]) in Zone C monitoring wells from quarterly sampling conducted during the RFI. COCs not exceeding the threshold concentrations are not shown.

Zone C soil COCs were selected based on their contribution to surface soil risk and hazard based on RFI analytical results. They include aluminum, arsenic, benzo(a)pyrene equivalents (BEQs), beryllium, chlordane, chromium, copper, dieldrin, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, lead, manganese, and thallium. Because no particular COC was present on a zone-wide scale, figures are provided in each site-specific section showing the distribution of that site's primary COCs for soil.

Human Health Risk and Hazard

Human health risk and hazard presented in the RFI were calculated for each site in Zone C using data not adjusted for background concentrations of inorganics or BEQs. Per USEPA Subpart S Initiative, *Corrective Action for Releases from Solid Waste Management Units at Hazardous Waste Management Facilities; Proposed Rule, 1996*, no cleanup level will be proposed that restores the site to more protective risk levels than the risks produced by native materials or background risk. Therefore, background contributions to risk will not be included in determining human health and ecological risk. **Furthermore, RFI risk calculations, when assessed with respect to background, include risk contributions from background concentrations. During the CMS, the Navy has excluded background results in the determination of risk from Navy induced site-related impact only. It is the goal of the CMS to address only risk exceeding background.**

Tables 4.3 and 4.4 summarize Zone C background study results for surface soil and groundwater risk and hazard. Where applicable, these background values were not included in each compound's contribution to surface soil point risk and hazard. For example, arsenic's background soil risk for the residential scenario is 3.7E-05. If arsenic's contribution to point risk is reported as 1.5E-06, its contribution would not include the background value (3.7E-05). It is reported as risk above background. If arsenic's point risk were less than background, its contribution above background would be zero. The same approach will be used in the discussion of hazard (above background).

Uncertainty in Risk Assessment

As stated in the Zone C RFI and in accordance with USEPA protocol, the risk assessment methodology is a very conservative process which produces results extremely protective of human health. This fact should be considered when setting cleanup goals consistent with future site reuse.

Table 4.3
 Naval Base Zone C — Corrective Measures Study
 Soil Risk/Hazard Associated with Background Inorganics and BEQs

| Parameter | Reference Conc. (mg/kg) | Residential | | Industrial | |
|------------------------------|----------------------------|---------------------------|-----------------|---------------------------|-----------------|
| | | Background Hazard (HI) | Background Risk | Background Hazard (HI) | Background Risk |
| B(a)P Equivalents (BEQ) | 0.344 | NA | 6.7E-06 | NA | 1.4E-06 |
| Aluminum | 9,990 | 1.4E-01 | NA | NA | NA |
| Arsenic | 14.2 | 6.5E-01 | 3.7E-05 | 3E-02 | 5.2E-06 |
| Beryllium | NA | NA | NA | NA | NA |
| Cadmium | .65 | 8.9E-03 | NA | NA | NA |
| Chromium | 26.4 | 3.6E-04 | NA | NA | NA |
| Copper | 34.7 | 1.2E-02 | NA | 6E-04 | NA |
| Manganese | 92.5 | 2.5E-02 | NA | 1E-03 | NA |
| Mercury | 0.24 | 1.1E-02 | NA | 6E-04 | NA |
| Nickel | 12.3 | 8.4E-03 | NA | 4E-04 | NA |
| Vanadium | 23.4 | 4.6E-02 | NA | 2E-03 | NA |
| Zinc | 159 | 7.3E-03 | NA | 4E-04 | NA |
| Cumulative Background Hazard | | 0.9 | — | 0.04 | — |
| Cumulative Background Risk | | — | 4.4E-05 | | 6.6E-06 |

Notes:

HI — Hazard Index
 NA — Not Applicable

Table 4.4
Naval Base Zone C — Corrective Measures Study
Groundwater Risk/Hazard Associated with Background Inorganics

| Parameter | Reference Conc. ($\mu\text{g/L}$) | Residential | | Industrial | |
|------------------------------|-------------------------------------|------------------------|-----------------|------------------------|-----------------|
| | | Background Hazard (HI) | Background Risk | Background Hazard (HI) | Background Risk |
| Aluminum | 410 | 0.026 | NA | 0.004 | NA |
| Arsenic | 6.07 | 1.21 | 1.38E-04 | 0.202 | 6.07E-05 |
| Beryllium | 0.33 | 0.004 | 1.65E-05 | 0.001 | 6.6E-06 |
| Manganese | 608 | 0.168 | NA | 0.054 | NA |
| Nickel | 3.59 | 0.012 | NA | 0.002 | NA |
| Cumulative Background Hazard | | 1.42 | — | 0.263 | — |
| Cumulative Background Risk | | — | 1.5E-04 | — | 6.73E-06 |

Notes:

HI — Hazard Index
 NA — Not Applicable

Uncertainty is a factor in each step of the exposure and toxicity assessments, and uncertainty associated with the initial risk assessment stages is magnified when combined with other uncertainties. Together, the use of high-end estimates of potential exposure concentrations, frequencies, duration, and rates leads to conservative estimates of chronic daily intake (CDI). For example, animals' toxicological responses to certain chemicals are extrapolated to hypothesize a potential human response. Safety factors are applied during these extrapolations to provide an adequate margin of safety in estimating the potential human response. The end effect is a risk assessment that is extremely protective of the potential human receptor.

4.7 CMS Groundwater Units

The project team agreed that groundwater associated with AOCs 508, 510, 511, ~~512, 513, 517, 518, 520,~~ and 523 will be addressed jointly from a zone-wide perspective and not as discrete groundwater units. A zone-wide groundwater assessment is appropriate because the RFI determined that, while it was unlikely for the groundwater at these seven sites to have been adversely impacted by site-specific operations, there is potential for adverse groundwater impacts due to non-site-specific zone-wide, or base-wide operations.

Therefore, with the exception of potential site-specific impacts to groundwater from previous activity at SWMU 44, SWMU 47 and AOC 516, Section 11.0, Zone-Wide Groundwater, has been included in this work plan for CMS consideration. In addition, because of its proximity to SWMU 44, AOC 700 groundwater will be incorporated as part of the SWMU 44 groundwater unit.

5.0 SWMU 44

5.1 Site Description

SWMU 44 was a coal storage yard used for unloading railcars and the intermediate storage of coal before use at the former steam-generation plant in Building 32. The site is approximately 8 acres, yet coal was typically stored in an approximate 3-acre area along the elevated railroad trestle leading into the coal storage yard. SWMU 44 is bound on the west and north by Noisette Creek, on the south by a drainage ditch, and on the east by Avenue D. Figure 4.1 shows SWMU 44 in relation to other Zone C CMS sites.

Site History Summary

Coal storage operations began in the 1940s, but were scaled down in late 1955. Two coal piles were onsite during the RFI, the largest of which was estimated to be 80 feet by 400 feet. The coal was removed during interim stabilization measures (ISM) conducted by the Navy environmental detachment (DET).

Previous studies at SWMU 44 focused on surface water runoff and surface water quality. Eight sampling events conducted between 1981 and 1985 indicated metals and total suspended solids in surface water runoff and surface water samples. The results of these data warranted an RFI, which was completed at SWMU 44 in 1997. The RFI assessed impacts from metals and semivolatile organic compounds (SVOCs) on soil, sediment, groundwater, and/or surface water as a result of onsite coal storage. Samples were collected from each medium in areas with the highest potential for contamination, such as areas downgradient of the coal piles. In 1996, the DET's extensive excavation of old coal and coal-dirt mixtures at SWMU 44 warranted additional sampling. This CMS work plan is based on the RFI and post-excavation sampling results.

Ground Cover

The site remains as it was during its coal storage era minus any obvious quantities of stored coal. Two concrete pads of approximately 40 feet by 350 feet are adjacent to the elevated railway in the south-central portion of the site. Most of the remaining area of the site is undeveloped and covered by dirt, gravel, vegetation, or a mixture of all three.

Native vegetation (low shrubs, wild grasses, cat-tails, etc.), has recently taken root in several areas excavated by the DET. As a result of the extensive excavation operation, two ponds approximately 100 to 200 feet in diameter and 3 feet deep have been formed at the former coal storage yard. The largest pond is located in the northern-most portion of the site and the smaller pond is located east of the elevated trestle and south of Building 1226. Reference Figure 5.1, SWMU 44 Sample Locations and Surface Cover, for a general rendering of SWMU 44's current surface conditions.

5.2 Current Use

SWMU 44 is not currently used by either federal or non-federal base tenants.

5.3 Future Use

According to the Charleston Naval Complex Redevelopment Authority, this area will likely be used for residential or recreational (i.e., park) purposes in the future.

5.4 ISM Status

As previously stated, the DET has completed extensive coal and coal-dirt mixture removal at SWMU 44. The ISM was completed in September 1996 with the removal of approximately 13,000 tons of material. The removal operation lowered the existing grade by six inches to as much as five feet, resulting in at least two areas that have become ponds with native vegetation.

The ISM was strictly based on a visual removal of coal and coal-dirt, with no confirmation samples collected at the time. However, nine confirmation surface soil samples were collected in July 1997 from the excavation area at a depth of 0 to 6 inches. The Navy DET collected samples from areas as near as possible to previous RFI sampling points to compare pre- and post-source removal analytical results. Shallow groundwater samples were collected from SWMU 44 wells, but subsurface soil samples (i.e., lower interval samples obtained from 3 to 5 feet below the ground surface) were not taken because of the high groundwater table. Figure 5.1, SWMU 44 Sample Locations and Surface Cover, shows the general area excavated by the Navy DET, soil confirmation sample locations and previous RFI sampling points. **The DETs Interim Measure Site Completion Report (February 10, 1997) summarizes the removal.**

5.5 Contaminant Nature and Extent Summary

The summary of constituents in SWMU 44 soil and groundwater presented herein is based on results of confirmation soil sampling and post-interim measure groundwater monitoring. Comparisons to the pre-interim measure results in the RFI are made for reference purposes only.

5.5.1 Confirmation Soil Sample Results

Surface soil was resampled after the Navy DET completed the removal of approximately 13,000 tons of coal and coal/dirt mixture from the former storage area. The confirmation sample results presented in Table 5.1 include the primary risk drivers and COCs for SWMU 44 as determined during the RFI: BEQs, arsenic, beryllium, and thallium.

Since the National Contingency Plan (NCP) does not require remediation to levels below native conditions, the inclusion of naturally occurring background concentrations in the evaluation of sample results has been addressed by the project team. Background reference concentrations for

Table 5.1
SWMU 44 Soil Confirmation Sample Results

| | S001 | S002 | S003 | S004 | S005 | S006 | S007 | S008 | S009 |
|-------------------------------------|-------|------|-------|------|-------|-------|------|-------|-------|
| BEQs ($\mu\text{g}/\text{kg}$) | 14.84 | ND | 79.57 | ND | 235.2 | 307.9 | 4242 | 246.4 | 86.82 |
| Arsenic (mg/kg) | 19.9 | 22.2 | 19.3 | 3.3 | 21.6 | 98.5 | 45.6 | 15.7 | 25.6 |
| Beryllium (mg/kg) | 0.95 | 1.1 | 0.85 | ND | 0.7 | 1.2 | 0.98 | ND | 0.84 |
| Thallium (mg/kg) | ND | ND | ND | ND | ND | 8.3 | ND | ND | ND |

Note:
 ND — Nondetect

inorganic constituents have been developed and approved. The background value for arsenic in Zone C surface soil is 14.2 mg/kg. A proposed background value for BEQs has been developed based on a methodology recommended to the team in a memo from EnSafe to Mr. Tony Hunt, Southern Division Naval Facilities Engineering Command, Engineer in Charge, dated November 8, 1996. The background value for BEQs proposed in a January 15, 1997 memo to Mr. Hunt included a Zone C reference concentration of 344 $\mu\text{g}/\text{kg}$.

Soil confirmation sample results indicate isolated samples with concentrations of BEQs and arsenic in excess of background. BEQs exceeded the proposed background at a single sample location, 044SS007. Arsenic concentrations exceeded background in eight samples, but only two, 044SS006 and 044SS007, were more than twice the background level. The highest beryllium detection and the only thallium detection occurred at 044SS006. Table 5.2 shows maximum detected concentrations and the Zone C reference concentration, and the maximum reference concentration for any zone at the base.

Table 5.2
SWMU 44 COC Maximum Soil Detections and Zone C Reference Concentrations
NAVBASE Charleston

| Parameter (Units) | Maximum Detection | Zone C Reference Concentration |
|----------------------------------|-------------------|--------------------------------|
| BEQs ($\mu\text{g}/\text{kg}$) | 4,242 | 344 ¹ |
| Arsenic (mg/kg) | 98.5 | 14.2 |
| Beryllium (mg/kg) | 1.2 | Not Calculated |
| Thallium (mg/kg) | 8.3 | Non-detect |

Note:

¹ — Proposed Reference Concentration

Confirmation sampling reflected arsenic concentrations up to 98.5 mg/kg with a mean of about 30 mg/kg versus the Zone C background level of 14.2 mg/kg. This mean level is only twice the Zone C natural background level and does not suggest significant site-wide impact. In addition, the former naval base has arsenic background levels as high as 23.9 mg/kg (determined for Zone E). Therefore, excessive Arsenic impact to surface soil exceeded the reference concentration in eight of the nine samples. is limited in areal extent and isolated to the two sample locations, 044SS006 (98.5 mg/kg) and 044SS007 (45.6 mg/kg).

The maximum beryllium concentration in the confirmation samples was 1.2 mg/kg. Although a background concentration for Zone C beryllium has not been determined, the mean background from combined Zones B, D, E, G, H, and I of the former naval base is approximately 1.1 mg/kg, and the maximum beryllium background concentration is 1.7 mg/kg (Zone E). Beryllium detections from confirmation samples were at or below the mean background concentration except for one sample, 044SS006 which was 1.2 mg/kg and essentially equivalent to the mean background. Therefore, beryllium concentrations appear to be consistent with naturally occurring base-wide conditions. Since the EPA RBC for beryllium is 160 mg/kg, beryllium in soil is not present at concentrations that reflect impact to human health and the environment.

Thallium was detected in one confirmation sample, 044SS007, at 8.3 mg/kg. Since the proposed background for Zone C is non-detect, there is potential for impact from site activities, but there is no evidence of site-wide impact due to the isolated detection.

5.5.2 Sediment Sample Results

RFI sediment samples reflected the presence of inorganic constituents above the groundwater protection soil screening level (SSL). These include arsenic, chromium, copper, mercury, selenium, and thallium. Chromium was only detected above the SSL in sample location NBCC-044-GW-0012, which also exceeded the SSL for arsenic, copper, selenium, and thallium. Five sample locations exceeded the SSL for one or more inorganic constituents; three of these samples were taken from the interim measure area .

In order to assess the potential for SWMU 44 sediment impact to Noisette Creek, sediment will be sampled and the results compared to the Zone J (Noisette Creek) sampling results and SSLs. During the CMS, sediment samples from SWMU 44 will be analyzed for inorganic constituents. If it is determined that SWMU 44 sediment concentrations pose a risk to Noisette Creek, corrective measure alternatives will be developed.

5.5.3 Groundwater Sample Results

The following discussion is based on the results of four rounds of quarterly sampling during 1995 and 1996 and additional groundwater sampling conducted in July 1997 by the DET after completion of source removal activities. The post-source-removal groundwater samples from all eight SWMU 44 monitoring wells were analyzed for metals and SVOCs. The sample from well NBCC-044-GW-008 was also analyzed for pesticides, polychlorinated biphenyls (PCBs), and volatile organic compounds (VOCs) due to project team concerns about storage and mixing of pesticides in the former golf course maintenance Building 1646, adjacent to SWMU 44 in AOC 700.

Figures 4.7 and 4.8 show organic and inorganic contaminant concentrations detected in Zone C RFI groundwater quarterly sampling above USEPA groundwater RBCs, BRVs, and MCLs. Groundwater sampling results reflected a presence of SVOCs above RBCs and MCLs in isolated SWMU 44 samples during the first round that were not detected in subsequent sampling rounds. These data suggest that the contaminant levels detected during the initial groundwater sampling event were not reflective of site conditions and that soil does not appear to be generating leachate at concentrations that threaten groundwater. Pesticides and PCBs were not detected in the post-source removal sample from NBCC-044-GW-008, approximately 50 feet west of Building 1646. Analytical results from post-interim-measure groundwater samples are shown in Table 5.3.

During RFI quarterly sampling, antimony exceeded its MCL in one well (NBCC-044-GW-007). Subsequent results in NBCC-044-GW-007 reflected a decrease in concentration and then a non-detect, suggesting minimal short-term impact to the aquifer. SWMU 44 post-source-removal groundwater samples had six antimony detections, but only well NBCC-044-GW-007 exceeded the MCL of 6 $\mu\text{g/L}$.

During RFI quarterly sampling, aluminum exceeded its Zone C BRV of 410 $\mu\text{g/L}$ in one well (NBCC-044-GW-001). Post-source-removal sample results for aluminum were similar to previous sampling rounds, exceeding the BRV only at NBCC-044-GW-001. In addition, the aluminum concentration in well NBCC-044-GW-008 exceeded the BRV following the ISM.

Arsenic concentrations in four of eight post-source-removal samples exceeded the Zone C groundwater BRV for arsenic (6.07 $\mu\text{g/L}$). However, the concentrations were below the MCL of 50 $\mu\text{g/L}$.

Table 5.3
SWMU 44 Post-Source Removal Groundwater Sample Results
 Monitoring Well

| Analyte | NBCC-044-GW-001 | NBCC-044-GW-002 | NBCC-044-GW-003 | NBCC-044-GW-004 | NBCC-044-GW-005 | NBCC-044-GW-006 | NBCC-044-GW-007 | NBCC-044-GW-008 |
|-------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Aluminum ($\mu\text{g/L}$) | 20,400 | ND | ND | ND | ND | ND | 28.3 | 7,780 |
| Antimony ($\mu\text{g/L}$) | 2.1 | ND | 1.6 | 2.0 | ND | 2.6 | 35.3 | 2.2 |
| Arsenic ($\mu\text{g/L}$) | 6.6 | 5.0 | ND | 34.0 | 3.3 | 4.2 | 23.2 | 7.2 |
| Beryllium ($\mu\text{g/L}$) | 17.5 | ND | ND | ND | 0.91 | ND | 0.25 | ND |
| Copper ($\mu\text{g/L}$) | 11.0 | ND | ND | ND | ND | ND | 2.6 | 12.6 |
| Manganese ($\mu\text{g/L}$) | 3660 | 307 | 703 | 1250 | 692 | 1770 | 173 | 467 |
| Nickel ($\mu\text{g/L}$) | 191 | 1.7 | 70.1 | 0.7 | 0.96 | 7.7 | 0.97 | 7.4 |

Note:

ND — Nondetect

Beryllium concentrations in post-source-removal samples exceeded its MCL ($4.0 \mu\text{g/L}$) in one well, NBCC-044-GW-001. ~~The isolated beryllium exceedence suggests minimal site impacts.~~

During post-source-removal groundwater sampling, manganese exceeded the Zone C BRV ($608 \mu\text{g/L}$) in six monitoring wells. ~~The mean concentration of manganese detected was $1,128 \mu\text{g/L}$. Although the Zone C BRV for manganese is $608 \mu\text{g/L}$, the average BRV of groundwater manganese for combined Zones E, F, G, H, and I is $2,700 \mu\text{g/L}$, a value substantially higher than what was estimated for Zone C. In addition, Manganese is a naturally occurring inorganic element frequently detected in estuarine environments. Since manganese~~

concentrations were **within an order of magnitude of the BRV**, they appear to be representative of natural ~~base-wide~~ conditions.

In summary, groundwater sampling results reflected the presence of contaminants above RBCs and MCLs in isolated SWMU 44 samples that were not detected in subsequent sampling rounds. This indicates that contaminant levels detected during the first sampling round were not reflective of site conditions. **However, an approach to the base-wide analysis of inorganics in groundwater was agreed upon in an October 29, 1998 meeting in Columbia, South Carolina. The study will include 15 to 20 wells that are known to reflect sporadic detections of inorganics that were found to be at, slightly above, or below MCLs or RBCs during multiple sampling rounds. This meeting also produced a decision rule which will apply the results of the study (expected late December 1998) toward a final goal of either 1) declaring the need for continued groundwater monitoring at specific sites and potential CMS evaluation, or 2) designating specific groundwater sites for no further action.**

5.6 Contaminant Fate and Transport Summary

5.6.1 Soil to Groundwater

To evaluate fate and transport between soil and groundwater at SWMU 44, constituents in groundwater were compared to constituents in soil samples prior to the DET removal activities. Maximum concentrations in groundwater and soil were compared to relevant fate and transport screening criteria to highlight potential migration pathways. Four constituents (aluminum, antimony, arsenic, and manganese) were detected above soil background reference concentrations or groundwater protection soil screening levels (SSLs), and above shallow groundwater RBCs or BRVs.

The primary source of these inorganic constituents is coal which has been removed by the DET. The removal activity occurred after RFI sampling and therefore any remaining contaminant fate

and transport concerns associated with antimony and arsenic should be based on analytical results from soil confirmation and groundwater samples acquired after the removal action. Post-excavation soil sample results reflect a general reduction in contaminant concentration except for soil in the northern portion of SWMU 44, where increases in arsenic at 044SS006 and BEQs at 044SS007 were observed.

Groundwater trend data collected before the interim measure reflect a negligible impact to the shallow aquifer. While antimony and arsenic were detected in well NBCC-044-GW-007 above RBCs, the trend data in Figure 4.8 reflect a reduction in these constituent concentrations through the course of the four sampling rounds. Antimony was not detected in the fourth round of sampling, and the mean arsenic value detected was $53.5 \mu\text{g/L}$ which is approximately equal to the MCL of $50 \mu\text{g/L}$. The other SWMU 44 wells were below MCL or non-detect for antimony and arsenic.

Post-source-removal groundwater monitoring results indicate the presence of antimony above the MCL ($6.0 \mu\text{g/L}$) at well NBCC-044-GW-007. ~~Since this well is not within the interim measure area and soil concentrations are not above background, potential transport between media is not proven. In addition, antimony concentrations during the five rounds of groundwater sampling have fluctuated from non-detect to above the MCL, suggesting natural variability rather than widespread contamination.~~

Post-source-removal groundwater arsenic concentrations were present at levels above the background concentration ($6.07 \mu\text{g/L}$) in three wells. However, they were not above the MCL ($50 \mu\text{g/L}$).

5.6.2 Groundwater to Surface Water

Evaluation of fate and transport between groundwater and surface water (Noisette Creek) identified 14 inorganic constituents detected in both media. However, copper and nickel were the only constituent detected in post-source-removal groundwater samples at concentrations above salt water chronic ambient water quality criteria (AWQC) of 2.9 $\mu\text{g/L}$ for copper and 8.3 $\mu\text{g/L}$ for nickel. It Copper was detected in wells NBCC-044-GW-001 (11 $\mu\text{g/L}$) and NBCC-044-GW-008 (12.6 $\mu\text{g/L}$) and nickel was in NBCC-044-GW-001 (191 $\mu\text{g/L}$) and NBCC-044-GW-003 (70.1 $\mu\text{g/L}$).

To evaluate the potential for contaminant migration, a travel-time analysis was performed during the RFI using the constituent with greatest mobility, acetophenone. Travel time from the well where acetophenone was detected (NBCC-044-GW-006) to Noisette Creek was calculated to be 34 years. Using the same assumptions, the travel time is estimated to be 79 years from NBCC-044-GW-008 and 125 years from NBCC-044-GW-001. Therefore, groundwater threats to Noisette Creek may be minimal due to the long travel time and likelihood of attenuation before discharge to surface water.

Surface water samples have not been collected since the source removal action and six of the ten surface water samples collected during the RFI were within the excavation area. The source removal resulted in the creation of two surface water ponds in SWMU 44. As stated in the soil-to-groundwater contaminant fate and transport discussion, it is expected that the removal activities initiated by the Navy DET would substantially reduce this cross-media transfer potential. ~~Because post-source-removal groundwater samples were not analyzed for copper;~~ Additional surface water and groundwater samples should be collected for comparison of copper and nickel concentrations and evaluation of cross-media transfer potential.

5.6.3 Soil to Air

Fate and transport from soil to air was evaluated by comparing volatile organic compound (VOC) concentrations to soil-to-air volatilization screening levels. Since the maximum VOC surface soil concentration did not exceed its corresponding soil-to-air screening level, this pathway is not expected to be significant and is excluded from further evaluation. In addition, source removal activities have likely reduced the potential migration even further.

5.6.4 Soil to Sediment

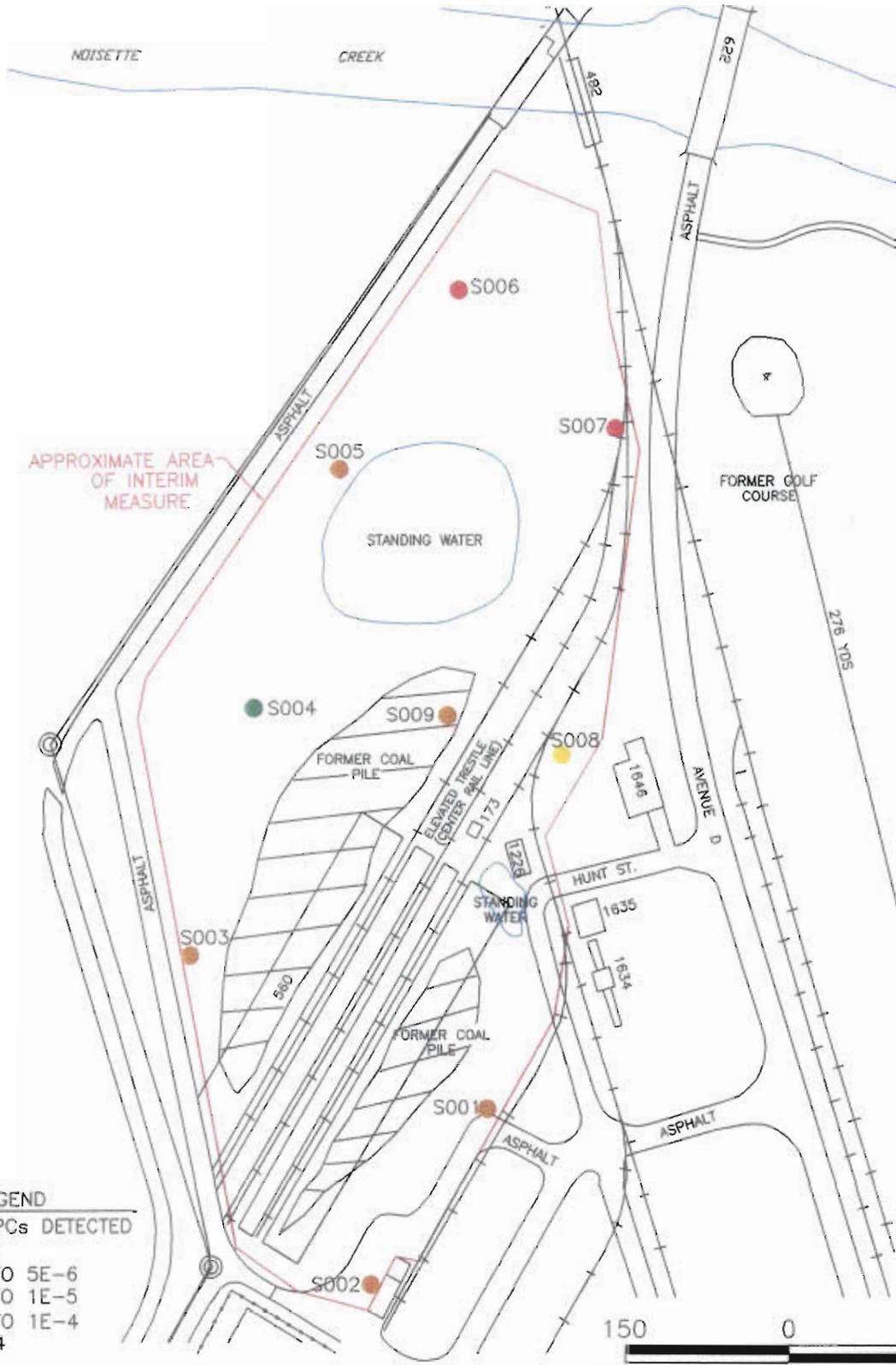
Fate and transport from surface soil to sediments was evaluated prior to source removal by comparing sediment sample and surface soil analytical results. Sixteen inorganic constituents were found in both sediment and surface soil samples. It is likely that surface soil erosion and coal storage area runoff have contributed to the presence of these constituents in sediment. Because source materials were removed during the ISM, future impacts are not expected since the coal was the most significant source of constituents in sediment.

5.7 Human Health Risk Assessment Summary

The risk and hazard posed by contaminants at SWMU 44 were assessed for the hypothetical site worker (industrial scenario) and the hypothetical future site resident (residential scenario) under reasonable maximum exposure assumptions. In addition, an adolescent trespasser scenario was addressed relative to potential surface soil and sediment exposure. Pathways assessed for surface soil include incidental ingestion and dermal contact. The ingestion pathway was evaluated for shallow groundwater based on first-quarter groundwater monitoring data.

5.7.1 Soil Risk

Figures 5.2 through 5.4 show the calculated point risk and hazard above background for SWMU 44 surface soil based on results of the nine confirmation samples. Residential and site worker risk above background estimates exceeded 1E-06 in eight samples. Residential risk

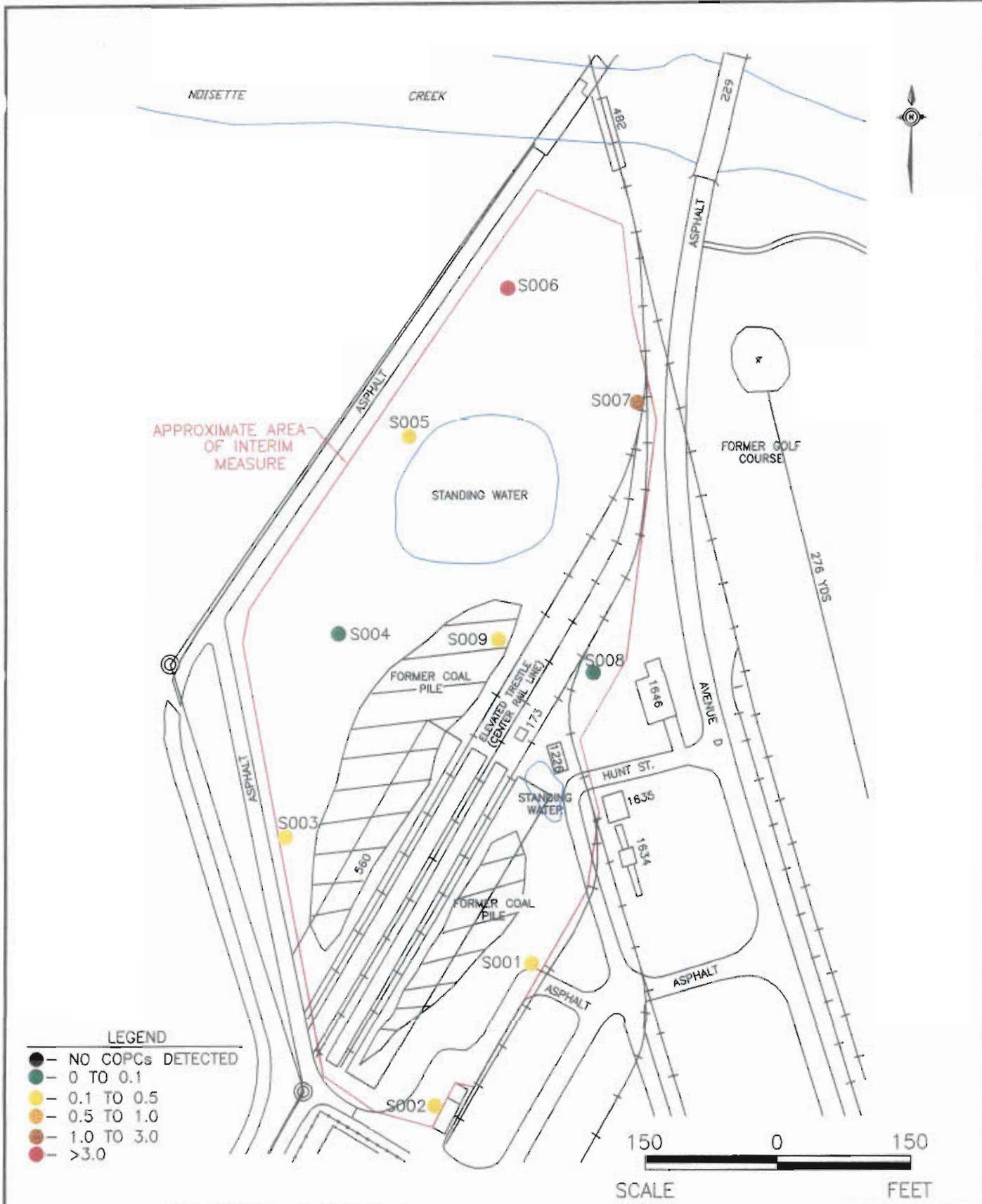


- LEGEND**
- - NO COPCs DETECTED
 - - $< 1E-6$
 - - $1E-6$ TO $5E-6$
 - - $5E-6$ TO $1E-5$
 - - $1E-5$ TO $1E-4$
 - - $> 1E-4$



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CHARLESTON, S.C.

FIGURE 5.2
SWMU 44 CONFIRMATION SAMPLES
POINT RISK ABOVE BACKGROUND
ESTIMATES FOR SURFACE SOIL
RESIDENTIAL SCENARIO



- LEGEND**
- - NO COPCs DETECTED
 - - 0 TO 0.1
 - - 0.1 TO 0.5
 - - 0.5 TO 1.0
 - - 1.0 TO 3.0
 - - >3.0



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FIGURE 5.3
 SWMU 44 CONFIRMATION SAMPLES
 HAZARD INDEX ABOVE BACKGROUND
 ESTIMATES FOR SURFACE SOIL
 RESIDENTIAL SCENARIO

above background exceeded $1E-5$ in seven samples. Residential point hazard index (HI) above background estimates exceeded one in two samples (044SS006 and 044SS007). **In comparison to pre-source removal samples, risk estimates increased at three of the nine sample locations and decreased at three locations. Three locations were not consistent with RFI sample locations.**

Based on the limited extent of confirmation sampling, additional sampling is warranted to better characterize SWMU 44 surface soil and human health risk. Risk estimates based on nine confirmation samples are not indicative of conditions throughout the site, but do indicate the need for further assessment.

5.7.2 Groundwater Risk

In addition to the changes in surface soil contaminant concentrations, groundwater monitoring results for the second, third and fourth quarter reflect a general decrease in groundwater contaminant concentrations, although well NBCC-044-GW-007, which is not in the interim measure area, reflects an increase in arsenic concentration from $30 \mu\text{g/L}$ to above the MCL at $63 \mu\text{g/L}$. Based on these changes, additional groundwater sampling is warranted as well as further evaluation of human health risk. The results of the base-wide groundwater background study for arsenic will also be used in the risk evaluation.

5.8 Ecological Risk Assessment Summary

The ecological risk assessment performed during the RFI for Zone C is based on data collected prior to the interim stabilization measure. Since confirmation sample analytical results reflect contaminant concentration changes (increase and decrease) in the northern portion of SWMU 44, a re-evaluation of ecological risk is warranted. During the CMS, this evaluation will be conducted based on the results of additional samples proposed, the post-interim measure sampling, and RFI

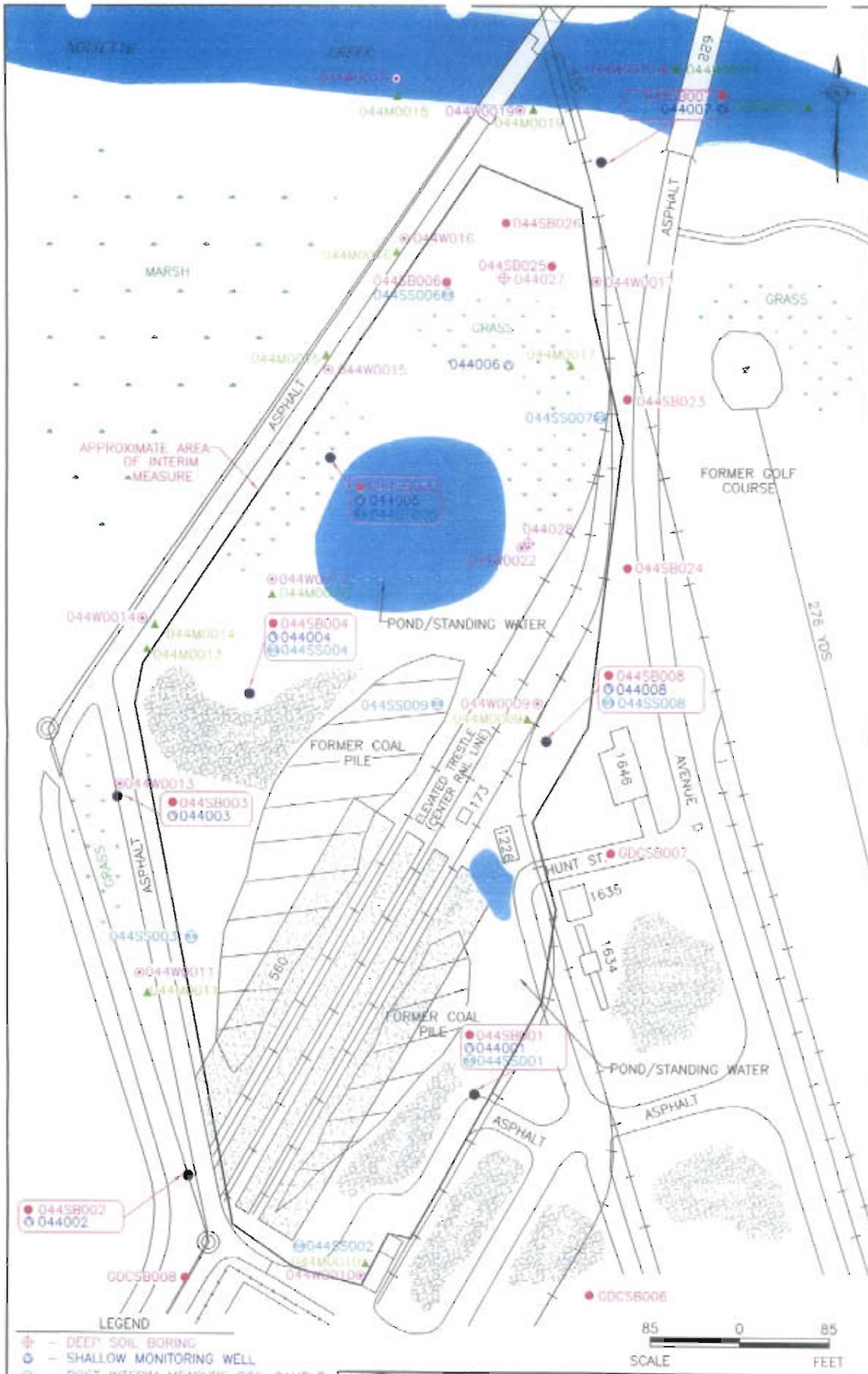
samples, and Zone J sample results. For comparison purposes, results of the pre-interim measure RFI ecological risk assessment for the indicated receptors are presented below.

5.8.1 Infaunal Invertebrates

Based on the Zone C RFI results of soil sampling in ecological sub-zone C-1 (in the northern portion of SWMU 44), the primary ecological risk to infaunal invertebrates (e.g., earthworms) is from copper. Maximum soil copper concentrations (122 mg/kg) present a moderate potential for risk, although the mean concentration (57 mg/kg) was well below the infaunal invertebrates effect level (100 to 150 mg/kg). ~~Since copper was not included in confirmation sample analysis, any potential adverse impacts to infaunal invertebrates due to changes in surface soil copper concentration has not been determined.~~ Copper should be included in further evaluations of SWMU 44 surface soil.

5.8.2 Terrestrial Wildlife

A moderate potential for risk to terrestrial wildlife (specifically the short-tailed shrew) has been predicted based on exposure to arsenic in surface soil resulting in an HI of 27.3. Potential sublethal effects to small vertebrates (shrew) and avian species (robin) are also predicted. Based on the sublethal HI generated by the ecological model for the American robin, cumulative exposure to selenium, mercury, copper, and cadmium in surface soil presents a low potential for excess risk (HI = 1.37), although the hazard quotient for each analyte is less than one. ~~Since these constituents were not included in confirmation sample analysis, any~~ Potential adverse impacts to terrestrial wildlife due to changes in surface soil concentration has not been determined. In addition to copper, selenium, mercury, and cadmium should be included in further evaluation of SWMU 44 surface soil.



- LEGEND**
- ⊕ - DEEP SOIL BORING
 - ⊙ - SHALLOW MONITORING WELL
 - ⊙ - POST INTERIM MEASURE SOIL SAMPLE
 - - SOIL SAMPLE LOCATION
 - ▲ - SEDIMENT SAMPLE
 - ⊖ - SURFACE WATER SAMPLE
 - ~ - GRASS
 - ▨ - MARSH
 - ▨ - FORMER COAL PILE
 - - CONCRETE

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FIGURE 5.1
 SWMU 44 SAMPLE LOCATIONS
 AND SURFACE COVER

DWG DATE: 05/21/98 DWG NAME: 2903B007

5.8.3 Vegetation

Pre-source removal concentrations of copper and arsenic in SWMU 44 soil constitute a potential risk to woody seedlings and young herbaceous species. Organic concentrations could not be assessed during the investigation because there are no reference values for ecological risk to vegetation. While this is considered a data gap, the CMS effort will not be able to provide additional information.

5.8.4 Aquatic Receptors

A potential risk to aquatic receptors exists in ecological sub-zone C-1 sediment in the northern portion of SWMU 44. Based on the maximum concentration of mercury, an HQ value greater than 10 is derived. Based on maximum concentrations of arsenic, copper, and lead, an HQ value greater than 1 is derived. Using mean concentrations of arsenic, the HQ value reflects a low risk to receptors. Actual risks to receptors within the water body may be lower than risks predicted from the screening assessment data. At sub-zone C-1, specific impacts to receptors from water and sediment concentrations ~~were not determined~~ but will be addressed in further CMS activities for Zone C at the former Charleston Naval Base Complex.

5.9 Remedial Objectives

Soil

Inorganics (primarily arsenic and to a much lesser extent, beryllium and thallium) and SVOCs (in the form of BEQs) could potentially require limited remediation based on post-ISM concentrations and suspected current risk and hazard levels. Therefore, the CMS will examine potential alternatives which could reduce risk above background to a level below 1E-06 or 1E-05, hazard above background to a level below 1.0 or 0.1, or a separate cost-benefit risk and hazard reduction based goal. Both residential and industrial reuse scenarios will be evaluated. To satisfy this objective a re-evaluation of risk and hazard will be required as identified in the subsequent section, CMS Data Needs.

The remedial objective for site soil will ensure that:

- risk and hazard has been sufficiently reduced to be protective of human health and the ecological community associated with Noisette Creek.

Sediment

Remedial objectives for sediment are based on the potential for impact to ecological receptors and Noisette Creek. The remedial objective for sediment will ensure that:

- **risk and hazard has been sufficiently reduced to be protective of human health and the ecological community associated with Noisette Creek.**

Groundwater

SVOCs and inorganics in the form of aluminum, arsenic, antimony, beryllium and manganese only slightly exceeded their background reference values and/or MCLs during the RFI or post-ISM sampling. As previously discussed in this work plan, these constituents were detected in isolated samples and trend data indicates a majority are decreasing in concentration. **However, as stated in Section 5.5.3, a base-wide analysis of inorganic constituents in groundwater will be used to determine the need for further assessment. The remedial objectives for groundwater remain achievement of MCLs or in the absence of MCLs, achievement of BSHWM remediation criteria.**

~~Therefore, additional groundwater sampling results will be combined with previous groundwater sampling results so the project team can make a risk management decision based on constituent concentration and frequency of detection, spatial distribution, and other relevant factors. The decision will determine the appropriateness of groundwater remedial objectives and whether to proceed with future groundwater corrective actions at this site.~~

5.10 Potential Remedial Alternatives

Soil and Sediment

Potential remedial alternatives for soil and sediment at this site include:

- Additional source material excavation and surface re-vegetation — removal of contaminated soil, disposal at an off-site facility, and re-vegetate excavated area.
- Full or partial surface capping and/or storm water controls — covering areas of contaminated soil with an impermeable cap with storm water runoff control.
- Phytoremediation (in-situ) — Vegetation is planted to uptake and/or enhance biodegradation of soil and groundwater contaminants. It has been shown to be effective for VOCs, SVOCs, and some inorganics.

Surface Water

Potential remedial alternatives for surface water at SWMU 44 include:

- Long-term monitored natural attenuation — COCs are allowed to remain in-place to allow naturally occurring processes such as biological degradation and physical dilution to reduce COC concentrations to acceptable levels. This technology is often used in conjunction with, or subsequent to, implementation of other remedial alternatives.
- Phytoremediation (in-situ) — Vegetation is planted to uptake and/or enhance biodegradation of soil and groundwater contaminants. It has been shown to be effective for VOCs, SVOCs, and some inorganics.

Groundwater

As previously stated, the need for groundwater remediation and its objective is pending the results of the base-wide evaluation of inorganic constituents in groundwater a risk management

~~decision from the project team. Additional groundwater sampling, as recommended in this work plan, will be completed to assist the project team in this process. The following is a list of potential remedial alternatives for groundwater should remediation be required:~~

- **Monitored natural attenuation processes - COCs remain in-place to allow naturally occurring processes such as biological degradation and physical dilution to reduce COC concentrations to acceptable levels. This technology is often used in conjunction with, or subsequent to, implementation of other remedial technologies.**
- **Phytoremediation (in-situ) - Vegetation is planted to uptake and/or enhance biodegradation of soil and groundwater contaminants. It has been shown to be effective for VOCs, SVOCs, and some inorganics.**

5.11 CMS Data Needs

Table 5.4 summarizes the proposed CMS sampling for SWMU 44 soil, surface water, sediment, and groundwater. The base-wide study for inorganic constituents in groundwater will be used to determine the need for further assessment of SWMU 44 groundwater.

Soil

Based on the remedial objectives and remedial alternatives identified previously, the following data needs are identified:

- **Conduct a characterization of the post-ISM surface and sub-surface soil for inorganics and SVOCs (BEQs) to delineate concentrations above background. Quantity and placement of soil borings will be based on a 25 foot grid sampling pattern standard RFI assessment protocol.**

- Re-evaluate risk and hazard to human health and the environment based on the results of the ISM confirmation and CMS samples. Compare pre- and post-ISM risk assessment results.

Table 5.4
SWMU 44 CMS Data Needs

| Location/Media | Activity | Analysis |
|-----------------------|---|--|
| SWMU 44/surface soil | Collect surface and subsurface soil samples (25 foot grid in the excavated area) | Inorganics — arsenic, cadmium, copper, mercury, nickel, selenium, and thallium SVOC — BEQ |
| SWMU 44/surface water | Collect surface water sample (one sample each from the two standing water bodies) | Inorganic — copper |
| SWMU 44/sediment | Collect sediment samples (one sample each from the two standing water bodies) | Inorganics — cadmium, copper, mercury, and selenium |
| SMWU 44/groundwater | Base-wide groundwater inorganic study | Inorganic — standard suite |

- Perform a comparative volume analysis, if necessary, to evaluate estimated soil volumes exceeding residential and industrial acceptable risk and hazard levels. The estimated volumes will be used to determine expected cost differentials between residential and industrial cleanup scenarios.
- If necessary, complete a laboratory and/or field phytoremediation pilot study. This would typically include the use of several different types of native surface vegetation grown in randomly selected block plots at the site. Contaminant reduction and plant harvest rates are determined over a several week to several month period.

Surface Water and Sediment

Based on the remedial objectives and remedial alternatives identified previously, the following data need is identified:

- Collect and analyze surface water and sediment samples from the two **areas of standing water ponds** recently formed by the ISM.
- **Compare results to Zone J sample results and screening criteria to determine if ecological and human health risk evaluations are necessary.**

Groundwater

Based on the remedial objectives and remedial alternatives identified previously, **and the base-wide groundwater study**, the following data needs are identified:

- Evaluate the results of the base-wide groundwater background study for use in the risk evaluation for arsenic, **antimony, beryllium, copper, and nickel**, ~~and potentially other inorganics.~~
- Phytoremediation pilot study as stated for soil applies here as well. This study will yield phyto-uptake and phyto-transformation results for SWMU 44 inorganic and organic contaminants in soil and groundwater.

6.0 SWMU 47 and AOC 516

6.1 General Background Information

SWMU 47 and AOC 516 were combined into a single RFI site because of their proximity and common potential contaminants. This investigative site is located in the eastern portion of Zone C, southwest of the intersection of Avenue D and Turnbull Avenue. Figure 4.1 shows the subject site in relation to the other CMS sites within Zone C.

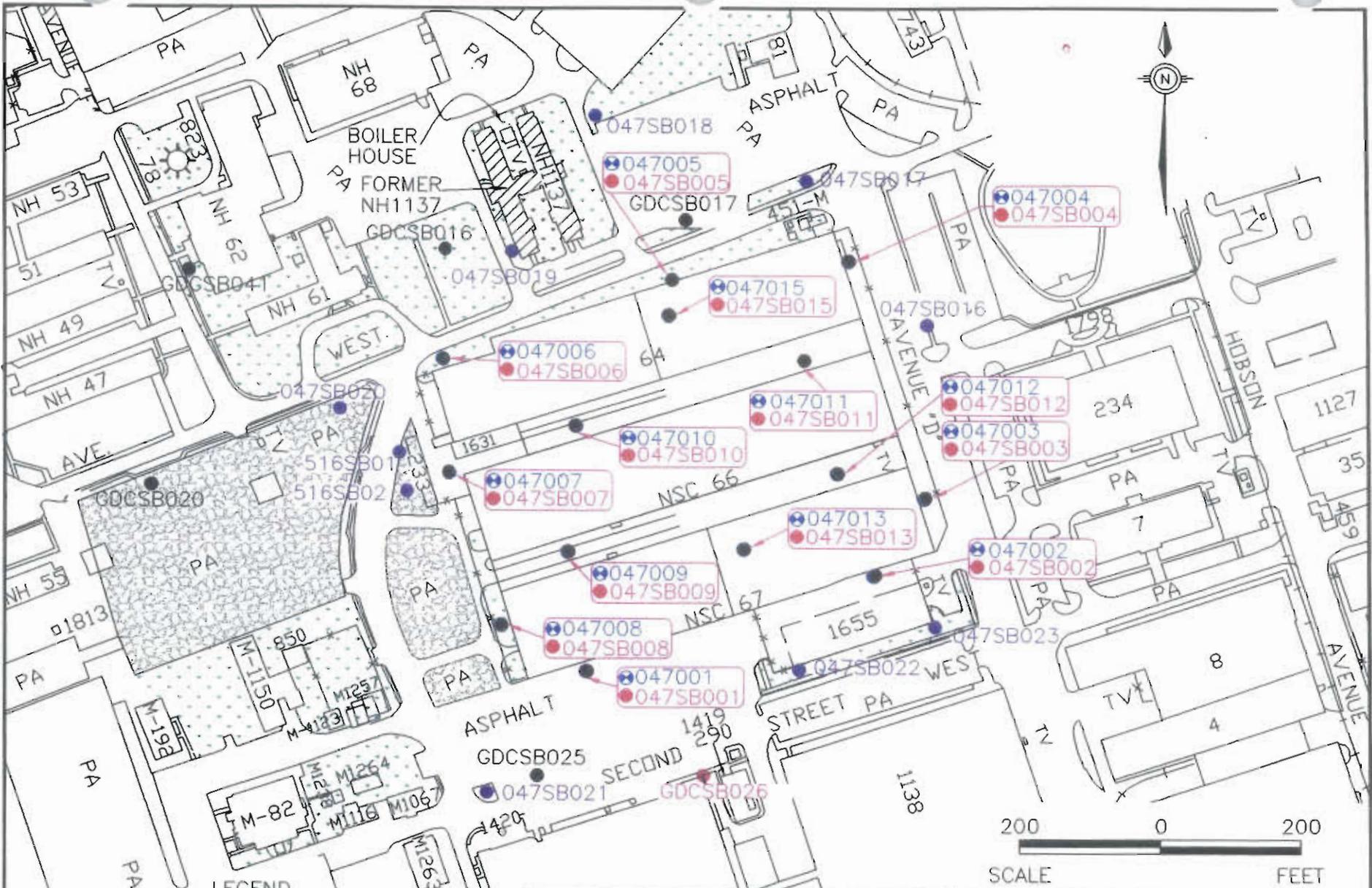
Site History Summary

SWMU 47 was a burning dump in the late 1920s where various types of wastes (including medical waste) were reportedly burned. Petroleum releases have also been reported onsite. Currently, the SWMU 47 site includes Buildings NSC-64, NSC-66, and NSC-67 and the surrounding asphalt and grassed areas. This SWMU also includes property north of Turnbull Avenue where former Building NH-1137 was located (prior to its demolition) and its associated parking lot and grassed areas. The RFI focused on site environmental media potentially impacted by products of incomplete combustion and residual petroleum hydrocarbons.

AOC 516 is just west of SWMU 47 and includes Building 233. This area was used for spray washing vehicles and equipment from 1972 until the 1980s. Prior to base closure in the spring of 1996, AOC 516 was used for recharging lead-acid batteries. Potential contaminants of concern included lead and other inorganics, solvents, acids, and petroleum hydrocarbons.

Ground Cover

As discussed, the site is currently comprised of three large warehouse-type buildings (NSC-64, NSC-66, and NSC-67), one smaller building (Building 233), and surrounding grassed and asphalt areas. Over 95% of the site is covered by the warehouse-type structures. Reference Figure 6.1 for a general rendering of SWMU 47 and AOC 516 surface conditions.



- - 1ST ROUND SOIL SAMPLE LOCATION
- - 2ND ROUND SOIL SAMPLE LOCATION
- NOTE: 047SB014 NOT INSTALLED
- ⊕ - MONITORING WELL LOCATION
- - GRASS ▨ - GRAVEL ▩ - FORMER BUILDING



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FIGURE 6.1
 SWMU 47 AND AOC 516
 SAMPLE LOCATIONS AND
 SURFACE COVER

6.2 Current Use

With the exception of the vacant site of the former Building NH-1137 on the north side of Turnbull Avenue, the area that comprises SWMU 47 and AOC 516 is currently being used by an industrial reuse tenant. Charleston Marine Containers, Inc. is using Buildings NSC-64, NSC-66, NSC-67, 233, and the surrounding parking and open storage areas north, west and south of the three main warehouse-type buildings. This tenant manufactures, assembles and distributes large steel marine cargo shipping containers.

6.3 Future Use

According to the Charleston Naval Complex Redevelopment Authority, this area will likely be used for residential or recreational (i.e., park) purposes. However, as noted above, the site is presently leased and is in full use by a private industrial-use entity.

6.4 ISM Status

There have been no ISMs conducted by the Navy DET or other parties at this site.

6.5 Contaminant Nature and Extent Summary

6.5.1 Soil

VOCs were not detected in surface soil samples at levels above their RBCs. Pesticides were not detected at levels above surface soil RBCs or above the subsurface soil SSLs. PCBs were not detected in site soil. Dioxins detected in two samples were below the 2,3,7,8-TCDD equivalent RBC (4.3 ±,000 ng/kg).

SVOCs in the form of polynuclear aromatic hydrocarbons (PAHs) were detected above RBCs in six upper interval samples. Calculated BEQs exceeded the RBC (88 µg/kg) at 12 ±4 upper interval locations. However, as shown in Figure 6.2, SWMU 47 and AOC 516 Surface Soil BEQ and TPH Concentrations, the two sample points (047SB005 and 047SB016) with the highest BEQ



- LEGEND**
- Soil Borings
 - Buildings
 - Zone C Boundary
 - Water
 - Sidewalk
 - Railroad
 - Road
 - Property Line
 - Fence
 - Transformer
 - Golf Course



NOTE:
 BEQ - Benzo(a)pyrene Equivalents
 TPH - Total Petroleum Hydrocarbons



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FIGURE 6-2
 SWMU 47 and AOC 516
 SURFACE SOIL
 BEQ & TPH CONCENTRATIONS

detections (7,648 and 4,373 $\mu\text{g}/\text{kg}$ respectively) are located near or adjacent to road surfaces which are possible BEQ sources. **Sample point 047SB005 is located in a strip of grass next to an asphalt road.** These two sample points also are separated by approximately 300 feet and three other sample points exist between them. The three sample points consist of two non-detects for BEQ and one detect (167 $\mu\text{g}/\text{kg}$) which is less than the proposed background concentration (344 $\mu\text{g}/\text{kg}$). This random distribution of BEQs infers that the BEQ impact is ~~not site-related and~~ more likely is indicative of **asphalt applications and vehicular traffic in addition to naturally occurring levels of BEQs throughout the former naval base and/or pavement.** ~~In addition, excluding the two previously mentioned sample points, the mean concentration of BEQs at the site is about 300 $\mu\text{g}/\text{kg}$ which is less than the proposed background concentration.~~

Petroleum hydrocarbons were detected above the TPH screening level (100 mg/kg) in nine upper interval soil samples at a ~~mean concentration of 316 mg/kg.~~ However, a more realistic mean value of 136 mg/kg is determined if three hot spots (047SB005 at 731 mg/kg, 047SB003 at 507 mg/kg, 047SB001 at 2,050 mg/kg) are disregarded. These three spots are at different areas of the investigated site. Soil samples acquired from the area between the three hot spots contain less than 100 mg/kg TPH. ~~This is indicative of limited TPH impacts.~~ Figure 6-2 shows detections of TPH in SWMU 47 and AOC 516 soil samples. ~~As seen in the figure, the isolated hot spots reflect the limited extent and discontinuous spatial distribution of TPH concentrations in SWMU 47 and AOC 516 soil.~~ **Per the comprehensive RFI work plan for the Charleston Naval Complex and site-specific sampling objectives identified in the zone work plans, sampled media were analyzed for a suite of potential chemicals of concern to characterize the sites. This included non-compound-specific analysis for TPH, at sites where petroleum hydrocarbons were of potential concern. Constituents identified during the RFI that are determined to exceed a regulatory threshold and/or drive an unacceptable risk/hazard are subsequently addressed in the CMS. TPH poses a unique challenge because the TPH value itself does not have a regulatory threshold and has no significance from a risk/hazard**

perspective. Even though TPH will not normally drive a clean-up action, remedial alternatives are designed to address some of the individual TPH components which are regulated and can be identified by the VOC and SVOC scans. Please refer to the TPH Memorandum in Appendix A for further discussion of this matter and how the relative significance of TPH will be addressed by site.

Inorganic elements were detected 18 times at levels greater than the respective reference concentrations in the upper interval. Copper and tin accounted for eight of the 18 detections.

Inorganic constituents were detected 15 times above the respective reference concentrations in lower interval soil samples. Chromium was detected in five samples. Hexavalent chromium was detected in one upper interval **duplicate** sample (047CB009) at 0.259 mg/kg which is well below the RBC of 39 mg/kg. Cyanide was not detected in the surface soil samples.

Lead was detected in one surface **and subsurface** soil sample (047SB007 001) at a levels exceeding **the RBC of 400** ~~its reference concentration of 330~~ mg/kg. There were no other detections of lead above the reference concentration in SWMU 47 and AOC 516 surface soil. **To further delineate the presence of lead around sample location 047SB007, surface and subsurface samples will be collected in the surrounding soil during the CMS.** ~~Lead in surface soil is isolated, limited in extent, and protective of human health. Lead, therefore, does not need to be evaluated during the CMS.~~

6.5.2 Groundwater

One VOC was detected in groundwater below its RBC and no SVOCs were detected. Maximum TPH concentrations in SWMU 47 and AOC 516 groundwater samples are less than 1 ppm and do not impose risk to human or ecological receptors. Pesticides and PCBs were not detected in groundwater samples above their respective MCLs. Figure 4.7, Organic Chemicals Detected in

Zone C Groundwater Exceeding RBC, or BRV, or MCL, shows SWMU 47 and AOC 516 groundwater organic chemical concentrations.

Twelve inorganic constituents were detected in groundwater samples above their respective BRVs. These are aluminum, antimony, arsenic, barium, chromium, copper, lead, nickel, selenium, tin, vanadium, and zinc. Except for lead, detections were isolated ~~and not representative of site impacts~~. Hexavalent chromium was not detected. **Arsenic detections in well NBCC-047-GW-011 are above the MCL (50 $\mu\text{g/L}$), but the last three samples show a decrease towards the MCL. Based on the results of a pending base-wide groundwater study, a decision regarding the need for further evaluation of arsenic in groundwater will be rendered.**

Lead concentrations in groundwater were detected in two wells (NBCC-047-GW-001 and NBCC-047-GW-010) during one sampling event each. The highest lead concentration was found in well NBCC-047-GW-001, which is farther from the former lead battery recharging building (Building 233) than well NBCC-047-GW-007, which was nondetect for lead. Figure 4.8, Inorganic Chemicals Detected in Zone C Groundwater Exceeding RBC, or BRV, or MCL, shows lead concentrations detected in groundwater for Zone C. ~~The inconsistent detection pattern in SWMU 47 and AOC 516 and isolation of the highest detection from the former lead battery recharging building indicates that lead in groundwater is not likely site-related. Therefore, lead in groundwater will not be addressed during the CMS.~~

6.6 Contaminant Fate and Transport Summary

6.6.1 Soil-to-Groundwater

To evaluate fate and transport between soil and groundwater at SWMU 47 and AOC 516, constituents in groundwater were compared to constituents in soil samples. Maximum concentrations in groundwater and soil were compared to relevant fate and transport screening criteria to highlight potential migration pathways. Based on this analysis, with the exception of

thallium, lead, and arsenic, existing soil quality is generally considered protective of shallow groundwater. In addition, thallium results were not reproducible and did not follow a pattern relative to a soil source or consistent groundwater detection. **The results of a pending base-wide groundwater study will be used to determine if additional analysis of these inorganic constituents in groundwater is required.**

6.6.2 Groundwater-to-Surface Water

Evaluation of fate and transport between groundwater and surface water resulted in the identification of seven constituents detected in both media. Travel time to the closest downgradient surface water body (Cooper River) for the most mobile of these constituents, carbon disulfide, was calculated to be 148 years. Although each of the seven groundwater constituents could theoretically reach the Cooper River, travel time suggests that the Cooper River is not threatened by groundwater migration, particularly given the likelihood of attenuation.

6.6.3 Soil-to-Air

Fate and transport from soil-to-air was evaluated by comparing VOC concentrations to soil-to-air volatilization screening levels. The maximum VOC surface soil concentration did not exceed its corresponding soil-to-air screening level.

6.6.4 Soil-to-Sediment

This pathway was not included in the RFI report and therefore will not be included in the CMS evaluation.

6.7 Human Health Risk Assessment Summary

The risk and hazard posed by contaminants at SWMU 47 and AOC 516 were assessed for the hypothetical site worker and the hypothetical future site resident under reasonable maximum exposure assumptions. Pathways assessed for surface soil include incidental ingestion and dermal contact. The ingestion pathway was evaluated for shallow groundwater. Due to the lack of VOCs in site groundwater, the inhalation pathway was not evaluated.

6.7.1 Soil Risk

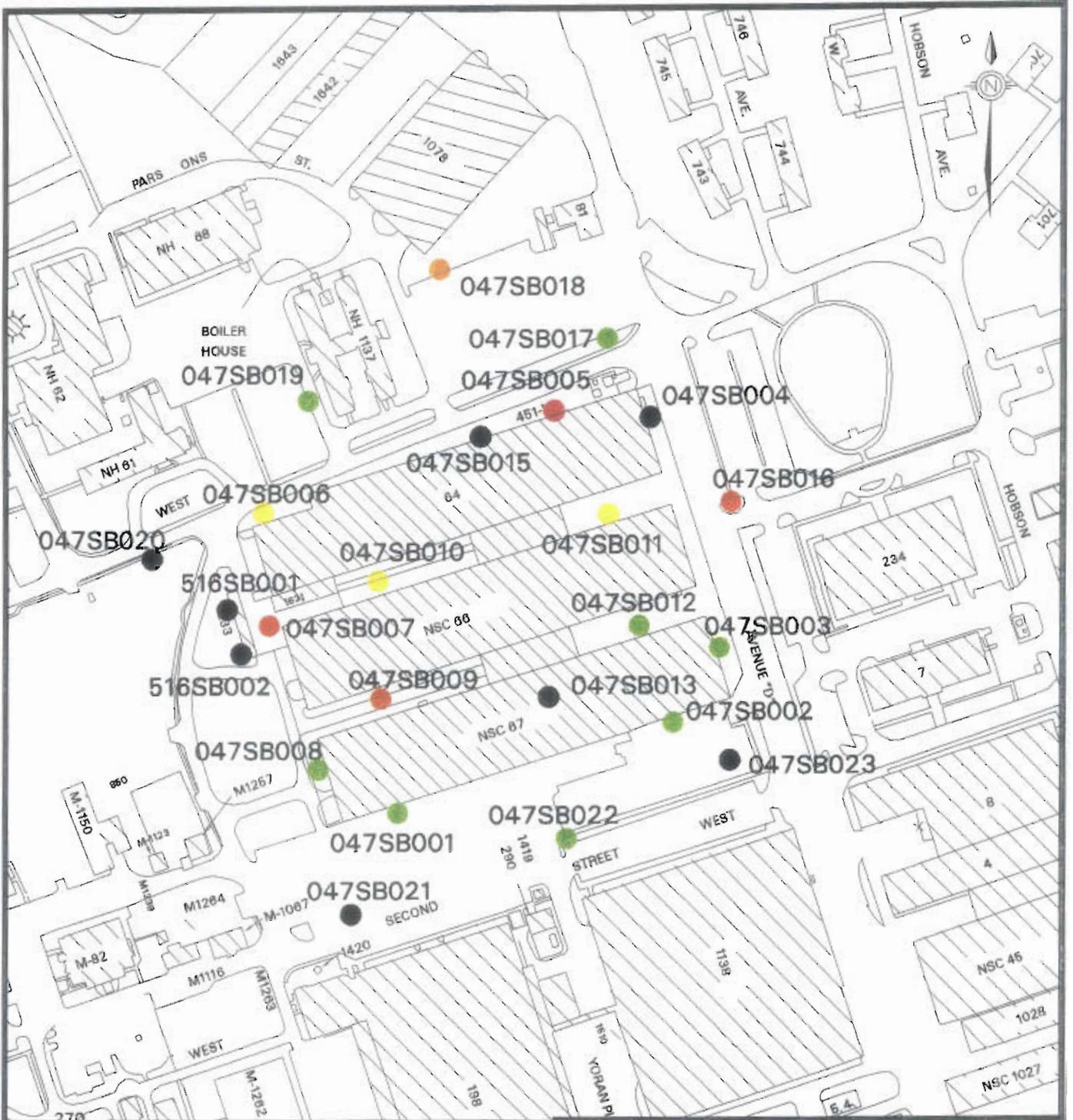
Figures 6.3 through 6.5 show the results of the point soil risk assessment in the form of point risk or hazard above background for RFI soil sampling points in SWMU 47 and AOC 516. Residential risk above background calculations exceeded $1E-04$ also at a single sample point, 047SB005. Six samples in addition to 047SB005 and 047SB007 resulted in residential risk above background estimates greater than $1E-06$. Three of these exceeded an industrial risk above background of $1E-06$. The primary risk drivers are BEQs. BEQs are characteristic of asphalt pavement and combustion by-products of associated vehicular traffic, which is near the eight samples reflecting residential risk above background.

Hazard calculations from soil ingestion or dermal contact in both hypothetical residential and site worker scenarios result in an HI above background greater than one in a single sample, 047SB007. The primary hazard driver is arsenic. There are no other point hazard estimates above background that exceed one.

Arsenic's contribution to the hazard above background estimate for 047SB007 is 27.8 mg/kg. This concentration is close (within a factor of two) to the Zone C background concentration of 14.2 mg/kg. The background arsenic concentration for Zone E is 23.9 mg/kg and for Zone I is 21.6 mg/kg. Therefore, hazard estimates do not reflect excessive impact from site activities but are more reflective of overall base wide conditions. **Additional sampling will be conducted during the CMS to determine the extent of soil arsenic concentrations in the vicinity of 047SB007.**

6.7.2 Groundwater Risk

As noted in the Zone C RFI, in addition to the unlikely potential that the residential reuse scenario at Zone C would occur, groundwater at the former military installation is not anticipated to be used as a potable drinking water source. The natural salinity and dissolved solids in the shallow aquifer would preclude its economical use as a potable water source. Since risk calculations were based on potential use of the shallow aquifer as a drinking water source, they reflect an unrealistic

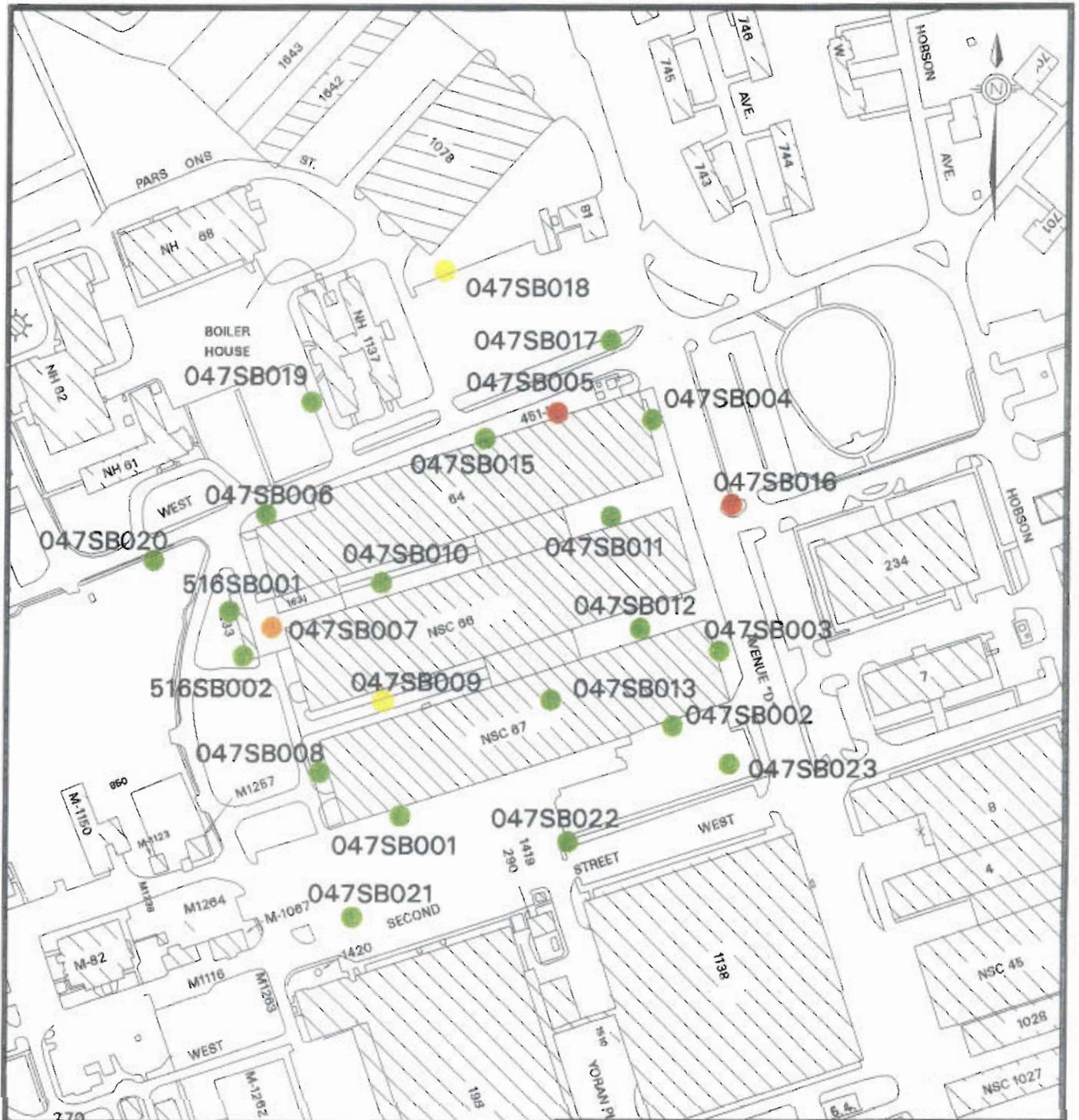


- LEGEND**
- NO COPCs DETECTED
 - < 1E-6
 - 1E-6 to 5E-6
 - 5E-6 to 1E-5
 - 1E-5 to 1E-4
 - > 1E-4



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FIGURE 6-3
 SWMU 47 and AOC 516
 POINT RISK ESTIMATES ABOVE BACKGROUND
 FOR SURFACE SOIL RESIDENTIAL SCENARIO



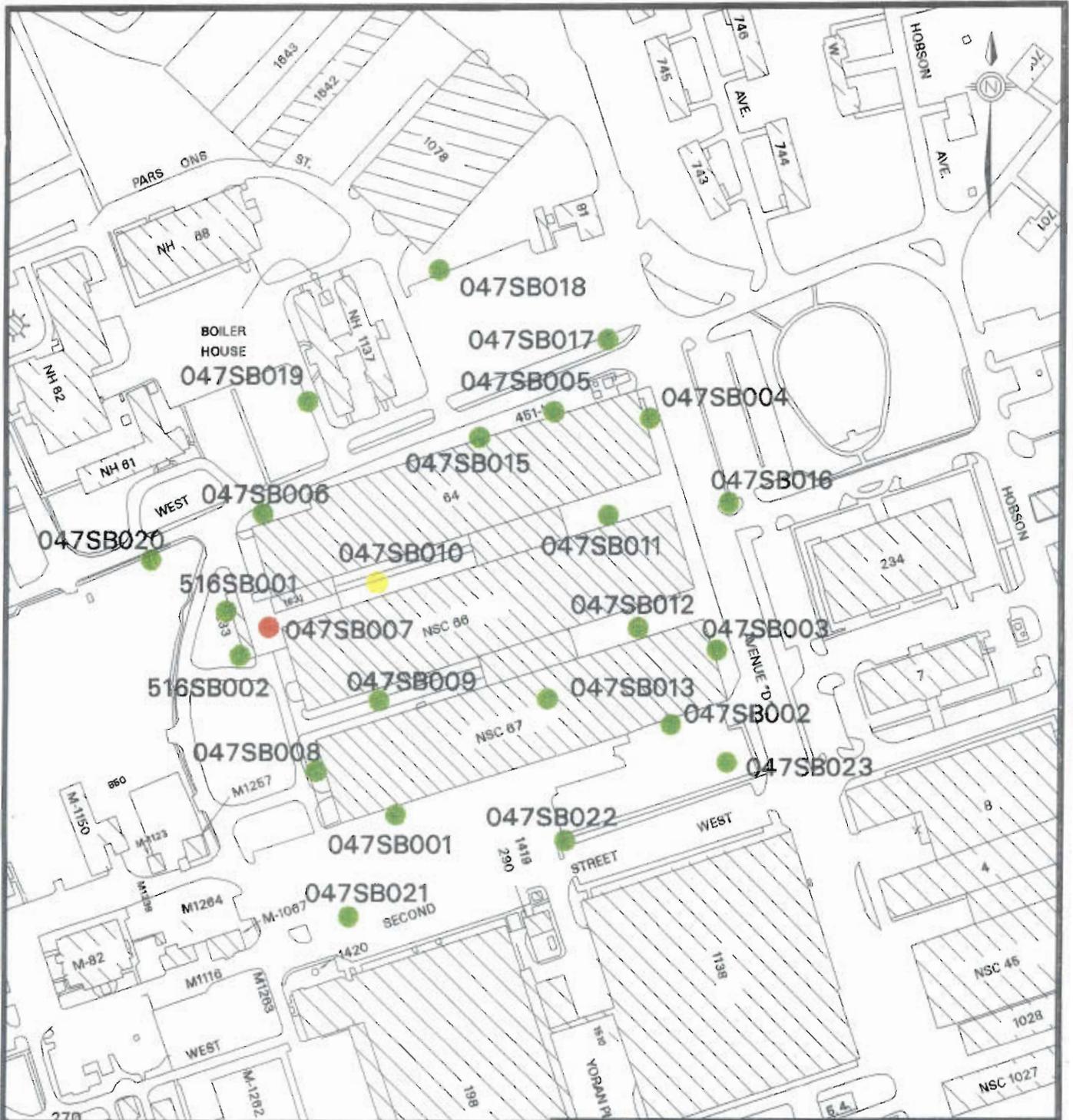
LEGEND

- < 1E-6
- 1E-6 to 5E-6
- 5E-6 to 1E-5
- 1E-5 to 1E-4
- > 1E-4



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FIGURE 6-5
SWMU 47 and AOC 516
POINT RISK ESTIMATES ABOVE BACKGROUND
FOR SURFACE SOIL INDUSTRIAL SCENARIO



LEGEND

- 0 to 0.1
- 0.1 to 0.5
- 0.5 to 1.0
- 1.0 to 3.0
- > 3.0



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**FIGURE 6-4
SWMU 47 and AOC 516
POINT HAZARD ESTIMATES ABOVE BACKGROUND
FOR SURFACE SOIL RESIDENTIAL SCENARIO**

~~pathway regardless of the current water quality. For this reason, risk concerns about hypothetical groundwater ingestion by humans are precluded from the CMS.~~

~~In addition to the conservative nature of the risk estimates, further~~ Evaluation of groundwater data for SWMU 47 and AOC 516 reveals that the primary risk driver is arsenic. Arsenic concentrations were below the MCL (50 $\mu\text{g/L}$) in 13 of the 14 monitoring wells for the four sampling rounds. The single well which indicated arsenic above the MCL, NBCC-047-GW-011, was below the MCL in the first-quarter sample, and has shown a decrease in arsenic concentrations since the second-quarter sample. Surrounding wells did not reflect arsenic presence above its MCL. Although none of these wells are downgradient of NBCC-047-GW-011, these results indicate that arsenic impacts are limited in extent, isolated, and could be statistically defended as less than MCL in site groundwater. Therefore, arsenic concentrations above background are attenuating naturally and do not warrant CMS consideration. **However, based on the results of a pending base-wide groundwater study, a decision will be made whether to address arsenic or lead in groundwater in Zone C. In addition, recently acquired water level measurements will be plotted and included in the CMS report to assess the potential for downgradient contamination crossing zone boundaries.**

6.8 Ecological Risk Assessment Summary

Ecological study areas (ESAs) established for Zone C did not include SWMU 47 and AOC 516 based on the lack of suitable habitat and acceptable receptors. Therefore, an ecological risk assessment was not conducted.

6.9 Remedial Objectives

Soil

Arsenic and BEQs in surface soil could potentially require limited remediation based on current site risk and hazard levels. The CMS will examine potential alternatives which could reduce risk

6.11 CMS Data Needs

Soil

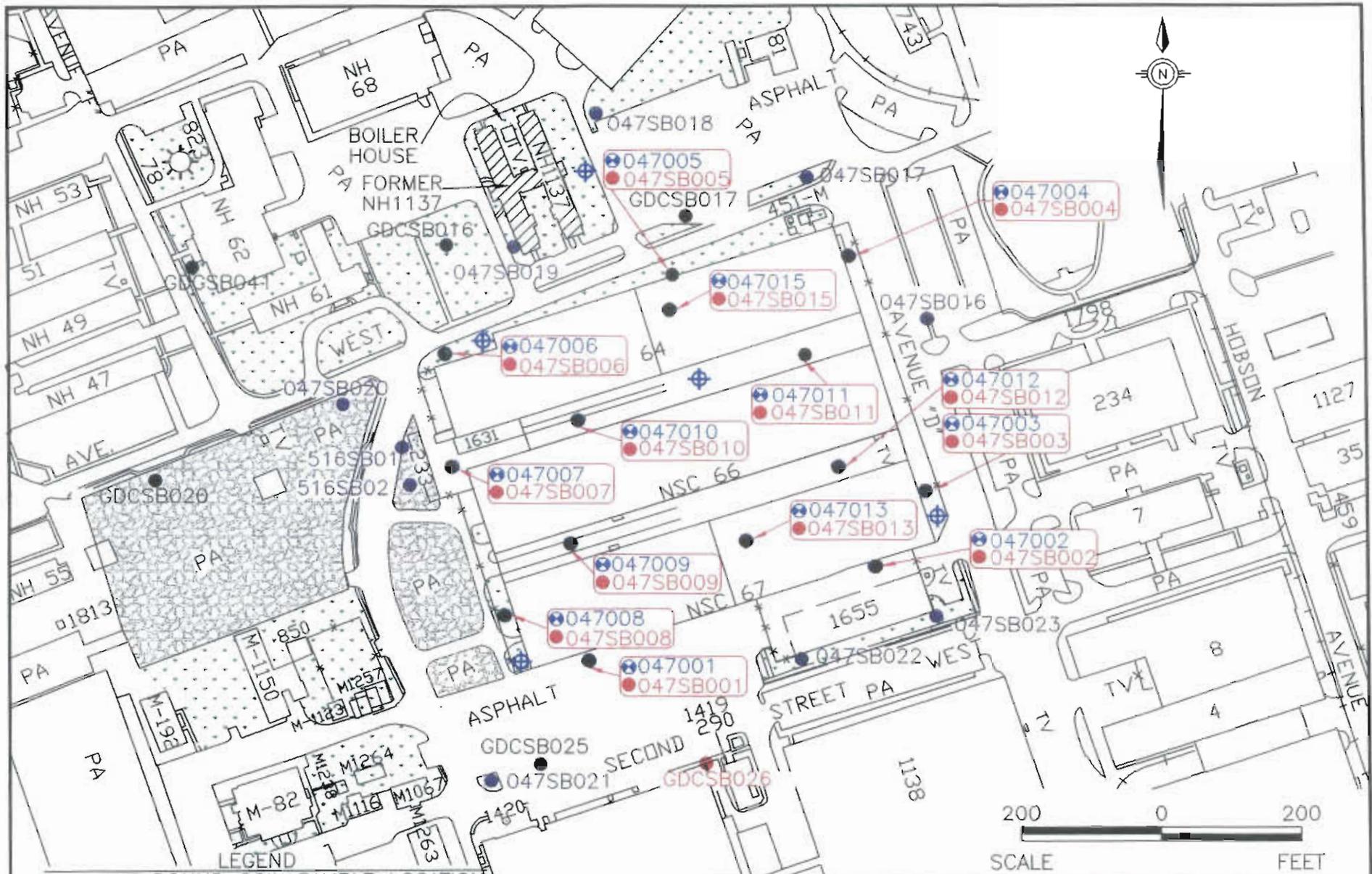
The information provided by the RFI is sufficient to fully evaluate the two listed potential remedial alternatives. Table 6.1 shows recommended CMS soil sampling. Figure 6.6 shows the proposed sampling locations. Results of the sampling will be used to determine if remedial action is required.

Table 6.1
 SWMU 47/AOC 516 CMS Data Needs

| Location/Media | Activity | Analysis |
|--------------------------------------|---|---------------------------------|
| 047SB007/surface and subsurface soil | Collect four surface and subsurface soil samples around the previous sample point (approximately 10 feet out) | Inorganics --- arsenic and lead |
| SWMU 47/surface and subsurface soil | Collect five surface and subsurface soil samples (10 samples) | Dioxins |
| SWMU 47/groundwater | Base-wide groundwater inorganic study | Inorganic -- standard suite |

Groundwater

A list of CMS data needs for groundwater at this site is not warranted. As shown in Table 6.1, an evaluation of the base-wide groundwater study will be conducted during the CMS to determine if groundwater data are adequate for developing remedial alternatives.



- - 1ST ROUND SOIL SAMPLE LOCATION
 ● - 2ND ROUND SOIL SAMPLE LOCATION
 NOTE: 047SB014 NOT INSTALLED
 ⊕ - MONITORING WELL LOCATION
 ⊕ - PROPOSED DIOXIN SAMPLE LOCATION
 □ - GRASS ▒ - GRAVEL ▨ - FORMER BUILDING



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FIGURE 6.6
 SWMU 47 AND AOC 516
 PROPOSED SURFACE AND SUBSURFACE
 DIOXIN SAMPLE LOCATIONS

7.0 AOC 508 and AOC 511

7.1 General Background Information

AOC 508 is the former location of an incinerator of unknown size. The site is an approximately 75 by 75 foot area along Avenue H, north of Building 762 (a former Naval residential housing unit). AOC 511, a former oil storehouse of unknown dimensions, is a small area between AOC 508 and Building 762. Figure 4.1 shows the subject sites in relation to the other CMS sites within Zone C.

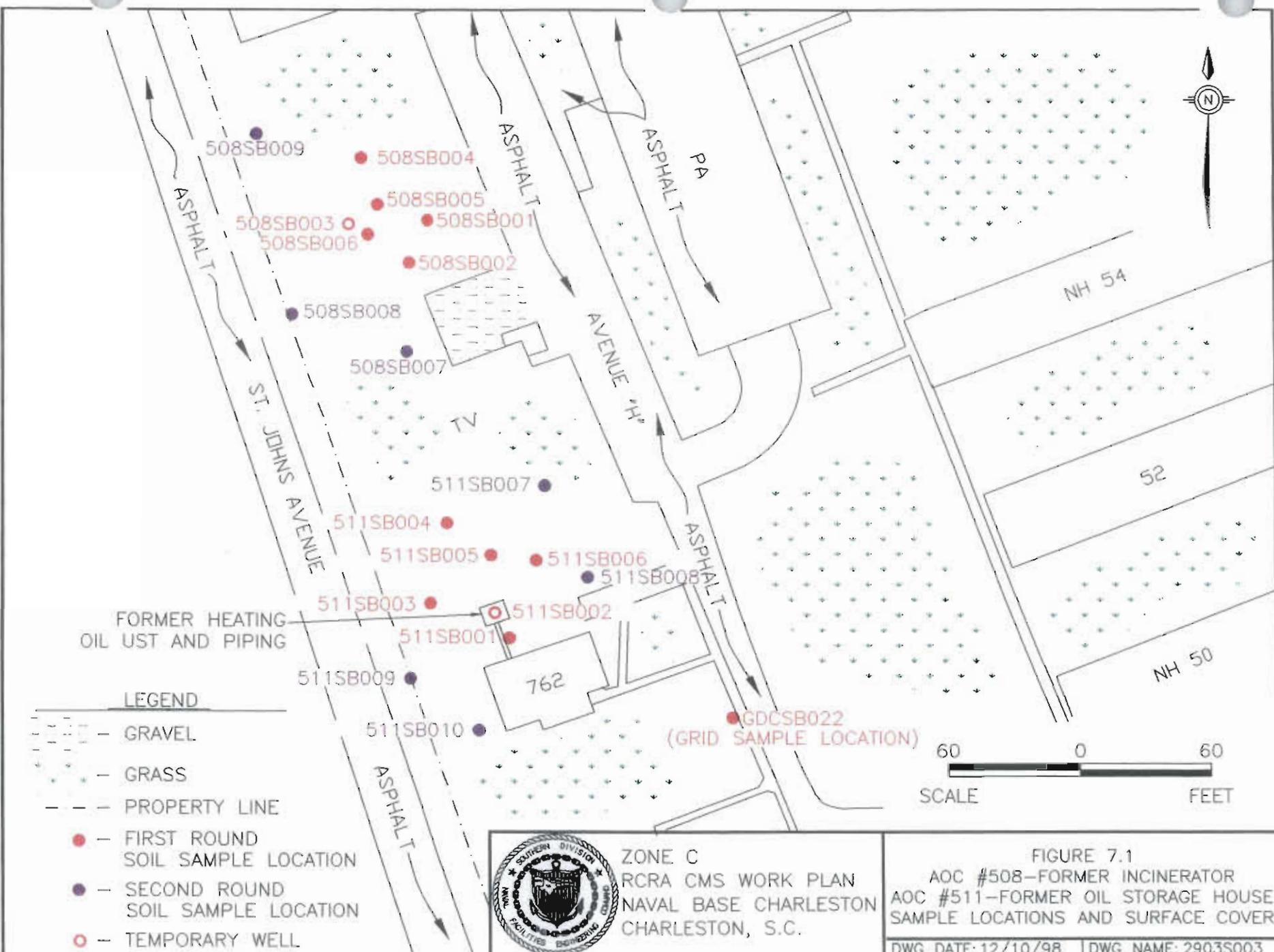
A confirmatory sampling investigation (CSI) was completed at AOC 508 and AOC 511 to identify impacts to soil from releases of former site operations. Groundwater was not included in this CSI as outlined in the *Zone C RFI Work Plan* (E/A&H November 1995). The project team agreed that groundwater would be addressed in the zone-wide groundwater evaluation (Section 11.0).

Site History Summary

The AOC 508 former incinerator operated from 1922 until 1929. Its operating practices are unknown, but the site was investigated based on the potential presence of contaminants such as petroleum hydrocarbons, metals, and residues of incomplete combustion. The AOC 511 former oil storehouse operated from 1922 until 1954. Its operating practices are also unknown, but the site was investigated based on the potential presence of petroleum hydrocarbons. Prior to the CSI and RFI, there were no previous environmental investigations at AOC 508 and AOC 511.

Ground Cover

Both sites are presently grass-covered as shown in Figure 7.1, AOC 508 and AOC 511
Soil Sample Locations and Surface Cover.



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FIGURE 7.1
 AOC #508-FORMER INCINERATOR
 AOC #511-FORMER OIL STORAGE HOUSE
 SAMPLE LOCATIONS AND SURFACE COVER

DWG DATE: 12/10/98 | DWG NAME: 2903S003

7.2 Current Use

AOC 508 and AOC 511 are not in use at this time.

7.3 Future Use

According to the Charleston Naval Complex Redevelopment Authority, this area will likely be used for residential or recreational (i.e., park) purposes.

7.4 ISM Status

In May 1998 the DET removed an underground storage tank. The 1,000-gallon tank had been used to store heating fuel oil for approximately 20 years. Upon completion, the DET produced closure report will be reviewed during the CMS.

7.5 Contaminant Nature and Extent Summary

VOCs were not detected in surface soil samples above RBCs or in subsurface samples above SSLs. While 17 SVOCs were detected at AOC 508 and AOC 511 only four constituents, all PAHs, were detected above RBCs. BEQs exceeded the RBC of 88 $\mu\text{g}/\text{kg}$ in five samples, but only samples from 508SB003 (1,546 $\mu\text{g}/\text{kg}$) and 508SB006 (1,213 $\mu\text{g}/\text{kg}$) exceeded the proposed Zone C background concentration for BEQs (344 $\mu\text{g}/\text{kg}$).

Two pesticides, 4,4-DDT and dieldrin, exceeded their respective RBCs in the upper interval. The sample from 508SB003 reported a 4,4-DDT concentration of 2,700 $\mu\text{g}/\text{kg}$, which is slightly above the USEPA RBC of 1,900 $\mu\text{g}/\text{kg}$. The sample from 511SB002 reported a dieldrin concentration of 200 $\mu\text{g}/\text{kg}$ (the dieldrin RBC is 40 $\mu\text{g}/\text{kg}$). No PCBs were reported in AOC 508 and AOC 511 soil samples.

Total petroleum hydrocarbons were detected in six samples above the arbitrary screening threshold of 100 mg/kg ranging from 113 mg/kg to 746 mg/kg. It is expected that the DET directed ISM

Total petroleum hydrocarbons were detected in six samples above the arbitrary screening threshold of 100 mg/kg ranging from 113 mg/kg to 746 mg/kg. It is expected that the DET directed ISM described in Section 7.4 above has addressed the TPH impact. One herbicide, 2,4,5-trichlorophenoxyacetic acid, an organophosphorous pesticide (phorate), and dioxins were quantified below their respective RBCs.

7.6 Contaminant Fate and Transport Summary

7.6.1 Soil-to-Groundwater

To evaluate fate and transport between soil and groundwater at AOC 508 and AOC 511, constituents in groundwater were compared to constituents in soil samples. **One subsurface sample was acquired for this evaluation.** Maximum concentrations in groundwater and soil were compared to relevant fate and transport screening criteria to highlight potential migration pathways. The RFI identified the potential for isolated impacts based on soil concentrations of dieldrin (**200 $\mu\text{g}/\text{kg}$**) in a single subsurface sample (**511SB002**). Groundwater sampling was conducted to determine the potential for contaminant transport. Based on the results of August 1997 groundwater sampling and analysis of chlorinated pesticides and petroleum products (**all non-detects**), the RFI concluded, **based on the lack of detections**, that soil levels are protective of shallow groundwater.

7.6.2 Groundwater-to-Surface Water

This pathway was not included in the RFI report and therefore will not be included in the CMS evaluation.

7.6.3 Soil-to-Air

Fate and transport from soil-to-air was evaluated by comparing VOC concentrations to soil-to-air volatilization screening levels. Since the maximum VOC surface soil concentration did not exceed

its corresponding soil-to-air screening level, this pathway is not expected to be significant and is excluded from further CMS consideration.

7.6.4 Soil-to-Sediment

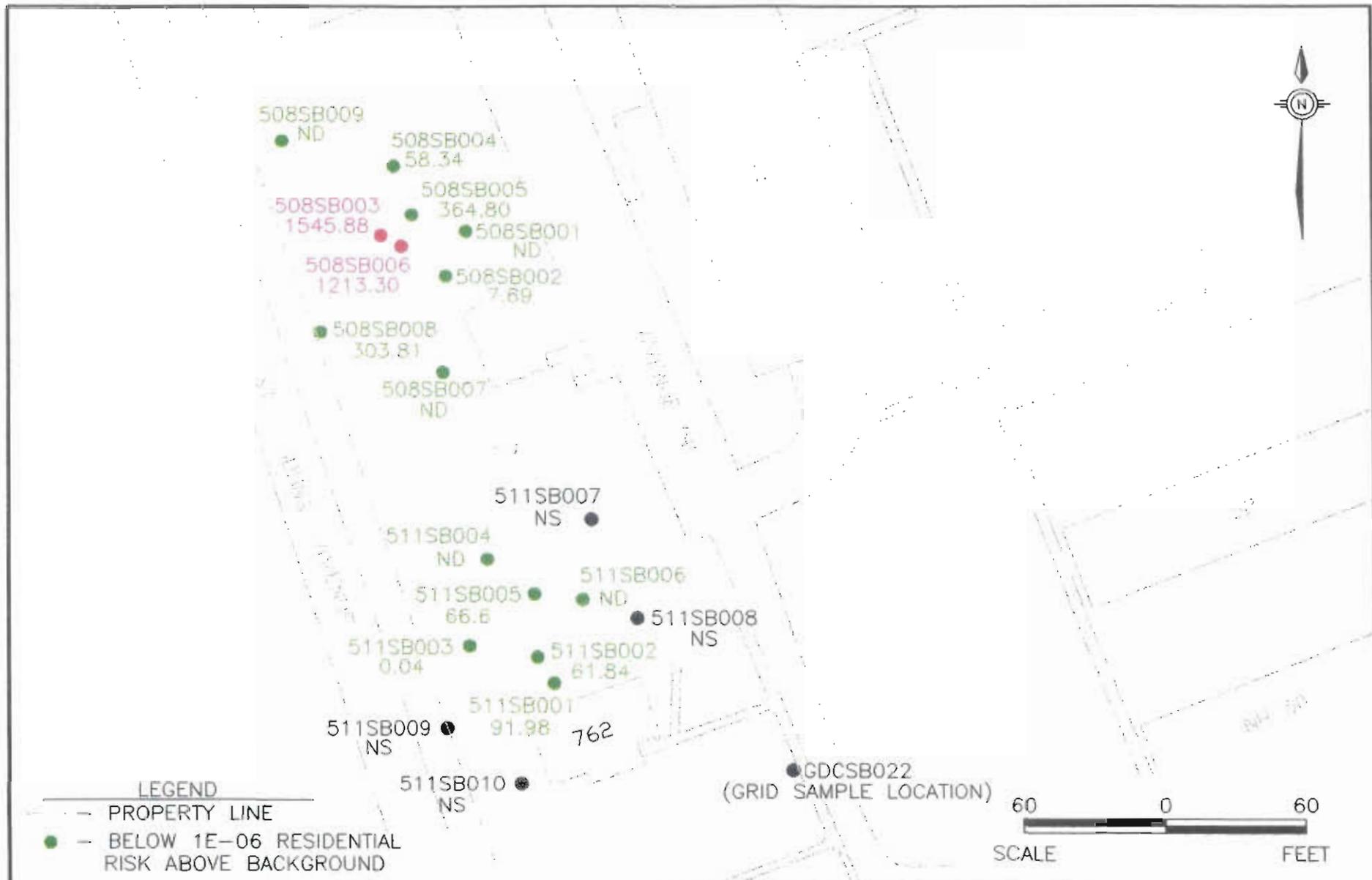
This pathway was not included in the RFI report and therefore will not be included in the CMS evaluation.

7.7 Human Health Risk Assessment Summary

The risk and hazard posed by contaminants at AOC 508 and AOC 511 were assessed for the hypothetical site worker (industrial scenario) and the hypothetical future site resident (residential scenario) under reasonable maximum exposure assumptions. Pathways assessed for surface soil include incidental ingestion and dermal contact.

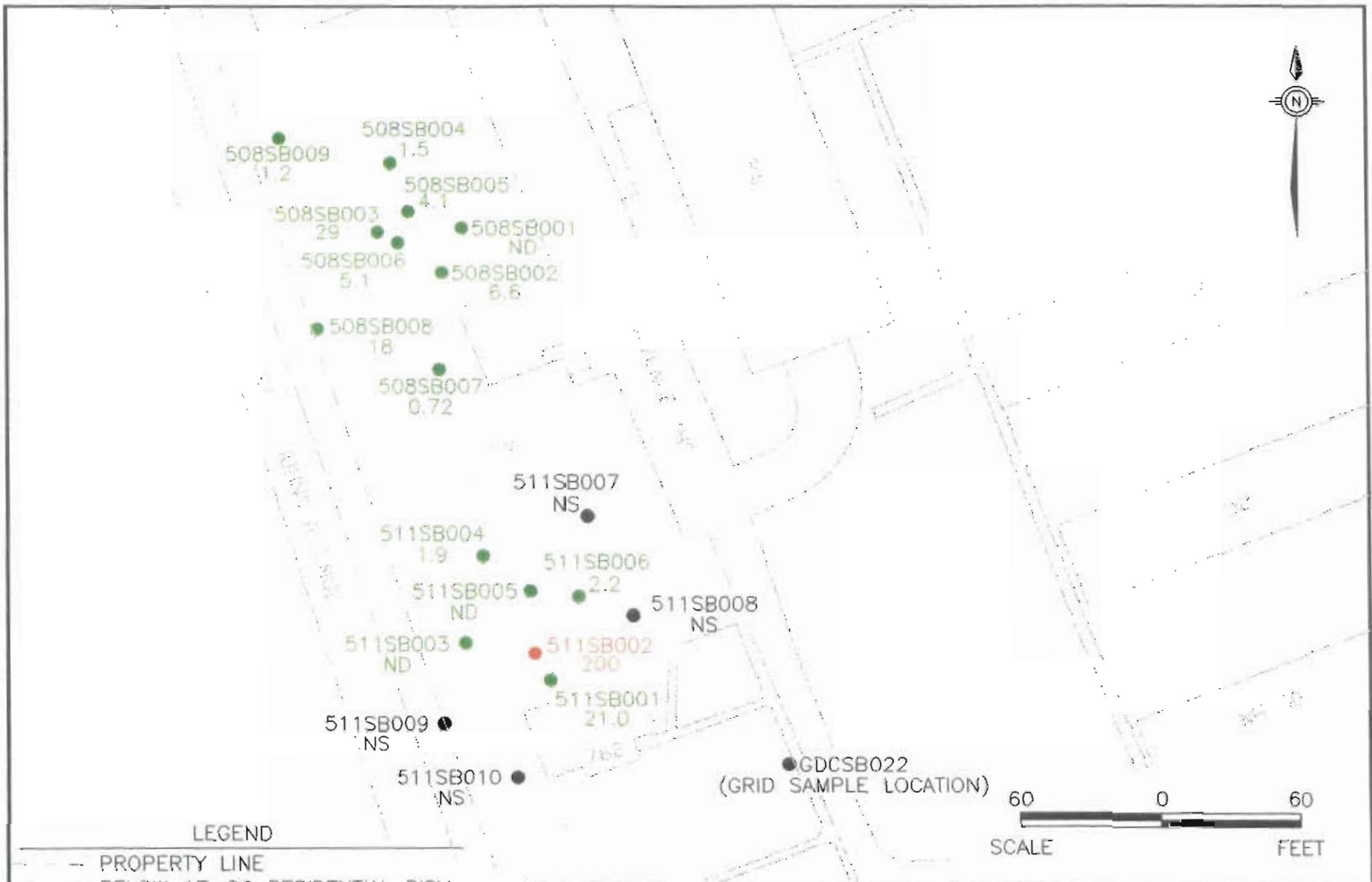
The risk evaluation for AOC 508 and AOC 511 did not result in a hazard index (HI) above background greater than 1 for any sample point. Concentrations of BEQs and dieldrin in three samples resulted in a residential point risk above background greater than $1E-6$. BEQs at 508SB003 and 508SB006 and dieldrin concentrations at 511SB002 resulted in residential risk greater than $1E-6$ above background.

Figures 7.2 and 7.3 contain BEQs and dieldrin concentrations and corresponding residential point risks above background calculated for AOC 508 and AOC 511 soil sampling points. These figures reflect the limited distribution and magnitude of point risk. The two samples in AOC 508 with BEQ concentrations above background are within 20 feet of each other. The other sample point of interest is in AOC 511. Therefore, there is one area in each AOC with a residential risk above background greater than $1E-06$.



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FIGURE 7.2
AOC #508-FORMER INCINERATOR
AOC #511-FORMER OIL STORAGE HOUSE
BEQs IN SURFACE SOIL AND
POINT RISK ABOVE BACKGROUND
DWG DATE: 06/04/98 | DWG NAME: 2903G005



LEGEND

- - PROPERTY LINE
 - - BELOW 1E-06 RESIDENTIAL RISK ABOVE BACKGROUND
 - - BETWEEN 1E-05 AND 1E-06 RESIDENTIAL RISK ABOVE BACKGROUND
- ALL RESULTS ARE IN µg/kg



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FIGURE 7.3
 AOC #508-FORMER INCINERATOR
 AOC #511-FORMER OIL STORAGE HOUSE
 DIELDRIN IN SURFACE SOIL AND
 POINT RISK ABOVE BACKGROUND
 DWG DATE: 06/04/98 | DWG NAME: 2903G006

7.8 Ecological Risk Assessment Summary

Ecological study areas (ESAs) established for Zone C did not include AOC 508 and AOC 511 based on the lack of suitable habitat and applicable receptors. Therefore, an ecological risk assessment was not conducted.

7.9 Remedial Objectives

Soil

Dieldrin and BEQs in surface soil could potentially require limited remediation based on current site risk and hazard levels. The CMS will examine potential alternatives which could reduce residential risk above background to a level below 1E-06 or 1E-05, hazard above background to a level below 1.0 or 0.1, or a separate cost-benefit risk and hazard reduction based goal. Both residential and industrial reuse scenarios will be evaluated.

Groundwater

~~There are no known groundwater concerns associated with AOC 508 and AOC 511. However, as previously mentioned in this work plan,~~ Groundwater at this site will be addressed from a zone-wide perspective and jointly with other Zone C sites **after completion of the base-wide groundwater study. Remedial objectives are MCLs or BSHWM cleanup criteria, as applicable.**

7.10 Potential Remedial Alternatives

Soil

Potential remedial alternatives for soil at this site include:

- Full or partial surface capping — **covering areas of contaminated soil with an impermeable cap.**

- Excavation and off-site disposal — **removal of contaminated soil and disposal at an off-site facility.**

Groundwater

Groundwater at this site will be addressed from a zone-wide perspective and jointly with other Zone C sites (Section 11) after completion of the base-wide groundwater study. Since the site's groundwater is considered sufficiently protective of human health and the environment, a list of potential groundwater remedial alternatives is not warranted.

7.11 CMS Data Needs

Soil

Table 7.1 shows recommended soil sampling. Based on the remedial objectives and remedial alternatives identified previously, the following data needs are identified:

- **Four** ~~Five~~ additional surface and subsurface soil samples near **sample location 511SB002** will be collected and analyzed for dieldrin to determine the extent of contamination. **Figure 7.4** shows the **proposed sample locations.** ~~the hot-spots identified in the risk assessment.~~
- Review of the DET Site Completion Report.

Groundwater

Groundwater at this site will be addressed from a zone-wide perspective and jointly with other Zone C sites (Section 11) after completion of the base-wide groundwater study. ~~A list of CMS data needs for groundwater at this site is not warranted.~~

Table 7.1
AOC 508/AOC 511 CMS Data Needs

| Location/Media | Activity | Analysis |
|--------------------------------------|---|----------------------|
| 511SB002/surface and subsurface soil | Collect four surface and subsurface soil samples around the previous sample point (approximately 10 feet out) | Pesticide — dieldrin |
| AOC 508/AOC 511/groundwater | Zone-wide groundwater study (Section 11) | Section 11 |

8.0 AOC 512

8.1 General Background Information

AOC 512 is the site of a former incinerator approximately 250 feet south of Building 1079. Figure 4-1 shows AOC 512 in relation to the other CMS sites within Zone C. A CSI was performed to identify impacts, if any, to site soil from on site waste incineration. The project team agreed that groundwater would be addressed in the zone-wide groundwater evaluation (Section 11.0).

Site History Summary

The AOC 512 former incinerator operated from 1943 until 1958. The site was investigated based on the potential presence of contaminants such as petroleum hydrocarbons, metals, and residues of incomplete combustion. Prior to the CSI and RFI, there were no previous investigations at AOC 512.

Ground Cover

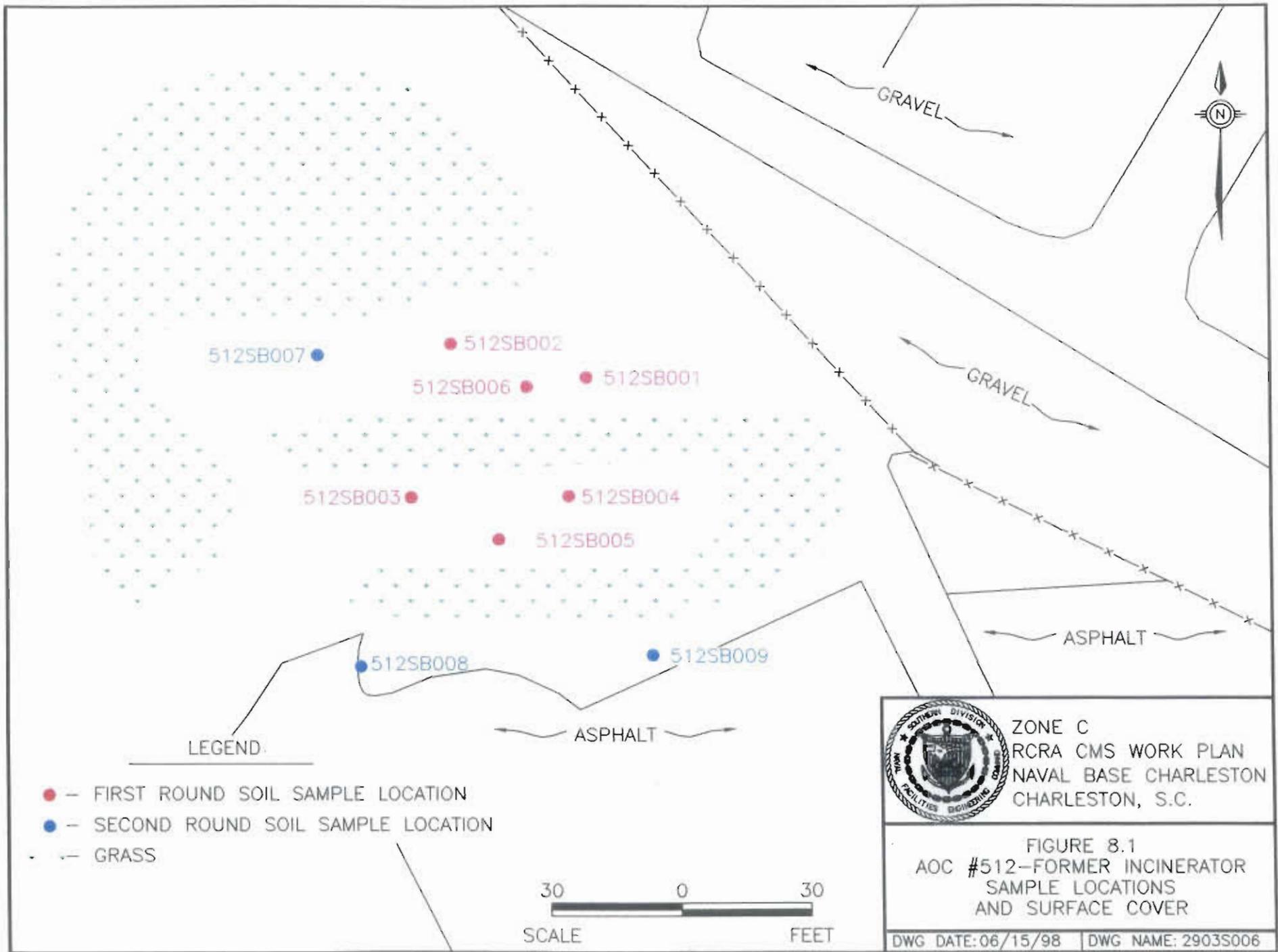
The site is presently grass-covered as shown in Figure 8.1, AOC 512 Soil Sample Locations and Surface Cover. Reference this figure for a general rendering of site surface conditions.

8.2 Current Use

AOC 512 is not in use at this time.

8.3 Future Use

According to the Charleston Naval Complex Redevelopment Authority, this area will likely be used for residential or recreational (i.e., park) purposes.



8.4 ISM Status

There have been no ISMs conducted by the Navy DET or other parties at this site.

8.5 Contaminant Nature and Extent Summary

VOCs were not detected in surface soil samples above RBCs or in subsurface samples above SSLs. While 10 SVOCs were detected at AOC 512, only two compounds, both PAHs, were detected above their respective RBCs. BEQs exceeded the RBC of 88 $\mu\text{g}/\text{kg}$ in four samples, but none exceeded the proposed Zone C background concentration for BEQs (344 $\mu\text{g}/\text{kg}$). Detections of pesticides, PCBs, herbicides, organophosphorous pesticide compounds, and dioxins were below respective RBCs or SSLs

Eight inorganic constituents exceeded their reference concentrations in surface soil samples. Only beryllium, manganese, and cobalt exceeded reference concentrations in more than one sample; these constituents were not detected at levels higher than background concentrations for other zones at the former naval base. Table 8.1 shows the the maximum detected concentrations for these two three inorganics in AOC 512 surface soil, and the Zone C reference concentrations, and the maximum reference concentrations for surface soil at any zone at the former naval base. As seen in the table, the maximum inorganic contaminant detections in AOC 512 are less than half the reference concentrations for Zone H. Therefore, detections at AOC 512 are likely representative of base-wide conditions, not impact from former Naval operations.

8.6 Contaminant Fate and Transport Summary

8.6.1 Soil to Groundwater

To evaluate fate and transport between soil and groundwater at AOC 512, constituents in soil were compared to groundwater protection SSLs or background reference concentrations. One subsurface sample was collected. Detections were below SSLs or reference concentrations,

Table 8.1
AOC 512 Maximum Inorganic Detected Concentrations and
Zone C Reference Concentrations

| Inorganic Constituent | AOC 512 Maximum Detected Concentration (mg/kg) | Zone C Reference Concentration (mg/kg) |
|------------------------------|---|---|
| Beryllium | 0.44 | Not calculated |
| Cobalt | 4.4 | 3.22 |
| Manganese | 280 | 92.5 |

indicating that no widespread threat to groundwater is posed by AOC 512 surface soil. **Pesticides and PCBs were non-detect in AOC 512 groundwater.**

8.6.2 Groundwater to Surface Water

This pathway was not included in the RFI report and therefore will not be included in the CMS evaluation.

8.6.3 Soil to Air

No VOCs were detected in AOC 512 surface soil. As a result, the soil to air migration pathway is not significant at this site.

8.6.4 Soil to Sediment

This pathway was not included in the RFI report and therefore will not be included in the CMS evaluation.

8.7 Human Health Risk Assessment Summary

The risk and hazard posed by contaminants at AOC 512 were assessed for the hypothetical site worker (industrial scenario) and the hypothetical future site resident (residential scenario) under

reasonable maximum exposure assumptions. Pathways assessed for surface soil include incidental ingestion and dermal contact.

The risk evaluation for AOC 512 did not result in a hazard index (HI) greater than one. Residential point risk above background estimates, calculated for BEQs and beryllium, are shown in Figures 8.2 and 8.3. As shown in the figures, residential risk estimates above background for AOC 512 surface soil do not exceed 1E-06.

8.8 Ecological Risk Assessment Summary

Ecological study areas (ESAs) established for Zone C included AOC 512. ESA C-2 includes AOC 512 and the area northwest to the Zone C boundary. The results of the ecological risk assessment are discussed below.

8.8.1 Infaunal Invertebrates

Based on a comparison of surface soil concentrations in AOC 512 and effects levels, no risk to infaunal organisms from inorganic and organic concentrations at Subzone C-2, including AOC 512, are predicted.

8.8.2 Terrestrial Wildlife

A slight potential for lethal effects to the short-tailed shrew (HI = 1.07) exists in ESA Subzone C-2 based on the maximum detected manganese concentration. However, as shown in Table 8.1, manganese detections did not exceed the maximum background concentration at the former naval base. Therefore, the potential for lethal effects exists due to naturally occurring manganese and does not warrant further consideration during the CMS. During the RFI, no potential sub-lethal effects from exposure to soil at AOC 512 were predicted since calculated values for HQ and HI were less than one.



LEGEND

- - BELOW 1E-06 RESIDENTIAL RISK ABOVE BACKGROUND
- - BETWEEN 1E-05 AND 1E-06 RESIDENTIAL RISK ABOVE BACKGROUND
- ND - NOT DETECTED

ALL RESULTS ARE IN µg/kg



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FIGURE 8.2
AOC #512-FORMER INCINERATOR
BEQs IN SURFACE SOIL AND
POINT RISK ABOVE BACKGROUND

DWG DATE: 06/04/98 | DWG NAME: 2903G007

8.8.3 Vegetation

During the RFI, a potential risk to woody seedlings and young herbaceous species was predicted to exist from metals contamination observed in Subzone C-2 soil. However, the metals contributing to this risk; copper, lead, manganese, and zinc, were not detected above background concentrations for either Zone C soil, or soil in other zones within the former naval base. Therefore, the calculated risks are reflective of naturally occurring metal concentrations and do not warrant further assessment during the CMS.

8.8.4 Aquatic receptors

Risk to aquatic wildlife was not addressed for Subzone C-2 during the RFI and therefore will not be addressed during the CMS.

8.9 Remedial Objectives

Based on the results of the human health risk assessment indicating lack of risk or hazard exceeding, 1E-06 and 1.0, respectively, and the lack of ecological risk above background, the site is sufficiently protective of human health and the environment. Therefore, the establishment of remedial objectives for site soil is not warranted.

Groundwater

There are no known groundwater concerns associated with AOC 512. However, as previously mentioned in this work plan, groundwater at this site will be addressed from a zone-wide perspective and jointly with other Zone C sites.

8.10 Potential Remedial Alternatives

Soil

Since the site's soil can be considered sufficiently protective of human health and the environment, a list of potential remedial alternatives is not warranted.

Groundwater

Groundwater at this site will be addressed from a zone-wide perspective and jointly with other Zone C sites (Section 11). Therefore, it is premature to assemble a list of potential remedial alternatives. Since the site's groundwater is considered sufficiently protective of human health and the environment, a list of potential groundwater remedial alternatives is not warranted.

8.11 CMS Data Needs

Soil

A list of CMS data needs for soil at this site is not warranted.

Groundwater

Groundwater at this site will be addressed from a zone-wide perspective and jointly with other Zone C sites (Section 11). Table 8.2 shows the CMS data needs for AOC 512. A list of CMS data needs for groundwater at this site is not warranted.

Table 8.2
 AOC 512 CMS Data Needs

| Location/Media | Activity | Analysis |
|---------------------|--|------------|
| AOC 512/soil | NA | NA |
| AOC 512/groundwater | Zone-wide groundwater study (Section 11) | Section 11 |

9.0 AOC 518

9.1 General Background Information

AOC 518 is a site where coal was stored in bins from 1926 until 1937. The coal storage bins have since been removed and the site is no longer used for coal storage. Figure 4.1 shows the subject site in relation to the other CMS sites within Zone C.

Site History Summary

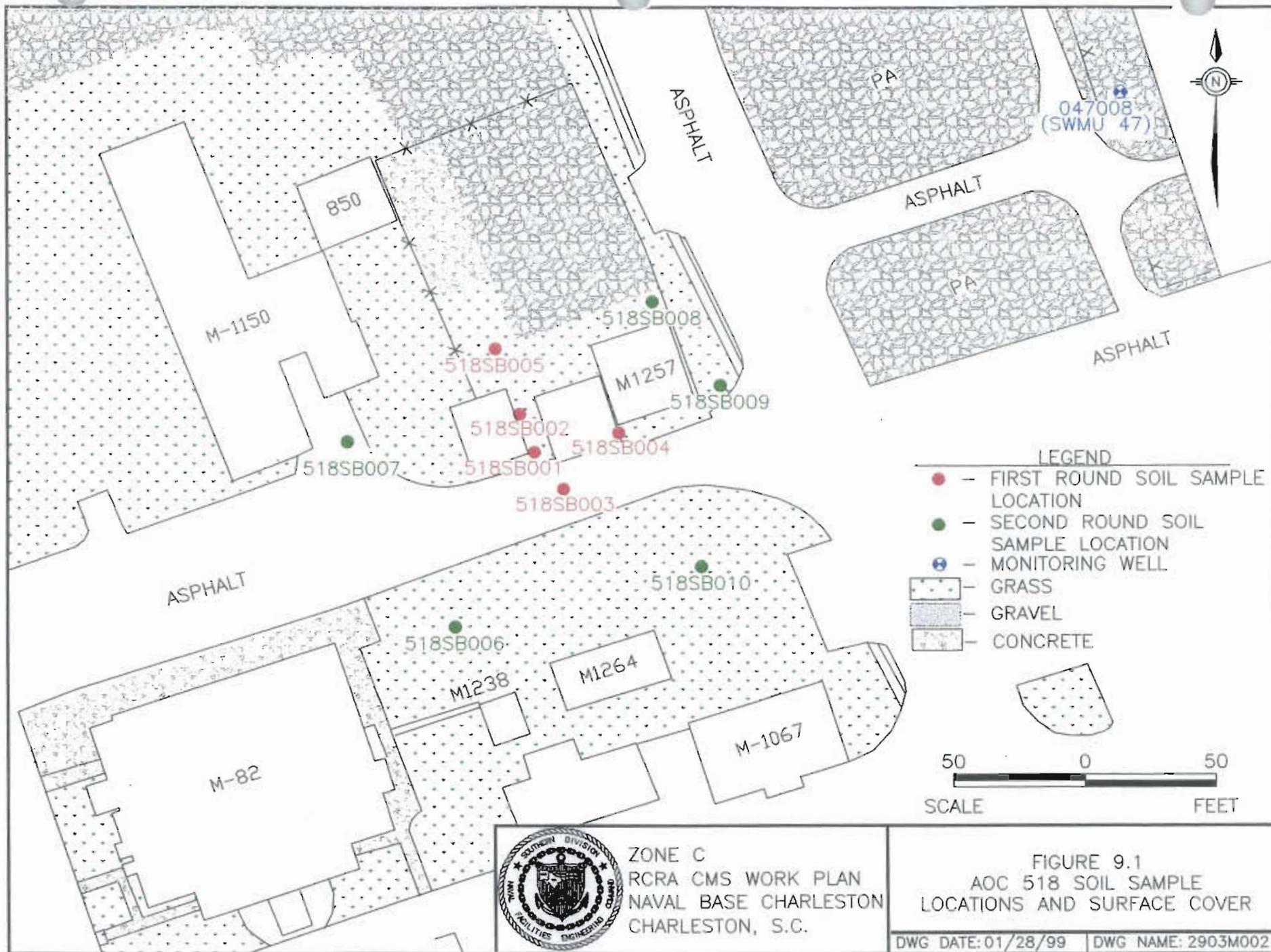
AOC 518 is a site of potential historical concern because it was used for coal storage. The coal was used at the former naval base to fuel steam generating boilers. The steam was primarily used to heat the building. The RFI focused on potential soil contaminants that may have resulted from coal storage including coal derivatives such as SVOCs and inorganics (metals). The project team agreed that groundwater would be addressed in the zone-wide groundwater evaluation (Section 11.0).

Ground Cover

The site is presently developed and is covered with grass, gravel, and asphalt parking lots and roads. In addition, Building M-1257 and other nearby buildings now occupy the former coal storage bins area. Reference Figure 9.1, AOC 518 Soil Sample Locations and Surface Cover, for a general rendering of site surface conditions.

9.2 Current Use

Several of the buildings near and at AOC 518 are either secured and empty because of BRAC requirements or are in use by a current base reuse tenant, the North Charleston Police Department. Roadways and parking lots in the vicinity of AOC 518 are also in use by the police department and/or other adjacent base reuse tenants.



9.3 Future Use

According to the Charleston Naval Complex Redevelopment Authority, this area will likely be used for residential or recreational (i.e., park) purposes. However, as noted above, a portion of the site is presently leased and in full use by the North Charleston Police Department.

9.4 ISM Status

There have been no ISMs conducted by the Navy DET or other parties at this site.

9.5 Contaminant Nature and Extent Summary

Soil sample results did not indicate the presence of VOCs above RBCs in the upper interval or above SSLs in the lower interval samples. PCBs were not detected, and calculated dioxin equivalents were below the TCDD RBC (4.3 ~~1,000~~ ng/kg).

One SVOC, benzo(a)pyrene, was detected at 150 $\mu\text{g}/\text{kg}$, slightly above its RBC (88 $\mu\text{g}/\text{kg}$) in one surface soil sample (518SB002), however, calculated BEQs for this sample point were below the proposed Zone C background value of 344 $\mu\text{g}/\text{kg}$. Calculated BEQs exceeded the RBC in one additional sample point, 518SB003, but also were below background. SVOCs were not detected above SSLs in the lower interval samples.

Chlordane was detected in one soil boring (518SB001) at 7,400 $\mu\text{g}/\text{kg}$, above its RBC of 490 $\mu\text{g}/\text{kg}$. However, this sample point is also beneath the former coal bin foundation **and asphalt**, and additional soil samples near this boring (within 15 feet) did not exceed the chlordane RBC. **Regardless, additional sampling will be conducted during the CMS to delineate the extent of chlordane concentrations.**

Eleven inorganic constituents were detected in surface soil samples above their respective reference concentrations: aluminum, antimony, barium, beryllium, cadmium, chromium, copper, lead, mercury, tin, and zinc. Only aluminum, beryllium, copper and lead exceeded the USEPA RBC. Aluminum and beryllium were detected above their reference concentrations (and RBC) at sample point 518SB005. However, the aluminum detection (10,000 mg/kg) is essentially equivalent to its background value of 9,990 mg/kg, and the beryllium concentration (0.49 mg/kg) is less than the RBC (160 mg/kg). ~~average base-wide background concentration (1.1 mg/kg).~~ Copper was detected above its reference concentration and RBC in two samples (518SB002 and 518SB004). The concentration at 518SB002 was 44.3 mg/kg which is only slightly above the Zone C reference concentration (34.7 mg/kg). Lead was detected above its reference concentration (330 mg/kg) and RBC (400 mg/kg) in a single sample (518SB010). The concentration was 750 mg/kg. **In order to delineate the extent of lead contamination, additional surface and subsurface sampling will be conducted during the CMS around sample location 518SB010.** ~~which is only slightly more than twice the reference concentration and less than twice the RBC.~~ These isolated detections of copper and lead do not reflect impact to surface soil from site activities. Inorganic contaminants were not detected in subsurface samples above reference concentrations.

9.6 Contaminant Fate and Transport Summary

9.6.1 Soil-to-Groundwater

To evaluate fate and transport between soil and groundwater at AOC 518, constituents in groundwater were compared to constituents in soil samples. Maximum concentrations in groundwater and soil were compared to relevant fate and transport screening criteria to highlight potential migration pathways. Nine constituents (antimony, beta-BHC, delta-BHC, chromium, copper, disulfoton, lead, mercury, and tin) were detected in surface soil above SSLs or background reference concentrations. However, subsurface soil did not reflect the presence of

these constituents above SSLs or reference concentrations. Therefore, vertical migration of contaminants does not appear to have occurred, and impact to groundwater is not expected.

9.6.2 Groundwater-to-Surface Water

This pathway was not included in the RFI report and therefore will not be included in the CMS evaluation.

9.6.3 Soil-to-Air

Fate and transport from soil to air was evaluated by comparing VOC concentrations to soil-to-air volatilization screening levels. Since the maximum VOC surface soil concentration did not exceed its corresponding soil-to-air screening level, this pathway is not expected to be significant and is excluded from further CMS consideration.

9.6.4 Soil-to-Sediment

This pathway was not included in the RFI report and therefore will not be included in the CMS evaluation.

9.7 Human Health Risk Assessment Summary

The risk and hazard posed by contaminants at AOC 518 were assessed for the hypothetical site worker (industrial scenario) and the hypothetical future site resident (residential scenario) under reasonable maximum exposure assumptions. Pathways assessed for surface soil include incidental ingestion and dermal contact.

The risk evaluation for AOC 518 did not result in a surface soil point hazard index (HI) above background greater than one for any sample point, and only resulted in a residential risk above background greater than the USEPA acceptable residential risk of 1E-06 at 518SB001. The risk

driver for 518SB001 is the chlordane concentration (point risk = 5.9E-06). This sample was collected from under the coal bin foundation and protected from access. **However, with the potential for residential reuse, additional surface and subsurface sampling will be conducted during the CMS to delineate the extent of chlordane in soil.** ~~Therefore, AOC 518 does not pose unacceptable site-related or widespread risk or hazard to human receptors.~~

Figures 9.2 and 9.3 contain point risks above background calculated for soil sampling points in AOC 518 for residential and industrial exposure scenarios. These figures reflect the limited distribution and magnitude of risk above background in AOC 518 surface soil.

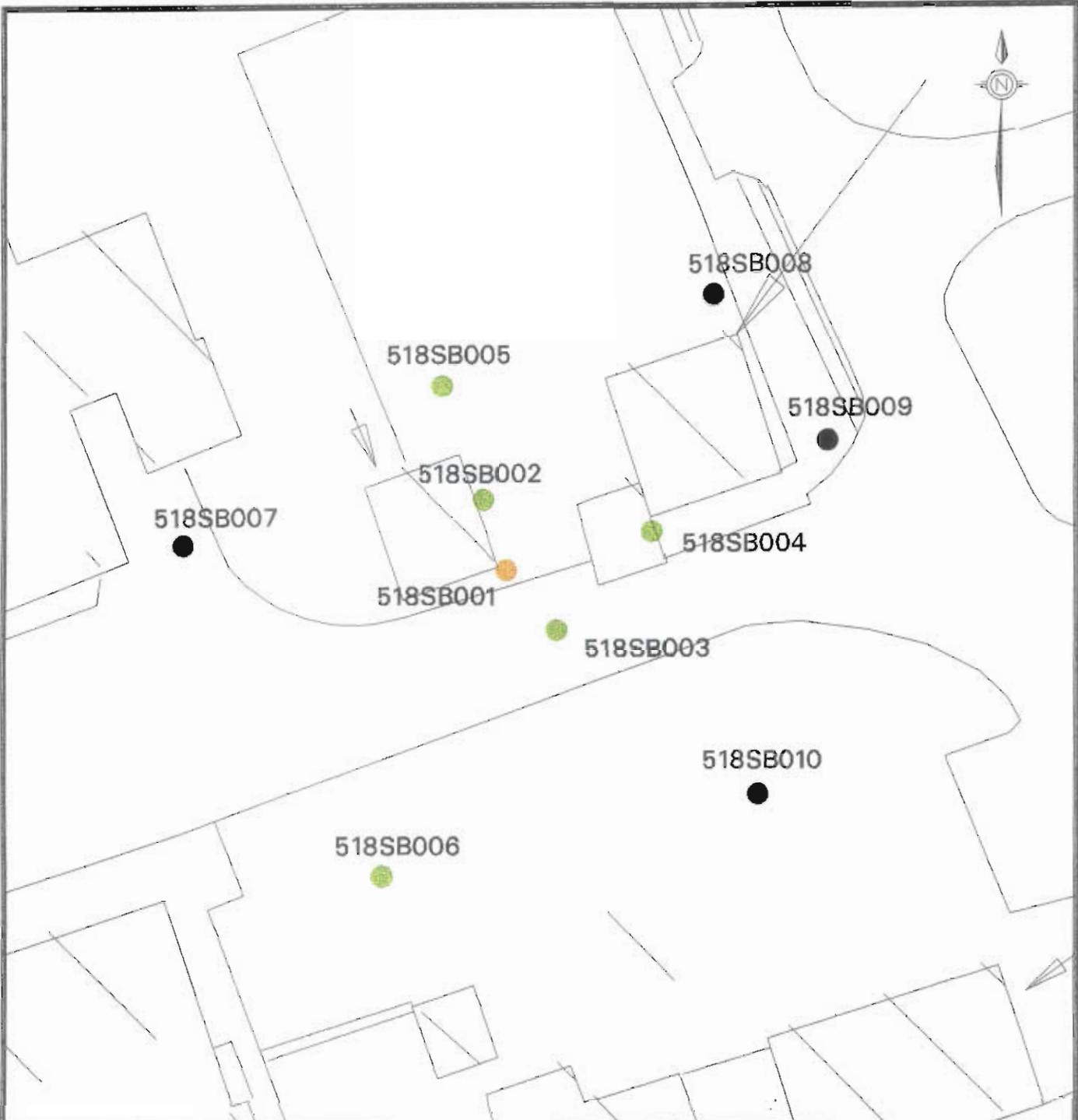
9.8 Ecological Risk Assessment Summary

Ecological study areas (ESAs) established for Zone C did not include AOC 518 based on the lack of suitable habitat and applicable receptors. Therefore, an ecological risk assessment was not conducted.

9.9 Remedial Objectives

Soil

Chlordane and lead in surface soil could potentially require limited remediation based on current site risk and hazard levels. The CMS will examine potential alternatives which could reduce risk above background to a level below 1E-06 or 1E-05, hazard above background to a level below 1.0 or 0.1, or a separate cost-benefit risk and hazard reduction based goal. Both residential and industrial reuse scenarios will be evaluated.



- LEGEND**
- NO COPCs DETECTED
 - < 1E-6
 - 1E-6 to 5E-6
 - 5E-6 to 1E-5
 - 1E-5 to 1E-4
 - > 1E-4



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**FIGURE 9-2
AOC 518
POINT RISK ESTIMATES ABOVE BACKGROUND
FOR SURFACE SOIL RESIDENTIAL SCENARIO**

0 feet 80

Groundwater

There are no known groundwater concerns associated with AOC 518. However, as previously mentioned in this work plan, groundwater at this site will be addressed from a zone-wide perspective and jointly with other Zone C sites (**Section 11**).

9.10 Potential Remedial Alternatives

Soil

Pending a risk management decision by the project team as to the necessity for remedial action of surface soils at this site, the following are potential remedial alternatives.

- Full or partial surface capping - **covering areas of contaminated soil with an impermeable cap.**
- Excavation and off-site disposal - **removal of contaminated soil and disposal at an off-site facility.**

Groundwater

Since the site's groundwater is considered sufficiently protective of human health and the environment, a list of potential remedial alternatives is not warranted.

9.11 CMS Data Needs

Soil

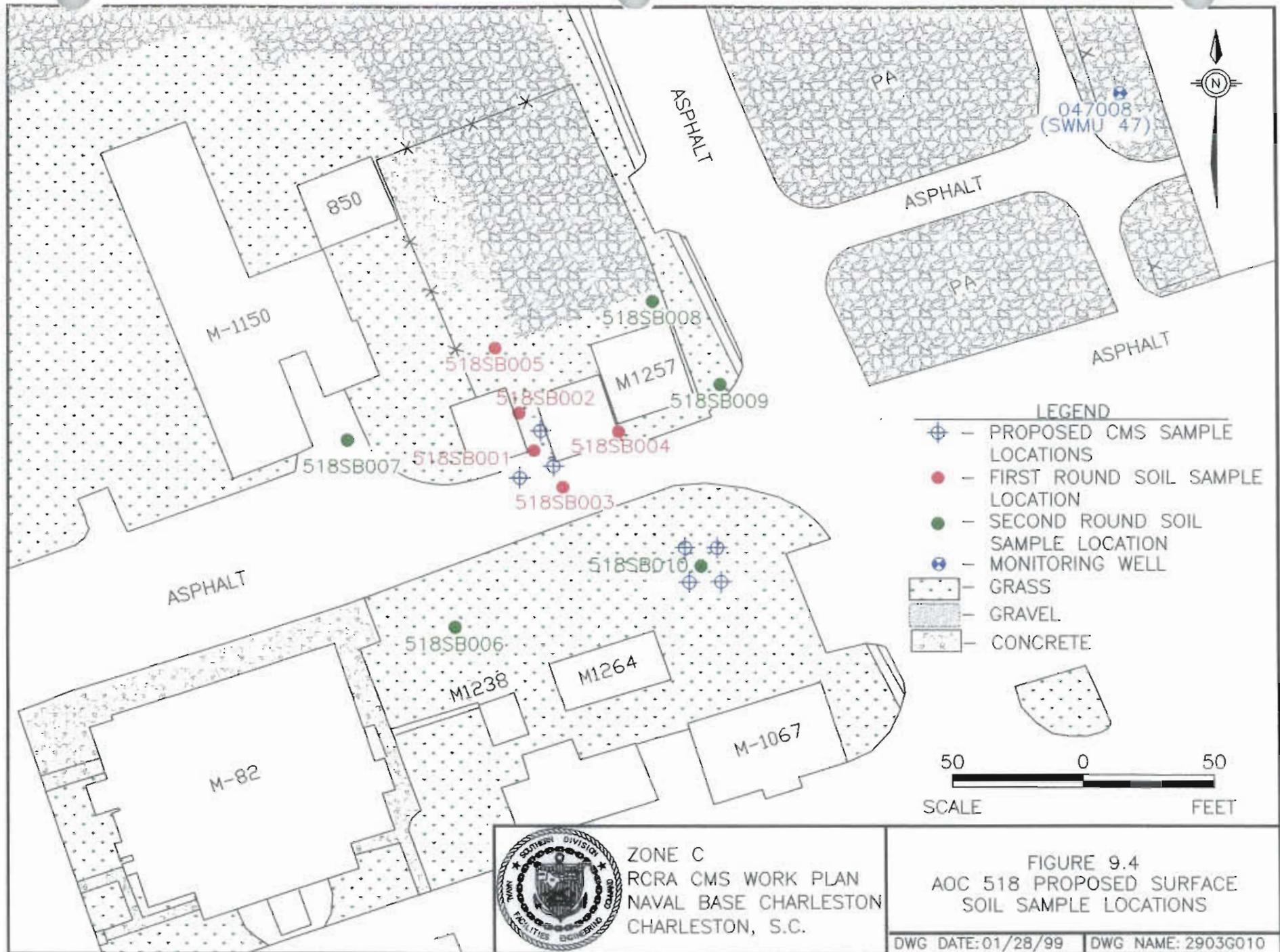
During the CMS, four surface and subsurface samples will be collected in the soil surrounding sample location 518SB001 to be analyzed for chlordane and surrounding sample location 518SB010 to be analyzed for lead (Table 9.1). Figure 9.4 shows the sample locations. The information provided by the RFI is sufficient to fully evaluate the two listed potential remedial alternatives:

Groundwater

A list of CMS data needs for groundwater at this site is not warranted.

**Table 9.1
 AOC 518 CMS Data Needs**

| Location/Media | Activity | Analysis |
|--------------------------------------|---|------------------------|
| 518SB001/surface and subsurface soil | Collect four surface and subsurface soil samples around the previous sample point (approximately 10 feet out) | Pesticide -- chlordane |
| 518SB010/surface and subsurface soil | Collect four surface and subsurface soil samples around the previous sample point (approximately 10 feet out) | Inorganic — lead |
| AOC 518/groundwater | NA | NA |



10.0 AOC 700

10.1 General Background Information

AOC 700 is the site of a golf course maintenance building, Building 1646, west of Avenue D and north of Hunt Street. Figure 4.1 shows the subject site in relation to the other Zone C CMS sites.

Ground Cover

Except for the roads and driveways around Building 1646, the area is covered with grass. Reference Figure 10-1, AOC 700 Soil Sample Locations and Surface Cover, for a general rendering of site surface conditions.

10.2 Current Use

Building 1646 is not currently in use.

10.3 Future Use

According to the Charleston Naval Complex Redevelopment Authority, this area will likely be used for residential or recreational (i.e., park) purposes.

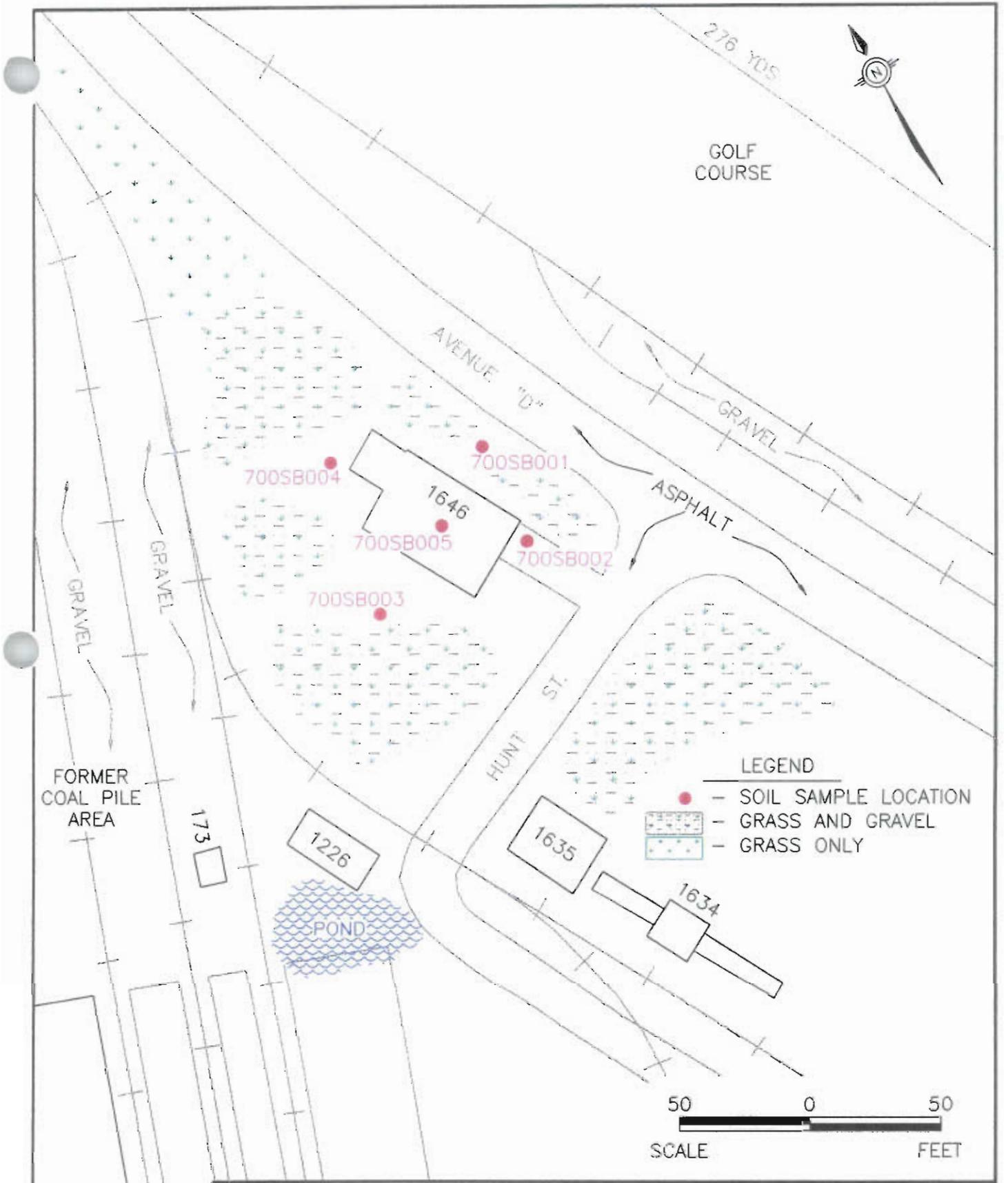
10.4 ISM Status

There have been no ISMs conducted by the Navy DET or other parties at this site. However, extensive ISM activity has occurred at SWMU 44, west of AOC 700.

10.5 Contaminant Nature and Extent Summary

10.5.1 Soil

VOCs were not detected in AOC 700 soil above RBCs and SSLs. BEQs were the only SVOCs detected above RBCs, although they were not detected above the proposed Zone C reference concentration (344 $\mu\text{g}/\text{kg}$). Pesticides and PCBs were not detected above their respective RBCs.



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FIGURE 10.1
 AOC 700
 GOLF COURSE MAINTENANCE BLDG.
 SAMPLE LOCATIONS AND SURFACE COVER

DWG DATE: 05/20/98 DWG NAME: 2903S002

While dioxins were detected in the single sample submitted for analysis, the calculated TEQ was 3.032 ng/kg, which is below the TCDD RBC of 4.3 ±,000 ng/kg.

Inorganic constituents chromium and copper were detected above SSLs and reference concentrations. Chromium exceedences occurred in four of the five surface samples and in five of five subsurface samples. Copper exceeded the SSL in two of the five subsurface samples.

10.5.2 Groundwater

AOC 700 groundwater is being addressed in the SWMU 44 CMS and thus will not be considered in the AOC 700 CMS work plan. **Water level measurements from the most recent (January 1998) base-wide evaluation (Figure 4.4) will be used to confirm the flow direction in the area of AOC 700.**

10.6 Contaminant Fate and Transport Summary

10.6.1 Soil-to-Groundwater

The SWMU 44 CMS will evaluate potential fate and transport between soil and groundwater at AOC 700. **However, a monitoring well will be installed east of Building 1646 to support this effort.**

10.6.2 Groundwater-to-Surface Water

This pathway was not included in the RFI report and therefore will not be included in the CMS evaluation.

10.6.3 Soil-to-Air

No VOCs were detected in AOC 700 surface soil. As a result, the soil-to-air migration pathway is not significant at this site.

10.6.4 Soil to Sediment

This pathway was not included in the RFI report and therefore will not be included in the CMS evaluation.

10.7 Human Health Risk Assessment Summary

The risk and hazard posed by contaminants at AOC 700 were assessed for the hypothetical site worker (industrial scenario) and the hypothetical future site resident (residential scenario) under reasonable maximum exposure assumptions. Pathways assessed for surface soil include incidental ingestion and dermal contact.

~~Because concentrations detected in AOC 700 soil were at or below background reference concentrations,~~ The risk evaluation for AOC 700 did not result in an HI above background greater than one or a residential risk above background greater than 1E-6. Therefore, AOC 700 surface soil does not pose an unacceptable risk or hazard to human receptors.

10.8 Ecological Risk Assessment Summary

Ecological study areas (ESAs) established for Zone C did not include AOC 700 based on the lack of suitable habitat and applicable receptors. Therefore, an ecological risk assessment was not conducted.

10.9 Remedial Objectives

Soil

Based on the results of the human health risk assessment indicating lack of risk or hazard exceeding residential thresholds, 1E-06 and 1.0, respectively, and the lack of ecological risk above background, the site is sufficiently protective of human health and the environment. Therefore, the establishment of remedial objectives for site soil is not warranted.

Groundwater

There are no known groundwater concerns associated with AOC 700. However, as previously mentioned in this work plan, groundwater at this site will be addressed jointly with SWMU 44 groundwater. **In addition, a monitoring well will be installed east of Building 1646 to support this effort.** Therefore, The establishment of any groundwater remedial objectives, if necessary, will be part of the SWMU 44 CMS.

10.10 Potential Remedial Alternatives

Soil

Since site's soil can be considered sufficiently protective of human health and the environment, a list of potential remedial alternatives is not warranted.

Groundwater

If necessary, potential remedial alternatives for AOC 700 groundwater will be identified during the SWMU 44 CMS.

10.11 CMS Data Needs

Soil

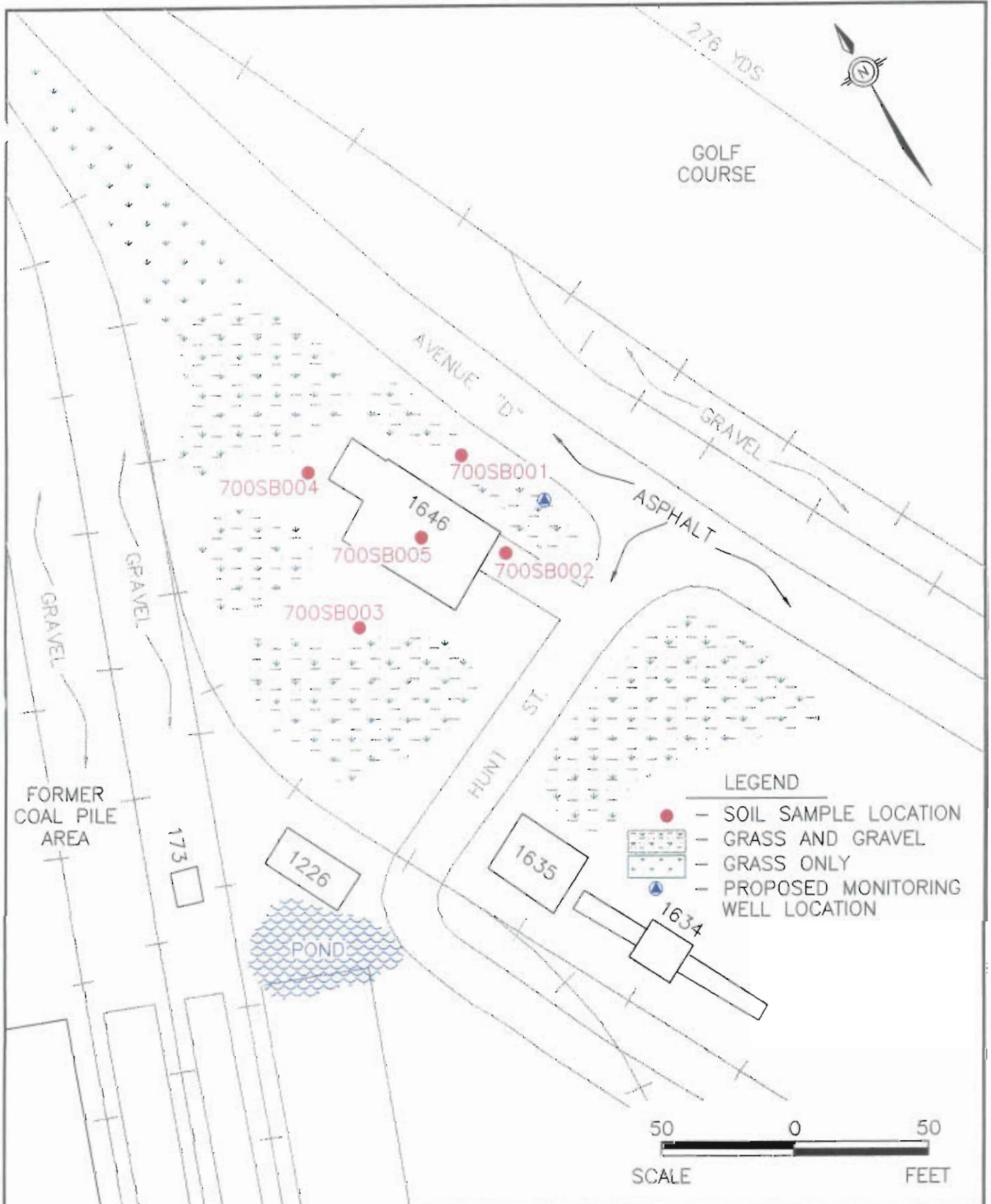
A list of CMS data needs for soil at this site is not warranted.

Groundwater

A monitoring well will be installed east of Building 1646 as shown on Figure 10.2. Table 10.1 presents the CMS data needs for AOC 700. ~~A list of CMS data needs for groundwater at this site is not warranted.~~

Table 10.1
AOC 700 CMS Data Needs

| Location/Media | Activity | Analysis |
|--|---|-----------------------------------|
| AOC 700/surface and subsurface soil | NA | NA |
| AOC 700/groundwater | Install monitoring well and sample | Inorganic – standard suite |



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 CHARLESTON, S.C.

FIGURE 10.2
 AOC 700
 GOLF COURSE MAINTENANCE BLDG.
 PROPOSED MONITORING WELL LOCATION

11.0 ZONE-WIDE GROUNDWATER

As stated in Section 4.6 of this work plan and except for groundwater associated with SWMU 44 (including AOC 700), SWMU 47 and AOC 516, Zone C groundwater will be addressed as a single entity. AOC 700 groundwater will be addressed as part of SWMU 44 groundwater due to its proximity to the former coal storage yard.

Groundwater associated with AOCs 508, 510, 511, 512, ~~513~~, ~~517~~, ~~518~~, ~~520~~, and 523 will be addressed from a zone-wide perspective as a combined effort. The zone-wide groundwater assessment addresses the analytical results of samples acquired from an existing monitoring well network in Zone C over a one-year period. Exclusive of SWMU 44 and SWMU 47 monitoring wells, this zone-wide monitoring well network consists of six shallow and two deep groundwater wells. These eight wells are generally located on the periphery of Zone C. The position of these zone-wide wells with respect to the other Zone C wells is shown in Figures 4.7 and 4.8. ~~4.1~~ Figure 4.4 shows shallow groundwater elevation contours for Zone C based on the most recent (January 1998) water level ~~June 28, 1996~~ measurements. Table 11.1 identifies each well used in the zone-wide assessment as well as the type (shallow or deep) and the depth. The pesticide analytical results from the temporary wells in AOC 508/AOC 511 are also included in the zone-wide analysis.

11.1 Zone-Wide COC Detections

11.1.1 Inorganics

The detections for Zone C inorganics above RBC, BRV, or MCL are shown in Figure 4.8. While the figure shows all Zone C wells with detection exceeding these values, this analysis excluded SWMU 44 and SWMU 47 wells. Inorganic constituents detected in Zone C groundwater include aluminum, arsenic, beryllium, and manganese.

Aluminum was detected in two wells above its RBC (3,700 $\mu\text{g/L}$) in the first round of sampling. Results from subsequent sampling rounds were below the RBC. Arsenic was detected in several wells above its RBC, but did not exceed the MCL (50 $\mu\text{g/L}$). Arsenic detections were not significantly above background (6.07 $\mu\text{g/L}$), and the higher detections were followed in

Table 11.1
Zone C — Zone-Wide Groundwater Monitoring Well Network
(Excluding SWMU 44 and SWMU 47 Wells)

| Monitoring Well Number | Grid or AOC Sample | Well Type | Well Depth (ft. bgs.) |
|------------------------|--------------------|-----------|-----------------------|
| NBCC-GDC-GW-001 | Grid | Shallow | 14 |
| NBCC-GDC-GW-01D | Grid | Deep | 36 |
| NBCC-GDC-GW-002 | Grid | Shallow | 14 |
| NBCC-GDC-GW-02D | Grid | Deep | 71 |
| NBCC-510-GW-001 | AOC 510 | Shallow | 21 |
| NBCC-510-GW-002 | AOC 510 | Shallow | 21 |
| NBCC-523-GW-001 | AOC 523 | Shallow | 12.6 |
| NBCC-523-GW-002 | AOC 523 | Shallow | 12.4 |

subsequent sampling rounds with non-detects or levels below MCL and/or background. Beryllium detections were below the MCL (4.0 $\mu\text{g/L}$) and were followed by rounds of non-detections. Manganese was detected at levels approximately equal to background (608 $\mu\text{g/L}$). The results of the base-wide groundwater study for inorganic constituents will be used to determine if there is a need to address zone-wide inorganic detections.

11.1.2 Organics

The detections for Zone C organics above RBC, BRV, or MCL are shown in Figure 4.7. Organic constituents were detected at three of the six shallow wells and both deep wells. As previously stated, this discussion does not include SWMU 44 and SWMU 47 wells. The temporary wells in AOC 508/AOC 511 were non-detect for pesticides.

Methylene chloride was detected above the RBC (4.1 $\mu\text{g/L}$) in one shallow groundwater monitoring well (NBCC-510-GW-002) in round three of sampling, and one deep groundwater

monitoring well (NBCC-GDC-GW-01D) in the first round of sampling. It was not detected in subsequent sampling rounds.

Dioxin equivalents were detected above the RBC (0.453 ng/L) in two shallow grid wells (NBCC-GDC-GW-001 and NBC-GDC-GW-002) and one deep grid well (NBC-GDC-GW-02D). While all three wells were non-detect for dioxin in round three, samples from round four reflected its presence. **However, the dioxin MCL (30 ng/L) was not exceeded.** Therefore, dioxins in groundwater appear to reflect natural background variations and are not indicative of site impacts.

11.2 Summary of Impact to Zone-Wide Groundwater

Based on the analytical trend data obtained during four quarters of sampling and as presented in Figures 4.7 and 4.8, there is no sufficient evidence that zone-wide groundwater has been adversely impacted by zone-specific or RCRA-related activities. The chemicals detected in zone-wide groundwater are sporadic in nature, minimal in magnitude, do not appear to be site related, represent insignificant risk, and therefore do not suggest the presence of an impacted aquifer system. ~~However, since dioxin equivalents were detected in three wells during round four, additional sampling is recommended.~~ While dioxin concentrations exceed the RBC, the MCL is not exceeded. ~~appear to reflect natural background variability, additional sampling would be used to determine if concentrations remain consistent and to support risk calculations, if necessary.~~

11.3 Zone-Wide Groundwater CMS Recommendations

Based on the RFI data and exclusive of groundwater units associated with SWMU 44 and SWMU 47, it appears that zone-wide groundwater in Zone C does not pose an imminent or substantial threat to human or ecological receptors. During the CMS, the results of the base-wide study of inorganic constituents in groundwater will be evaluated for the need of additional assessment of zone-wide groundwater. However, the presence of dioxin equivalents in the fourth sampling round at levels slightly above the RBC suggests the need for additional

~~sampling over several more quarters, but no more than one year. The purpose of this sampling would be to verify or refute the long-term presence of dioxin equivalents at concentrations representative of risk levels warranting corrective measures.~~

12.0 CMS SCHEDULE AND REPORT OUTLINE

Figure 12.1 outlines the anticipated schedule for the CMS process for Zone C. The total time to complete the entire Zone C CMS is strictly site-specific. The forecasted completion time could be increased or decreased if site conditions or cleanup goals change during the CMS process.

Innovative technologies typically require more preparation and evaluation time (i.e., treatability studies) than demonstrated technologies. However, the possible benefit, such as reduced costs, more effective remediation, less site disruption, and public acceptance/perception obtained from implementing an innovative technology can far outweigh any possible increases in project completion time. Moreover, not all innovative technologies adversely impact the project time line.

The CMS report will present the objective and goals of the study, site conditions applicable to the CMS, the results of any additional field activities, and a matrix that shows how the remedial alternatives rank compared to the five balancing criteria previously described. The CMS report will include:

| | |
|-----------|--|
| Section 1 | Introduction |
| Section 2 | Purpose of the CMS |
| Section 3 | Proposed Cleanup Objectives |
| Section 4 | Site Description |
| Section 5 | Results of Additional Studies (CMS sampling, treatability studies, pump tests, etc.) |
| Section 6 | Identification, Screening, Evaluation and Ranking of Remedial Alternative(s) |
| Section 7 | Community Relations Plan |
| Section 8 | Signatory Requirement |
| Appendix | If needed |

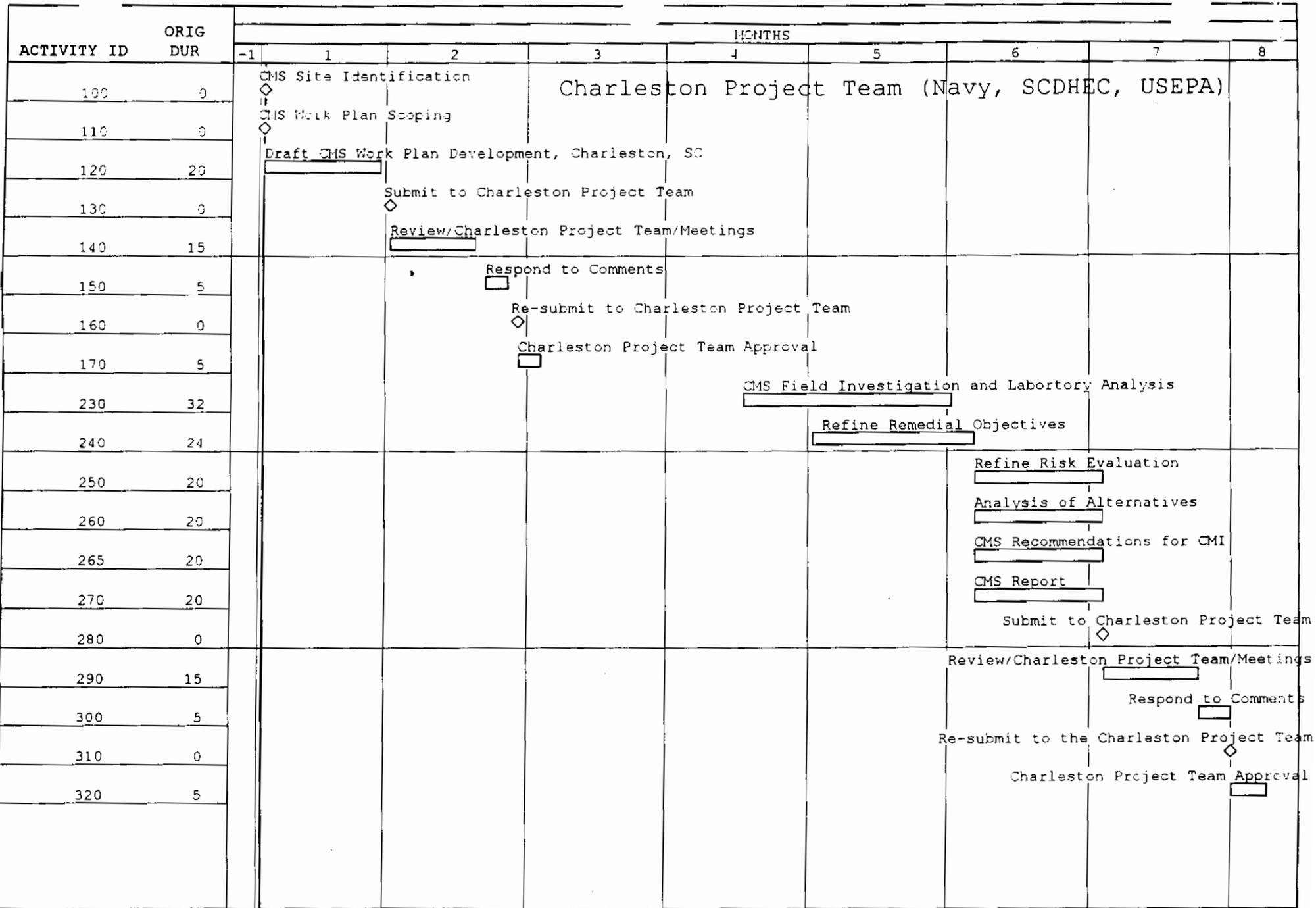


Figure 12.1
Naval Base Charleston, Zone C, CMS
Zone C CMS Project Schedule

Plot Date 4JUN98
 Data Date 2FEB98
 Project Start 2FEB98
 Project Finish 8SEP98

Activity Bar/Barly Dates
 Critical Activity
 Progress Bar
 Milestone/Flag Activity

| NAVY CLEAN #6246789-D-0318 | | | |
|----------------------------|----------|---------|----------|
| Date | Revision | Checked | Approved |
| | | | |
| | | | |
| | | | |
| | | | |

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14.0 SIGNATORY REQUIREMENT

Condition I.E. of the Hazardous and Solid Waste Amendments (HSWA) portion of the RCRA Part B Permit (EPA SCO 170 022 560) states: All applications, reports, or information submitted to the Regional Administrator shall be signed and certified in accordance with Section 40 CFR 270.11. The certification reads as follows:

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

 for _____

Henry N. Sheppard II, P.E.

Caretaker Site Office

Date 1 JULY 1998

Appendix A

Total Petroleum Hydrocarbon Memorandum

USE OF TPH AND TIC ANALYTICAL RESULTS FOR RFI EVALUATION AT CNC

INTRODUCTION

Following the announcement of base closure, the number of environmental sites investigated at the Charleston Naval Complex (CNC) increased dramatically from 36 to over 400. Petroleum releases were identified as a concern at a large number of these sites throughout the base and considerable discussion occurred between members of the project team whether these petroleum impacted sites should be investigated in the RFI or managed under guidelines established for addressing petroleum in the SCDHEC underground storage tank program. Generally, a decision was made on a site-by-site basis and depended on whether the project team had sufficient knowledge to know whether the product managed at the site was virgin petroleum or if other RCRA-regulated compounds were potentially present. At questionable sites, the team agreed to keep the sites in the RFI, analyze for a broad spectrum of constituents, and also analyze for total petroleum hydrocarbons (TPH).

TPH presents the total amount of petroleum hydrocarbons present as a single number, but it doesn't give any information on the individual hydrocarbon constituents present. TPH analysis is a useful tool for cost effectively identifying hotspots or delineating boundaries of contamination which is why it is commonly used. The TPH analysis at the CNC was originally performed using Method 418.1 by IR, and then later the switch was made to Method 8015 (modified for Gasoline Range Organics/Diesel Range Organics) by GC methods.

If the analytical data confirmed only TPH or those constituents which make up petroleum hydrocarbons were found, the site would be transferred over to the petroleum program. The feeling of the team was that it would save time and money to address these sites in the petroleum corrective action program than the more cumbersome RCRA corrective action program. For the most part this approach has worked. Yet, there does exist a number of sites where the analytical scheme of analyzing for a full suite of compounds plus TPH has led to some confusion. A typical question which often arises is; "What needs to be done at sites where the risk drivers are not TPH

related, yet TPH detections were reported?" While TPH itself is not explicitly regulated, some of the components that make up TPH are subject to regulatory thresholds and/or cleanup criteria. However, TPH is covered under the broad wording of the SC Pollution Control Act.

This memo is intended to provide the project team a summary of available literature references regarding the composition of TPH, how TPH values are used in risk assessments, and site-specific examples of how TPH data were used in the RFI. The CNC information contained in this memo and the references cited should be useful in helping the project team make appropriate risk management decisions concerning TPH.

COMPONENTS OF PETROLEUM HYDROCARBONS

To understand how the approach used for the RFI at the CNC can work, it is helpful to first have a basic knowledge of the composition of petroleum fuels. Petroleum fuels are complex mixtures of hundreds to thousands of chemicals. Petroleum fuels are derived from crude oil that is primarily hydrocarbons (organic compounds composed of hydrogen and carbon) but some non-hydrocarbons (compounds containing other elements such as oxygen, sulfur, and nitrogen) are also present.

Petroleum hydrocarbons are made up of paraffinic, cycloparaffinic, and aromatic hydrocarbons. The most important petroleum fractions are various hydrocarbon gases (butane, ethane, and propane), naphtha of several grades, gasoline, kerosene, diesel oil, fuel oil, gas oil, lubricating oils, paraffins, and asphalt. Paraffins (interchangeable with the word *alkanes*) are a class of aliphatic hydrocarbons which are straight- or branched-chain hydrocarbons. The branched-chain paraffins are much more suitable for gasoline than the straight-chain. Cycloparaffins such as cyclopropane, cyclobutane, and cyclohexane are ring-structured hydrocarbons and are derived from petroleum or coal tar. Aromatic compounds are single or multi-benzene ring hydrocarbons which comprise about 10 to 40% of gasoline and about 25 to 35% of No. 2 fuel oil. Heavy fuel oils typically contain 15 to 40% aromatic hydrocarbons, dominated by the heavier polynuclear aromatic hydrocarbons (PAHs), which are the multi-benzene ring hydrocarbons.

As stated above, TPH can be divided into the Gasoline Range Organics (GRO) and the Diesel Range Organics (DRO). The GRO values consist of fractions of hexanes, cycloparaffins, and aromatic hydrocarbons. Because methyl-tert-butyl ether (MTBE) has been added to gasoline since about 1980, analysis of samples for MTBE by Method 8260 can determine if the gasoline present is pre-1980. MTBE was added as an oxygenate to reduce carbon monoxide exhaust emissions and also as an antiknock agent. Some aromatic hydrocarbons that may be present in gasoline are benzenes, toluenes, cycloalkanes, and xylenes.

The DRO compounds consist mainly of fuel and diesel oils, naphtha, lubricating oil, paraffins, and PAH. There are mainly four types of fuel oils which may be found totaled in the DRO analysis. The No.1 fuel is used for domestic heating. No.4 fuel is used for commercial or industrial burner installation not equipped with preheating facilities. The No.5 and No.6 fuel oils are bunker fuels, which must usually be preheated before being burned. These fuels are used in furnaces and boilers of utility plants, ships, locomotives, metallurgical operations, and industrial power plants. Diesel oil is fuel for diesel engines in trucks, ships, and other automotive equipment, and is obtained from distillation of petroleum. Diesel oil is composed chiefly of unbranched paraffins.

ANALYSIS FOR TPH AND TPH COMPONENTS

Analysis for TPH used for site characterization purposes is typically performed by EPA Method 8015. The results can be separated into the diesel range fraction and the gasoline range fraction as noted above; however, these results are not compound specific and only represent the total amount of petroleum hydrocarbons.

The SW846 8260 Appendix IX and USEPA Contract Laboratory Program (CLP) methods of analysis for volatile organic compounds (VOCs) are capable of generating compound-specific results. Of the indicator compounds listed above, compounds such as benzene, toluene, ethylbenzene, and xylene are normally reported in the volatile organic analysis. MTBE and naphthalene can also be reported in the SW846 8260 method upon request. Because those compounds only represent a portion of the gasoline components which may be present, the laboratory can be asked to report them as "tentatively identified compounds" (TICs). These are

compounds that are present in the sample, show up on the chromatogram, and are identified by a comparison to the analytical laboratory's mass spectra library in the gas chromatograph/mass spectrometer (GC/MS). A typical library contains 50,000 to 70,000 compounds and their mass spectra.

For every GC/MS, a calibration curve is created with five standards made up from the method analyte or regulatory list and the compound's instrument response factor is determined. Quantitation of the results can then be made on the compounds present in the sample. Typically a list consists of 25 to 50 compounds, therefore, quantitation of the TICs is not exact since standards were not analyzed for these compounds and TICs can only be reported as a estimated value since there is no response factor associated with the TICs. Reviewing the TICs can provide useful information when there appears to be a large discrepancy between TPH values and VOC and semi-volatile organic compound (SVOC) results, but the procedure still does not account for petroleum hydrocarbons that do not separate in the GC column and elute as a extremely elevated baseline on the chromatogram.

Similarly, the SW846 method for SVOCs can identify compounds specific to the diesel range petroleum hydrocarbons. The TICs for the samples discussed later did show detections of unknown PAHs, methyl-naphthalenes, alkanes, and cycloalkanes, which are all constituents of petroleum hydrocarbons.

TOTAL PETROLEUM HYDROCARBONS IN RISK ASSESSMENTS

As mentioned above, TPH analyses usually determine the total amount of hydrocarbons present as a single number and give little or no indication of the types of hydrocarbons present. These analyses are useful for site characterization, but are not suitable for risk assessments because the general measure of TPH does not provide sufficient information about the amounts of individual compounds present. On the other hand, it is not practicable to attempt to evaluate every compound present in petroleum hydrocarbons. This effort would be time consuming, cost prohibitive, and counter to the goal of expedited cleanup. For this reason, the risk assessment community has focused on assessing the impacts of a select group of indicator compounds that are

inherently assumed to represent a significant fraction of the overall potential risk associated with petroleum hydrocarbons.

INDICATOR COMPOUNDS

Indicator compounds are selected based on their concentrations, exposure routes, toxicological properties, mobility, and aesthetic characteristics. Aromatic hydrocarbons (BTEX, PAHs, etc.) are typically selected because they are the constituents that human and ecological receptors tend to be the most sensitive to with respect to adverse affects. Aliphatic hydrocarbons are usually of less concern because of their relatively low toxicities. Additives such as MTBE, ethylene dibromide (EDB), and ethylene dichloride (EDC) may need to be considered if they are identified as being present in significant quantities. Toxicity information for the indicator compounds is readily available from the Integrated Risk Information System (IRIS) and EPA Health Effects Assessment Summary Tables (HEAST) databases. Significant information may exist in the literature regarding a number of the other components of petroleum hydrocarbons, but if confirmatory information is not available on either IRIS or HEAST, there is generally a reluctance to use the information for risk assessment purposes.

Of the 162 recognized compounds in GRO and 82 compounds in DRO, only 18 compounds are listed in the IRIS or HEAST databases. Some of the most common indicator compounds selected based on the criteria outlined above are:

| |
|--|
| <p>Benzene Toluene Ethylbenzene Xylenes Lead Benzo(a)pyrene Anthracene Fluoranthene Benzo(a)anthracene</p> |
|--|

| |
|--|
| <p>Fluorene Naphthalene Pyrene Phenanthrene Chysene Benzo(k)flouranthene Benzo(g,h,i)perylene Benzo(b)flouranthene Dibenz(a,h)anthracene</p> |
|--|

Other compounds that are sometimes present as additives that are occasionally used as indicator compounds are:

| | |
|-------------------------------|---------------------|
| Methyl- <i>t</i> -butyl Ether | Isopropylbenzene |
| <i>n</i> -Butyl Alcohol | <i>n</i> -Hexane |
| Methyl Alcohol | Ethylene Dibromide |
| Dibromoethane | Ethylene Dichloride |

The significance placed on these compounds is evidenced by the fact that the majority of them are listed as the chemicals of concern (COCs) in the SCDHEC *Risk Based Corrective Action for Petroleum Releases* guidance. The only other prominent COCs that are of interest to the petroleum program that are not listed above are the metals (in addition to lead) that are commonly associated with waste oil.

APPLICATION AT CHARLESTON NAVAL COMPLEX

Generally, sites with TPH detections can be characterized under one of three scenarios. For illustrative purposes of this memo, samples in Zones A, C, and H that were identified as having high TPH concentrations were selected to demonstrate how the information is being evaluated to support the RCRA Facility Investigation/Corrective Measures Study (RFI/CMS) process.

Scenario 1

- High TPH detections
- Indicator compounds detected
- Indicator compounds are risk drivers. (Other COCs may also be present.)
- Site was retained in the RFI/CMS process.

Scenario 2

- High TPH detections
- Indicator compounds detected
- No or very low risk at site
- Site is candidate for completion under the UST program.

Scenario 3

- TPH detected
- No or very few indicator compounds detected
- Either no risk or risk drivers are COCs other than indicators
- Site may be retained in the RFI/CMS process, may be transferred to the UST program, or the site may be recommended for NFA.

Scenario 1

Under the first scenario, the risk management decision making process with respect to TPH is the easiest for the project team. SWMU 39 in Zone A was selected as an example of this situation. TPH detections are reported in multiple soil samples along with various indicator compounds. The analytical results for samples 039SB00801 and 039SB00802 presented in Table 1 are representative of much of the soil data for the site. These samples are from the same location, but different depth intervals. The laboratory data sheets reporting the VOC and SVOC TICs are in Attachment 1.

Table 1
SWMU 39
Data Comparison of TPH and Associated Indicator Compounds ($\mu\text{g}/\text{kg}$)

| Parameter | 039SB00801 | 039SB00802 |
|--------------|------------|------------|
| TPH-Gasoline | 1300000 | 19000000 |
| TPH-Diesel | 380000 | 9500000 |
| Benzene | 6 U | 990 D |
| Ethylbenzene | 6 U | 22000 D |
| Xylenes | 6 U | 48000 D |
| Anthracene | 810 U | 1100 |
| Fluorene | 810 U | 10000 |
| Phenanthrene | 300 J | 12000 |
| Pyrene | 810 U | 890 |

Notes:

- U — non-detect
- J — estimated
- D — diluted

In both samples, high TPH concentrations are evident. The surface interval sample (039SB00801) does not contain the indicator compounds that are present in the 3- to 5-foot interval sample (039SB00802). Similarly, the laboratory only reported two TICs in the surface interval, whereas 30 were reported in the lower interval. A number of possible explanations related to the fate and transport characteristics of these compounds in the environment could be given to explain the

differences in the respective concentrations of the samples, but that is beyond the scope of this memo. What is important is that indicator compounds are identified at this site as contaminants of concern (COCs) for both soil and groundwater in the baseline risk assessment (BRA).

Site characterization, the baseline risk assessment, and ultimately CMS decisions will be based on these indicator compounds, along with other COCs which happen to be present at this site. The TPH data served its intended purpose as screening data to alert the team to the presence of petroleum contamination but its significance was down played once individual COCs were identified. In the end, the project team can be confident that TPH will be addressed when the individual COCs are addressed. The collection of additional TPH data during the CMS would not be recommended since it would not offer any additional value to the study.

Scenario 2

Under the second scenario, high TPH detections are reported at SWMU 178 in Zone H along with multiple indicator compounds. Soil samples were collected from six locations at this site. TPH was detected at all six locations. Nine indicator compounds were detected with an individual sample detection frequency ranging from none detected to all nine being detected in one sample. To demonstrate how the data evaluation was performed with respect to SWMU 178, the surface and subsurface interval samples results (TPH and indicator compounds only) from the same location are presented in Table 2.

The surface interval sample 178SB00501 is the location where all nine indicator compounds were detected. With the exception of toluene, the indicator compounds are the heavier fraction petroleum hydrocarbons identified by a semi-volatile scan. Since the TPH result is approximately two orders of magnitude greater in the deeper interval sample, it might be reasonable to expect similar detections of indicator compounds, but that is not the case.

Table 2
SWMU 178
Data Comparison of TPH and Associated Indicator Compounds (ug/kg)

| Parameter | 178SB00501 | 178SB00502 |
|----------------------|-------------------|-------------------|
| TPH | 140000 | 10000000 |
| Benzene | 6 U | 6 U |
| Ethylbenzene | 6 U | 6 U |
| Toluene | 4.7 J | 6 U |
| Xylenes | 6 U | 6 U |
| Chrysene | 150 J | 21000 U |
| Benzo(a)pyrene | 140 J | 21000 U |
| Fluoranthene | 270 J | 21000 U |
| Benzo(a)anthracene | 140 J | 21000 U |
| Benzo(b)fluoranthene | 200 J | 21000 U |
| Benzo(k)fluoranthene | 130 J | 21000 U |
| Phenanthrene | 110 J | 21000 U |
| Pyrene | 290 J | 21000 U |

Notes:

U — non-detect
 J — estimated

The results of the volatile and semi-volatile organic scans for 17800502 are all non-detect, which seems to contradict the TPH data. In reality, the TPH data for this sample provide valuable insight as to why the quantitation limits for the semi-volatile scan are significantly elevated. The substantially elevated petroleum hydrocarbon concentrations have created a matrix interference which, as previously mentioned, results in an extremely elevated baseline on the chromatogram.

At this point in the data evaluation process, the TIC results become very important. A review of the TICs for sample 178SB00502 (Attachment 2) shows that the laboratory has reported the presence of 20 hydrocarbon compounds with a combined estimated concentration of

862,000 $\mu\text{g}/\text{kg}$. More may be present, but in this case the laboratory was asked to report the 20 highest concentrations.

The carcinogenic PAHs (expressed as benzo[a]pyrene equivalents) were the only COCs identified in the baseline risk assessment for SWMU 178. A residential risk of 2E-06 was calculated for the site (Attachment 2). The risk may be slightly understated due to the fact that the indicator compounds could not be positively identified and quantified in some samples due to concentrations of petroleum hydrocarbons being elevated to the point they caused analytical interferences. This is a concern that should not be completely dismissed, but it does not affect the foregone conclusion that the primary concern at this site is petroleum hydrocarbons. As a result, the project team was able to transfer this site for completion under the UST program.

Future decisions will likely be based on the presence/absence of indicator compounds, but TPH analyses may have some added benefit to assessment work under the petroleum program. The analytical laboratory should be informed of the past results and potential interference problems so they can offer possible remedies or alternative means of quantifying the indicator compounds. Another consideration is the fact that TPH could be used to delineate or screen the areas of highest concentrations and the more sensitive, compound-specific analyses used to define the outer perimeter where the concentrations will eventually reach non-detect levels.

Scenario 3

The third scenario has proven to be one of the more difficult for the team when it comes to making risk management decisions. The difficulties appear to stem largely from data presentation deficiencies and lack of a clear explanation of how the available data are used to make decisions. Under Scenarios 1 and 2, this memo has focused on the comparison of compound-specific VOC/SVOC results to TPH results and how TIC results were used to help interpret that data. Under those scenarios, it is apparent that a sufficient number of indicator compounds were detected to make decisions and that the TPH and TIC results are simply ancillary data. What has not been addressed is that TIC data, while available for use by the authors of the RFI reports, has not been included, or at least minimally discussed in the RFI reports for the benefit of the

reviewers. Since one of the criteria for Scenario 3 is none or very few detections of indicator compounds, the TIC data become a necessary tool in helping to evaluate the TPH results.

Consider AOC 698 in Zone K as an example. No indicator compounds were detected in any of the eight samples analyzed for VOCs and SVOCs. The sampling protocol for the CNC RFI calls for duplicate samples to be collected at a frequency of one per every 10 site samples. The duplicate is analyzed for a broader spectrum of constituents which in this case included TPH. This duplicate sample was collected at soil boring 698SB002 from the surface interval. A TPH detection of 149,000 $\mu\text{g}/\text{kg}$ was reported. Benzene and TPH were detected in groundwater. Considering the fact a petroleum aboveground storage tank (AST) is located at the site, the team could reasonably assume it to be the source of the release.

The primary surface soil risk driver at the site is not benzene, but rather arsenic with a maximum detection of only 10.5 mg/kg. With the exception of benzene, the other groundwater COCs are either metals or pesticides (Attachment 3).

To evaluate Scenario 3, TIC data (Attachment 3) were reviewed for the same sample for which TPH analysis was performed, plus two additional sample locations near the AST to see if it provided an explanation of TPH detections in soil. Not surprisingly, petroleum constituents were found in every sample. It should not be a concern that TPH analysis was only performed on one sample because the TIC data can provide the same basic information about the presence of petroleum at the site.

Ironically, the TPH data were minimally discussed in the RFI report and the TIC data were not discussed at all. The reason is that, to date, these parameters are generally considered insignificant in the RFI in terms of decision making because neither TPH nor the TICs contribute to risk values nor are they "regulated" constituents.

To the contrary, the TPH and TIC data provide valuable information to the project team in the absence of indicator compounds. Even if TPH and TICs are not regulated under either the RCRA

or UST programs and neither contributes to risk, their presence could present some interesting problems to the team if regarded too lightly. If a decision were made by the team to proceed into the CMS with this site on the basis of the primary risk driver arsenic, the presence of petroleum in soil could potentially be overlooked and have unknown consequences on remedies designed to address non-petroleum-related contaminants. Sites that pose low risk such as AOC 698 could possibly be considered for no further action solely on the basis of calculated risk numbers. What if a site similar to AOC 698 were located near a sensitive environment such as the Cooper River and future reuse plans call for considerable construction activities? The site could be deemed suitable for redevelopment on the basis of non-detect results for regulated constituents. In reality, petroleum is present and could be released into the river during construction activities causing a visible product sheen on the water. This actually happened on a site currently listed in the Georgia Hazardous Sites Index.

On the other hand, the team may decide that the TPH poses no risk, the site is not located near a sensitive receptor, there is little chance it will migrate to other media, or it won't adversely affect remedies selected to address other COCs. In such a case, a prudent risk management decision could simply be to acknowledge its presence but leave it be. The data have to at least be presented so the project team can make a risk management decision considering all the facts.

CONCLUSIONS

Petroleum indicator compounds identified as COCs and/or non-petroleum-related COCs identified through the baseline risk assessment process clearly serve as the basis for making risk management decisions under the first two scenarios described above. Though not discussed in the memo, Scenarios 1 and 2 are far more common at CNC than the third scenario. Even so, the third scenario illustrates that there are unique situations where the identification of petroleum constituents through the reporting of TICs and TPH with respect to soil can have a substantial impact on risk management decisions despite the fact there are no regulatory thresholds for either.

The CNC data support what the literature references point out; TPH analysis is a cost effective tool for site characterization, but most often the data are of little use in risk assessments and

subsequently in risk management decisions. TPH data were most helpful when used as ancillary information to help interpret the results of the compound-specific analyses. The same can be said for the TIC data since the two contain redundant information. The only significant difference in how the two were used in the RFI is that the TPH results were presented in the report, whereas the TIC data were not.

A review of the data and how it was presented in the RFI showed that the confusion caused by the presence of TPH with the conspicuous absence of COCs can be eliminated through a logical, sequential explanation of the data. In all three scenarios, there were sufficient data gathered to adequately characterize the site, but often some of the data were either not presented or presented separately rather than discussed in the context of what it meant in terms of the "big picture." Every site is unique, and how TPH and TIC data are best used will likely be determined on a case-by-case basis, but through effective data presentation, the best use should become evident.

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Attachment 1

SWMU 39

**VOC and SVOC TIC Laboratory Data Sheets
and Summary of Risk and Hazard-Based COCs**

**VOLATILE ORGANIC ANALYSIS RESULTS
FOR ANALYSES USING METHOD 8260
TENTATIVELY IDENTIFIED COMPOUNDS**

| | |
|--|---|
| Client Sample ID: NBCA\039SB00801 | LAL Sample ID: L5506-11 |
| Date Received: 03-OCT-95 | Date Analyzed: 12-OCT-95 |
| Matrix: SOIL | Analytical Dilution Factor: 1 |
| Analytical Batch: 101195-8260-J2 | Preparation Dilution Factor: 0.982 |

| Tentatively Identified Compound | Estimated Concentration (µg/Kg) | Retention Time (minutes) | Data Qualifier(s) |
|--|--|---------------------------------|--------------------------|
| UNKNOWN | 30 | 8.52 | J |
| UNKNOWN HYDROCARBON | 20 | 11.68 | J |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

VOLATILE ORGANIC ANALYSIS RESULTS
FOR ANALYSES USING METHOD 8260
TENTATIVELY IDENTIFIED COMPOUNDS

| | |
|-----------------------------------|------------------------------------|
| Client Sample ID: NBCA\039SB00802 | LAL Sample ID: L5506-12 |
| Date Received: 03-OCT-95 | Date Analyzed: 13-OCT-95 |
| Matrix: SOIL | Analytical Dilution Factor: 1 |
| Analytical Batch: 101295-8260-J2 | Preparation Dilution Factor: 0.982 |

| Tentatively Identified Compound | Estimated Concentration (µg/Kg) | Retention Time (minutes) | Data Qualifier(s) |
|---------------------------------|---------------------------------|--------------------------|-------------------|
| UNKNOWN | 300 | 9.05 | J |
| UNKNOWN | 200 | 9.45 | J |
| UNKNOWN | 200 | 10.76 | J |
| UNKNOWN | 400 | 13.01 | J |
| UNKNOWN | 400 | 13.50 | J |
| UNKNOWN | 30 | 14.75 | J |
| UNKNOWN | 40 | 14.91 | J |
| UNKNOWN | 50 | 15.98 | J |
| UNKNOWN HYDROCARBON | 30 | 18.33 | J |
| UNKNOWN | 50 | 19.01 | J |
| | | | |

**SEMIVOLATILE ORGANIC ANALYSIS RESULTS
FOR ANALYSES USING METHOD 8270
TENTATIVELY IDENTIFIED COMPOUNDS**

| | |
|-----------------------------------|------------------------------------|
| Client Sample ID: NBCA\039SB00802 | LAL Sample ID: L5506-32 |
| Date Received: 03-OCT-95 | Date Analyzed: 16-OCT-95 |
| Matrix: SOIL | Analytical Dilution Factor: 1 |
| Analytical Batch: 101695-8270-K | Preparation Dilution Factor: 0.980 |

| Tentatively Identified Compound | Estimated Concentration (µg/Kg) | Retention Time (minutes) | Data Qualifier(s) |
|---------------------------------|---------------------------------|--------------------------|-------------------|
| ETHYLBENZENE | 1,000 | 3.95 | J |
| XYLENE ISOMER | 1,000 | 4.06 | J |
| XYLENE ISOMER | 1,000 | 4.73 | J |
| UNKNOWN | 2,000 | 4.95 | J |
| SUBSTITUTED BENZENE | 20,000 | 6.01 | J |
| SUBSTITUTED NAPHTHALENE | 2,000 | 10.46 | J |
| UNKNOWN | 2,000 | 10.65 | J |
| UNKNOWN | 2,000 | 10.95 | J |
| UNKNOWN | 30,000 | 11.37 | J |
| UNKNOWN | 7,000 | 11.42 | J |
| UNKNOWN | 50,000 | 11.51 | J |
| UNKNOWN HYDROCARBON | 70,000 | 11.86 | J |
| UNKNOWN | 8,000 | 12.05 | J |
| UNKNOWN | 30,000 | 12.51 | J |
| UNKNOWN PAH | 20,000 | 12.84 | J |
| UNKNOWN PAH | 10,000 | 13.05 | J |
| UNKNOWN PAH | 7,000 | 13.09 | J |
| UNKNOWN PAH | 6,000 | 13.69 | J |
| UNKNOWN PAH | 7,000 | 13.77 | J |
| UNKNOWN PAH | 10,000 | 13.92 | J |

Table 10.4.46
 Summary of Risk and Hazard-based COCs
 SWMU 39
 NAVBASE - Charleston, Zone A
 Charleston, South Carolina

| Medium | Exposure Pathway | | Future | Future | Future | Site Worker | | Identification of COCs | |
|----------------------------|----------------------|----------------------------|--------------------------------|--------------------------------|-------------------|-----------------|---------|------------------------|---------|
| | | | Resident Adult Hazard Quotient | Resident Child Hazard Quotient | Resident Iwa ILCR | Hazard Quotient | ILCR | | |
| Surface Soil | Incidental Ingestion | Aluminum | 0.014 | 0.13 | ND | 0.0018 | ND | 1 | |
| | | Aroclor 1260 | ND | ND | 5.3E-07 | ND | 5.9E-08 | | |
| | | Arsenic | 0.032 | 0.29 | 1.6E-05 | 0.0040 | 1.8E-06 | 1 2 4 | |
| | | Benzo(a)pyrene equivalents | ND | ND | 1.4E-05 | ND | 1.6E-06 | 2 4 | |
| | | Beryllium | 0.000048 | 0.00044 | 1.2E-06 | 0.0000061 | 1.3E-07 | 2 | |
| | | Manganese | 0.0031 | 0.029 | ND | 0.00039 | ND | | |
| | | Mercury | 0.006 | 0.06 | ND | 0.0008 | ND | | |
| | Dermal Contact | Aluminum | 0.0029 | 0.0094 | ND | 0.0020 | ND | | |
| | | Aroclor 1260 | ND | ND | 2.4E-07 | ND | 9.6E-08 | | |
| | | Arsenic | 0.0065 | 0.021 | 1.8E-06 | 0.0046 | 7.4E-07 | 2 | |
| | | Benzo(a)pyrene equivalents | ND | ND | 6.5E-06 | ND | 2.7E-06 | 2 4 | |
| | | Beryllium | 0.000010 | 0.000032 | 1.3E-07 | 0.0000070 | 5.3E-08 | | |
| | | Manganese | 0.00063 | 0.0021 | ND | 0.00045 | ND | | |
| | | Mercury | 0.0013 | 0.0043 | ND | 0.00094 | ND | | |
| Surface Soil Pathway Sum | | | 0.07 | 0.6 | 4E-05 | 0.02 | 7E-06 | | |
| Groundwater Pathways | Ingestion | Aluminum (Al) | 0.031 | 0.072 | ND | 0.011 | ND | | |
| | | Arsenic (As) | 4.0 | 9.2 | 9.8E-04 | 1.4 | 2.3E-04 | 1 2 3 4 | |
| | | Barium (Ba) | 0.027 | 0.063 | ND | 0.0096 | ND | | |
| | | Benzene | 0.94 | 2.2 | 4.5E-05 | 0.34 | 1.0E-05 | 1 2 3 4 | |
| | | Beryllium (Be) | 0.0014 | 0.0033 | 1.7E-05 | 0.00050 | 3.9E-06 | 2 4 | |
| | | Chlorobenzene | 0.0043 | 0.0101 | ND | 0.0015 | ND | | |
| | | Chloroform | 0.0099 | 0.023 | 3.3E-07 | 0.0035 | 7.7E-08 | | |
| | | Chloromethane | ND | ND | 2.6E-07 | ND | 6.1E-08 | | |
| | | Chromium (Cr) | 0.015 | 0.035 | ND | 0.0053 | ND | | |
| | | 1,2-Dichloroethane | ND | ND | 4.1E-06 | ND | 9.5E-07 | 2 | |
| | | 1,1-Dichloroethene | 0.010 | 0.024 | 3.1E-05 | 0.0037 | 7.1E-06 | 2 4 | |
| | | cis-1,2-Dichloroethene | 0.38 | 0.89 | ND | 0.14 | ND | 1 3 | |
| | | 1,2-Dichloroethene (total) | 0.38 | 0.89 | ND | 0.14 | ND | 1 3 | |
| | | Dioxin Equiv. | ND | ND | 1.2E-06 | ND | 2.7E-07 | 2 | |
| | | Ethylbenzene | 0.013 | 0.031 | ND | 0.0048 | ND | | |
| | | bis(2-Ethylhexyl)phthalate | 0.0076 | 0.018 | 1.2E-06 | 0.0027 | 2.7E-07 | 2 | |
| | | Lead (Pb) | ND | ND | ND | ND | ND | | |
| | | Manganese (Mn) | 2.8 | 6.6 | ND | 1.0 | ND | 1 3 | |
| | | 2-Methylnaphthalene | 0.13 | 0.30 | ND | 0.046 | ND | 1 | |
| | | 4-Methylphenol | 0.085 | 0.20 | ND | 0.030 | ND | 1 | |
| | | Naphthalene | 0.20 | 0.46 | ND | 0.071 | ND | 1 | |
| | | 1,1,2,2-Tetrachloroethane | ND | ND | 6.7E-06 | ND | 1.6E-06 | 2 4 | |
| | | Tetrachloroethene | 0.043 | 0.10 | 1.2E-05 | 0.015 | 2.9E-06 | 1 2 4 | |
| | | Thallium (Tl) | 0.85 | 2.0 | ND | 0.30 | ND | 1 3 | |
| | | Trichloroethene | 0.027 | 0.062 | 9.6E-07 | 0.0095 | 2.2E-07 | | |
| | | Vanadium (V) | 0.0089 | 0.021 | ND | 0.0032 | ND | | |
| | | Vinyl chloride | ND | ND | 1.7E-04 | ND | 3.9E-05 | 2 4 | |
| | | m+p Xylene | 0.00059 | 0.0014 | ND | 0.00021 | ND | | |
| | | Inhalation | Benzene | 1.65 | 3.9 | 4.5E-05 | 0.59 | 1.0E-05 | 1 2 3 4 |
| | | | Chlorobenzene | 0.015 | 0.035 | ND | 0.0054 | ND | |
| | | | Chloroform | 0.0099 | 0.023 | 0.0 | 0.0035 | 1.0E-06 | 2 4 |
| | | | Chloromethane | ND | ND | 0.0 | ND | 2.9E-08 | |
| | | | 1,2-Dichloroethane | 0.029 | 0.067 | 4.1E-06 | 0.010 | 9.5E-07 | 2 |
| 1,1-Dichloroethene | 0.0103 | | 0.024 | 8.9E-06 | 0.0037 | 2.1E-06 | 2 4 | | |
| cis-1,2-Dichloroethene | 0.38 | | 0.89 | ND | 0.14 | ND | 1 3 | | |
| 1,2-Dichloroethene (total) | 0.38 | | 0.89 | ND | 0.14 | ND | 1 3 | | |
| Ethylbenzene | 0.0047 | | 0.011 | ND | 0.0017 | ND | | | |
| 1,1,2,2-Tetrachloroethane | ND | | ND | 6.8E-06 | ND | 1.6E-06 | 2 4 | | |
| Tetrachloroethene | 0.043 | | 0.10 | 4.8E-07 | 0.015 | 1.1E-07 | 1 | | |
| Trichloroethene | 0.027 | | 0.062 | 5.3E-07 | 0.0095 | 1.2E-07 | | | |
| Vinyl chloride | ND | | ND | 2.6E-05 | ND | 6.1E-06 | 2 4 | | |
| m+p Xylene | 0.14 | | 0.32 | ND | 0.049 | ND | 1 | | |
| Groundwater Pathway Sum | | | 13 | 30 | 1E-03 | 5 | 3E-04 | | |
| Sum of All Pathways | | | 13 | 30 | 1E-03 | 5 | 3E-04 | | |

Notes:

ND Indicates not determined due to the lack of available risk information.

NA Not applicable

ILCR Indicates incremental excess lifetime cancer risk

HI Indicates hazard index

1- Chemical is a COC by virtue of projected child residence non-carcinogenic hazard.

2- Chemical is a COC by virtue of projected future resident lifetime ILCR.

3- Chemical is a COC by virtue of projected site worker non-carcinogenic hazard.

4- Chemical is a COC by virtue of projected site worker ILCR.

Attachment 2

SWMU 178

**VOC and SVOC TIC Laboratory Data Sheets
and Summary of Risk and Hazard
and Hazard Quotients and Incremental Lifetime Cancer Risks**

1F
SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

CLIENT SAMPLE NO.

082427
178SB00502

Lab Name: PACE INCORPORATED

Contract: _____

Lab Code: _____

Case No.: CHARL

SAS No.: _____

SDG No.: CHS06

Matrix: (soil/water) SOLID

Lab Sample ID: 41292-029

Sample wt/vol: 31 (g/mL) G

Lab File ID: >F8409

Level: (low/med) LOW

Date Received: 08/24/94

Moisture: not dec. 19 dec. ____

Date Extracted: 08/29/94

Extraction: (SepF/Cont/Sonc)

Date Analyzed: 09/15/94

GPC Cleanup: (Y/N) N

pH: _____

Dilution Factor: 50

CONCENTRATION UNITS:

(ug/L or ug/Kg) UG/KG

Number TICs found: 20

| CAS NUMBER | COMPOUND NAME | RT | EST. CONC. | Q |
|------------|--|-------|------------|---|
| 1. | 26730143 TRIDECANE, 7-METHYL- | 10.09 | 47000 | J |
| 2. | UNKNOWN | 10.32 | 17000 | J |
| 3. | 54105667 CYCLOHEXANE, UNDECYL- | 10.90 | 15000 | J |
| 4. | 31295564 DODECANE, 2,6,11-TRIMETHYL- | 11.14 | 72000 | J |
| 5. | UNKNOWN | 11.28 | 13000 | J |
| 6. | UNKNOWN | 11.36 | 13000 | J |
| 7. | UNKNOWN | 11.89 | 40000 | J |
| 8. | 52896909 HEPTANE, 3-ETHYL-5-METHYL- | 11.94 | 74000 | J |
| 9. | UNKNOWN | 12.24 | 45000 | J |
| 10. | 14905567 TETRADECANE, 2,6,10-TRIMETHYL | 12.76 | 25000 | J |
| 11. | UNKNOWN | 12.86 | 19000 | J |
| 12. | 2131422 NAPHTHALENE, 1,4,6-TRIMETHYL | 12.99 | 23000 | J |
| 13. | UNKNOWN | 13.07 | 17000 | J |
| 14. | UNKNOWN | 13.14 | 28000 | J |
| 15. | UNKNOWN | 13.37 | 21000 | J |
| 16. | 1921706 PENTADECANE, 2,6,10,14-TETRA | 13.56 | 68000 | J |
| 17. | 1921706 PENTADECANE, 2,6,10,14-TETRA | 14.03 | 190000 | J |
| 18. | UNKNOWN | 14.40 | 23000 | J |
| 19. | 74764117 IRON, TRICARBONYL[N-(PHENYL- | 14.84 | 91000 | J |
| 20. | 629970 DOCOSANE | 15.45 | 21000 | J |

Table 6.2.6.12

Summary of Risk and Hazard for SWMU 178

NAVBASE - Charleston Zone H

Charleston, South Carolina

| Medium | Exposure Pathway | HI (Adult) | HI (Child) | ILCR (LWA) | HI (Worker) | ILCR (Worker) |
|---------------------|----------------------|------------|------------|------------|-------------|---------------|
| Surface Soil | Incidental Ingestion | ND | ND | 2E-08 | ND | 2E-07 |
| | Dermal Contact | ND | ND | 8E-07 | ND | 3E-07 |
| Sum of All Pathways | | ND | ND | 2E-06 | ND | 5E-07 |

Notes:

ND indicates not determined due to the lack of available risk information.

ILCR indicates incremental excess lifetime cancer risk

HI indicates hazard index

Table 6.2.6.10

Hazard Quotients and Incremental Lifetime Cancer Risks

Incidental Surface Soil Ingestion

SWMU 178

Naval Base Charleston

Charleston, SC

| Chemical | Oral RfD Used (mg/kg-day) | Oral SF Used (mg/kg-day)⁻¹ | Potential Future Resident adult Hazard Quotient | Potential Future Resident child Hazard Quotient | Potential Future Resident lwa ILCR | Future Site Worker adult Hazard Quotient | Future Site Worker adult ILCR |
|----------------------------|--|--|--|--|---|---|--|
| Benzo(a)pyrene equivalents | NA | 7.3 | ND | ND | 2.0E-06 | ND | 2.2E-07 |

NOTES:

- NA Not available
- ND Not Determined due to lack of available information
- lwa lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
- ILCR Incremental Lifetime excess Cancer Risk

Table 6.2.6.11

Hazard Quotients and Incremental Lifetime Cancer Risks

Dermal Contact With Surface Soil

SWMU 178

Naval Base Charleston

Charleston, SC

| Chemical | Dermal Adjustment | Oral RfD Used (mg/kg-day) | Oral SF Used (mg/kg-day) ⁻¹ | Potential Future Resident adult Hazard Quotient | Potential Future Resident child Hazard Quotient | Potential Future Resident lwa ILCR | Potential Current Worker adult Hazard Quotient | Potential Current Worker adult ILCR |
|---------------------------|-------------------|---------------------------|--|---|---|------------------------------------|--|-------------------------------------|
| Benz(a)pyrene equivalents | 0.5 | NA | 14.6 | ND | ND | 9.0E-07 | ND | 3.7E-07 |

NOTES:

- NA Not available
- ND Not Determined due to lack of available information
- lwa lifetime weighted average; used to calculate excess carcinogenic risk derived from RAGS Part A
- ILCR Incremental Lifetime excess Cancer Risk
 - Dermal to absorbed dose adjustment factor is applied to adjust for Oral SF and RfD (i.e., the oral RfD is based on oral absorption efficiency which should not be applied to dermal exposure and dermal CDI)

Attachment 3

AOC 698

**VOC and SVOC TIC Laboratory Data Sheets
and Summary of Risk and Hazard-Based COCs**

G:\DCOOKE\WP\CLEAN\charl\TPH Memo\TPH Risk Memo 5.wpd

1E
VOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

698SB00101

Lab Name: S-CUBED Contract:
 Lab Code: CEIMIC Case No.: ZONE K SAS No.: SDG No.: 6797
 Matrix: (soil/water) SOIL Lab Sample ID: 6797-05
 Sample wt/vol: 5.00 (g/mG) Lab File ID: S9705
 Level: (low/med) LOW Date Received: 12/04/96
 %Moisture: not dec. 13.19 Date Analyzed: 12/05/96
 GC Column: CAP ID: 0.53 (mm) Dilution Factor: 1.00
 Soil Extract Volume: (uL) Soil Aliquot Volume: (uL)

Number of TICs found: 12 CONCENTRATION UNITS:
 (ug/L or ug/Kg) UG/KG

| CAS NUMBER | COMPOUND NAME | RT | EST. CONC. | Q |
|------------|---------------------|-------|------------|---|
| 1. | Unknown | 14.51 | 330 | J |
| 2. | Unknown | 15.60 | 480 | J |
| 3. | Unknown | 15.85 | 440 | J |
| 4. | Unknown Hydrocarbon | 16.01 | 360 | J |
| 5. | Unknown | 16.52 | 510 | J |
| 6. | Unknown | 16.68 | 390 | J |
| 7. | Unknown Hydrocarbon | 16.84 | 1200 | J |
| 8. | Unknown | 17.46 | 680 | J |
| 9. | Unknown Hydrocarbon | 17.74 | 1000 | J |
| 10. | Unknown | 18.20 | 310 | J |
| 11. | Unknown | 18.39 | 330 | J |
| 12. | Unknown | 18.67 | 310 | J |

.1F
SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

698SB00101DL1

Lab Name: S-CUBED Contract:
 Lab Code: CEIMIC Case No.: ZONE K SAS No.: SDG No.: 6797
 Matrix: (soil/water) SOIL Lab Sample ID: 6797-05DL1
 Sample wt/vol: 30 (g/ml)G Lab File ID: L679705.D
 Level: (low/med) LOW Date Received:
 *Moisture: 13.19 decanted: (Y/N) N Date Extracted: 12/03/96
 Concentrated Extract Volume: 1000.00 (uL) Date Analyzed: 01/02/97
 Injection Volume: 2.00 (u/L) Dilution Factor: 40.00
 GPC Cleanup: (Y/N) N pH: 0.00

Number of TICs found: 22 CONCENTRATION UNITS:
 (ug/L or ug/Kg) UG/KG

| CAS NUMBER | COMPOUND NAME | RT | EST. CONC. | Q |
|------------|------------------------------|-------|------------|---|
| 1. | Unknown | 8.77 | 16000 | J |
| 2. | Unknown | 12.57 | 22000 | J |
| 3. | Unknown | 12.74 | 28000 | J |
| 4. | Unknown | 12.94 | 48000 | J |
| 5. | Unknown | 13.58 | 53000 | J |
| 6. | Unknown aliphatic hydrocarbo | 13.89 | 50000 | J |
| 7. | Unknown | 14.02 | 69000 | J |
| 8. | Unknown | 14.44 | 19000 | J |
| 9. | Unknown | 15.07 | 17000 | J |
| 10. | Unknown | 16.24 | 43000 | J |
| 11. | Unknown aliphatic hydrocarbo | 16.49 | 310000 | J |
| 12. | Unknown | 17.13 | 29000 | J |
| 13. | Unknown aliphatic hydrocarbo | 17.41 | 31000 | J |
| 14. | Unknown aliphatic hydrocarbo | 17.47 | 240000 | J |
| 15. | Unknown aliphatic hydrocarbo | 18.21 | 95000 | J |
| 16. | Unknown aliphatic hydrocarbo | 18.31 | 62000 | J |
| 17. | Unknown aliphatic hydrocarbo | 19.18 | 60000 | J |
| 18. | Unknown aliphatic hydrocarbo | 19.78 | 43000 | J |
| 19. | Unknown aliphatic hydrocarbo | 20.00 | 38000 | J |
| 20. | Unknown aliphatic hydrocarbo | 20.33 | 21000 | J |
| 21. | Unknown aliphatic hydrocarbo | 21.57 | 25000 | J |
| 22. | Unknown aliphatic hydrocarbo | 22.29 | 21000 | J |

1E
VOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

698SB00102DL

Lab Name: S-CUBED Contract:
 Lab Code: CEIMIC Case No.: ZONE K SAS No.: SDG No.: 6797
 Matrix: (soil/water) SOIL Lab Sample ID: 6797-06DL
 Sample wt/vol: 5.00 (g/mg) Lab File ID: SR976
 Level: (low/med) LOW Date Received: 12/04/96
 %Moisture: not dec. 4.67 Date Analyzed: 12/06/96
 GC Column: CAP ID: 0.53 (mm) Dilution Factor: 5.00
 Soil Extract Volume: (uL) Soil Aliquot Volume: (uL)

Number of TICs found: 12 CONCENTRATION UNITS:
 (ug/L or ug/Kg) UG/KG

| CAS NUMBER | COMPOUND NAME | RT | EST. CONC. | Q |
|---------------|------------------------------|-------|------------|----|
| 1.04926-90-3 | Cyclohexane, 1-ethyl-1-methy | 12.57 | 1200 | J |
| 2. | Unknown | 12.98 | 1700 | JJ |
| 3. | Unknown | 13.79 | 170 | JJ |
| 4. | Unknown | 14.32 | 190 | JJ |
| 5. | Unknown | 15.62 | 240 | JJ |
| 6. | Unknown Hydrocarbon | 15.75 | 1200 | JJ |
| 7. | Unknown ethyldimethylbenzene | 16.05 | 380 | J |
| 8. | Unknown | 16.26 | 250 | JJ |
| 9. | Unknown | 16.54 | 190 | JJ |
| 10. | Unknown | 16.65 | 240 | JJ |
| 11. | Unknown | 16.86 | 170 | JJ |
| 12.00767-58-8 | 1H-Indene, 2,3-dihydro-4-met | 17.42 | 240 | J |

.1F
SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

698SB00102DL

Lab Name: S-CUBED Contract:
 Lab Code: CEIMIC Case No.: ZONE K SAS No.: SDG No.: 6797
 Matrix: (soil/water) SOIL Lab Sample ID: 6797-06DL
 Sample wt/vol: 30 (g/ml)G Lab File ID: 679706.D
 Level: (low/med) LOW Date Received: 12/04/96 (2096)
 %Moisture: 4.67 decanted: (Y/N) N Date Extracted: 12/03/96 (21096)
 Concentrated Extract Volume: 1000.00 (uL) Date Analyzed: 01/02/97
 Injection Volume: 2.00 (uL) Dilution Factor: 5.00
 GPC Cleanup: (Y/N) N pH: 0.00

CONCENTRATION UNITS:

Number of TICs found: 21 (ug/L or ug/Kg) UG/KG

| CAS NUMBER | COMPOUND NAME | RT | EST. CONC. | Q |
|--------------|--|-------|------------|----|
| 1.00123-42-2 | 2-Pentanone, 4-hydroxy-4-met | 3.85 | 200000 | J |
| 2. | Unknown aliphatic hydrocarbo | 7.48 | 13000 | J |
| 3. | Unknown benzene substituted benzene isomer | 7.82 | 5700 | J |
| 4. | Unknown benzene | 7.88 | 9900 | J |
| 5. | Unknown benzene substituted benzene isomer | 8.37 | 3200 | J |
| 6. | Unknown benzene substituted benzene isomer | 8.48 | 16000 | J |
| 7. | Unknown (2,4,6) | 8.61 | 11000 | J |
| 8. | Unknown (2,4,6) | 8.72 | 5000 | J |
| 9. | Unknown benzene substituted benzene isomer | 8.82 | 7200 | J |
| 10. | Unknown aliphatic hydrocarbo | 9.22 | 3900 | J |
| 11. | Unknown | 9.43 | 41000 | J |
| 12. | Unknown | 10.01 | 8100 | J |
| 13. | Unknown | 10.09 | 4700 | J |
| 14. | Unknown | 10.50 | 5100 | J |
| 15. | Unknown aliphatic hydrocarbon | 10.69 | 51000 | J |
| 16. | Unknown aliphatic hydrocarbo | 12.09 | 61000 | J |
| 17. | Unknown aliphatic hydrocarbo | 19.30 | 3500 | J |
| 18. | Unknown aliphatic hydrocarbo | 20.13 | 4000 | J |
| 19. | Unknown aliphatic hydrocarbo | 21.63 | 12000 | J |
| 20. | Unknown aliphatic hydrocarbo | 22.34 | 6900 | JB |
| 21. | Unknown aliphatic hydrocarbo | 24.97 | 3800 | J |

1F
SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

698SB00201

Lab Name: S-CUBED Contract:
 Lab Code: CEIMIC Case No.: ZONE K SAS No.: SDG No.: 6797
 Matrix: (soil/water) SOIL Lab Sample ID: 6797-07
 Sample wt/vol: 30 (g/ml)G Lab File ID: AB265.D
 Level: (low/med) LOW Date Received: 12/04/96
 %Moisture: 3.88 decanted: (Y/N) N Date Extracted: 12/09/96
 Concentrated Extract Volume: 1000.00 (uL) Date Analyzed: 12/17/96
 Injection Volume: 2.00 (u/L) Dilution Factor: 1.00
 GPC Cleanup: (Y/N) N pH: 0.00

Number of TICs found: 20 CONCENTRATION UNITS:
 (ug/L or ug/Kg) UG/KG

| CAS NUMBER | COMPOUND NAME | RT | EST. CONC. | Q |
|------------|------------------------------|-------|------------|----|
| 1. | Unknown | 6.72 | 130 | J |
| 2. | Unknown | 7.34 | 99 | JB |
| 3. | Unknown | 7.51 | 110 | J |
| 4. | Unknown | 7.65 | 450 | JB |
| 5. | Unknown | 8.12 | 420 | JB |
| 6. | Unknown | 8.16 | 310 | J |
| 7. | Unknown | 8.25 | 360 | JB |
| 8. | Unknown | 8.30 | 270 | JB |
| 9. | Unknown | 9.88 | 490 | J |
| 10. | Unknown | 10.66 | 530 | J |
| 11. | Unknown | 11.08 | 120 | J |
| 12. | Unknown | 11.82 | 1000 | J |
| 13. | Unknown aliphatic hydrocarbo | 20.00 | 480 | J |
| 14. | Unknown caboxylic acid | 22.48 | 430 | J |
| 15. | Unknown aliphatic hydrocarbo | 26.85 | 330 | J |
| 16. | Unknown aliphatic hydrocarbo | 27.72 | 150 | JB |
| 17. | Unknown aliphatic hydrocarbo | 28.73 | 400 | JB |
| 18. | Unknown aliphatic hydrocarbo | 31.24 | 100 | J |
| 19. | Unknown | 31.37 | 190 | J |
| 20. | Unknown | 39.79 | 1000 | J |

1F
SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

698SB00202

Lab Name: S-CUBED Contract:
 Lab Code: CEIMIC Case No.: ZONE K SAS No.: SDG No.: 6797
 Matrix: (soil/water) SOIL Lab Sample ID: 6797-08
 Sample wt/vol: 30 (g/ml)G Lab File ID: AB266.D
 Level: (low/med) LOW Date Received: 12/04/96
 %Moisture: 5.78 decanted: (Y/N) N Date Extracted: 12/09/96
 Concentrated Extract Volume: 1000.00 (uL) Date Analyzed: 12/17/96
 Injection Volume: 2.00 (u/L) Dilution Factor: 1.00
 GPC Cleanup: (Y/N) N pH: 0.00

Number of TICs found: 3 CONCENTRATION UNITS:
 (ug/L or ug/Kg) UG/KG

| CAS NUMBER | COMPOUND NAME | RT | EST. CONC. | Q |
|------------|---------------|-------|------------|---|
| 1. | Unknown | 8.10 | 44000 | J |
| 2. | Unknown | 13.23 | 390 | J |
| 3. | Unknown | 13.93 | 600 | J |

1F
SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

698SB00301

Lab Name: S-CUBED Contract:
 Lab Code: CEIMIC Case No.: ZONE K SAS No.: SDG No.: 6797
 Matrix: (soil/water) SOIL Lab Sample ID: 6797-10
 Sample wt/vol: 30 (g/ml)G Lab File ID: AB268.D
 Level: (low/med) LOW Date Received: 12/04/96
 %Moisture: 25.93 decanted: (Y/N) N Date Extracted: 12/09/96
 Concentrated Extract Volume: 1000.00 (uL) Date Analyzed: 12/17/96
 Injection Volume: 2.00 (uL) Dilution Factor: 1.00
 GPC Cleanup: (Y/N) N pH: 0.00

Number of TICs found: 20 CONCENTRATION UNITS:
 (ug/L or ug/Kg) UG/KG

| CAS NUMBER | COMPOUND NAME | RT | EST. CONC. | Q |
|------------|------------------------------|-------|------------|----|
| 1. | Unknown | 6.77 | 460 | J |
| 2. | Unknown | 7.43 | 320 | J |
| 3. | Unknown | 7.54 | 140 | J |
| 4. | Unknown | 7.67 | 550 | JB |
| 5. | Unknown | 8.14 | 510 | JB |
| 6. | Unknown | 8.19 | 340 | JB |
| 7. | Unknown | 8.28 | 420 | JB |
| 8. | Unknown | 8.32 | 280 | JB |
| 9. | Unknown | 9.64 | 1000 | J |
| 10. | Unknown | 9.89 | 240 | J |
| 11. | Unknown | 10.24 | 140 | J |
| 12. | Unknown | 10.67 | 660 | J |
| 13. | Unknown | 11.86 | 3000 | J |
| 14. | Unknown aliphatic hydrocarbo | 19.99 | 280 | J |
| 15. | Unknown aliphatic hydrocarbo | 21.02 | 160 | J |
| 16. | Unknown aliphatic hydrocarbo | 22.42 | 160 | J |
| 17. | Unknown aliphatic hydrocarb | 25.27 | 140 | JB |
| 18. | Unknown aliphatic hydrocarb | 26.84 | 270 | J |
| 19. | Unknown aliphatic hydrocarb | 28.74 | 200 | JB |
| 20. | Unknown aliphatic hydrocarb | 31.23 | 140 | J |

.1F
 SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET
 TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

698SB00302

Lab Name: S-CUBED Contract:
 Lab Code: CEIMIC Case No.: ZONE K SAS No.: SDG No.: 6797
 Matrix: (soil/water) SOIL Lab Sample ID: 6797-11
 Sample wt/vol: 30 (g/ml)G Lab File ID: AB269.D
 Level: (low/med) LOW Date Received: 12/04/96
 %Moisture: 8.30 decanted: (Y/N) N Date Extracted: 12/09/96
 Concentrated Extract Volume: 1000.00 (uL) Date Analyzed: 12/17/96
 Injection Volume: 2.00 (u/L) Dilution Factor: 1.00
 GPC Cleanup: (Y/N) N pH: 0.00

Number of TICs found: 19 CONCENTRATION UNITS:
 (ug/L or ug/Kg) UG/KG

| CAS NUMBER | COMPOUND NAME | RT | EST. CONC. | Q |
|------------|--|-------|------------|----|
| 1. | Unknown | 5.43 | 76 | J |
| 2. | Unknown | 5.73 | 78 | J |
| 3. | Unknown | 6.85 | 110 | J |
| 4. | Unknown | 7.16 | 78 | J |
| 5. | Unknown | 7.32 | 180 | JB |
| 6. | Unknown | 7.49 | 140 | J |
| 7. | Unknown | 7.62 | 490 | JB |
| 8. | Unknown | 8.10 | 430 | JB |
| 9. | Unknown | 8.16 | 340 | JB |
| 10. | Unknown | 8.25 | 420 | JB |
| 11. | Unknown | 8.28 | 240 | JB |
| 12. | Unknown | 8.39 | 91 | J |
| 13. | Unknown | 9.63 | 200 | J |
| 14. | Unknown | 9.86 | 400 | J |
| 15. | Unknown | 10.66 | 320 | J |
| 16. | Unknown | 11.08 | 82 | J |
| 17. | Unknown | 11.80 | 320 | J |
| 18. | Unknown | 19.90 | 82 | J |
| 19. | Unknown aliphatic hydrocarbo 120197 _g | 24.55 | 110 | J |

Table 10.9.19
 Summary of Risk and Hazard-based COCs
 AOC 698
 Naval Base Charleston, Zone K
 Charleston, South Carolina

| Medium | Exposure Pathway | | Future | Future | Future | Current Site Worker | | Identification of COCs | | |
|---------------------------------|--------------------------|--------------------------|--------------------------------|--------------------------------|-------------------|---------------------|--------------|------------------------|---|--|
| | | | Resident Adult Hazard Quotient | Resident Child Hazard Quotient | Resident Iwa ILCR | Hazard Quotient | ILCR | | | |
| Surface Soil | Incidental Ingestion | Inorganics | | | | | | | | |
| | | Arsenic (As) | 0.048 | 0.45 | 2.5E-05 | 0.017 | 2.8E-06 | 2 | 4 | |
| | | Beryllium (Be) | 0.00018 | 0.0017 | 4.4E-06 | 0.00006 | 4.9E-07 | 2 | | |
| | | Cadmium (Cd) | 0.005 | 0.05 | ND | 0.0020 | ND | | | |
| | | Pesticides | | | | | | | | |
| | Heptachlor epoxide | 0.014 | 0.13 | 1.8E-06 | 0.0049 | 2.1E-07 | 2 | | | |
| | Dermal | Inorganics | | | | | | | | |
| | | Arsenic (As) | 0.010 | 0.032 | 2.8E-06 | 0.0070 | 1.1E-06 | 2 | 4 | |
| | | Beryllium (Be) | 0.000037 | 0.00012 | 4.9E-07 | 0.000026 | 2.0E-07 | | | |
| | | Cadmium (Cd) | 0.0011 | 0.0037 | ND | 0.0008 | ND | | | |
| Pesticides | | | | | | | | | | |
| Heptachlor Epoxide | 0.0011 | 0.0037 | 8.3E-08 | 0.0008 | 3.4E-08 | | | | | |
| Surface Soil Pathway Sum | | | 0.08 | 0.7 | 3E-05 | 0.03 | 5E-06 | | | |
| Groundwater Pathways | Ingestion | Pesticides | | | | | | | | |
| | | delta-BHC | ND | ND | 5.7E-06 | ND | 1.8E-06 | 2 | 4 | |
| | | Volatile Organics | | | | | | | | |
| | Benzene | ND | ND | 2.2E-06 | ND | 7.0E-07 | 2 | | | |
| Inhalation | Volatile Organics | | | | | | | | | |
| Benzene | 0.08 | 0.2 | 2.2E-06 | 0.03 | 7.0E-07 | 2 | | | | |
| Groundwater Pathway Sum | | | 0.08 | 0.2 | 1E-05 | 0.03 | 3E-06 | | | |
| Sum of All Pathways | | | 0.2 | 0.9 | 4E-05 | 0.06 | 8E-06 | | | |

Notes:

ND indicates not determined due to the lack of available risk information.

ILCR indicates incremental excess lifetime cancer risk

HI indicates hazard index

1- Chemical is a COC by virtue of projected child residence noncarcinogenic hazard.

2- Chemical is a COC by virtue of projected future resident lifetime ILCR.

3- Chemical is a COC by virtue of projected site worker noncarcinogenic hazard.

4- Chemical is a COC by virtue of projected site worker ILCR.