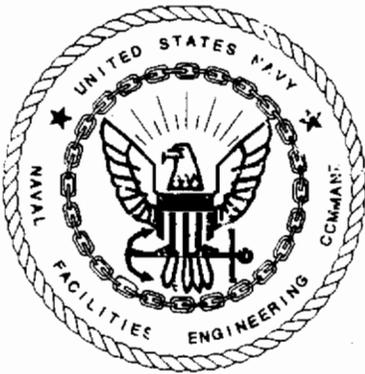


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FINAL RESOURCE CONSERVATION AND RECOVERY ACT FACILITY INVESTIGATION  
REPORT ZONE H VOLUME III SECTIONS 7 THROUGH 11 CNC CHARLESTON SC  
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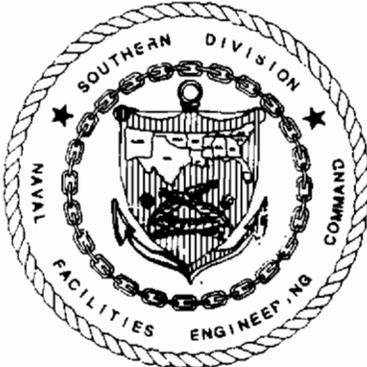


**VOLUME III  
SECTIONS 7-11**

**CONTRACT N62467-89-D-0318  
CTO-029**

**Prepared for:**

**Comprehensive Long-Term Environmental Action Navy  
(CLEAN)  
Charleston Naval Shipyard  
Charleston, South Carolina**



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**July 5, 1996**

## **7.0 ECOLOGICAL RISK ASSESSMENT**

The ecological risk assessment (ERA) is a key component of the BRA. Its purpose is to develop a qualitative and/or quantitative ecological appraisal of the actual or potential effects of Zone H contamination on the surrounding ecosystem. The assessment considers environmental media and exposure pathways that could result in unacceptable levels of exposure to flora and fauna now or in the foreseeable future. The approach to assessing risk components at Zone H was based on USEPA *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (Draft, USEPA, 1994e), *Risk Assessment Guidance for Superfund Volume II — Environmental Evaluation Manual*, (USEPA, 1989b), and *Framework for Ecological Risk Assessment* (USEPA, 1992b).

### **7.1 Zone Rationale**

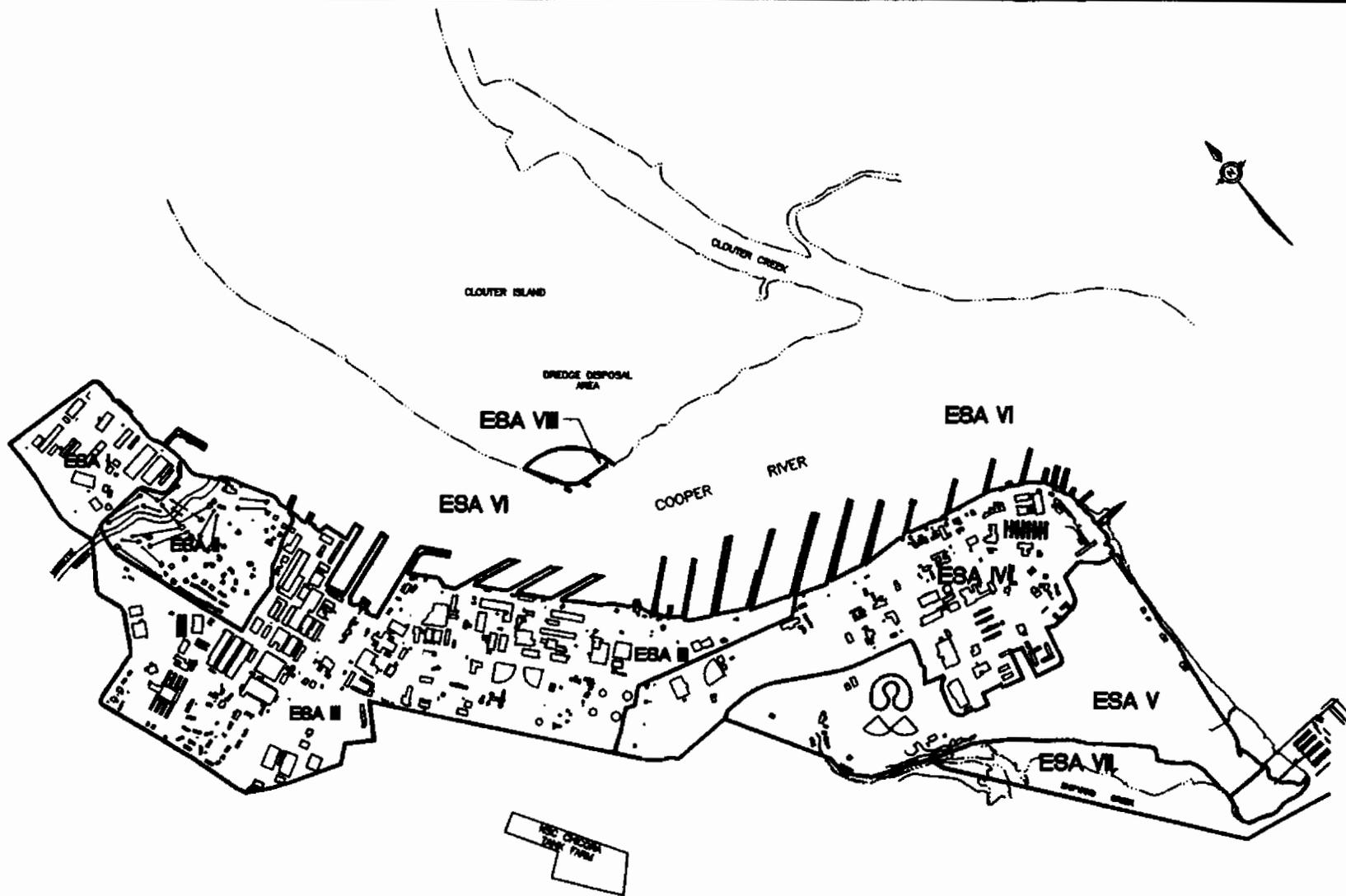
Basewide, eight Ecological Study Areas (ESAs) were designated to assist in appropriately qualifying geographic boundaries with contiguous habitats or similar ecosystem distributions (Figure 7-1). Within these ESAs, Areas of Ecological Concern (AECs) were further specified to focus the investigation relative to potential SWMU/AOC contribution and thus receptor exposure. Using an ecological survey form, all ESAs and AECs underwent habitat and resident biota evaluations to obtain preliminary ecological information essential to the Zone H ERA. The completed forms are presented in Appendices A and B of the Zone J RFI Work Plan and summarized below. This survey methodology, which is used in conjunction with the Zone H RFI report is also described in the Zone J RFI Work Plan (draft submitted November 22, 1995).

Basewide, zone configurations were based on SWMU or AOC locations and therefore do not necessarily parallel ESA boundaries. Within the designated Zone H boundaries are portions of two ESAs and three AECs. Some portions of Zone H were not relevant to this ERA based on the lack of habitat and, thus, receptors. These areas were generally the industrialized sections of the zone. They are designated on Figure 7-2 as "Non-Ecological Areas" and, due to the lack of habitat and receptors within the area, will not be discussed relative to ecological risk. If there

is a potential for contaminant migration to aquatic areas out of the Zone H perimeter (Shipyard Creek), risks to applicable receptors will be evaluated during the Zone J investigation. Subsequent to the AEC evaluations, four distinct ecological areas, each with similar and contiguous habitats comprising portions of AEC V-2, and V-3, were defined within Zone H and will be specifically addressed in this risk assessment. For the discussion these areas will be designated as Subzones H-1, H-2, H-3, and H-4 (Figure 7-2). Specific endpoints and assessment techniques for each subzone are presented below. The AOCs/SWMUs within each subzone are identified in Table 7-1, along with nearby areas potentially impacted by those sites.

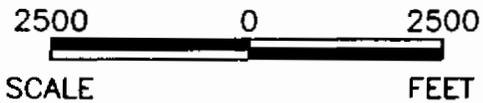
**Table 7-1**  
**AOCs/SWMUs within Zone H Subzones**

AOC/SWMU		Potentially Impacted Areas Outside Subzone
<b>Subzone H-1</b>		
SWMU 9	Landfill	Subzone H-2 Subzone H-4 Shipyard Creek/Cooper River
SWMU 19	Solid Waste Transfer Station	No impact expected outside H-1
SWMU 20	Waste Disposal Area	Shipyard Creek/Cooper River
AOC 648-651	Shipbuilding Storage Areas, etc.	No impact expected outside H-1
<b>Subzone H-2</b>		
SWMU 121	SAA	Subzone H-4 Shipyard Creek/Cooper River
SWMU 159	SAA	Shipyard Creek/Cooper River
AOC 503	UXO Site	No impact expected outside H-2
<b>Subzone H-3</b>		
SWMU 14	Chemical Disposal Area	Zone I/ESA V
SWMU 15	Incinerator	
AOC 669	Indoor Firing Range	
AOC 670	Open Field	
AOC 684	Pistol Range	
<b>Subzone H-4</b>		
AOC 654	Septic Tank/Drainage Field	Shipyard Creek/Cooper River



LEGEND

— — ESA BOUNDARY



SOURCES: SOUTHCO, n.d. ESE 1001.



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FIGURE 7-1  
ECOLOGICAL STUDY AREA  
LOCATION MAP

DWG DATE: 06/30/96 | DWG NAME: 29CHZSAM

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**Figure 7-2 Ecological Subzones within Zone H**

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## **7.2 Environmental Setting**

### **7.2.1 Problem Formulation**

Subzone H-1 is a 14-acre terrestrial setting consisting grass fields with low shrub cover interspersed with a few stands of trees. The subzone also contains a running track, two baseball fields, gravel parking lots, and several buildings. H-1's western portion is an old field exhibiting early successional vegetation including Southern bayberry (*Myrica cerifera*), *Viburnum* spp., and groundsel tree (*Baccharis halimifolia*), as well as several herbaceous species. Black willow (*Salix nigra*) and Eastern red cedar (*Juniperus virginiana*) are present near the creek that transects this area. The area provides habitat suitable for use by bird species such as killdeer (*Chadradrius vociferus*), red-tailed hawk (*Buteo jamaicensis*), American kestrel (*Falco sparverius*), Eastern meadowlark (*Sturnella magna*), and Savannah sparrow (*Passerculus sandwichensis*). Major terrestrial faunal species associated with this habitat include Eastern cottontail rabbit (*Sylvilagus floridanus*), gray fox (*Urocyon cinereoargenteus*), and raccoon (*Procyon lotor*), along with other small rodents (mice, voles, shrews), amphibians, and reptiles. In addition, shorebirds intermittently use the narrow headwaters of Shipyard Creek that transect the subzone. Appendix O lists potential species occurring within Zone H subzones. The surface water and sediment samples collected from the two locations along this portion of Shipyard Creek will be qualitatively assessed with those samples in H-4.

Subzone H-2 is a 45-acre densely forested transitional zone between the upland areas and the littoral zone north of Shipyard Creek. Portions of this area are periodically flooded yet, based on the nature of potential exposure in H-2, it was more suitable to classify the majority of the substrate as soil rather than sediment. Vegetation throughout the subzone consists of mid- to lower-canopy trees typical of midsuccession areas including tallow (*Sapium sebiferum*), Eastern sycamore (*Platanus occidentalis*), Eastern red cedar, and red mulberry (*Morus rubra*). The dense understory found throughout the subzone consists of woody and herbaceous species such as green briar (*Smilax* spp), honeysuckle (*Lonicera* spp.) and pepper-vine (*Ampelopsis arborca*).

Fauna within the area is typical of midsuccession habitats and includes passerine species such as sparrows, warblers, and the American robin (*Turdus migratorius*). Potential mammals in H-2 include Eastern gray squirrel (*Sciurus carolinensis*), Eastern cottontail rabbit, and other small rodents species.

Subzone H-3 is a grass field habitat near several designated AOCs and SWMUs. The fields are maintained to some degree and a limited number of shrubs are along the area's perimeter, except the southeast boundary, which is bordered by the thickly vegetated edge of the dredged materials area (Zone I). This open field environment provides habitat for Eastern cottontail rabbit, red-tailed hawk, and lesser mammal species. Other fauna associated with the area include egrets (*Egretta* spp.) and white ibis (*Eudocimus albus*).

Subzone H-4 encompasses the estuarine littoral marsh north of Least Tern Lane, exclusive of the heavily forested areas included in Subzone H-2. This area is significantly tied to tidal fluctuations within proximal Shipyard Creek. The marsh is dominated by *Spartina* spp. but contains irregular topography that provides elevated areas on which Eastern red cedar predominates. The array of fauna in this zone includes a wide variety of avian and invertebrate species including black-crowned night herons (*Nycticorax*), marsh wrens (*Cistothorus palustris*), and fiddler crabs (*Uca* spp.).

### 7.2.2 Threatened and Endangered Species

Within portions of Zone H several state-designated species of concern may be present. Table 7-2 lists those federally- and state-listed species which have been historically or recently identified at or near NAVBASE. Risks to these species from observed contamination will be addressed as appropriate.

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Table 7-2  
 Federal and State Listed Threatened, Endangered and Candidate Species  
 That Occur or Potentially Occur on NAVBASE

Common Name	Scientific Name	Residence Status	Status	
			USF&WS	SCWMRD
<b>Reptiles and Amphibians</b>				
American Alligator	<i>Alligator mississippiensis</i>	PR	T/SA	T/SA
Flatwoods Salamander	<i>Ambystoma cingulatum</i>	UR	C2	SC
Eastern Tiger Salamander	<i>Ambystoma tigrinum</i>	PR	—	SC
Broad-Striped Dwarf Siren	<i>Pseudobranchius striatus</i>	PR	—	SC
Crawfish Frog	<i>Rana areolata</i>	PR	—	SC
Loggerhead Turtle	<i>Caretta</i>	PM	T	T
Kemp's Ridley Sea Turtle	<i>Lepidochelys kempi</i>	PM	E	E
Island Glass Lizard	<i>Ophisaurus compressus</i>	UR	SR	SR
<b>Birds</b>				
Brown Pelican	<i>Pelecanus occidentalis</i>	LM	—	SC
Wood Stork	<i>Mycteria americana</i>	LM	E	E
Osprey	<i>Pandion haliaetus</i>	CR	—	SC
American Swallow-Tailed Kite	<i>Elanoides forficatus forficatus</i>	PM	SR	E
Bachman's Sparrow	<i>Aimophila aestivalis</i>	UR	SR	SR
Red-Cockaded Woodpecker	<i>Picoides borealis</i>	UR	E	E
Bachman's Warbler	<i>Vermivora bachmanii</i>	UR	E	E
Bald Eagle	<i>Haliaeetus leucocephalus</i>	LM	E	E
Arctic Peregrine Falcon	<i>Falco peregrinus tundrius</i>	PM	T	T
Piping Plover	<i>Charadrius melodus</i>	PM	T	T
Least Tern	<i>Sterna antillarum</i>	CR	—	T
Least Tern Breeding Colony		CR	—	SC
Wading Bird Breeding Colony		CR <sup>a</sup>	—	SC
<b>Mammals</b>				
Black Bear	<i>Ursus americanus</i>	UM	—	SC
West Indian Manatee	<i>Trichechus manatus</i>	PM	E	E

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Table 7-2  
 Federal and State Listed Threatened, Endangered and Candidate Species  
 That Occur or Potentially Occur on NAVBASE

Common Name	Scientific Name	Residence Status	Status	
			USF&WS	SCWMRD
<b>Fish</b>				
Shortnose Sturgeon	<i>Acipenser brevirostrum</i>	LM	E	E
<b>Plants</b>				
Canby's Dropwort	<i>Oxpolis canbyi</i>	UR	E	E
Pondberry	<i>Lindera melissifolia</i>	UR	E	E
Incised Groovebur	<i>Agrimonia incisa</i>	UR	C2	NC
Sea-Beach Pigweed	<i>Amaranthus pumilus</i>	UR	SR	NC
Cypress Knee Sedge	<i>Carex decomposita</i>	UR	SR	—
Chaff-Seed	<i>Schwalbea americana</i>	UR	SR	NC
Whisk Fern	<i>Ptilotus nudum</i>	UR	—	SL
Climbing Fern	<i>Lygodium palmatum</i>	UR	—	SL
Piedmont Flatsedge	<i>Cyperus tetragonus</i>	PR	—	SL
Baldwin Nutrush	<i>Scleria baldwinii</i>	UR	—	SL
Nodding Pogonia	<i>Triphora trianthophora</i>	UR	—	SL
Savannah Milkweed	<i>Asclepias pedicellata</i>	UR	—	RC
Venus's Flytrap	<i>Dionaea muscipula</i>	UR	—	RC
Sweet Pinesap	<i>Monotropsis odorata</i>	UR	—	RC
Climbing Fetter-Bush	<i>Pieris phillyreifolia</i>	UR	—	SL
Sea Purslane	<i>Trianthema portulacastrum</i>	CR	—	SC

Notes:

- a = Wading bird colony has been a confirmed resident at the base, but was not present during field studies in April 1994.
  - CR = Confirmed resident.
  - PR = Possible resident.
  - UR = Unlikely resident.
  - LM = Likely migrant or occasional visitor.
  - PM = Possibly migrant or occasional visitor.
  - UM = Unlikely migrant or occasional visitor.
  - SC = Of concern, state.
  - SR = Status review.
  - E = Endangered.
  - T = Threatened.
  - SL = State listed.
  - RC = Of concern, regional.
  - NC = Of concern, national.
  - C2 = Candidate species for federal listing, Category 2.
  - T/SA = Threatened due to similarity of appearance.
  - USF&WS = U.S. Fish and Wildlife Service.
  - SCWMRD = South Carolina Wildlife and Marine Resources Department.
- Source: Final Environmental Impact Statement for Disposal and Reuse of the Charleston Naval Base, North Charleston, South Carolina (Ecology and Environment, 1995).

### **7.3 Conceptual Model**

Figure 7-3 presents a conceptual model of the potential contaminant pathways from source to ecological receptors for Zone H subzones. For this assessment, exposure routes directly related to soil pathways are evaluated for subzones H-1, H-2 and H-3. Subzone H-4 will be preliminarily characterized for sediment and water exposure routes to determine the need for subsequent assessment during the Zone J RFI. Direct impacts to plants are not included in this assessment but transfer mechanisms are considered in food chain transfer analyses. Information related to specific contaminant toxic mechanisms to vegetation are also discussed.

### **7.4 Selection of Ecological Chemicals of Potential Concern**

Previous sections of this report (Section 4) discuss past activities at Zone H SWMUs and AOCs that may have impacted the surrounding ecosystem. COCs resulting from these activities have been identified and quantified according to USEPA methods and protocols for analyses of soil, surface water, and sediment.

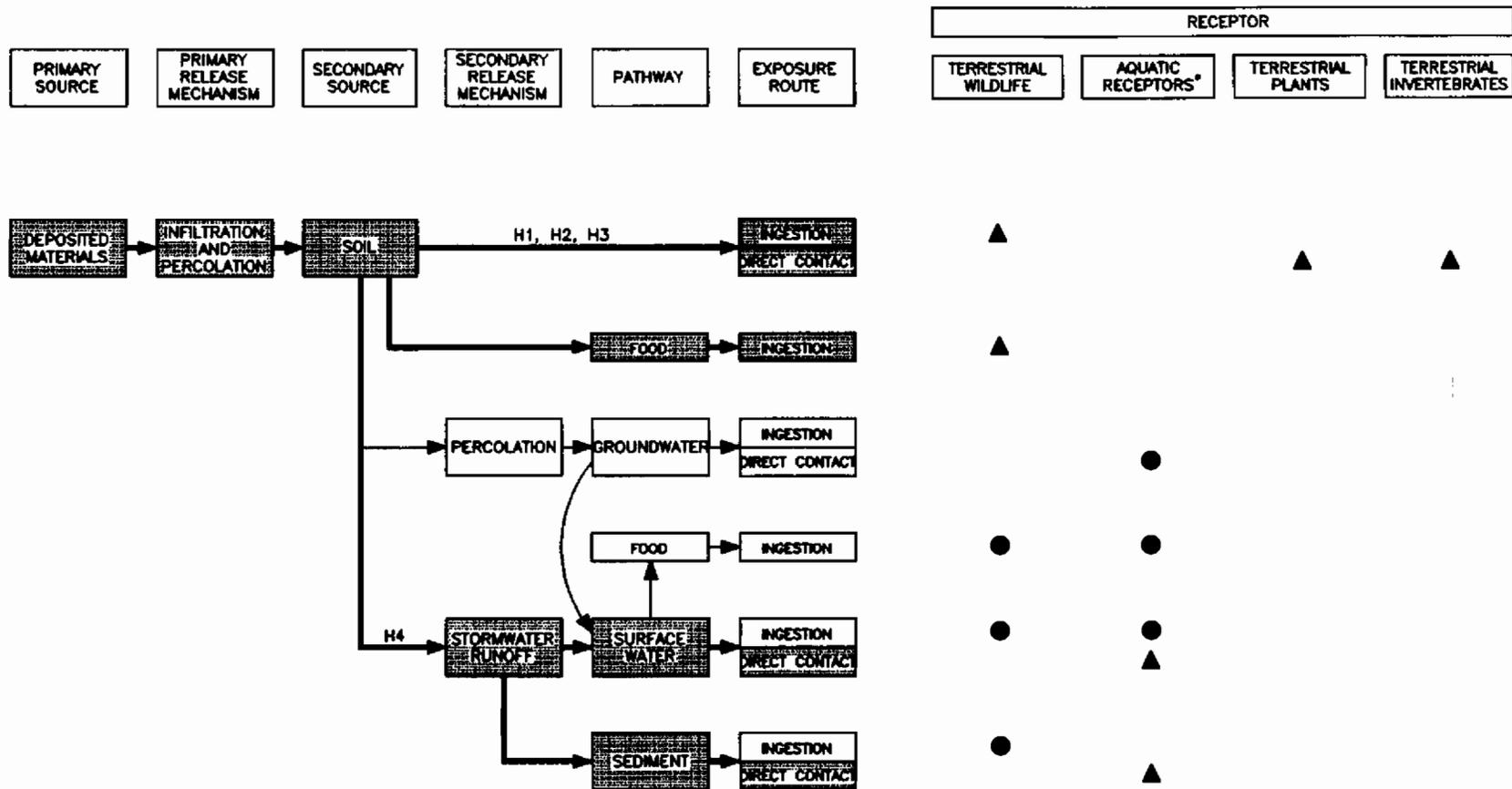
For ecological risk, only the results from surficial soil (0 to 1 foot bgs interval) are addressed. It is presumed, even considering root development in the lower strata, that most biological effects will be limited to the upper zone. Based on the transient or mobile nature of biological components within the subzones, parameter concentrations detected at one location within a sub-zone will be used to assess the entire subzone. Therefore, mean concentrations (of detected parameter concentrations only) and maximum values determined from all sample locations within the subzone are used in this assessment. Although groundwater has been monitored, water table depth (averaging approximately 5 feet bgs) within Zone H uplands precludes assessing ecological impacts from this medium immediately within the zone perimeter. Those wetland habitats present in Zone H (primarily in Subzone H-4) are tidally influenced and not considered significantly affected by groundwater discharge. See Section 5 for further information on groundwater-to-surface water cross-media transport.

Inorganic parameters detected in site surface soil exceeding twice the maximum concentration detected in reference sample concentrations, or not detected in reference samples, are identified as Ecological Chemicals of Potential Concern (ECPCs). Any constituent detected in less than 5% of the samples was not considered as an ECPC. Any organic constituent detected in greater than 5% of the samples was considered an ECPC.

In sediment, analytes were selected as ECPCs if the maximum concentration detected either: (1) exceeded the USEPA Region IV Sediment Screening Value, (2) exceeded the most conservative effects level found in literature, or (3) if neither benchmark was available.

In surface water, analytes were selected as ECPCs if the maximum concentration detected either: (1) exceeded the South Carolina or USEPA water quality criteria, (2) exceeded the USEPA Region IV Screening Value, or (3) if neither benchmark was available.

Calcium, magnesium, potassium, and sodium were not assessed as they are naturally occurring nutrients. Tables 7-3 (a and b), 7-4 (a,b, and c) , 7-5 (a and b), and 7-6 (a, b, and c) present ECPCs identified for subzones H-1, H-2, H-3, and Shipyard Creek/H-4, respectively.



\*AQUATIC RECEPTORS - INVERTEBRATES, PLANTS, ALGAE, AMPHIBIANS, AND FISH  
 NOTE: SHADED BOXES, BOLD ARROWS, AND TRIANGLES INDICATE SELECTED PATHWAY.



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FIGURE 7-3  
 CONTAMINANT PATHWAY MODEL FOR  
 ECOLOGICAL RECEPTORS

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Table 7-3a  
 Subzone H-1  
 Inorganic Constituents in Surface Soil

Inorganic Elements	Number of Samples	Number of Detections	Range of Concentrations (mg/kg)	Upper Tolerance Limit of Background <sup>c</sup>	ECPC
Aluminum	36	36	488 — 10,900	25,310	No
Antimony	36	8	0.74 — 726	Not Valid <sup>d</sup>	Yes
Arsenic	36	36	0.65 — 22.1	14.81	Yes
Barium	36	22	8.9 — 128	40.33	Yes
Beryllium	36	34	0.08 — 3.0	1.466	Yes
Cadmium	36	22	0.13 — 1.8	1.05	Yes
Chromium	36	34	4.3 — 49.2	85.65	No
Chromium VI <sup>b</sup>	3	0	0	Not Valid <sup>d</sup>	No
Cobalt	36	33	0.57 — 43.3	5.863	Yes
Copper	36	36	1.1 — 3,040	27.6	Yes
Cyanide	9	0	0	Not Valid <sup>d</sup>	No
Iron <sup>a</sup>	36	36	1,470 — 26,300	30,910	No
Lead	36	34	3.4 — 6,170	118	Yes
Mercury	36	36	0.02 — 6.9	0.485	Yes
Magnesium <sup>a</sup>	36	33	54.8 — 4,370	9,592	No
Manganese <sup>a</sup>	36	36	4.8 — 320	636.4	No
Nickel	36	34	0.93 — 282	33.38	Yes
Selenium	36	12	0.22 — 1.1	2.0	No
Silver	18	1	0.92	Not Valid <sup>d</sup>	Yes
Thallium	36	3	0.32 — 0.54	0.63	No
Tin <sup>a</sup>	5	3	5.9 — 43.8	Not Valid <sup>d</sup>	Yes
Vanadium	36	35	4.3 — 43.5	77.38	No
Zinc	36	36	6.0 — 2,800	214.3	Yes

**Notes:**

- a Elements that are not included in both SW-846 and Appendix IX methods.
- b Included in duplicate sample analyses only.
- c See Appendix J for UTL determination.
- d Number of nondetections prevented determining UTL.

Table 7-3b  
 Subzone H-1  
 Organic Constituents in Surface Soil

Compound Name	Number of Detections	Range of Concentrations ( $\mu\text{g}/\text{kg}$ )	ECPC
<b>Volatile Organic Compounds (N = 24)</b>			
Acetone	5	20 — 33	Yes
Carbon disulfide	1	64	No
Chlorobenzene	2	4.8 — 9.9	Yes
1,1-Dichloroethene	3	1.8 — 64.0	Yes
Chloroform	1	1.5	No
Toluene	19	2.4 — 72	Yes
Trichloroethene	2	1.3 — 54	Yes
Xylene (total)	24	1.6 — 7.1	Yes
Acrylonitrile	2	5.8 — 36.9	Yes
<b>Semivolatile Organic Compounds (N = 47)</b>			
Acenaphthene	4	100 — 244	Yes
Benzoic Acid	5	76.9 — 269	Yes
Anthracene	11	64.1 — 450	Yes
Benzo(a)anthracene	32	79 — 1,900	Yes
Benzo(b)fluoranthene	32	100 — 4,000	Yes
Benzo(k)fluoranthene	23	83 — 864	Yes
Benzo(g,h,i)perylene	13	78 — 1,100	Yes
Benzo(a)pyrene	29	80.3 — 2,000	Yes
bis(2-Ethylhexyl)phthalate (BEHP)	26	80 — 16,000	Yes
Butylbenzylphthalate	17	60.2 — 4,200	Yes
4-Methylphenol	2	125 — 200	No
Chrysene	36	60.6 — 1,900	Yes
Dibenzo(a,h)anthracene	4	72.1 — 390	Yes

**Table 7-3b  
 Subzone H-1  
 Organic Constituents in Surface Soil**

Compound Name	Number of Detections	Range of Concentrations ( $\mu\text{g}/\text{kg}$ )	ECPC
<b>Semivolatile Organic Compounds (N = 47) (continued)</b>			
Dibenzofuran	6	42.9 — 220	Yes
Di-n-butylphthalate	12	68.9 — 1,100	Yes
Di-n-octylphthalate	2	98 — 150	No
Fluoranthene	36	98 — 3,200	Yes
Fluorene	5	40.6 — 340	Yes
Indeno(1,2,3-cd)pyrene	8	78 — 260	Yes
2-Methylnaphthalene	9	94.3 — 322	Yes
Naphthalene	9	57.9 — 620	Yes
Phenol	1	100	No
Phenanthrene	35	65.5 — 1,900	Yes
Pyrene	37	86.9 — 3,300	Yes
<b>Pesticides (N = 23)</b>			
alpha-Chlordane	10	1.8 — 15.7	Yes
gamma-Chlordane	5	1.3 — 6	Yes
4,4'-DDD	3	2.4 — 8	Yes
4,4'-DDE	7	4 — 10.2	Yes
4,4'-DDT	4	2 — 8	Yes
Endosulfan II	1	2.1	No
Endosulfan sulfate	1	7	No
Endrin aldehyde	1	14	No

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Table 7-3b  
 Subzone H-1  
 Organic Constituents in Surface Soil

Compound Name	Number of Detections	Range of Concentrations (µg/kg)	ECPC
<b>Polychlorinated Biphenyls (N = 36)</b>			
Aroclor-1248	1	52	No
Aroclor-1254	5	30 — 2300	Yes
Aroclor-1260	11	32 — 560	Yes
<b>Dioxin (ng/kg) (N = 4)</b>			
2,3,7,8 TCDD	2	0.2771 <sup>a</sup> — 8.154	Yes

Notes:

- a = Concentration is estimated (EMPC qualified).
- N = Number of samples
- ECPC = Ecological Chemicals of Potential Concern.
- µg/kg = micrograms per kilogram
- ng/kg = nanograms per kilogram

Table 7-4a  
 Subzone H-2  
 Inorganic Constituents in Surface Soil

Inorganic Elements	Number of Samples	Number of Detections	Range of Concentrations (mg/kg)	Upper Tolerance Limit of Background <sup>a</sup>	ECPC
Aluminum	43	43	719 — 29,600	25,310	Yes
Antimony	43	5	1.4 — 7.3	Not Valid <sup>b</sup>	Yes
Arsenic	43	33	1.8 — 18.7	14.81	Yes
Barium	43	38	10.1 — 530	40.33	Yes
Beryllium	43	31	0.16 — 14.6	1.466	Yes
Cadmium	43	18	0.12 — 2.5	1.05	Yes
Chromium	43	43	6.3 — 210	85.68	Yes
Cobalt	43	27	1.0 — 97.2	5.9	Yes
Copper	43	34	2.2 — 4,060	27.6	Yes
Cyanide	18	1	9.9	Not Valid <sup>b</sup>	No
Iron	43	43	2,230 — 80,800	30,910	Yes

Table 7-4a  
 Subzone H-2  
 Inorganic Constituents in Surface Soil

Inorganic Elements	Number of Samples	Number of Detections	Range of Concentrations (mg/kg)	Upper Tolerance Limit of Background <sup>a</sup>	ECPC
Lead	43	38	4.6 — 2,770	118	Yes
Manganese	43	43	20.7 — 1,020	636.4	Yes
Mercury	43	28	0.02 — 3.5	0.485	Yes
Nickel	43	43	2.0 — 995	33.38	Yes
Selenium	43	27	0.28 — 3.2	2.0	Yes
Silver	43	7	0.33 — 1.2	Not Valid <sup>b</sup>	Yes
Thallium	43	4	0.12 — 2.7	0.63	Yes
Tin	1	1	19.7	Not Valid <sup>b</sup>	Yes
Vanadium	43	43	5.3 — 470	77.38	Yes
Zinc	43	38	11.3 — 15,100	214.3	Yes

**Notes:**

- a = See Appendix J for UTL determination.
- b = Number of nondetections prevented determining the UTL.

Table 7-4b  
 Subzone H-2  
 Organic Constituents in Surface Soil

Compound Name	Number of Detections	Range of Concentrations (µg/kg)	ECPC
<b>Volatile Organic Compounds (N = 18)</b>			
Acetone	14	14 — 12,000	Yes
4-Methyl-2-Pentanone	1	2.4	Yes
2-Butanone (MEK)	1	37.1	Yes
Tetrachloroethene	4	7 — 22	Yes
Toluene	11	3.5 — 13	Yes
Trichloroethene	10	2 — 21.0	Yes
Xylene (total)	1	6.0	Yes
Acrylonitrile	1	34.5	Yes

Table 7-4b  
 Subzone H-2  
 Organic Constituents in Surface Soil

Compound Name	Number of Detections	Range of Concentrations ( $\mu\text{g}/\text{kg}$ )	ECPC
<b>Semivolatile Organic Compounds (N = 30)</b>			
Acenaphthene	1	130	No
Acenaphthylene	2	160 — 590	Yes
Anthracene	6	100 — 610	Yes
Benzo(a)anthracene	10	48 — 1,900	Yes
Benzo(b)fluoranthene	13	68 — 2,700	Yes
Benzo(k)fluoranthene	9	69 — 2,200	Yes
Benzo(g,h,i)perylene	6	61 — 780	Yes
Benzo(a)pyrene	11	77 — 1,700	Yes
bis(2-Ethylhexyl)phthalate (BEHP)	12	62 — 1,000	Yes
Chrysene	13	87 — 2,000	Yes
Dibenzo(a,h)anthracene	5	98 — 280	Yes
Dibenzofuran	1	89	No
Diethylphthalate	1	85.2	No
Butylbenzylphthalate	4	88 — 2,600	Yes
Fluoranthene	13	120 — 3,900	Yes
Fluorene	1	200	No
Indeno(1,2,3-cd)pyrene	7	50.2 — 750	Yes
2-Methylnaphthalene	2	110 — 470	Yes
Naphthalene	1	330	No
Phenanthrene	12	77.6 — 2,200	Yes
Pyrene	15	84 — 3,400	Yes

**Table 7-4b  
 Subzone H-2  
 Organic Constituents in Surface Soil**

Compound Name	Number of Detections	Range of Concentrations ( $\mu\text{g}/\text{kg}$ )	ECPC
<b>Polychlorinated Biphenyls (N = 29)</b>			
Aroclor-1248	4	66 — 160	Yes
Aroclor-1254	7	140 — 4,300	Yes
Aroclor-1260	16	46 — 1,100	Yes
<b>Dioxins (ng/kg) (N = 4)</b>			
2,3,7,8 TCDD	4	1.6568 — 4.5217	Yes

**Notes:**

N = Number of Samples  
 $\mu\text{g}/\text{kg}$  = micrograms per kilogram  
 ng/kg = nanograms per kilogram

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Table 7-4c  
 Subzone H-2 Sediment Concentrations

Parameter	Number of Samples	Number Detected	Range	Mean	Effects Level <sup>a</sup> (EL)	Number of Times EL Exceeded	HQ	ECPC
<b>Inorganic (mg/kg)</b>								
Aluminum	3	3	4,640 — 32,900	16,346.67	NA	—	—	Yes
Arsenic	3	3	11.5 — 15.6	14.2	7.24	3	2.16	Yes
Barium	3	3	29.0 — 64.8	14.2	NA	—	—	Yes
Beryllium	3	2	1.1 — 1.1	1.1	NA	—	—	Yes
Cadmium	3	3	0.6 — 1.0	0.81	1.0	1	1.0	Yes
Chromium	3	3	40.8 — 71.5	60.3	52.3	2	1.4	Yes
Cobalt	3	2	5.4 — 6.4	5.9	NA	—	—	Yes
Copper	3	3	22.6 — 29.4	25.8	18.7	3	1.6	Yes
Lead	3	3	47.7 — 89.1	70.2	30.2	3	2.95	Yes
Manganese	3	3	104 — 245	163.3	NA	—	—	Yes
Mercury	3	3	0.07 — 0.15	0.1	0.13	2	1.2	Yes
Nickel	3	3	11.9 — 24.5	16.9	15.9	1	1.5	Yes
Selenium	3	3	1.3 — 2.7	2.1	NA	—	—	Yes
Vanadium	3	3	22.6 — 66.2	49.5	NA	—	—	Yes
Zinc	3	3	92.4 — 279	167.5	124	2	2.25	Yes
<b>Organic (µg/kg)</b>								
Aroclor-1260	3	1	890	—	33	1	26.9	Yes
alpha-Chlordane	3	3	29 — 560	229.3	NA	—	—	Yes
gamma-Chlordane	3	3	26 — 760	290	NA	—	—	Yes
4,4'-DDT	3	1	51	—	3.3	1	15.5	Yes
4,4'-DDE	3	1	15	—	3.3	1	4.6	Yes
Fluoranthene	3	3	148 — 920	432	330	1	2.8	Yes
Pyrene	3	3	162 — 720	380.7	330	1	2.18	Yes
Phenanthrene	3	1	310	—	330	0	0.94	No
Chrysene	3	3	90 — 510	263.3	330	1	1.6	Yes
tPAHs	33	20	75 — 920	326.6	330	7	0.5	Yes

Notes:

- a = Effects levels represent USEPA Region IV (1995b) Draft Sediment Screening Values (SSVs).
- HQ = Hazard Quotient = maximum concentration/effects level.
- ECPC = Ecological Chemical of Potential Concern.
- mg/kg = milligrams per kilogram
- µg/kg = micrograms per kilogram

**Table 7-5a**  
**Subzone H-3**  
**Inorganic Constituents in Surface Soil**

Inorganic Elements	Number of Samples	Number of Detections	Range of Concentrations (mg/kg)	Upper Tolerance Limit of Background <sup>a</sup>	ECPC
Aluminum	56	26	2,600 — 29,600	25,310	Yes
Iron	26	26	4,360 — 31,800	30,910	Yes
Lead	74	55	3.96 — 20,900	118	Yes
Nickel	74	49	4.1 — 29.0	33.38	No
Silver	74	1	1.8	Not Valid <sup>b</sup>	No
Thallium	74	10	0.07 — 2.9	0.63	Yes
Antimony	74	12	2.0 — 167	Not Valid <sup>b</sup>	Yes
Arsenic	74	51	0.89 — 69	14.81	Yes
Barium	74	38	2.9 — 121	40.33	Yes
Beryllium	74	64	0.13 — 1.51	1.466	Yes
Cadmium	74	24	0.29 — 3.60	1.05	Yes
Cobalt	74	35	1.3 — 7.2	5.863	Yes
Copper	74	38	3.7 — 79.7	27.6	Yes
Vanadium	74	74	7.9 — 72	77.38	No
Zinc	75	59	3.1 — 180	214.3	No
Selenium	74	51	0.13 — 6.2	2.0	Yes
Mercury	74	47	0.02 — 0.24	0.485	No
Manganese	26	26	42.4 — 506	636.4	No
Chromium	76	76	3.6 — 91	85.68	Yes
Tin	30	3	32.8 — 81	Not Valid <sup>b</sup>	Yes
Cyanide	74	1	0.002	Not Valid <sup>b</sup>	No

**Notes:**

a = See Appendix J for UTL determination.

b = Number of nondetections prevented determining UTL.

Table 7-5b  
 Subzone H-3  
 Organic Constituents in Surface Soil

Compound Name	Number of Detections	Range of Concentrations ( $\mu\text{g}/\text{kg}$ )	ECPC
<b>Volatile Organic Compounds (N = 71)</b>			
Acetone	13	7.6 — 97.4	Yes
Carbon disulfide	4	1.2 — 5.4	Yes
Chlorobenzene	2	63.8 — 66.7	No
1,1-Dichloroethene	7	1.8 — 75.9	No
Dibromochloromethane	14	11 — 30	Yes
Methylene chloride	13	11 — 212	Yes
2-Butanone (MEK)	3	3.9 — 9.9	No
Tetrachloroethene	2	1.4 — 2.8	No
Toluene	55	1.9 — 116	Yes
Trichloroethene	4	64.1 — 69	Yes
Xylene (total)	25	1.4 — 10	Yes
1,2,3-Trichloropropane	1	91.2	No
<b>Semivolatile Organic Compounds (N = 89)</b>			
Acenaphthene	20	28.7 — 5,810	Yes
Acenaphthylene	1	286	No
Anthracene	19	14.3 — 8,300	Yes
Benzo(a)anthracene	46	34.5 — 27,200	Yes
Benzo(b)fluoranthene	45	50.4 — 28,400	Yes
Benzo(k)fluoranthene	41	48.1 — 26,500	Yes
Benzo(g,h,i)perylene	29	72 — 20,500	Yes
Benzo(a)pyrene	46	53.1 — 36,800	Yes
bis(2-Ethylhexyl)phthalate (BEHP)	12	45.7 — 127	Yes
4-Chloro-3-methylphenol	2	1,760 — 1,930	No
2-Chlorophenol	4	1,630 — 1,830	No
Chrysene	51	46.4 — 29,800	Yes

**Table 7-5b  
 Subzone H-3  
 Organic Constituents in Surface Soil**

Compound Name	Number of Detections	Range of Concentrations (µg/kg)	ECPC
<b>Semivolatile Organic Compounds (N = 89)</b>			
Dibenzo(a,h)anthracene	19	62 — 7,380	Yes
Dibenzofuran	7	54.7 — 2,510	Yes
1,4-Dichlorobenzene	4	1,200 — 1,420	No
2,4-Dinitrotoluene	4	1,390 — 1,480	No
Fluoranthene	52	44.8 — 18,000	Yes
Fluorene	8	55.5 — 1,500	Yes
Hexachlorobutadiene	1	86	No
Indeno(1,2,3-cd)pyrene	29	74 — 17,000	Yes
2-Methylnaphthalene	3	44.6 — 524	No
Naphthalene	7	75.6 — 1,070	Yes
4-Nitrophenol	3	1,830 — 3,040	No
N-Nitroso-di-n-propylamine	4	1,320 — 1,750	No
Pentachlorophenol	4	1,220 — 1,830	No
Phenanthrene	39	49.2 — 33,500	Yes
Pyrene	55	47.8 — 41,800	Yes
3-Methylphenol	2	1,860 — 1,890	No
<b>Pesticides (N = 71)</b>			
delta-BHC	3	1.2 — 1.7	No
alpha-Chlordane	10	1.2 — 24.7	Yes
gamma-Chlordane	8	1.7 — 52.5	Yes
4,4'-DDD	10	2.4 — 12.2	Yes
4,4'-DDE	22	2 — 19.7	Yes
4,4'-DDT	30	2.4 — 64.6	Yes
Dieldrin	5	2.4 — 10	Yes
Endosulfan I	1	1.4	No
Endosulfan II	4	1.4 — 6.2	Yes

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Table 7-5b  
 Subzone H-3  
 Organic Constituents in Surface Soil

Compound Name	Number of Detections	Range of Concentrations ( $\mu\text{g}/\text{kg}$ )	ECPC
<b>Pesticides (N = 71)</b>			
Endrin	8	2.2 — 65.8	Yes
Endrin aldehyde	5	2.2 — 6.1	Yes
Heptachlor	6	1.1 — 30.5	Yes
Heptachlor epoxide	6	1.4 — 17.8	Yes
Methoxychlor	3	12.4 — 13.5	No
Chlorobenzilate	3	25.6 — 160	No
Isodrin	2	3.2 — 3.3	No
<b>Polychlorinated Biphenyls (N = 29)</b>			
Aroclor-1254	2	50 — 160	No
Aroclor-1260	3	60 — 376	No
<b>Herbicides (N = 51)</b>			
2,3,5-TP (Silvex)	24	5.6 — 1,067	Yes
2,3,4-T	20	6.5 — 107	Yes
2,4-D	16	35.1 — 545	Yes
<b>Organophosphate Pesticides (N = 51)</b>			
Parathion	9	21.3 — 37.5	Yes
<b>Dioxin (ng/kg) (N = 46)</b>			
2,3,7,8 TCDD	37	0.1202 — 3.7747 <sup>a</sup>	Yes

**Notes:**

- a = Concentration is estimated (EMPC qualified).
- N = Numbers of Samples
- $\mu\text{g}/\text{kg}$  = micrograms per kilogram
- ng/kg = nanograms per kilogram

**Table 7-6a**  
**Surface Water Concentrations (Shipyard Creek)**

Parameter	Number of Samples	Number Detected	Range	Mean	Effect Levels (EL)	HQ	ECPC
<b>Inorganic (µg/L)</b>							
Aluminum	2	2	4,100 — 6,210	5,155	1,500 <sup>c</sup>	4.1	Yes
Arsenic	2	2	7.2 — 8	7.6	36 <sup>a</sup>	0.22	No
Cadmium	2	1	2.4	2.4	9.3 <sup>a</sup>	0.25	No
Chromium (Total)	2	2	200 — 221	210.5	103/50 <sup>b</sup>	NC	Yes
Copper	2	2	40.7 — 50.0	45.7	2.9 <sup>a</sup>	17.5	Yes
Lead	2	2	51.3 — 55.5	53.4	8.5 <sup>a</sup>	6.5	Yes
Nickel	2	2	12.7 — 15	13.9	8.3 <sup>a</sup>	1.8	Yes
Zinc	2	2	196 — 229	212.5	86 <sup>a</sup>	2.7	Yes
<b>Organic (µg/L)</b>							
None Detected							

**Notes:**

- a = USEPA/SCDHEC ambient water quality criteria — chronic saltwater
- b = USEPA Region IV saltwater screening value for trivalent and hexavalent chromium (1995b)
- c = Florida surface water quality criteria (closest state having criteria for constituent)
- HQ = Hazard Quotient — calculated using maximum concentration divided by EL
- ECPC = Ecological Chemical of Potential Concern
- NC = Not Calculable (Concentrations detected were *total* chromium, which does not have an available EL)

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Table 7-6b  
 Sediment Concentrations (Shipyard Creek)

Parameter	Number of Samples	Number Detected	Range	Mean	Effects Level (EL)	Number of Times EL Exceeded	HQ	ECPC
<b>Inorganic (mg/kg)</b>								
Aluminum	4	4	5,160 — 21,400	16,190	NA	—	—	Yes
Antimony	4	1	2.7	2.7	12	0	0.2	No
Arsenic	4	4	3.3 — 15.6	11.2	7.24	3	2.2	Yes
Barium	4	4	17.7 — 29.1	21.7	NA	—	—	Yes
Beryllium	4	4	.57 — 1.0	0.9	NA	—	—	Yes
Cadmium	4	2	.23 — .64	0.4	1.0	0	0.64	No
Chromium	4	4	17.8 — 291	122.3	52.3	2	5.6	Yes
Cobalt	4	4	2.3 — 5.7	4.7	NA	—	—	Yes
Copper	4	4	28.7 — 228.0	107.3	18.7	4	12.2	Yes
Lead	4	4	44.8 — 107	82.1	30.2	4	3.5	Yes
Manganese	4	4	25.7 — 274	184	NA	—	—	Yes
Mercury	4	4	0.02 — 0.69	0.35	0.13	3	5.3	Yes
Nickel	4	4	14.2 — 37.3	23.5	15.9	3	2.3	Yes
Selenium	4	4	.56 — 1.5	1.1	NA	—	—	Yes
Vanadium	4	4	17.4 — 52.2	41.7	NA	—	—	Yes
Zinc	4	4	115 — 387	189.0	124	2	3.1	Yes

**Table 7-6b**  
**Sediment Concentrations (Shipyards Creek)**

Parameter	Number of Samples	Number Detected	Range	Mean	Effects Level <sup>a</sup> (EL)	Number of Times EL Exceeded	HQ	ECPC
<b>Organic (<math>\mu\text{g}/\text{kg}</math>)</b>								
tPCBs	4	3	110 — 4,460	1,175	33	3	135	Yes
Aldrin	4	1	18	18	NA	—	—	No
beta-BHC	4	1	7	7	NA	—	—	No
4,4'-DDT	4	1	15	15	3.3	1	4.5	Yes
4,4'-DDD	4	2	4 — 41	22.5	3.3	2	12.4	Yes
4,4'-DDE	4	4	4 — 110	34.7	3.3	4	33.3	Yes
tDDT	4	4	4 — 151	52.3	3.3	4	15.8	Yes
Fluoranthene	4	2	230 — 9,500	4,900	330	1	28.8	Yes
Pyrene	4	2	280 — 6,400	3,340	330	1	19.4	Yes
Benzo(a)anthracene	4	1	87	87	330	0	0.3	No
tPAHs	4	2	587 — 15,900	8,243.5	1,684	1	9.4	Yes

**Notes:**  
 a = Effects levels represent USEPA Region IV (1995b) Draft Sediment Screening Values (SSVs).  
 HQ = Hazard Quotient - calculated using maximum concentration divided by EL.  
 ECPC = Ecological Chemical of Potential Concern.  
 mg/kg = milligrams per kilogram  
 $\mu\text{g}/\text{kg}$  = micrograms per kilogram

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Table 7-6c  
 Subzone H-4 Sediments Concentrations

Parameter	Number of Samples	Number Detected	Range	Mean	Effects Level (EL)	Number of Times EL Exceeded	HQ	ECPC
<b>Inorganic (mg/kg)</b>								
Aluminum	9	9	3,830 — 20,400	8,742	NA	—	—	Yes
Antimony	9	1	6.9	6.9	12	0	0.6	No
Arsenic	9	9	0.62 — 19.6	9.4	7.24	6	2.7	Yes
Barium	9	5	5.3 — 122	36.1	NA	—	—	Yes
Beryllium	9	9	0.07 — 1.1	0.46	NA	—	—	Yes
Cadmium	9	5	0.7 — 1.7	0.84	1.0	2	1.7	Yes
Chromium	9	9	6.5 — 59.2	41.6	52.3	2	1.1	Yes
Cobalt	9	9	0.6 — 5.5	2.7	NA	—	—	Yes
Copper	9	9	6.3 — 53.7	25.7	18.7	5	2.9	Yes
Cyanide	9	1	2.0	2.0	NA	—	—	No
Lead	9	5	5.3 — 92.2	34.1	30.2	2	3.1	Yes
Manganese	9	9	8.8 — 266	89.5	NA	—	—	Yes
Mercury	9	8	0.3 — 0.26	0.1	0.13	3	2.0	Yes
Nickel	9	9	2.8 — 24.6	16.5	15.9	5	1.5	Yes
Selenium	9	3	1.2 — 2.2	1.7	NA	—	—	Yes
Vanadium	9	9	4.6 — 56.0	30.8	NA	—	—	Yes
Zinc	9	9	8.5 — 147	80.0	124	2	1.2	Yes
<b>Organic (µg/kg)</b>								
tPCBs	9	3	210 — 360	277	33	3	10.9	Yes
alpha-Chlordane	9	2	2 — 14	8	NA	—	—	Yes

Table 7-6c  
 Subzone H-4 Sediments Concentrations

Parameter	Number of Samples	Number Detected	Range	Mean	Effects Level (EL)	Number of Times EL Exceeded	HQ	ECPC
<b>Organic (<math>\mu\text{g}/\text{kg}</math>)</b>								
gamma-Chlordane	9	2	1 – 17	9	NA	—	—	Yes
4,4'-DDT	9	4	3 – 29	16.5	3.3	3	8.8	Yes
4,4-DDD	9	3	10 – 11	10.7	3.3	3	3.3	Yes
4,4'-DDE	9	3	2 – 36	13	3.3	3	10.9	Yes
$\alpha$ -DDT	9	6	2 – 65	27.2	3.3	3	19.7	Yes
Fluoranthene	9	1	120	—	330	0	0.4	No
Acenaphthene	9	1	230	—	330	0	0.7	No
Pyrene	9	1	110	—	330	0	0.3	No
Fluorene	9	1	160	—	330	0	0.5	No
Phenanthrene	9	1	150	—	330	0	0.5	No
Dibenzofuran	9	1	140	—	NA	—	—	No
Dichlorophenol	9	1	120	—	NA	—	—	No
Chrysene	9	1	140	—	330	0	0.4	No
Benzo(b)fluoranthene	9	1	100	—	NA	—	—	No
$\Sigma$ PAHs	9	1	910	—	1684	0	0.5	No

**Notes:**

- a = Effects levels represent USEPA Region IV (1995b) Draft Sediment Screening Values (SSVs).
- HQ = Hazard Quotient = maximum concentration/effects level.
- ECPC = Ecological Chemical of Potential Concern.
- mg/kg = milligrams per kilogram
- $\mu\text{g}/\text{kg}$  = micrograms per kilogram

## **7.5 Contaminant Fate and Transport**

Surface soil across the site consists of fine- to medium-grained sand with silt and some clay. This soil type is typically low in organic material with medium permeability. These factors most likely limit development of a microbial community, thereby reducing the likelihood of microbial decomposition of sorbed organic contaminants. The fate of these contaminants then will be expected to: 1) remain in the soil to undergo degradation and/or 2) migrate downward.

In addition, contaminants sorbed to surface soil conceivably could be transported via air or surface water runoff. However, both of these pathways are unlikely as major routes. Contaminants are not expected to spread far via surface runoff due to the highly permeable nature of the substrate. Although storm drains and ditches are near Zone H AOC/SWMUs, most of these act more as detention basins rather than surface water conveyances. Therefore, the risk from surface water migration from Zone H AOC/SWMUs to ecological subzones is considered negligible. The physical adsorption of contaminants to soil particles and available organic material also limits horizontal migration. Migration via air pathways could be significant only as it relates to dispersal of upper soil layer particles during high winds typical to coastal areas. Because sand particles are relatively large and heavy, extended migration through this route is not expected. Fate and transport issues are discussed in detail in Section 5.

### **Stressor Characteristics**

#### ***Inorganics***

In general, heavy metals adversely affect survival, growth, reproduction, development, and metabolism of both terrestrial and aquatic invertebrate species, but effects are substantially modified by physical, chemical, and biological variables. Pascoe et al. (1994) observed that, in general, bioavailability of metals and arsenic in soil to small mammals was limited. The study also suggests that metal and arsenic intake for higher tropic species may be similarly limited. Most heavy metals do not biomagnify. In contact tests with terrestrial earthworms the

order of toxicity for heavy metals from most toxic to least toxic was copper > zinc > nickel = cadmium > lead.

There are relatively little data on the behavior of antimony. Over a broad range of soil redox conditions (Eh -0.5 to 0.5), most soil antimony would be expected to exist in insoluble forms, if pH is less than 7.5. As a result of these conditions, antimony would be expected to have low mobility.

Arsenic naturally occurs and, with respect to cycling in the environment, is constantly changing. Many inorganic arsenicals are known teratogens and are more toxic than organic arsenicals (Eisler, 1988a). Soil biota appear to be capable of tolerating and metabolizing relatively high concentrations (microbiota to 1,600 mg/kg) of arsenic (Wang et al., 1984). But adverse effects to aquatic organisms have been reported at concentrations of 19 to 48 µg/L in water. Arsenic soil does not appear to magnify along the aquatic food chain.

Cadmium is a relatively rare heavy metal. It is a known teratogen and carcinogen and probably a mutagen, and has been implicated as the cause of severe deleterious effects on fish and wildlife (Eisler, 1985). Birds and mammals are comparatively resistant to the biocidal properties of cadmium. Freshwater organisms appear to be the most susceptible group to cadmium toxicity and this is modified significantly by water hardness. Adsorption and desorption processes are likely to be major factors in controlling cadmium concentrations in natural waters. Adsorption and desorption rates of cadmium are rapid on mud solids and particles of clay, silica, humic material, and other naturally occurring solids.

Hexavalent chromium (Cr VI) produces more adverse effects to biota than does the trivalent phase. In clayey sediments, trivalent chromium dominates and benthic invertebrate bioaccumulation is limited (Neff et al., 1978). The solubility and potential bioavailability of

waste chromium added to soil through sewage sludge are modified by soil pH and organic complexing substances (James and Bartlett, 1983).

Copper is an essential micronutrient and, therefore, it is readily accumulated by aquatic organisms. It is a broad-spectrum biocide which may be associated with both acute and chronic toxicity.

In soil, lead concentrates in organic-rich surface horizons (NRCC, 1973). Estimated residence time of lead in soil is about 20 years (Nriagu, 1978). In sediments lead is primarily found in association with iron and manganese hydroxides and may also form associations with clays and organic matter. Under oxidizing conditions, lead tends to remain tightly bound to sediments, but is released into the water column under reducing conditions. Lead may accumulate to relatively high concentrations in aquatic biota.

Mercury is a known mutagen, teratogen, and carcinogen. It adversely affects reproduction, growth and development, motor coordination, and metabolism. Mercury has a high potential for bioaccumulation and biomagnification, and is slow to depurate. Organomercury compounds produce more adverse effects than inorganic mercury compounds. Inorganic mercury can be modified to organic mercury compounds through biological transformation processes.

In natural waters zinc speciates into the toxic aquo ion, other dissolved chemical species, and various inorganic and organic complexes, and, in addition, it is readily transported. Most zinc introduced into aquatic environments is eventually partitioned into the sediments. Reduced conditions enhance zinc's bioavailability.

No information was available on the toxicological effects associated with other inorganic ECPCs for soil and sediment.

### ***Organics***

PAHs vary by molecular weight. With increasing molecular weight, aqueous solubility decreases and the log  $K_{ow}$  increases, suggesting increased solubility in fats, a decrease in resistance to oxidation and reduction, and a decrease in vapor pressure (Eisler, 1987a). Accordingly, PAHs of different molecular weight vary substantially in their behavior and distribution in the environment and in their biological effects. In water, PAHs either evaporate, disperse into the water column, become incorporated into sediments, or undergo degradative processes such as photooxidation, chemical oxidation, and biological transformation by bacteria and animals (Neff, 1979).

Most environmental concern has focused on PAHs that range in molecular weight from 128.16 (naphthalene) to 300.36 (coronene). Generally, lower molecular weight PAH compounds with containing two or three aromatic rings exhibit significant acute toxicity but are not carcinogenic. Higher molecular weight PAH compounds, four to seven rings, are significantly less toxic, but are demonstrably carcinogenic, mutagenic, or teratogenic to aquatic species. PAHs show little tendency to biomagnify in food chains because most are rapidly metabolized (Eisler, 1987a). Very little information is available on food chain adverse effects as a result of soil PAH contamination.

Organochlorine pesticides have been used extensively in the United States since the 1940s. They appear to be ubiquitous in the environment, being found in surface water, sediment, and biological tissues. They are readily absorbed by warm-blooded species and degradatory products are frequently more toxic than the parent form. Food chain biomagnification is usually low, except in some marine mammals. In soil invertebrates, organochlorine pesticides can accumulate to concentrations higher than those in the surrounding soil, and residues may in turn be ingested by birds and other animals feeding on earthworms (Beyer and Gish, 1980). Most environmental effects studies have been directed at mammals and birds.

PCBs are distributed worldwide with measurable concentrations recorded in fishery and wildlife resources from numerous locations (Eisler, 1986). They are known to bioaccumulate and to biomagnify within the food chain and to elicit biological effects such as death, birth defects, tumors, and a wasting syndrome. In terrestrial environments, PCBs are rapidly metabolized from the soil into the terrestrial food chain (McKee, 1992). Subsoil-dwelling organisms may directly absorb PCBs and food chain transfer to lower-level vertebrate species may occur.

Dioxins are present as trace compounds in some commercial herbicides and chlorophenols (Eisler, 1986). The most toxic and most extensively studied dioxin is 2,3,7,8-TCDD. Laboratory studies with birds, mammals, aquatic organisms, and other species have demonstrated that exposure to 2,3,7,8-TCDD can result in acute and delayed mortality as well as mutagenic and reproductive effects. In soil, microbial decomposition of TCDD is slow (Ramel, 1978) and uptake by vegetation is considered negligible (Blair, 1973).

## **7.6 Exposure Pathways and Assessment**

### ***Infaunal Invertebrates***

The primary exposure pathway evaluated for infaunal invertebrates will be via direct contact with surface soil. An assessment endpoint of a well-balanced soil infaunal community will be qualitatively measured by comparing literature data on toxic effects to actual soil concentrations.

### ***Terrestrial Wildlife***

For terrestrial wildlife species, exposure would include direct dermal contact, ingestion of soil particles, and food-chain transfer. Small mammals could contact contaminated soil if the area is used as a migratory corridor or if animals burrow into it. The contact time, and thus exposure, will be limited when animals are crossing the area, but could be lengthy if burrows are established. Dermal contact by small reptiles and amphibians would be similar to that for mammals. For insect populations, direct exposure to ground-dwelling species could provide a link for contaminant transfer to higher-level predators.

The assessment endpoint selected for terrestrial wildlife in subzones H-1, H-2, and H-3 is the maintenance of well-balanced terrestrial wildlife populations and communities. As a measure of the assessment endpoint selected, results of laboratory toxicity studies in literature that relate the oral dose of a contaminant with adverse response to growth, reproduction, or survival were used. Selected representative wildlife species evaluated through this comparison include: Eastern cottontail rabbit (*Sylvilagus floridanus*), red-tailed hawk (*Buteo jamaicensis*), and short-tailed shrew (*Blarina brevicauda*) in H-1; American robin (*Turdus migratorius*) and Eastern cottontail in H-2; and Eastern cottontail rabbit, red-tailed hawk and short-tailed shrew in H-3. All of these species (or an equivalent) are likely to occur within the designated subzones in Zone H.

To assess biotransfer of contaminants along food chains the total potential dietary exposure (PDE) has been modeled for representative wildlife species within subzones H-1, H-2, and H-3. PDEs are calculated based on predicted concentrations of the ECPC in food items that the species would consume, the amount of soil it would ingest, the relative amount of different food items in its diet, body weight, and food ingestion rate (Table 7-7). The concentrations of ECPCs in food items are estimated based upon literature-reported bioaccumulation factors (BAFs), which are a ratio of the ECPC concentration in dietary items to the concentration in soil. The BAFs reported for avian and mammalian species are reported ratios of ECPCs in the tissue of the animals to the concentrations of ECPCs in their diets.

The site foraging factor (SFF) allows for consideration of the frequency of feeding in the site area by estimating the acreage of the site relative to the receptors feeding range and by considering the fraction of the year the receptor would be exposed to site contaminants.

**Table 7-7  
 Wildlife Contaminant Exposure Model for Surface Soil  
 Zone H**

$$\text{Food Contaminant Concentration (mg/kg)} = \text{BAF}^1 \times \text{Soil Contaminant Concentration (mg/kg)}$$

$$\text{Soil Exposure (SE) (mg/kg)} = (\% \text{ of diet as soil}) \times \text{Soil Contaminant Concentration (mg/kg)}$$

$$\text{PDE (mg contaminant/kg BW/day)} = \frac{[P_1 \times T_1 + P_2 \times T_2 + \dots P_n \times T_n + \text{SE}] \times \text{IR}_{\text{diet}} \times \text{SFF}}{\text{BW}}$$

where:

- $P_n$  = percent of diet composed of food item N
- $T_n$  = tissue concentration in food item N (mg/kg), (Food Contaminant Concentration)
- $\text{IR}_{\text{diet}}$  = food ingestion rate of receptor (kg of food per day)
- SFF = site foraging factor (cannot exceed 1)
- BW = receptor body weight (kg)
- 1 = BAF from Table 7-9
- PDE = Potential Dietary Exposure

### ***Vegetation***

Woody and herbaceous vegetation in subzones H-1, H-2, and H-3 could likely incorporate certain detected constituents (metals) through processes such as uptake/accumulation, translocation, adhesion, or biotransformation. Terrestrial herbivores could ingest plant-borne constituents.

### ***Aquatic Wildlife***

The primary exposure pathway evaluated for aquatic wildlife species in Shipyard Creek and within subzone H-4, is contact/interface with water and sediment. An assessment endpoint, evaluating the aquatic community health, has been selected with a measurement endpoint that predicts chronic-effects to aquatic community species.

## **7.7 Ecological Effects Assessment**

### ***Infaunal Invertebrates***

Predicted potential adverse ecological effects to soil invertebrates from identified ECPCs are based on effects information in available literature. Because soil MCLs are unavailable for effects levels, studies are used for comparative qualitative assessments only.

### ***Terrestrial Wildlife***

Potential adverse effects associated with the identified ECPCs to bird and mammal species are based on food uptake potential. Available reference toxicity values (RTVs) were determined for each measurement endpoint species selected. The RTV relates the dose of a respective ECPC in an oral exposure with an adverse effect. The lethal RTV has been determined to be one-fifth of the lowest reported LD<sub>50</sub> value (concentration of a contaminant at which half of the exposed test population die) for the most closely related test species. One-fifth of an oral LD<sub>50</sub> value is considered to be protective of lethal effects for 99.9% of individuals in a test population (USEPA, 1986). It is assumed that this level of risk to individuals within terrestrial wildlife populations across Zone H is acceptable.

A sublethal RTV is also identified, representing a threshold for sublethal effects. Sublethal effects are defined as those that impair or prevent reproduction, growth, or survival. The sublethal RTV reflects the assessment endpoint chosen as the basis for establishing risk.

### ***Vegetation***

Toxicity to terrestrial plants from soil contaminants detected within the subzones is qualitatively evaluated. Risk potentials are discussed relative to literature studies and general information on phytotoxic mechanisms by selected ECPCs.

### ***Aquatic Wildlife***

Potential adverse ecological effects to aquatic species from identified ECPCs are predicted based on the most conservative benchmark available (i.e., chronic water quality criteria, sediment screening value, or effects information from literature). Effects are predicted using a preliminary screening approach. Maximum water and sediment concentrations for ECPCs are divided by the available benchmark to produce an HQ. Calculated HQs for ECPCs from each media will be summed to determine an HI. HQs that show a result higher than 1 are considered to demonstrate risk. Values higher than 10 are considered to be of moderately high risk and above 100, extreme risk.

## **7.8 Risk Characterization**

Little information exists on the toxic effects to terrestrial organisms from VOCs. Primarily, the only information available are effects studies related to human health from inhalation of specific compounds by laboratory animals. Impact from the limited occurrence and relatively low concentrations of volatile compounds observed in soil is difficult to assess but it is predicted that little to no effect to terrestrial species will occur.

Most toxicological information reviewed for the infaunal invertebrates (Section 7.8.1) dealt with earthworms and other infaunal species. It is important to note that soil found in Zone H is

predominantly sand and may not support these specific-type organisms. Although infaunal species found in the sandy environment may not be the same as those dealt with in the literature, the ecological niche which they occupy should be similar and, therefore, comparison to toxicological concentrations should apply.

### **7.8.1 Infaunal Invertebrates**

Although some semivolatiles in soil are considered carcinogenic to mammals, very few field studies exist on their toxicity to terrestrial infauna. Generally, PAHs break down in natural systems via photodegradation and microbial transformation. Neuhauser et al. (1986) found that specific phenol compounds (4-nitrophenol, 2,4,6-trichlorophenol, and phenol) were somewhat toxic to earthworms, with PAHs being relatively less toxic than other semivolatile compounds studied. Artificial soil tests produced lethal concentration ( $LC_{50}$ ) values for fluorene and phenol near 200 mg/kg and 400 mg/kg, respectively (Table 7-8). Callahan et al. (1994) found similar results in their study on toxicity of 62 chemicals to several earthworm species. Fluorene is acutely toxic at certain concentrations but it is not a carcinogen. It is important to note that field variability and soil chemical matrices can greatly influence toxicological effects of PAH compounds.

Most toxicological studies on terrestrial infaunal organisms have been directed at measuring pesticide effects. Earthworm toxicology and response information is the most prevalent. In a study by Beyer and Gish (1980), persistence of DDT, dieldrin, and heptachlor were observed in earthworms from field study plots. Investigators agree that earthworms can accumulate pesticides to concentrations found in residence soil. Callahan, et al. (1991), showed very good soil-to-tissue correlation ( $R = .725$ ), with accumulation of DDT in single earthworms up to 22 mg/kg. Beyer and Gish (1980) found that earthworms accumulated DDT to 32 mg/kg. Barker (1958) associated poisoning (lethality) of robins with 60 mg/kg DDT in earthworms, and Collett and Harrison (1968) found that blackbirds and thrushes were impacted at residues near

Table 7-3  
 Summary of Chemical Effects Studies on Terrestrial Infaunal Invertebrates

Study	Organisms	Measured Parameter	Effects Level	Measured Response
Parmelee et al. (1993)	Nematode/micrarthropods	Copper	200 mg/kg	Significant decline in numbers
Neuhauser et al. (1986)	earthworm <i>Eisenia foetida</i>	Copper salts	643 mg/kg	LC <sub>50</sub>
		Zinc salts	662 mg/kg	LC <sub>50</sub>
		Nickel salts	757 mg/kg	LC <sub>50</sub>
		Cadmium salts	1843 mg/kg	LC <sub>50</sub>
		Lead salts	6,000 mg/kg	LC <sub>50</sub>
		4-Nitrophenol	38 mg/kg	LC <sub>50</sub>
		Fluorene	173 mg/kg	LC <sub>50</sub>
Roberts & Dorough (1984)	<i>Eisenia foetida</i>	Cadmium chloride	10-100 µg/cm <sup>2</sup>	LC <sub>50</sub>
		Copper sulfate	10-100 µg/cm <sup>2</sup>	LC <sub>50</sub>
		Lead nitrate	10-100 µg/cm <sup>2</sup>	LC <sub>50</sub>
Malecki et al. (1982)	<i>Eisenia foetida</i>	Cadmium	250 mg/kg	Growth difference to control
		Nickel	440 mg/kg	Growth difference to control
		Copper	1,320 mg/kg	Growth difference to control
		Zinc	2,800 mg/kg	Growth difference to control
		Lead	21,600 mg/kg	Growth difference to control
Strait (1984)	Mite <i>Platynothrus peltifer</i>	Copper	200 mg/kg	Population decrease
van Straalen et al. (1989)	Mites	Cadmium	> 128 mg/kg	Mortality

Table 7-8  
 Summary of Chemical Effects Studies on Terrestrial Infaunal Invertebrates

Study	Organisms	Measured Parameter	Effects Level	Measured Response
McKee (1992)	Terrestrial epigeic <sup>a</sup> Invertebrates	PCBs	120,000 mg/kg	No community structure effects
Callahan et al. (1991)	earthworms <i>L. terrestris</i>	DDT	400 µg/kg	No detectable concentration in tissue from soil concentrations
		DDD	700 µg/kg	
		DDE	200 µg/kg	
Menzis et al. (1992)	<i>E. foetida</i>	DDT	1,000 [4,000] <sup>b</sup> µg/kg	Survival; no effect for LC <sub>50</sub> test
		DDD	1,000 [12,000] <sup>b</sup> µg/kg	
		DDE	1,000 [2,000] <sup>b</sup> µg/kg	
Miller et al. (1985)	Earthworm	Copper	644 mg/kg	EC <sub>50</sub>
		Zinc	628 mg/kg	EC <sub>50</sub>
	Microtox (15 min.)	Copper	0.28-0.42 mg/kg	Photo reduction
		Zinc	1.6 mg/kg	Photo reduction
Palma et al. (1993)	Crickets <i>Acheta domesticus</i>	PCB	1,200 mg/kg	LC <sub>50</sub>
Reinecke & Nash (1984)	earthworm <i>Allolobophora caliginosa</i> <i>Lumbricus rubellus</i>	Dioxin	< 5 mg/kg	No mortality
			> 10 mg/kg	Lethality
Ma (1984)	<i>Lumbricus rubellus</i>	Copper	100 --- 150 mg/kg	Cocoon production decrease
		Copper	300 mg/kg	Mortality
Beyer et al. (1985)	<i>Eisenia foetida</i>	Methyl mercury	25 mg/kg	100% mortality
			5 mg/kg	21% mortality

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Table 7-8  
 Summary of Chemical Effects Studies on Terrestrial Infaunal Invertebrates

Study	Organisms	Measured Parameter	Effects Level	Measured Response
Abbasi and Sani (1983)	earthworm <i>Octochaetus pattoni</i>	Inorganic mercury	0.79 mg/kg	50% mortality
			5 mg/kg	100% mortality
Rhett et al. (1988)	<i>Eisenia foetida</i>	PCB	240 mg/kg	LC <sub>50</sub>
Nielson (1951)	earthworms	Copper	150 mg/kg	Population reduced by 1/2
			260 mg/kg	Population eliminated
Van Rhee (1967)	earthworms	Copper	85 mg/kg	Gradual decline of population
Ma (1982)	<i>Lumbricus rubellus</i>	Copper chloride	1,000 mg/kg	6-week LC <sub>50</sub>

Notes:

- a = Growth effects levels are average of at least five of six compounds; metal acetate; metal carbonate; metal chloride; metal nitrate; metal oxide, metal sulfate
- b = Carabidae, entobeyidae, formicidae, gryllidae and staphylinidae
- c = Average soil concentration levels [maximum values].

20 mg/kg. At concentrations observed in their study, Callahan et al. (1991) suggested that a feeding rate by robins of 10 to 12 earthworms in as many minutes (as observed by Macdonald, 1983) could provide a sufficient concentration of contamination for impacts to robins. Callahan et al. (1991), also found that chlordane, as with other pesticides, was taken up rapidly by earthworms. In Callahan et al. (1991), total DDT concentrations greater than 1,000 mg/kg in soil, along with documented long half-life information (5.7 years DDT), indicated a long-term significant risk to receptors.

Risk factors associated with PCBs are similar to those for pesticides. After acute mortality, food chain biomagnification and transfer are the most important issues to be considered when assessing long-term risk. Paine et al. (1993) suggested a benchmark value between 100 to 300 mg/kg PCB for mortality in terrestrial insects. Also, Rhett et al. (1988) observed  $LC_{50}$  values for earthworms treated with PCBs at 240 mg/kg. McKee (1992) reported that soil invertebrate community structure was not reduced by exposure to PCB-contaminated soil (maximum concentrations to 120,000 mg/kg wet weight), based on family-level classification of invertebrates.

Reinecke and Nash (1984) studied the toxic effects of dioxin (2,3,7,8-TCDD) in soil to earthworms. For two species, *Allolobophora caliginosa* and *Lumbricus rebellus*, concentrations of 5 mg/kg or less had no acute effect, but concentrations of 10 mg/kg and above were lethal.

Most studies on metals toxicity to terrestrial receptors have been directed at infaunal ecosystems or avian biology. Information on relative metal toxicities to earthworms was provided by Roberts and Dorough (1984) where, along with 90 other chemicals, three metal salts (cadmium chloride, copper sulfate, and lead nitrate) were tested. The results showed that these heavy metal salts fell into the "very toxic" category, with  $LC_{50}$  values in the 10 to 100  $\mu\text{g}/\text{cm}^2$  range. Although these concentrations (more specifically, application doses) may be relative to earthworms, it is improper to apply them to upper-level trophic species. Studies indicate that

some degradation products become increasingly more toxic to earthworms and less toxic to upper-level vertebrates. Other studies on toxicities of metal salts to earthworms have been conducted by Neuhauser et al. (1986), and Malecki et al. (1982). In the former study, metal nitrate compounds were relatively toxic to earthworms in this order: copper > zinc > nickel > cadmium > lead. Mean LC<sub>50</sub> values were 643, 662, 757, 1,843 and 6,000 mg/kg, respectively. In the latter study, six chemical forms of each metal were chosen to cover a broad range of solubility and to represent the forms likely to be found in the soil. Overall, cadmium was most toxic, followed by nickel, copper, zinc, and lead. It appears obvious from the results of these two studies that the form of the metal in soil is a major consideration in judging effects of its concentration on soil biota.

Ma (1984) investigated sublethal effects of copper in soil to growth, cocoon production, and litter breakdown activity for *Lumbricus rubellus*. Cocoon and litter breakdown activity were significantly reduced at 131 mg/kg copper and mortality was first observed at concentrations near 300 mg/kg.

Parmelee et al. (1993) found that total nematode/microarthropod (mostly mites) numbers declined in soil having copper concentrations above 200 mg/kg; omnivore-predator nematodes and specific microarthropod groups were significantly reduced at 100 mg/kg copper.

### ***Subzone H-1***

Maximum concentrations for some inorganic constituents found in H-1 may pose a high risk to infaunal species. The maximum copper concentration of 3,040 mg/kg is above the effects levels for earthworms as observed in several studies: Neuhauser et al. (1986), 643 mg/kg; Ma (1982), 150 mg/kg; and Nielsen (1951), 150 mg/kg. The maximum copper concentration was also above an effects level for mites as observed by Strait (1984). Also, the maximum soil concentration for lead (6,170 mg/kg) was just above the 6,000 mg/kg effects level to earthworms found by Neuhauser et al. (1986). The maximum zinc concentration (2,800 mg/kg) was above

or near the levels found to impact earthworms in two separate studies: Neuhauser et al. (1986), 662 mg/kg, and Malecki et al. (1982), 2,800 mg/kg. Effects to earthworms from inorganic mercury have also been documented at concentrations as low as 0.79 mg/kg, which is below the maximum mercury concentration (6.9 mg/kg) detected at H-1. Therefore, risks to infauna from mercury contamination is also possible.

Within H-1, risk to infaunal communities from observed inorganic and PAH concentrations is predicted. Although concentrations of individual PAH compounds (maximum to 4,200  $\mu\text{g}/\text{kg}$ ) are not above the minimum effects levels observed by Neuhauser et al. (1986) in earthworms ( $LC_{50} = 173,000 \mu\text{g}/\text{kg}$  for fluorene), the high frequency of occurrence across the site and potential additive effects of the 23 PAH compounds detected may impact soil biota. Risks related to biotransfer of contaminants through infaunal species to terrestrial vertebrate species will be addressed later.

Overall, risk to soil infaunal receptors from pesticide concentrations in H-1 are low. Observed concentrations (maximum near 16  $\mu\text{g}/\text{kg}$ ) are negligible and well below those cited in the literature (12,000+  $\mu\text{g}/\text{kg}$ ) where no effect was observed to earthworms. Potential transfer of pesticides through infaunal organisms to upper-level species is expected to be low. Again, this pathway will be evaluated relative to upper-level vertebrate species in subsequent sections.

The maximum PCB concentrations found in H-1 soil (2.30  $\mu\text{g}/\text{kg}$ ) were observed at two orders of magnitude below the lowest concentrations for PCBs cited in the literature where acute effects to soil invertebrates ( $LC_{50}=240 \mu\text{g}/\text{kg}$ ; Rhett et al., 1988). No effect is predicted to infauna from PCBs in soil.

Also, no acute effects to infauna from dioxin in soil at H-1 should occur. The observed maximum concentration of 8 nanograms per kilogram (ng/kg) is several orders of magnitude below the acute effects level to earthworms of 10 mg/kg as observed by Reinecke and Nash

(1984). No information was found related to chronic effects of dioxin to soil invertebrate populations.

### ***Subzone H-2***

Some inorganic constituents found in H-2 surface soil are at concentrations that pose a high risk to infaunal species. The maximum zinc concentration of 15,100 mg/kg is well above the effects levels observed in the literature which cause acute mortality and negative growth effects in earthworms (i.e. Neuhauser et al. [1986], 660 mg/kg; Malecki et al. [1982], 2,800 mg/kg; and Miller et al. [1985], 628 mg/kg). Also, maximum soil concentrations for copper (4,060 mg/kg) and lead (2,770 mg/kg) could conceivably present a risk to invertebrate populations. Effects to earthworms have also been documented (Abbasi and Soni [1983], 0.79 mg/kg) below the maximum mercury concentration (3.5 mg/kg) detected at H-2. Therefore, risks to infauna from mercury contamination is possible. Limited spatial distribution of elevated concentrations for all inorganics, however, will reduce risk potential within H-2.

PAH concentrations are not at individual compound concentrations that would indicate toxicity to infauna (see Table 7-4b). Considering the maximum concentrations detected and the limited spatial distribution, the potential for effects from total SVOCs detected is low. Based on literature studies (see Table 7-8), toxic effects resulting from PCB and dioxin concentrations detected should not be occurring.

Pesticides were not measured in soil at H-2.

### ***Subzone H-3***

Except for lead, soil inorganic concentrations should not present a risk to infaunal species. The maximum lead concentration detected of (20,900 mg/kg) was considerably above the LC<sub>50</sub> value (6,000 mg/kg) reported by Neuhauser et al. (1986), but was similar to the effects concentration (21,600 mg/kg) reported in Malecki et al. (1982), for the same earthworm species. Therefore,

the risk potential exists, but the wide range for effects reported in the literature tends to reduce this concern.

As in subzone H-1, individual PAH concentrations may not be critical, but additive effects from PAHs found, along with other SVOCs detected, may threaten soil infaunal species. Overall individual PAH concentrations were higher in H-3 than other subzones and this would be expected considering the area's historical use. Although PAH transfer to other biological organisms is possible, high PAH concentrations in soil can also lead to increased populations of microorganisms capable of degrading the compounds (Edwards, 1983).

Spatially, pesticide occurrence at H-3 appears to be limited. DDE was found most often but at less than half of the sample locations. Concentrations found for all pesticides, when compared to effects information for DDT, DDD, and DDE, do not indicate a risk to infaunal organisms. Also, PCB and dioxin concentrations detected (maximum: 376  $\mu\text{g}/\text{kg}$  and 3.77  $\text{ng}/\text{kg}$ , respectively) do not indicate a serious threat to lower-level soil invertebrates.

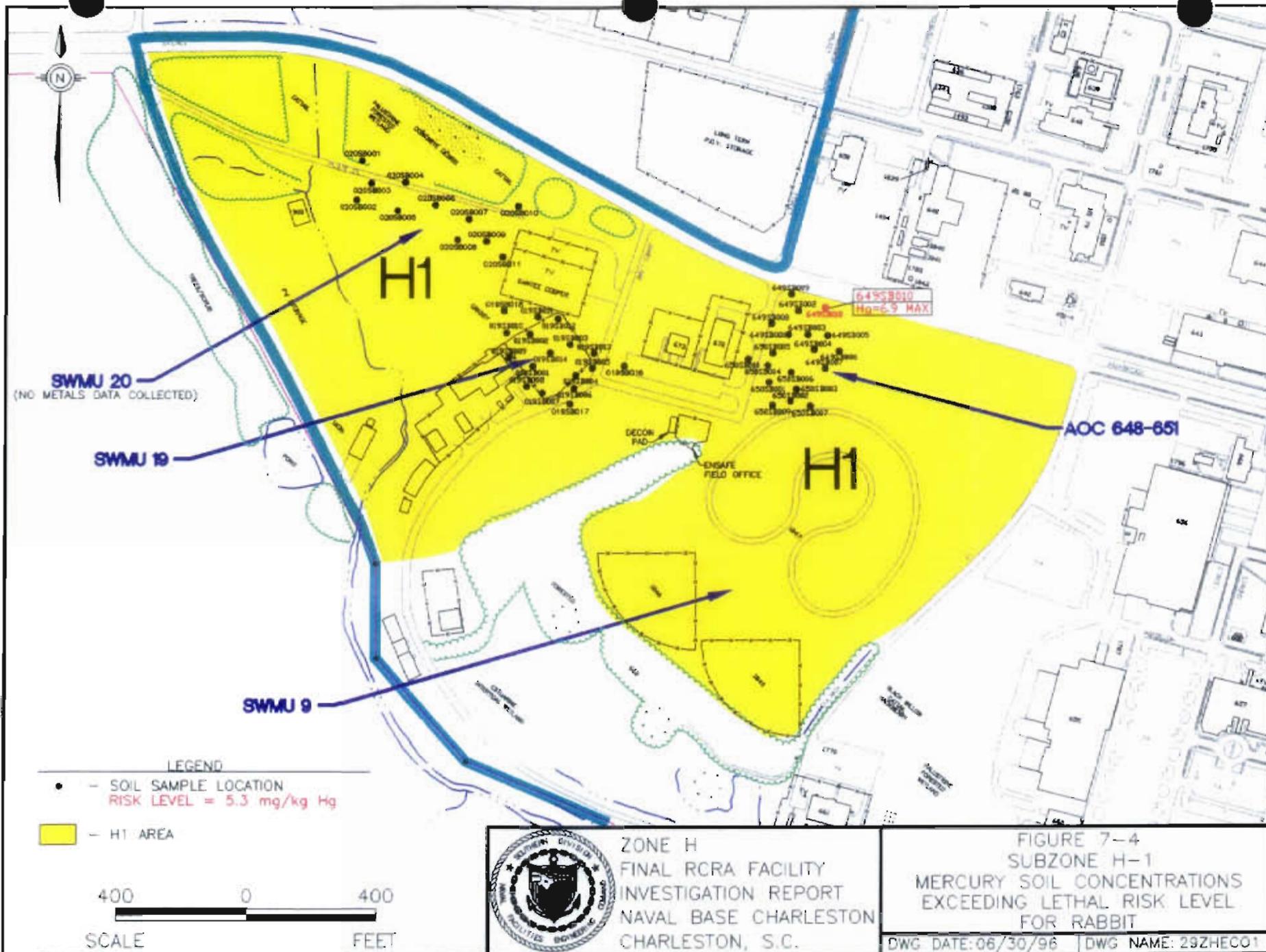
### **7.8.2 Terrestrial Wildlife**

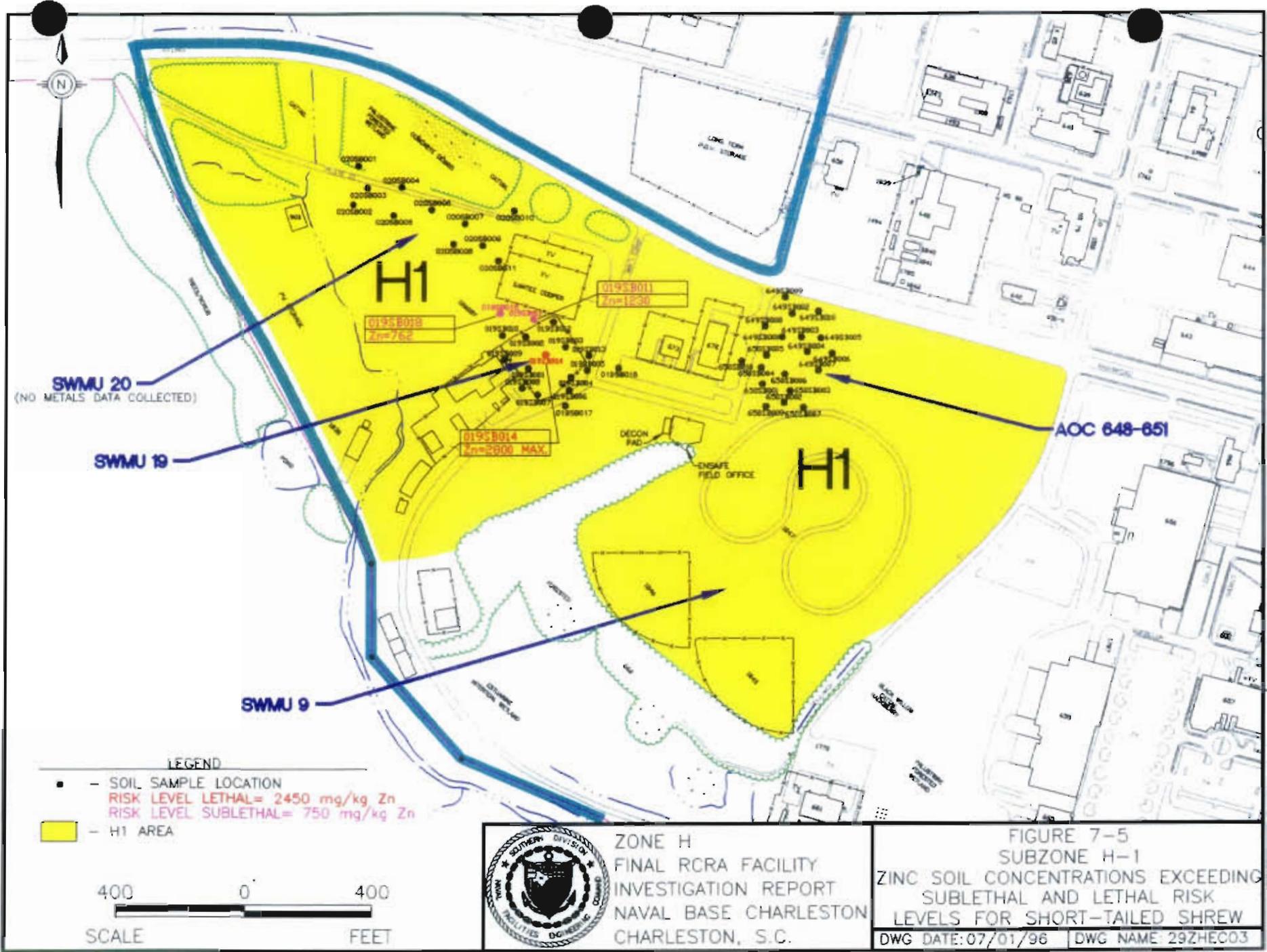
Risks for the representative wildlife species associated with ingestion of surface soil and food are quantitatively evaluated using HQs, which are calculated for each ECPC by dividing the estimated dietary exposure concentration (PDE) by the toxicological benchmark (RTV). HIs are determined for each representative wildlife species by summing the HQs for all ECPCs. When the estimated PDE is less than the RTV ( $\text{HQ} < 1$ ), the contaminant exposure is assumed to fall below the range considered to be associated with adverse effects for growth, reproduction, and survival and no risk to the wildlife populations is assumed. When the HQ or HI is greater than one, the ecological significance is discussed and risk is assumed. When HIs are greater than 1, the HQs comprising the HI were evaluated.

For representative terrestrial wildlife species, PDEs were calculated using available bioaccumulation data (Table 7-9) for ECPCs presented in Tables 7-3, 7-4, and 7-5. PDEs could not be calculated for those compounds without an associated BAF. Exposure parameters and assumptions for representative species at subzones H-1, H-2, and H-3 (Tables 7-10, 7-11, and 7-12 respectively) were used to calculate food contaminant concentrations. PDE values were obtained using the model for prediction of contaminant exposure presented in Table 7-7. When the maximum concentration of an ECPC produced HQs greater than 1, mean values for those constituents were then used to determine the soil concentration necessary to produce risk quotients (HQs) below 1 (see Table 7-13). HQs for both lethal and sublethal effects for ECPCs at subzones H-1, H-2, and H-3 were determined and are presented in Tables 7-14(a, b, c, and d), 7-15(a, b, c, and d), and 7-16(a, b, c, and d). This concentration is referred to as the Significant Risk Level (SRL) and is discussed in the following sections. Also, spatial relevance of concentrations exceeding the SRL for those ECPCs with HQs greater than 1 are presented as figures.

### ***Subzone H-1***

Potential lethal effects ( $HI > 1$ ) from maximum soil concentrations in subzone H-1 are present based on the HI values calculated for the Eastern cottontail rabbit and short-tailed shrew (Table 7-14a). For the rabbit, only mercury had an  $HQ > 1$ . Back-calculation, to determine at what concentration the HQ would fall below 1, showed only one location had a maximum concentration that was above the SRL for mercury of 5.3 mg/kg (Table 7-13 and Figure 7-4). For the shrew, only zinc had an HQ greater than 1. Seven locations had concentrations exceeding the SRL for zinc (Table 7-13 and Figure 7-5). Mean values for those ECPCs identified as major contributors to risk in H-1 all produced HQs below 1 (Table 7-14c).





**LEGEND**

- - SOIL SAMPLE LOCATION
- - H1 AREA

RISK LEVEL LETHAL= 2450 mg/kg Zn  
 RISK LEVEL SUBLETHAL= 750 mg/kg Zn

400 0 400  
 SCALE FEET



ZONE H  
 FINAL RCRA FACILITY  
 INVESTIGATION REPORT  
 NAVAL BASE CHARLESTON  
 CHARLESTON, S.C.

FIGURE 7-5  
 SUBZONE H-1  
 ZINC SOIL CONCENTRATIONS EXCEEDING  
 SUBLETHAL AND LETHAL RISK  
 LEVELS FOR SHORT-TAILED SHREW  
 DWG DATE: 07/01/96 DWG NAME: 29ZHEC03

Potential sublethal effects from maximum soil contaminant concentrations in subzone H-1 are present to all three wildlife species (Table 7-13b). HQs for the red-tailed hawk produced an HI above 1, but no single ECPC had an HQ which exceeded 1. Sublethal SRLs for the hawk were, therefore, not calculated.

For the rabbit, the sublethal HQ for copper was greater than 1. An SRL of 2,850 mg/kg was determined (Table 7-13). Only the location with the maximum concentration exceeded this level (Figure 7-6). For the shrew, both zinc and organic had an HQ above 1. Three locations across this subzone had concentrations exceeding the SRL for zinc (Table 7-13 and Figure 7-5) and 18 locations exceed the shrew's SRL for organic (Figure 7-7). Mean values for those ECPCs identified as major contributors to risk all produced HQs below 1 (see Table 7-14d).

### ***Subzone H-2***

Potential lethal and sublethal effects from maximum concentrations of soil contaminants in subzone H-2 are present based HI values calculated for the Eastern cottontail rabbit (Tables 7-15a and 7-15b). Maximum soil concentrations for copper, zinc, cadmium, and manganese produced the HQ values responsible for a lethal HI value of 2.9. Only zinc had an HQ above 1. Only the highest concentration of zinc (15,100 mg/kg) exceeded the respective SRL of 12,000 mg/kg (see Table 7-13 and Figure 7-8). Mean values for those ECPCs identified as major contributors to risk all produced HQs below 1 (Table 7-15c).

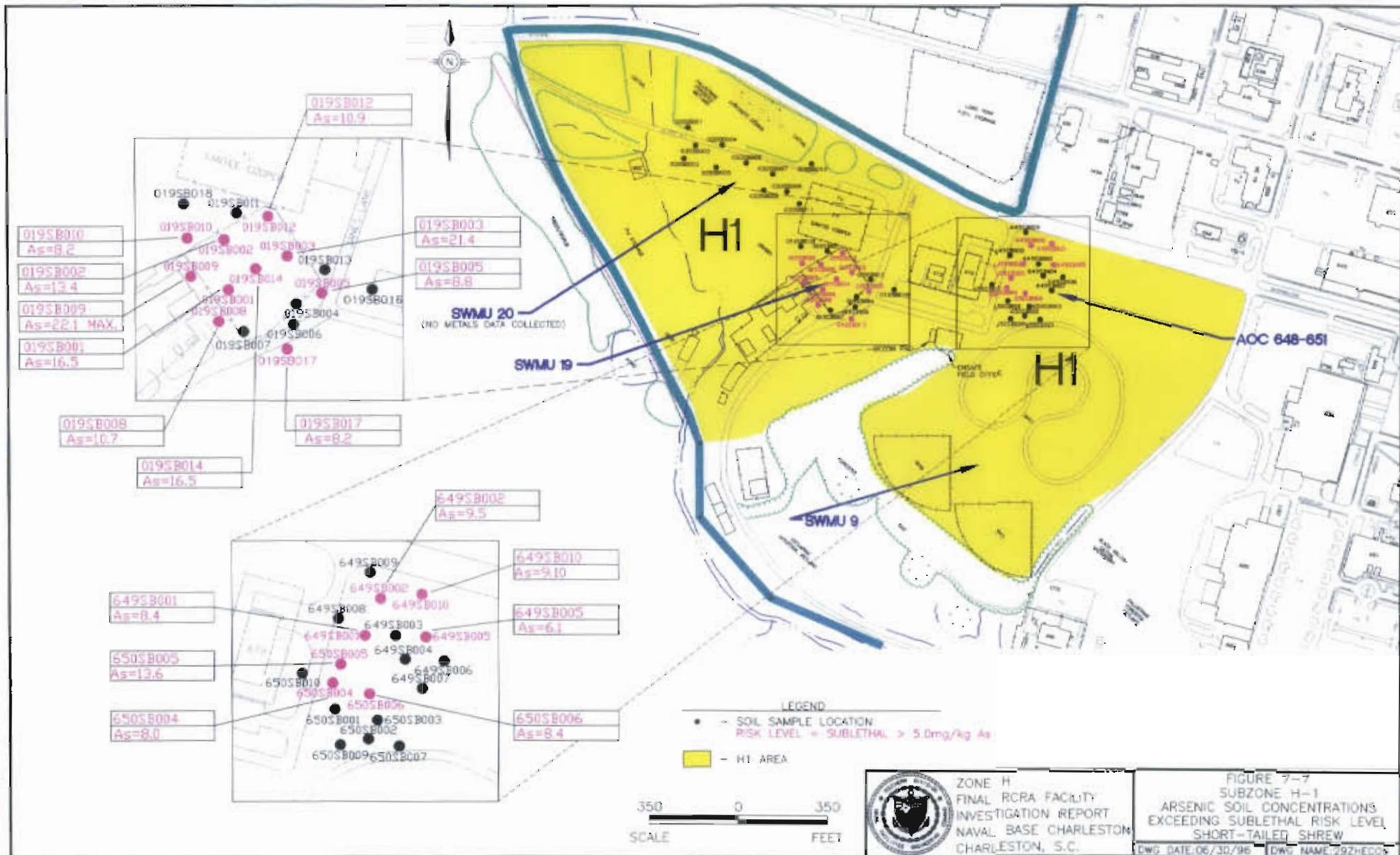
For sublethal effects, again, arsenic, cadmium, copper, zinc, and mercury had highest overall HQ values resulting in an HI of 6.6 for the cottontail and HI of 17 for the robin. Copper and zinc were the only inorganics having HQs greater than 1 (Table 7-15b). For copper, the 155 mg/kg SRL was exceeded at 13 locations (see Figure 7-9). The SRL for zinc (400 mg/kg) was also exceeded at 13 locations (see Table 7-13 and Figures 7-8). Mean values for those ECPCs identified as major contributors to risk all produced HQs below 1 (Table 7-15d).

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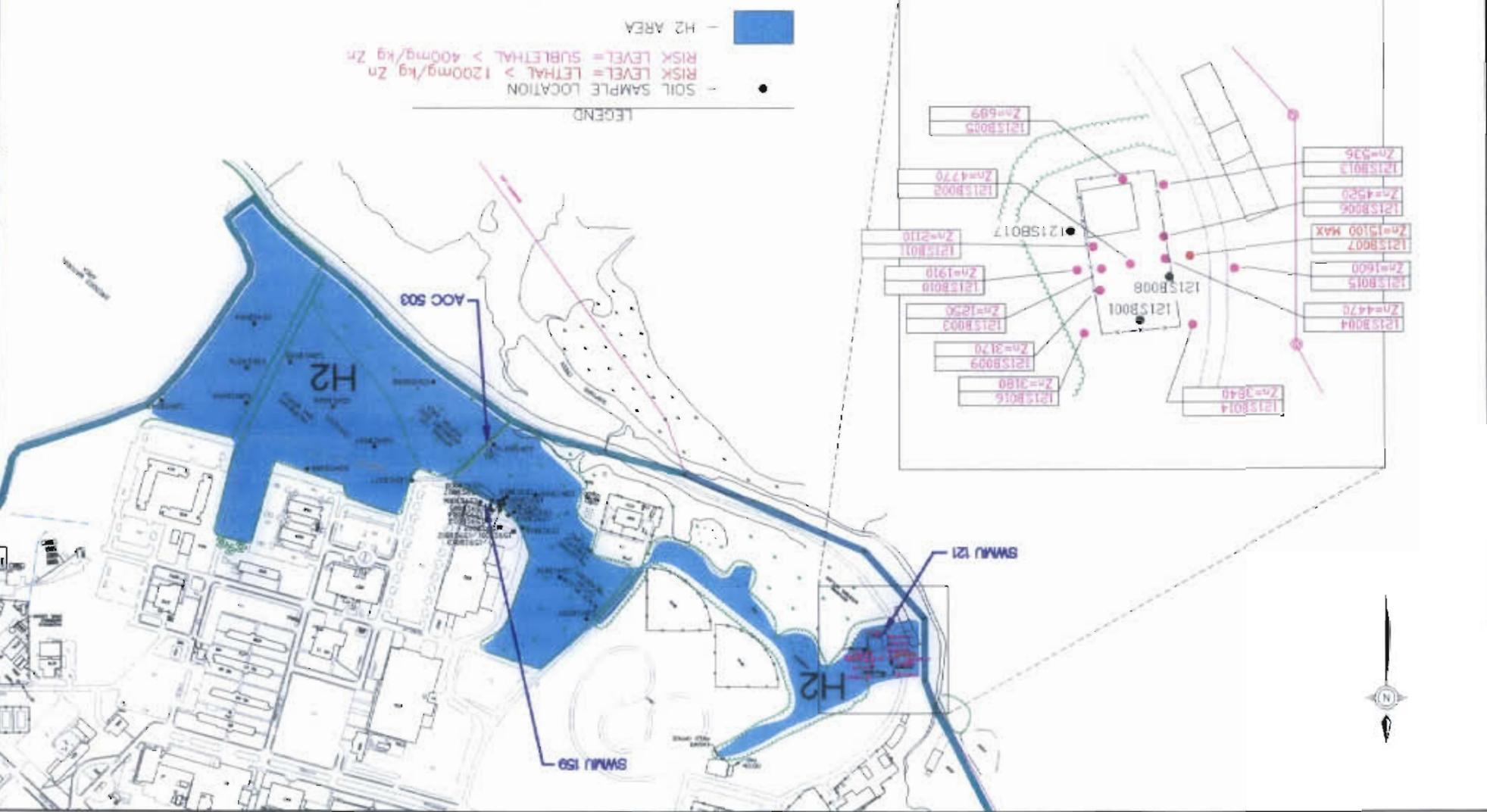


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FIGURE 7-7  
SUBZONE H-1  
ARSENIC SOIL CONCENTRATIONS  
EXCEEDING SUBLETHAL RISK LEVEL  
SHORT-TAILED SHREW  
DWG DATE: 06/30/98 DWG NAME: 292HECO2

FIGURE 7-8  
 SUBZONE H-2  
 ZINC SOIL CONCENTRATIONS  
 EXCEEDING SUBLETHAL AND LETHAL  
 RISK LEVELS FOR RABBIT  
 DWG DATE: 08/30/98 DWG NAME: 292HEC08

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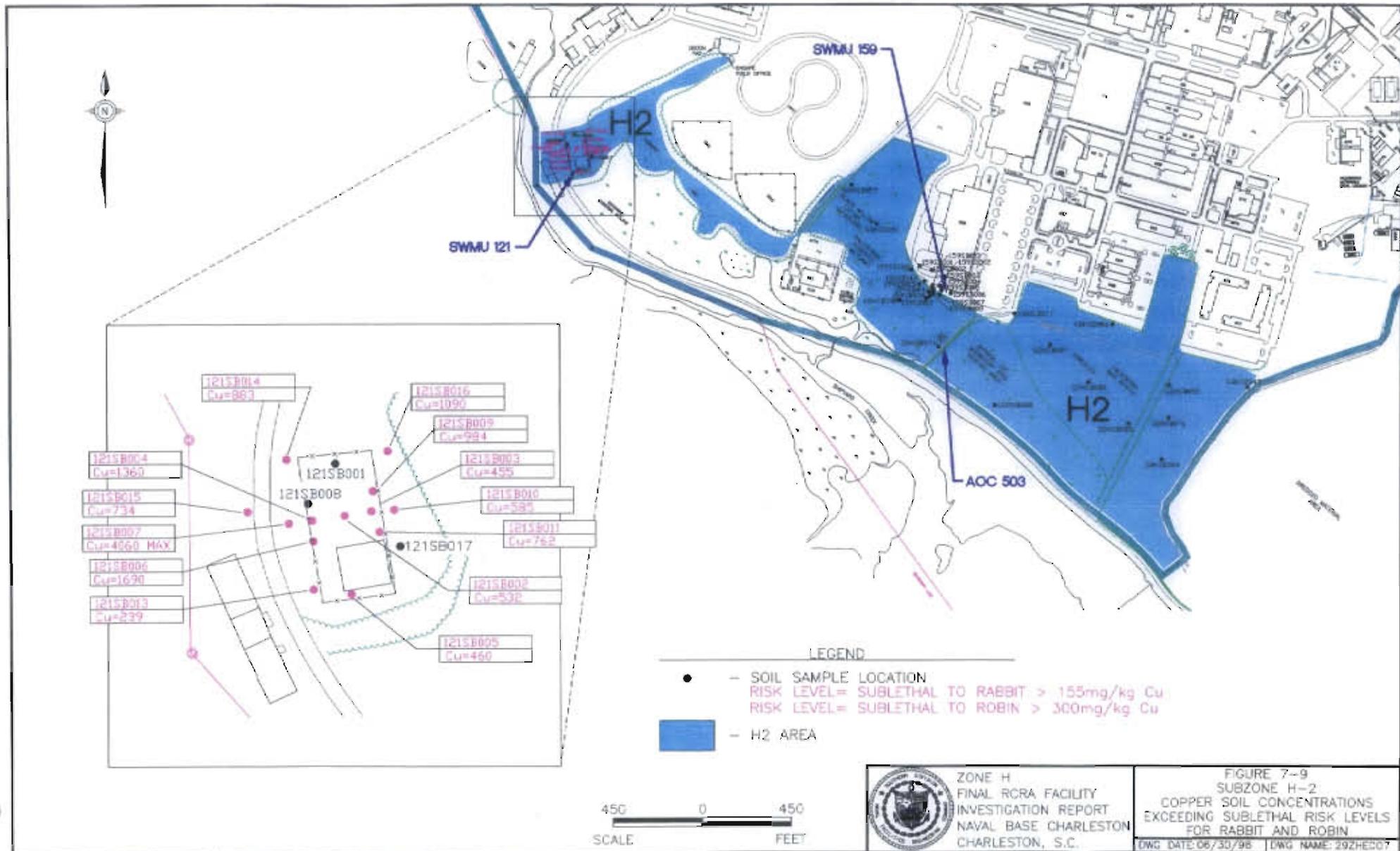


Table 7-9  
 Bioaccumulation Data<sup>1</sup>  
 Baseline Risk Assessment  
 Zone H  
 NAVBASE

Bioaccumulation or Biotransfer Factor (unitless)

Analyte	Log $K_{ow}$	Plant	Terrestrial Invertebrate	Mammal	Bird
<b>Semivolatiles</b>					
Acenaphthene	NA	NA	NA	NA	NA
Acenaphthylene	NA	NA	NA	NA	NA
Anthracene	4.4 [c]	NA	0.005 [d]	6.30E-04 [a]	1 [ab]
Benzoic acid	NA	NA	NA	NA	NA
Benzo(a)anthracene	5.74 [c]	0.019 [e]	0.0125 [d]	1.38E-02 [a]	1 [ab]
Benzo(a)pyrene	6.07 [c]	0.012 [e]	0.0342 [d]	2.95E-02 [a]	1 [ab]
Benzo(b)fluoranthene	6.32 [c]	0.008 [e]	0.032 [d]	5.25E-02 [a]	1 [ab]
Benzo(g,h,i)perylene	7 [c]	0.003 [e]	0.024 [d]	2.50E-01 [a]	1 [ab]
Benzo(k)fluoranthene	6.45 [c]	0.007 [e]	0.025 [d]	7.08E-02 [a]	1 [ab]
Bis(2-ethylhexyl)phthalate (BEHP)	5.3 [f]	0.033 [e]	0.022 [aj]	5.00E-03 [a]	1 [ab]
Butylbenzylphthalate	4.78 [g]	0.049 [e]	0.022 [aj]	1.50E-03 [a]	1 [ab]
Chrysene	5.71 [c]	0.019 [e]	0.031 [d]	1.29E-02 [a]	1 [ab]
Dibenzo(a,h)anthracene	6.42 [c]	0.008 [e]	0.022 [aj]	6.61E-02 [a]	1 [ab]
Di-n-butylphthalate	4.8 [h]	NA	0.022 [aj]	1.60E-03 [a]	1 [ab]
Di-n-octylphthalate	NA	NA	NA	NA	NA
Fluoranthene	5.25 [c]	0.036 [e]	0.007 [d]	4.50E-03 [a]	1 [ab]

Table 7-9  
 Bioaccumulation Data<sup>1</sup>  
 Baseline Risk Assessment  
 Zone H  
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Analyte	Log K <sub>ow</sub>	Plant	Bioaccumulation or Biotransfer Factor (unitless)		
			Terrestrial Invertebrate	Mammal	Bird
<b>Semivolatiles</b>					
Fluorene	NA	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene	7.7 [c]	0.0014 [e]	0.042 [d]	1.26E+00 [a]	1 [ab]
2-Methylnaphthalene	NA	NA	NA	NA	NA
4-Methylphenol	NA	NA	NA	NA	NA
Naphthalene	NA	NA	NA	NA	NA
Phenanthrene	4.43 [c]	NA	0.012 [d]	6.70E-04 [a]	1 [ab]
Pyrene	5.09 [c]	0.044 [e]	0.018 [d]	3.10E-03 [a]	1 [ab]
<b>Pesticides/Herbicides/PCBs/Dioxins</b>					
Aroclor-1248	6 [c]	0.013 [e]	1.2 [i]	1.00E+00 [ak]	1 [ab]
Aroclor-1254	6.02 [c]	0.013 [e]	1.2 [i]	1.00E+00 [ak]	1 [ab]
Aroclor-1260	6 [c]	0.013 [e]	1.2 [i]	1.00E+00 [ak]	1 [ab]
alpha-Chlordane	2.78 [f]	0.027 [ac]	0.8 [j]	7.10E-01 [ak]	0.71 [ai]
gamma-Chlordane	3.32 [f]	0.027 [ac]	0.8 [j]	7.10E-01 [ak]	0.71 [ai]
4,4'-DDE	5.69 [f]	0.02 [e]	0.98 [v]	2.91E+00 [ak]	2.91 [l]
4,4'-DDT	4.48 [f]	0.027 [ac]	0.98 [v]	2.91E+00 [ak]	2.91 [l]

Table 7-9  
 Bioaccumulation Data<sup>1</sup>  
 Baseline Risk Assessment  
 Zone H  
 NAVBASE

Bioaccumulation or Biotransfer Factor (unitless)

Analyte	Log K <sub>ow</sub>	Plant	Terrestrial Invertebrate	Mammal	Bird
<b>Pesticides/Herbicides/PCBs/Dioxins</b>					
Dieldrin	4.95 [f]	0.049 [e]	1.2 [m]	7.10E-01 [ak]	0.71 [n]
Endosulfan II	NA	NA	NA	NA	NA
Endrin	NA	NA	NA	NA	NA
Endrin aldehyde	NA	NA	NA	NA	NA
Heptachlor	NA	NA	NA	NA	NA
Heptachlor epoxide	NA	NA	NA	NA	NA
2,3,5-TP (Silvex)	NA	NA	NA	NA	NA
2,3,4-T	NA	NA	NA	NA	NA
2,4-D	NA	NA	NA	NA	NA
Parathion	NA	NA	NA	NA	NA
2,3,7,8 TCDD	6.80 [am]	0.005 [e]	5.0 [b]	8.40E-01 [an]	1 [ab]
<b>Inorganics</b>					
Aluminum	NA	NA	NA	NA	NA
Antimony	NA	NA	NA	NA	NA
Arsenic	NA	0.3 [p]	0.77 [ae]	3.60E-01 [ag]	0.45 [ah]

Table 7-9  
 Bioaccumulation Data<sup>1</sup>  
 Baseline Risk Assessment  
 Zone H  
 NAVBASE

Bioaccumulation or Biotransfer Factor (unitless)

Analyte	Log K <sub>ow</sub>	Plant	Terrestrial Invertebrate	Mammal	Bird
<b>Inorganics</b>					
Barium	NA	0.56 [ag]	0.77 [ae]	3.40E-01 [af]	0.45 [ah]
Beryllium	NA	NA	NA	NA	NA
Cadmium	NA	33 [q]	1.4 [k]	2.06E+00 [r]	0.38 [s]
Chromium	NA	NA	NA	NA	NA
Cobalt	NA	NA	NA	NA	NA
Copper	NA	0.78 [ti]	0.16 [ii]	6.00E-01 [q]	0.45 [ah]
Iron	NA	NA	NA	NA	NA
Lead	NA	0 [q]	0.22 [u]	5.40E-01 [w]	0.45 [ah]
Manganese	NA	0.56 [ag]	0.77 [ae]	3.40E-01 [ag]	0.45 [ah]
Mercury	NA	0.56 [ag]	0.34 [x]	1.00E-02 [aa]	2.33 [aa]
Nickel	NA	NA	NA	NA	NA
Selenium	NA	0.009 [y]	0.77 [ae]	3.40E-01 [af]	0.51 [z]
Silver	NA	NA	NA	NA	NA
Tin	NA	NA	NA	NA	NA

**Table 7-9**  
**Bioaccumulation Data<sup>1</sup>**  
**Baseline Risk Assessment**  
**Zone H**  
**NAVBASE**

Bioaccumulation or Biotransfer Factor (unitless)

Analyte	Log $K_{ow}$	Plant	Terrestrial Invertebrate	Mammal	Bird
<b>Inorganics</b>					
Vanadium	NA	NA	NA	NA	NA
Zinc	NA	0.61 [i]	1.77 [j]	2.06E+00 [w]	0.45 [ah]

- Notes:**
- [a] = Calculated using the following equation (Travis and Arms, 1988), unless otherwise noted:  $\log \text{BAF} - \log K_{ow} - 7.6$ ; result multiplied by average of ingestion rates for nonlactating and lactating test animals. There is an uncertainty involved in using this equation for PAHs, because this study did not use any PAHs in the regression analysis.
  - [b] = Reinecke and Nash (1984).
  - [c] = Geometric mean of values from USEPA (1986).
  - [d] = Marquerie et al. (1987) as cited in Beyer (1990). Mean of values. Converted to wet weight assuming 90% bodyweight as water.
  - [e] = Calculated using the following equation in Travis and Arms (1988) for analytes with  $\log K_{ow}s > 5$ :  $\log (\text{Plant Uptake Factor}) = 1.588 - 0.578 \log K_{ow}$ .
  - [f] = From USEPA (1986).
  - [g] = Value from Verschueren (1983).
  - [h] = Value from Howard (1990).
  - [i] = BCF for earthworms from Diercxsens, et al. (1985).
  - [j] = Value from Gish (1970).
  - [k] = Mean of values reported for soil invertebrates in Macfadyen (1980) converted from dry weight to wet weight.
  - [l] = Whole body pheasant BAF for 4,4'-DDT presented in USEPA (1985), derived from Kenaga (1973).
  - [m] = Average of values reported for soil invertebrates in Edwards and Thompson (1973).
  - [n] = Jeffries and Davis (1968).
  - [o] = Value reported for endrin from Gish (1970).
  - [p] = Average of BAF values reported from Wang et al. (1984), Sheppard et al. (1985) and Merry et al. (1986).
  - [q] = Levine et al. (1989).

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Notes (continued):

- [r] = Mean of values reported for *Sorex araneus* in Macfadyen (1980).
- [s] = Based on accumulation of cadmium in kidneys of European quail in Pimentel et al. (1984).
- [t] = Median of values reported from Levine et al. (1989).
- [u] = Geometric mean of BAF values (fresh st. worm/dry st. soil) for worms and woodlice (USEPA, 1985). Fresh weight tissue concentrations calculated assuming 90% body water content.
- [v] = Beyer and Gish (1980) reported dry weight to wet weight ratio.
- [w] = Mean of values for *Microtus agrestis* and *Apodemus sylvaticus* in Macfadyen (1980).
- [x] = Value from USEPA (1985) sludge document.
- [y] = Based on reported ratio of selenium in plant tissue and iron fly ash amended soil (Stoewsand et al., 1978).
- [z] = Based on average of reported ratio of selenium in diet to liver, kidney, and breast tissue of chickens (Ort and Lafshaw, 1977).
- [aa] = USEPA, 1985.
- [ab] = Assumption.
- [ac] = Assumed value based on average of BAFs calculated for other pesticides and PCBs.
- [ad] = Assumed value based on average of BAFs for Aroclor-1260, alpha-Chlordane, 4,4'-DDE, dieldrin and endrin ketone.
- [ae] = Assumed value based on average of BAFs reported for other metals.
- [af] = Assumed value based on average of reported BAFs for Cd, Cu, Pb and Hg.
- [ag] = Assumed value based on average of reported BAFs for As, Cu, Hg and Zn.
- [ah] = Assumed value based on average of reported BAF values for Cd and Se.
- [ai] = Assumed value based on reported BAF for dieldrin.
- [aj] = Assumed value based on average of BAFs for semivolatiles.
- [ak] = Value for mammal unavailable. Bioaccumulation assumed to be the same as values reported for birds.
- [am] = Polder et al. (1995).
- [an] = Rose et al. (1976).
- NA = Not available.
- † = Table adapted from BRA, NAS Cecil Field, Jacksonville, Florida.

Table 7-10  
 Exposure Parameters and Assumptions for Representative Wildlife Species at Subzone H-1  
 Prey in Diet (%)

Representative Wildlife Species	Trophic Status	Inverts	Plants	Small Mammals	Herpetofauna	Small Birds	Incidental Soil Ingestion (%)	Home Range (acres)	ED	Site Foraging Frequency (SFF)	Ingestion Rate (kg/day)	Body Weight (kg)
Red-tailed Hawk <sup>a</sup>	Predatory Bird	0	0	82	3	10	5	1073	1	6.37-E-02	0.10	1.1
Eastern Cottontail <sup>b</sup>	Small Herbivorous Mammal	0	97	0	0	0	3	9.3	1	1.00E+00	0.08	1.2
Short-tailed Shrew <sup>c</sup>	Small Carnivorous Mammal	78	12	0	0	0	10	0.96	1	1.00E+00	0.0025	0.018
SITE AREA: 68.37 acres												

Notes:

- a = — Diet assumptions based on data from Craighead & Craighead, 1956.  
 — Ingestion rates determined from mean values from Craighead & Craighead, 1956.  
 — Body weight reflects interpolated values for adults from Craighead & Craighead, 1956; Steenhof, 1983; Springer & Osborne, 1983.  
 — Home range reflects interpolated values from Andersen & Rongstad, 1989; Craighead & Craighead, 1956; and USDI, 1979.
- b = — Diet assumptions based on data from Dusi, 1952; and Spencer & Chapman, 1986.  
 — Food ingestion rate (FI) from formula:  $FI(kg/day) = 0.0687 \times W^{0.75} (kg)$  (Nagy, 1987).  
 — Body weight reflects interpolated values from Chapman & Morgan 1973; Pelton & Jenkins, 1970.  
 — Home range reflects interpolated values from Althoff & Storm, 1989; and Dixon et al., 1981.
- c = — Diet assumption based on data from Whitaker & Ferraro, 1963.  
 — Food ingestion rate (FI) from formula:  $FI(kg/day) = 0.0687 \times W^{0.75} (kg)$  (Nagy, 1987).  
 — Body weight from Lomolino, 1984.  
 — Home range value from Buckner, 1966.
- ED = Exposure Duration (percentage of year receptor is expected to be found at study area expressed as a factor, i.e., 100% = 1.0)  
 SFF = Site area (acres) times exposure duration (ED) divided by Home Range (HR); cannot exceed 1.0.

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Table 7-11  
 Exposure Parameters and Assumptions for Representative Wildlife Species at Subzone H-2

Representative Wildlife Species	Trophic Status	Prey in Diet (%)						Incidental Soil Ingestion (%)	Home Range (acres)	ED	Site Foraging Frequency (SFF)	Ingestion Rate (kg/day)	Body Weight (kg)
		Inverts	Plants	Small Mammals	Herpeto- fauna	Small Birds							
American Robin <sup>a</sup>	Small Carnivorous Bird	83	7	0	0	0	10	1.04	1	1.00E+00	0.01	0.077	
Eastern Cottontail <sup>b</sup>	Small Herbivorous Mammal	0	97	0	0	0	3	9.3	1	1.00E+00	0.08	1.2	
SITE AREA: 45.32 acres													

Notes:

- a = — Diet assumptions based on data from Hamilton, 1943 and Wheelwright, 1986.  
 — Food ingestion rate (FI) from formula:  $FI(kg/day) = 0.0582 W^{0.451}$  (kg) (Nagy, 1987).  
 — Body weight from Clench & Leberman, 1978.  
 — Home range reflects interpolated values from Howell, 1992; and Weatherhead & McRae, 1990.
- b = — Diet assumptions based on data from Dusi, 1952; and Spencer & Chapman, 1986.  
 — Food ingestion rate (FI) from formula:  $FI(kg/day) = 0.0687 \times W^{0.422}$  (kg) (Nagy, 1987).  
 — Body weight reflects interpolated values from Chapman & Morgan 1973; Pelton & Jenkins, 1970.  
 — Home range reflects interpolated values from Althoff & Storm, 1989; and Dixon et al., 1981.
- ED = Exposure Duration (percentage of year receptor is expected to be found at study area expressed as a factor, i.e., 100% = 1.0)
- SFF = Site area (acres) times exposure duration (ED) divided by Home Range (HR); cannot exceed 1.0.

Table 7-12  
 Exposure Parameters and Assumptions for Representative Wildlife Species at Subzone H-3

Prey in Diet (%)

Representative Wildlife Species	Trophic Status	Prey in Diet (%)						Incidental Soil Ingestion (%)	Home Range (acres)	ED	Site Foraging Frequency (SFF)	Ingestion Rate (kg/day)	Body Weight (kg)
		Inverts	Plants	Small Mammals	Herpeto- fauna	Small Birds							
Red-tailed Hawk <sup>a</sup>	Predatory Bird	0	0	82	3	10	5	1073	1	1.30E-02	0.10	1.1	
Eastern Cottontail <sup>b</sup>	Small Herbivorous Mammal	0	97	0	0	0	3	9.3	1	1.00E+00	0.08	1.2	
Short-tailed Shrew <sup>c</sup>	Small Carnivorous Mammal	78	12	0	0	0	10	0.96	1	1.00E+00	0.0025	0.018	

SITE AREA: 13.98 acres

Notes:

- a = — Diet assumptions based on data from Craighead & Craighead, 1956.  
 — Ingestion rates determined from mean values from Craighead & Craighead, 1956.  
 — Body weight reflects interpolated values for adults from Craighead & Craighead, 1956; Steenhof, 1983; Springer & Osborne, 1983.  
 — Home range reflects interpolated values from Andersen & Rongstad, 1989; Craighead & Craighead, 1956; and USDI, 1979.
- b = — Diet assumptions based on data from Dusi, 1952; and Spencer & Chapman, 1986.  
 — Food ingestion rate (FI) from formula:  $FI(kg/day) = 0.0687 \times W^{0.622}$  (kg) (Nagy, 1987).  
 — Body weight reflects interpolated values from Chapman & Morgan 1973; Pelton & Jenkins, 1970.  
 — Home range reflects interpolated values from Althoff & Storm, 1989; and Dixon et al., 1981.
- c = — Diet assumption based on data from Whitaker & Ferraro, 1963.  
 — Food ingestion rate (FI) from formula:  $FI(kg/day) = 0.0687 \times W^{0.622}$  (kg) (Nagy, 1987).  
 — Body weight from Lomolino, 1984.  
 — Home range value from Buckner, 1966.
- ED = Exposure Duration (percentage of year receptor is expected to be found at study area expressed as a factor, i.e., 100% = 1.0)  
 SFF = Site area (acres) times exposure duration (ED) divided by Home Range (HR); cannot exceed 1.0.

Table 7-13  
 Significant Risk Levels<sup>a</sup> for Terrestrial Wildlife within Zone H Subzones

Subzone	Species	Parameter	Significant Risk Level (mg/kg)		Number of Samples which Exceed Significant Risk Level
			Lethal	Sublethal	
H-1	Rabbit	Mercury	>5.3	NA	1
		Copper	NA	>2,850	1
	Shrew	Arsenic	NA	>5.0	18
		Zinc	>2,450	>750	7/3
H-2	Rabbit	Copper	NA	>155	13
		Zinc	>12,000	>400	1/13
	Robin	Mercury	NA	>1.2	3
		Copper	NA	>300	12
H-3	Rabbit	Arsenic	NA	>27	2
	Shrew	Lead	>8,000	NA	1

**Notes:**  
 a Significant risk levels (sublethal and lethal) were back-calculated using the minimum concentrations resulting in an HQ > 1. Contaminant concentrations which exceed the corresponding risk level pose a risk for that species-type.  
 NA Value could not be calculated

**Table 7-14a**  
**Hazard Quotients for Potential Lethal Effects for Wildlife Species Associated with**  
**Maximum Exposure Concentrations of ECPCs in Soil at Subzone H-1**

Analyte	Max Conc (mg/kg)	Red-tailed Hawk			Eastern Cottontail Rabbit			Short-tailed Shrew		
		PDE	RTV	HQ	PDE	RTV	HQ	PDE	RTV	HQ
Acenaphthene	0.244	NA	NA	NC	NA	NA	NC	NA	NA	NC
Benzoic Acid	0.269	NA	NA	NC	NA	NA	NC	NA	NA	NC
Anthracene	0.430	0.000043	NA	NC	NA	NA	NC	NA	NA	NC
Benzo(a)anthracene	1.9	0.000363	NA	NC	0.00613	NA	NC	2.96-E-02	NA	NC
Benzo(b)fluoranthene	4	0.000917	NA	NC	0.0101	NA	NC	0.0699	NA	NC
Benzo(k)fluoranthene	0.864	0.000213	NA	NC	0.00212	NA	NC	0.0144	NA	NC
Benzo(g,h,i)perylene	1.1	0.000462	NA	NC	0.00241	NA	NC	0.0182	NA	NC
Benzo(a)pyrene	2	0.000414	NA	NC	0.00555	1.0E+01	0.00056	0.0356	10	0.0036
bis(2-Ethylhexyl)phthalate (BEHP)	16	0.00293	NA	NC	0.0661	6.8E+03	0.00001	0.269	160	0.0017
Butylbenzylphthalate	4.2	0.000754	NA	NC	0.0217	4.7E+02	0.000046	0.0718	830	9e-05
4-Methylphenol	0.200	NA	NA	NC	NA	NA	NC	NA	NA	NC
Chrysene	1.9	0.000363	NA	NC	0.00613	NA	NC	0.0334	NA	NC
Dibenzo(a,h)anthracene	0.390	0.000094	NA	NC	0.000982	NA	NC	0.0064	NA	NC
Dibenzofuran	0.220	NA	NA	NC	NA	NA	NC	NA	NA	NC
Di-n-butylphthalate	1.1	0.00019	NA	NC	NA	NA	NC	NA	NA	NC
Di-n-octylphthalate	0.150	NA	NA	NC	NA	NA	NC	NA	NA	NC
Fluoranthene	3.2	0.000582	NA	NC	0.0139	NA	NC	0.0488	NA	NC
Fluorene	0.340	NA	NA	NC	NA	NA	NC	NA	NA	NC
Indeno(1,2,3-cd)pyrene	0.260	0.000364	NA	NC	0.000544	NA	NC	0.0048	NA	NC
2-Methylnaphthalene	0.322	NA	NA	NC	NA	NA	NC	NA	NA	NC
Naphthalene	0.620	NA	NA	NC	NA	NA	NC	NA	NA	NC

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Table 7-14a  
 Hazard Quotients for Potential Lethal Effects for Wildlife Species Associated with  
 Maximum Exposure Concentrations of ECPCs in Soil at Subzone H-1

Analyte	Max Conc (mg/kg)	Red-tailed Hawk			Eastern Cottontail Rabbit			Short-tailed Shrew		
		PDE	RTV	HQ	PDE	RTV	HQ	PDE	RTV	HQ
Phenol	0.100	NA	NA	NC	NA	NA	NC	NA	NA	NC
Phenanthrene	1.9	0.000111	NA	NC	NA	1.4E+02	NC	NA	140	NC
Pyrene	3.3	0.000597	NA	NC	0.016	5.4E+02	0.000029	0.0547	160	NC
alpha-Chlordane	0.16	0.000014	4.8E+00*	2.9E-06	0.00006	2.0E+01*	0.000003	0.00162	5.7E+01*	3e-05
gamma-Chlordane	0.006	0.000005	4.8E+00*	1.0E-06	0.000022	2.0E+01*	0.000001	0.000606	5.7E+01*	1e-05
DDD	0.008	NA	NA	NC	NA	NA	NC	NA	NA	NC
DDE	0.010	0.000033	NA	NC	0.000033	1.6E+02	2.00e-07	0.0012	140	9e-06
DDT	0.008	0.000026	5.9E+02	4.4E-06	0.00003	5.0E+01	6.00e-07	0.000964	27	4e-03
Aroclor-1254	2.3	0.00273	NA	NC	0.00653	NA	NC	0.331	NA	NC
Aroclor-1260	0.560	0.000666	NA	NC	0.00139	1.0E+02	0.000016	0.0721	100	0.0007
2,3,7,8-TCDD	0.0000815	9.50e-09	7.4E-03	1.2E-06	1.90e-08	2.3E-02	8.30e-07	0.0000045	0.057	8e-05
Aluminum	10,900	NA	NA	NC	NA	1.0E+02	NC	NA	NA	NC
Antimony	726	NA	NA	NC	NA	NA	NC	NA	NA	NC
Arsenic	22.1	0.0528	NA	NC	0.47	1.5E+02	0.0031	2.26	29	0.077
Barium	128	0.294	NA	NC	4.89	NA	NA	136	NA	NC
Beryllium	3	NA	NA	NC	NA	2.0E+00	NC	NA	2	NC
Cadmium	1.8	0.0189	NA	NC	3.84	3.0E+01	0.13	1.28	180	0.0071
Chromium	49.2	NA	2.3E+01	NC	NA	NA	NC	NA	NA	NC
Cobalt	43.3	NA	NA	NC	NA	NA	NC	NA	NA	NC
Copper	3,040	10.4	NA	NC	159	2.4E+02	0.66	134	NA	NC
Iron	26,300	NA	NA	NC	NA	NA	NC	NA	NA	NC
Lead	6,170	19.4	4.9E+03	3.9E-03	0.0442	NA	NC	232	300	0.77

**Table 7-14a**  
**Hazard Quotients for Potential Lethal Effects for Wildlife Species Associated with**  
**Maximum Exposure Concentrations of ECPCs in Soil at Subzone H-1**

Analyte	Max Conc (mg/kg)	Red-tailed Hawk			Eastern Cottontail Rabbit			Short-tailed Shrew		
		PDE	RTV	HQ	PDE	RTV	HQ	PDE	RTV	HQ
Mercury	6.9	0.012	3.5E+00	3.4E-03	0.263	2.0E-01	1.3	0.414	3.6	0.11
Magnesium	4,370	NA	NA	NC	NA	NA	NC	NA	NA	NC
Manganese	320	0.735	NA	NC	12.2	8.0E+01	0.15	34.1	45	0.75
Nickel	282	NA	NA	NC	NA	1.3E+01	NC	NA	160	NC
Selenium	1.1	0.00256	NA	NC	0.00284	1.3E+03	0.000002	0.107	130	0.0008
Silver	0.92	NA	NA	NC	NA	NA	NC	NA	NA	NC
Thallium	0.54	NA	NA	NC	NA	NA	NC	NA	NA	NC
Tin	43.8	NA	NA	NC	NA	NA	NC	NA	NA	NC
Vanadium	43.5	NA	1.9E+01	NC	NA	NA	NC	NA	NA	NC
Zinc	2,800	29.8	NA	NC	116	5.0E+02	0.23	604	520	1.2
HI =				7.3E-03			2.5			2.4

- Notes:**
- maxconc = Maximum Concentration of Analyte.
  - NA = Data not available
  - NC = Not able to calculate value
  - PDE = Potential Dietary Exposure (mg/kg/BW) calculated based on equation in Table 7-7.
  - RTV = Reference Toxicity Value (mg/kg/BW/day) - 1/5 of the lowest reported LD<sub>50</sub> value from Appendix P for closest related species.
  - HQ = Hazard Quotient - PDE divided by the RTV.
  - HI = Hazard Index (HQ<sub>1</sub> + HQ<sub>2</sub> + ...HQ<sub>n</sub>).
  - a = Represents RTV for technical chlordane (alpha- and gamma-chlordane makeup approximately 19% and 24% of technical chlordane, respectively).

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Table 7-14b  
 Hazard Quotients for Potential Sublethal Effects for Wildlife Species Associated with  
 Maximum Exposure Concentrations of ECPCs in Soil at Subzone H-1

Analyte	Max Conc (mg/kg)	Red-tailed Hawk			Eastern Cottontail Rabbit			Short-tailed Shrew		
		PDE	RTV	HQ	PDE	RTV	HQ	PDE	RTV	HQ
Aconaphthene	0.244	NA	NA	NC	NA	NA	NC	NA	NA	NC
Benzoic Acid	0.269	NA	NA	NC	NA	NA	NC	NA	NA	NC
Anthracene	0.45	4.30E-05	NA	NC	NA	NA	NC	NA	NA	NC
Benzo(a)anthracene	1.9	3.63E-04	NA	NC	0.00613	NA	NC	2.96E-02	NA	NC
Benzo(b)fluoranthene	4	9.17E-04	NA	NC	0.0101	NA	NC	0.0699	NA	NC
Benzo(k)fluoranthene	0.864	2.13E-04	NA	NC	0.00212	NA	NC	0.0144	NA	NC
Benzo(g,h,i)perylene	1.1	4.62E-04	NA	NC	0.00241	NA	NC	0.0182	NA	NC
Benzo(a)pyrene	2	4.14E-04	NA	NC	0.00555	40	1.4E-04	0.0356	40	0.0009
bis(2-Ethylhexyl)phthalate (BEHP)	16	2.93E-03	NA	NC	0.0661	35	1.9E-03	0.269	50	0.0054
Butylbenzylphthalate	4.2	7.54E-04	NA	NC	0.0217	4900	4.4E-06	0.0718	4900	2e-05
4-Methylphenol	0.2	NA	NA	NC	NA	NA	NC	NA	NA	NC
Chrysene	1.9	3.63E-04	NA	NC	0.00613	NA	NC	0.0334	NA	NC
Dibenzo(a,h)anthracene	0.39	9.40E-05	NA	NC	0.000982	NA	NC	0.0064	NA	NC
Dibenzofuran	0.22	NA	NA	NC	NA	NA	NC	NA	NA	NC
Di-n-butylphthalate	1.1	1.90E-04	NA	NC	NA	130	NC	NA	130	NC
Di-n-octylphthalate	0.15	NA	NA	NC	NA	NA	NC	NA	NA	NC
Fluoranthene	3.2	5.82E-04	NA	NC	0.0139	400	3.5E-05	0.0488	400	0.0001
Fluorene	0.34	NA	NA	NC	NA	NA	NC	NA	NA	NC
Indeno(1,2,3-cd)pyrene	0.26	3.64E-04	NA	NC	0.000544	NA	NC	0.0048	NA	NC
2-Methylnaphthalene	0.322	NA	NA	NC	NA	NA	NC	NA	NA	NC
Naphthalene	0.62	NA	NA	NC	NA	NA	NC	NA	NA	NC

Table 7-14b  
 Hazard Quotients for Potential Sublethal Effects for Wildlife Species Associated with  
 Maximum Exposure Concentrations of ECPCs in Soil at Subzone H-1

Analyte	Max Conc (mg/kg)	Red-tailed Hawk			Eastern Cottontail Rabbit			Short-tailed Shrew		
		PDE	RTV	HQ	PDE	RTV	HQ	PDE	RTV	HQ
Phenol	0.1	NA	NA	NC	NA	NA	NC	NA	NA	NC
Phenanthrene	1.9	1.11E-04	NA	NC	NA	NA	NC	NA	NA	NC
Pyrene	3.3	5.97E-04	NA	NC	0.016	NA	NC	0.0547	NA	NC
alpha-Chlordane	0.16	1.40E-05	NA	NC	0.00006	NA	NC	0.00162	NA	NC
gamma-Chlordane	0.006	5.20E-06	NA	NC	0.000022	NA	NC	0.000606	NA	NC
DDD	0.008	NA	NA	NC	NA	NA	NC	NA	NA	NC
DDE	0.01	3.30E-05	0.39	0.00008	0.000033	NA	NC	0.0012	NA	NC
DDT	0.008	2.60E-05	0.16	0.00016	0.00003	150	2.0E-07	0.000964	81	1e-05
Aroclor-1254	2.3	2.73E-03	9	0.0003	0.00653	0.096	6.8E-02	0.331	1.5	0.22
Aroclor-1260	0.56	6.66E-04	0.9	0.00074	0.00159	6.4	2.3E-04	0.0721	6.4	0.011
2,3,7,8-TCDD	8.15E-06	9.50E-09	0.001	0.00001	1.900e-08	0.00001	1.9E-03	0.0000045	0.00001	0.45
Aluminum	10,900	NA	NA	NC	NA	NA	NC	NA	NA	NC
Antimony	726	NA	NA	NC	NA	NA	NC	NA	NA	NC
Arsenic	22.1	5.28E-02	NA	NC	0.47	0.58	8.1E-01	2.26	0.58	3.9
Barium	128	2.94E-01	NA	NC	4.89	NA	NA	136	NA	NC
Beryllium	3	NA	NA	NC	NA	NA	NC	NA	2	NC
Cadmium	1.8	1.89E-02	10	0.00187	3.84	22	1.7E-01	1.28	450	0.0028
Chromium	49.2	NA	NA	NC	NA	NA	NC	NA	NA	NC
Cobalt	43.3	NA	NA	NC	NA	NA	NC	NA	830	NC
Copper	3,040	1.04E+01	11	0.94	159	150	1.1E+00	134	150	0.89
Iron	26,300	NA	NA	NC	NA	NA	NC	NA	NA	NC
Lead	6,170	1.94E+01	4900	0.0039	0.0442	520	8.5E-05	232	300	0.77

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Table 7-14b  
 Hazard Quotients for Potential Sublethal Effects for Wildlife Species Associated with  
 Maximum Exposure Concentrations of ECPCs in Soil at Subzone H-1

Analyte	Max Conc (mg/kg)	Red-tailed Hawk			Eastern Cottontail Rabbit			Short-tailed Shrew		
		PDE	RTV	HQ	PDE	RTV	HQ	PDE	RTV	HQ
Mercury	6.9	1.20E-02	0.064	0.19	0.263	0.5	5.2E-01	0.414	0.5	0.83
Magnesium	4,370	NA	NA	NC	NA	NA	NC	NA	NA	NC
Manganese	320	7.35E-01	NA	NC	12.2	930	1.3E-02	34.1	140	0.24
Nickel	282	NA	NA	NC	NA	160	NC	NA	160	NC
Selenium	1.1	2.56E-03	1.7	0.0015	0.00284	130	2.2E-05	0.107	134	0.0008
Silver	0.92	NA	NA	NC	NA	NA	NC	NA	NA	NC
Thallium	0.54	NA	NA	NC	NA	NA	NC	NA	NA	NC
Tin	43.8	NA	NA	NC	NA	NA	NC	NA	NA	NC
Vanadium	43.5	NA	19	NC	NA	NA	NC	NA	NA	NC
Zinc	2,800	2.98E+01	NA	NC	1.16E+2	160	7.2E-01	604	160	3.8
HI =				1.1			3.4E+00			14

- Notes:
- maxconc = Maximum Concentration of Analyte.
  - NA = Data not available
  - NC = Not able to calculate value
  - PDE = Potential Dietary Exposure (mg/kg/BW) calculated based on equation in Table 7-7.
  - RTV = Reference Toxicity Value (mg/kg/BW/day) - lowest reported LOAEL from Appendix P.
  - HQ = Hazard Quotient - PDE divided by the RTV.
  - HI = Hazard Index (HQ<sub>1</sub> + HQ<sub>2</sub> + ...HQ<sub>n</sub>).

Table 7-14c  
 Hazard Quotients for Potential Lethal Effects for Wildlife Species Associated with  
 Mean Exposure Concentrations of Selected ECPCs in Soil at Subzone H-1

Analyte	Mean Conc (mg/kg)	Eastern Cottontail Rabbit			Short-tailed Shrew		
		PDE	RTV	HQ	PDE	RTV	HQ
Mercury	0.49	1.88E-02	1.3E+00	1.4E-02			
Zinc	346				7.47E+01	5.0E+02	1.4E-01

- Notes:**
- meanconc = Mean Concentration of Analyte.
  - NA = Data not available
  - NC = Not able to calculate value
  - PDE = Potential Dietary Exposure (mg/kg/BW) calculated based on equation in Table 7-7.
  - RTV = Reference Toxicity Value (mg/kg/BW/day) - 1/5 of the lowest reported LD<sub>50</sub> value from Appendix P for closest related species.
  - HQ = Hazard Quotient - PDE divided by the RTV.

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Table 7-14d  
 Hazard Quotients for Potential Sublethal Effects for Wildlife Species Associated with  
 Mean Exposure Concentrations of Selected ECPCs in Soil at Subzone H-1

Analyte	Mean Conc (mg/kg)	Eastern Cottontail Rabbit			Short-tailed Shrew		
		PDE	RTV	HQ	PDE	RTV	HQ
Arsenic	8.0				8.20E-01	5.8E-01	1.4E+00
Copper	439	2.30E+01	1.5E+02	1.5E-01			
Zinc	346				7.47E+01	1.6E+02	4.7E-01

Notes:

- meanconc = Mean Concentration of Analyte.
- NA = Data not available
- NC = Not able to calculate value
- PDE = Potential Dietary Exposure (mg/kg/BW) calculated based on equation in Table 7-7.
- RTV = Reference Toxicity Value (mg/kg/BW/day) - 1/5 of the lowest reported LOAEL from Appendix P for closest related species.
- HQ = Hazard Quotient - PDE divided by the RTV.

**Table 7-15a**  
**Hazard Quotients for Potential Lethal Effects for Wildlife Species Associated with**  
**Maximum Exposure Concentrations of ECPCs in Soil at Subzone H-2**

Analyte	Max Conc (mg/kg)	American Robin			Eastern Cottontail		
		PDE	RTV	HQ	PDE	RTV	HQ
Acenaphthylene	0.590	NA	NA	NC	NA	NA	NC
Anthracene	0.610	NA	NA	NC	NA	NA	NC
Benzo(a)anthracene	1.900	2.75E-02	NA	NC	6.13E-03	NA	NC
Benzo(b)fluoranthene	2.700	4.46E-02	NA	NC	6.80E-03	NA	NC
Benzo(k)fluoranthene	2.200	5.46E-02	NA	NC	5.40E-03	NA	NC
Benzo(g,h,i)perylene	0.780	1.22E-02	NA	NC	1.71E-03	NA	NC
Benzo(a)pyrene	1.700	2.85E-02	NA	NC	4.72E-03	1.0E+01	4.7E-04
bis(2-Ethylhexyl)phthalate (BEHP)	1.000	1.57E-02	NA	NC	4.13E-03	6.8E+03	6.0E-07
Chrysene	2.000	3.30E-02	NA	NC	6.46E-03	NA	NC
Dibenzo(a,h)anthracene	0.280	4.32E-03	NA	NC	7.05E-04	NA	NC
Butylbenzylphthalate	2.600	4.11E-02	NA	NC	1.34E-02	4.7E+02	2.9E-05
Fluorantrene	3.900	5.49E-02	NA	NC	1.69E-02	NA	NC
Indeno(1,2,3)pyrene	0.750	1.31E-02	NA	NC	1.57E-03	NA	NC
2-methylnaphthalene	0.470	NA	NA	NC	NA	NA	NC
Phenanthrene	2.200	NA	NA	NC	NA	1.4E+02	NC
Pyrene	3.400	5.21E-02	NA	NC	1.65E-02	5.4E+02	3.1E-05
Aroclor-1248	0.160	2.28E-02	NA	NC	4.55E-04	2.2E+03	2.0E-07
Aroclor-1254	0.840	1.20E-01	NA	NC	2.39E-03	NA	NC
Aroclor-1260	0.540	7.69E-02	NA	NC	1.33E-03	1.0E+02	1.5E-05

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Table 7-15a  
 Hazard Quotients for Potential Lethal Effects for Wildlife Species Associated with  
 Maximum Exposure Concentrations of ECPCs in Soil at Subzone H-2

Analyte	Max Conc (mg/kg)	American Robin			Eastern Cottontail		
		PDE	RTV	HQ	PDE	RTV	HQ
2,3,7,8-TCDD	4.52E-06	2.50E-06	3.0E-03	8.3E-04	NA	2.3E-02	NC
Aluminum	29,600	NA	NA	NC	NA	1.0E+02	NC
Iron	80,800	NA	NA	NC	NA	2.4E+02	NC
Lead	2,770	1.02E+02	4.9E+03	2.1E-02	5.54E+00	NA	NC
Nickel	995	NA	NA	NC	NA	1.3E+01	NC
Silver	1.2	NA	NA	NC	NA	NA	NC
Antimony	7.3	NA	NA	NC	NA	NA	NC
Arsenic	18.7	1.85E+00	NA	NC	4.00E-01	1.5E+02	2.7E-03
Barium	530	5.36E+01	NA	NC	2.03E+01	NA	NC
Beryllium	14.6	NA	NA	NC	NA	2.0E+00	NC
Cadmium	2.5	1.16E+00	NA	NC	5.34E+00	3.0E+01	1.8E-01
Cobalt	97.2	NA	NA	NC	NA	NA	NC
Copper	4,060	1.52E+02	NA	NC	2.13E+02	2.4E+02	8.9E-01
Vanadium	470	NA	1.9E+01	NC	NA	NA	NC
Zinc	15,100	3.16E+03	NA	NC	6.26E+02	5.0E+02	1.3E+00
Selenium	3.2	3.07E-01	NA	NC	8.26E-03	1.3E+03	6.3E-06
Mercury	3.5	1.92E-01	2.5E+00	7.7E-02	1.34E-01	1.8E+01	7.4E-03
Manganese	1,020	1.03E+02	NA	NC	3.90E+01	8.0E+01	4.9E-01
Chromium	210	NA	NA	NC	NA	NA	NC

**Table 7-15a**  
**Hazard Quotients for Potential Lethal Effects for Wildlife Species Associated with**  
**Maximum Exposure Concentrations of ECPCs in Soil at Subzone H-2**

Analyte	Max Conc (mg/kg)	American Robin			Eastern Cottontail		
		PDE	RTV	HQ	PDE	RTV	HQ
Tin	19.7	NA	NA	NC	NA	NA	NC
HI =				9.9E-02			2.9E+00

**Notes:**

- maxconc = Maximum Concentration of Analyte.
- NA = Data not available
- NC = Not able to calculate value
- PDE = Potential Dietary Exposure (mg/kg/BW) calculated based on equation in Table 7-7.
- RTV = Reference Toxicity Value (mg/kg/BW/day) - 1/5 of the lowest reported LD<sub>50</sub> value from Appendix P for closest related species.
- HQ = Hazard Quotient - PDE divided by the RTV.
- HI = Hazard Index (HQ<sub>1</sub> + HQ<sub>2</sub> + ...HQ<sub>n</sub>).

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Table 7-15b  
 Hazard Quotients for Potential Sublethal Effects for Wildlife Species Associated with  
 Maximum Exposure Concentrations of ECPCs in Soil at Subzone H-2

Analyte	Max Conc (mg/kg)	American Robin			Eastern Cottontail		
		PDE	RTV	HQ	PDE	RTV	HQ
Acenaphthylene	0.590	NA	NA	NC	NA	NA	NC
Anthracene	0.610	NA	NA	NC	NA	NA	NC
Benzo(a)anthracene	1.900	2.75E-02	NA	NC	6.13E-03	NA	NC
Benzo(b)fluoranthene	2.700	4.46E-02	NA	NC	6.80E-03	NA	NC
Benzo(k)fluoranthene	2.200	3.46E-02	NA	NC	NA	NA	NC
Benzo(g,h,i)perylene	0.780	1.22E-02	NA	NC	1.71E-03	NA	NC
Benzo(a)pyrene	1.700	2.85E-02	NA	NC	4.72E-03	4.0E+01	1.2E-04
bis(2-Ethylhexyl)phthalate (BEHP)	1.000	1.57E-02	NA	NC	4.13E-03	3.5E+01	1.2E-04
Chrysene	2.000	3.30E-02	NA	NC	6.46E-03	NA	NC
Dibenzo(a,h)anthracene	0.280	4.32E-03	NA	NC	7.05E-04	NA	NC
Butylbenzylphthalate	2.600	4.11E-02	NA	NC	1.34E-02	4.9E+03	2.7E-06
Fluoranthene	3.900	5.49E-02	NA	NC	1.69E-02	NA	NC
Indeno(1,2,3)pyrene	0.750	1.31E-02	NA	NC	1.57E-03	NA	NC
2-Methylnaphthalene	0.470	NA	NA	NC	NA	NA	NC
Phenanthrene	2.200	NA	NA	NC	NA	NA	NC
Pyrene	3.400	5.21E-02	NA	NC	1.65E-02	NA	NC
Aroclor-1248	0.160	2.28E-02	1.7E+01	1.3E-03	4.55E-04	NA	NC
Aroclor-1254	0.840	1.20E-01	9.0E-01	1.3E-01	2.39E-03	9.6E-02	2.5E-02
Aroclor-1260	0.540	7.69E-02	NA	NC	1.33E-03	6.4E+00	2.4E-04
2,3,7,8-TCDD	4.52E-06	2.50E-06	1.0E-03	2.5E-03	NA	1.0E-05	NC
Aluminum	29,600	NA	NA	NC	NA	NA	NC
Iron	80,800	NA	NA	NC	NA	NA	NC
Lead	2,770	1.02E+02	NA	NC	5.54E+00	5.2E+02	1.1E-02

Table 7-15b  
 Hazard Quotients for Potential Sublethal Effects for Wildlife Species Associated with  
 Maximum Exposure Concentrations of ECPCs in Soil at Subzone H-2

Analyte	Max Conc (mg/kg)	American Robin			Eastern Cottontail		
		PDE	RTV	HQ	PDE	RTV	HQ
Nickel	995	NA	NA	NC	NA	1.6E+02	NC
Silver	1.2	NA	NA	NC	NA	NA	NC
Antimony	7.3	NA	NA	NC	NA	NA	NC
Arsenic	18.7	1.85E+00	NA	NC	4.00E-01	5.8E-01	6.9E-01
Barium	530	5.36E+01	NA	NC	2.03E+01	NA	NC
Beryllium	14.6	NA	NA	NC	NA	NA	NC
Cadmium	2.5	1.16E+00	1.0E+01	1.2E-01	5.34E+00	2.2E+01	2.4E-01
Cobalt	97.2	NA	NA	NC	NA	NA	NC
Copper	4,060	1.52E+02	1.1E+01	1.4E+01	2.13E+02	1.5E+02	1.4E+00
Vanadium	470	NA	NA	NC	NA	NA	NC
Zinc	15,100	3.16E+03	NA	NC	6.26E+02	1.6E+02	3.9E+00
Selenium	3.2	3.07E-01	1.8E+00	1.7E-01	8.26E-03	1.3E+02	6.4E-05
Mercury	3.5	1.92E-01	6.4E-02	3.0E+00	1.34E-01	5.0E-01	2.7E-01
Manganese	1,020	1.03E+02	NA	NC	3.90E+01	9.3E+02	4.2E-02
Chromium	210	NA	2.5E+01	NC	NA	NA	NC
Tin	19.7	NA	NA	NC	NA	NA	NC
HI =				1.7E+01			6.6E+00

- Notes:
- maxconc = Maximum Concentration of Analyte.
  - NA = Data not available
  - NC = Not able to calculate value
  - PDE = Potential Dietary Exposure (mg/kg/BW) calculated based on equation in Table 7-7.
  - RTV = Reference Toxicity Value (mg/kg/BW/day) - lowest reported LOAEL from Appendix P.
  - HQ = Hazard Quotient - PDE divided by the RTV.
  - HI = Hazard Index (HQ<sub>1</sub> + HQ<sub>2</sub> + ...HQ<sub>n</sub>).

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Table 7-15c  
 Hazard Quotients for Potential Lethal Effects for Selected Wildlife Species Associated with  
 Mean Exposure Concentrations of Selected ECPCs in Soil at Subzone H-2

Eastern Cottontail

Analyte	Mean Conc (mg/kg)	PDE	RTV	HQ
Zinc	2.012	8.34E+01	5.0E+02	1.7E-01

- Notes:
- meanconc = Mean Concentration of Analyte.
  - PDE = Potential Dietary Exposure (mg/kg/BW) calculated based on equation in Table 7-7.
  - RTV = Reference Toxicity Value (mg/kg/BW/day) - 1/5 of the lowest reported LF<sub>50</sub> value for closest related species.
  - HQ = Hazard Quotient - PDE divided by the RTV.

Table 7-15d  
 Hazard Quotients for Potential Sublethal Effects for Wildlife Species Associated with  
 Mean Exposure Concentrations of Selected ECPCs in Soil at Subzone H-2

American Robin

Eastern Cottontail

Analyte	Mean Conc (mg/kg)	American Robin			Eastern Cottontail		
		PDE	RTV	HQ	PDE	RTV	HQ
Copper	694	2.59E+01	1.1E+01	2.3E+00	3.64E+01	1.5E+02	2.4E-01
Mercury	0.77	4.21E-02	6.4E-02	6.6E-01			
Zinc	2.012				8.34E+01	1.6E+02	5.2E-01

- Notes:
- meanconc = Mean Concentration of Analyte.
  - PDE = Potential Dietary Exposure (mg/kg/BW) calculated based on equation in Table 7-7.
  - RTV = Reference Toxicity Value (mg/kg/BW/day) - 1/5 of the lowest reported LOAEL from Appendix P for closest related species.
  - HQ = Hazard Quotient - PDE divided by the RTV.

Table 7-16a  
 Hazard Quotients for Potential Lethal Effects for Wildlife Species Associated with  
 Maximum Exposure Concentrations of ECPCs in Soil at Subzone H-3

Analyte	Max Conc (mg/kg)	Red-tailed Hawk			Eastern Cottontail Rabbit			Short-tailed Shrew		
		PDE	RTV	HQ	PDE	RTV	HQ	PDE	RTV	HQ
Acenaphthene	5.810	NA	NA	NC	NA	NA	NC	NA	NA	NC
Anthracene	8.300	1.48E-03	NA	NC	NA	NA	NC	NA	NA	NC
Benzo(a)anthracene	27.2	5.20E-03	NA	NC	8.78E-02	NA	NC	4.23E-01	NA	NC
Benzo(b)fluoranthene	28.4	6.51E-03	NA	NC	7.15E-02	NA	NC	4.97E-01	NA	NC
Benzo(k)fluoranthene	26.5	6.54E-03	NA	NC	6.50E-02	NA	NC	4.43E-01	NA	NC
Benzo(g,h,i)perylene	20.5	8.62E-03	NA	NC	4.50E-02	NA	NC	3.39E-01	NA	NC
Benzo(a)pyrene	36.8	7.62E-03	NA	NC	1.02E-01	1.0E+01	1.0E-02	6.55E-01	NA	NC
bis(2-Ethylhexyl)phthalate (BEHP)	0.127	2.30E-05	NA	NC	5.25E-04	6.8E+03	7.0E-07	2.14E-03	NA	NC
Chrysene	29.8	5.69E-03	NA	NC	9.62E-02	NA	NC	5.23E-01	NA	NC
Dibenzo(a,h)anthracene	7.38	1.79E-03	NA	NC	1.86E-02	NA	NC	1.21E-01	NA	NC
Dibenzofuran	2.51	NA	NA	NC	NA	NA	NC	NA	NA	NC
Fluoranthene	18.0	3.27E-03	NA	NC	7.79E-02	NA	NC	2.74E-01	NA	NC
Fluorene	1.50	NA	NA	NC	NA	NA	NC	NA	NA	NC
Indeno(1,2,3-cd)pyrene	17.0	2.38E-02	NA	NC	3.55E-02	NA	NC	3.14E-01	NA	NC
2-Methylnaphthalene	0.524	NA	NA	NC	NA	NA	NC	NA	NA	NC
Naphthalene	1.07	NA	NA	NC	NA	NA	NC	NA	NA	NC
Phenanthrene	33.5	5.98E-03	NA	NC	NA	1.4E+02	NC	NA	NA	NC
Pyrene	41.8	7.56E-03	NA	NC	2.03E-01	5.4E+02	3.8E-04	6.93E-01	NA	NC

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Table 7-16a  
 Hazard Quotients for Potential Lethal Effects for Wildlife Species Associated with  
 Maximum Exposure Concentrations of ECPCs in Soil at Subzone H-3

Analyte	Max Conc (mg/kg)	Red-tailed Hawk			Eastern Cottontail Rabbit			Short-tailed Shrew		
		PDE	RTV	HQ	PDE	RTV	HQ	PDE	RTV	HQ
alpha-Chlordane	0.025	2.10E-05	4.8E+00*	4.3E-06	9.40E-05	2.0E+01*	4.7E-06	2.53E-03	5.7E+01*	4.4E-05
gamma-Chlordane	0.053	4.60E-05	4.8E+00*	9.5E-06	1.99E-04	2.0E+01*	9.9E-06	5.35E-03	5.7E+01*	9.4E-05
DDD	0.012	NA	NA	NC	NA	NA	NC	NA	NA	NC
DDE	0.020	6.50E-05	NA	NC	6.60E-05	1.6E+02	NC	2.41E-03	1.4E+02	1.7E-05
DDT	0.065	2.12E-04	5.9E+02	3.0E-07	2.43E-04	5.0E+01	4.8E-06	7.83E-03	2.7E+01	2.9E-04
Dieldrin	0.010	8.70E-06	6.0E-01	1.5E-05	5.20E-05	9.0E+00	5.7E-06	1.45E-03	7.6E+00	1.9E-04
Endosulfan II	0.006	NA	6.24E+00*	NC	NA	4.8E+00*	NC	NA	4.8E+00*	NC
Endrin	0.066	NA	NA	NC	NA	5.3E-01	NC	NA	5.3E-01	NC
Endrin aldehyde	0.006	NA	NA	NC	NA	NA	NC	NA	NA	NC
Heptachlor	0.031	NA	NA	NC	NA	NA	NC	NA	NA	NC
Heptachlor epoxide	0.018	NA	NA	NC	NA	NA	NC	NA	NA	NC
2,3,5-TP	1.067	NA	NA	NC	NA	NA	NC	NA	NA	NC
2,3,4-T	0.107	NA	NA	NC	NA	NA	NC	NA	NA	NC
2,4-D	0.545	NA	NA	NC	NA	NA	NC	NA	NA	NC
Parathion	0.038	NA	NA	NC	NA	NA	NC	NA	NA	NC
2,3,7,8-TCDD	3.77E-06	4.40E-09	1.2E-06	3.7E-03	8.80E-09	2.3E-02	3.8E-07	2.10E-06	5.7E-02	3.7E-05
Aluminum	29,600	NA	NA	NC	NA	NA	NC	NA	NA	NC
Iron	31,800	NA	NA	NC	NA	2.4E+02	NC	NA	2.0E+02	NC
Lead	20,900	1.34E+01	4.9E+03	2.7E-03	4.18E+01	8.0E+01	5.2E-01	7.88E+02	300	2.6

**Table 7-16a**  
**Hazard Quotients for Potential Lethal Effects for Wildlife Species Associated with**  
**Maximum Exposure Concentrations of ECPCs in Soil at Subzone H-3**

Analyte	Max Conc (mg/kg)	Red-tailed Hawk			Eastern Cottontail Rabbit			Short-tailed Shrew		
		PDE	RTV	HQ	PDE	RTV	HQ	PDE	RTV	HQ
Thallium	2.9	NA	NA	NC	NA	NA	NC	NA	NA	NC
Antimony	167	NA	NA	NC	NA	NA	NC	NA	NA	NC
Arsenic	69	3.37E-02	NA	NC	1.48E+00	1.5E+02	9.9E-03	7.06E+00	2.9E+01	2.4E-01
Barium	121	5.68E-02	NA	NC	4.62E+00	NA	NC	1.29E+01	NA	NC
Beryllium	1.51	NA	NA	NC	NA	2.0E+00	NC	NA	2.0E+00	NC
Cadmium	3.6	7.74E-03	NA	NC	7.69E+00	5.0E+01	1.5E-01	2.58E+00	1.8E+02	1.4E-02
Cobalt	7.2	NA	NA	NC	NA	NA	NC	NA	NA	NC
Copper	79.7	5.57E-02	NA	NC	4.18E+00	240	1.7E-02	3.52E+00	NA	NC
Vanadium	72	NA	1.9E+01	NC	NA	NA	NC	NA	NA	NC
Selenium	6.2	2.95E-03	NA	NC	1.60E-02	1.3E+03	1.2E-05	6.04E-01	130	0.0046
Chromium	91	NA	2.5E+01	NC	NA	NA	NC	NA	NA	NC
Tin	81	NA	NA	NC	NA	NA	NC	NA	NA	NC
HI =				6.4E-03			7.1E-01			2.8

- Notes:**
- maxconc = Maximum Concentration of Analyte.
  - NA = Data not available
  - NC = Not able to calculate value
  - PDE = Potential Dietary Exposure (mg/kg/BW) calculated based on equation in Table 7-7.
  - RTV = Reference Toxicity Value (mg/kg/BW/day) - 1/5 of the lowest reported LD<sub>50</sub> value from Appendix P for closest related species.
  - HQ = Hazard Quotient - PDE divided by the RTV.
  - HI = Hazard Index (HQ<sub>1</sub> + HQ<sub>2</sub> + ...HQ<sub>n</sub>).
  - a = Represent RTV values for technical Chlordane (alpha- and gamma-Chlordane makeup approximately 19% and 24% of technical Chlordane, respectively).
  - b = Represent RTV values for technical endosulfan.

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Table 7-16b  
 Hazard Quotients for Potential Sublethal Effects for Wildlife Species Associated with  
 Maximum Exposure Concentrations of ECPCs in Soil at Subzone H-3

Analyte	Max Conc (mg/kg)	Red-tailed Hawk			Eastern Cottontail Rabbit			Short-tailed Shrew		
		PDE	RTV	HQ	PDE	RTV	HQ	PDE	RTV	HQ
Acenaphthene	5.810	NA	NA	NC	NA	NA	NC	NA	NA	NC
Anthracene	8.300	1.48E-03	NA	NC	NA	NA	NC	NA	NA	NC
Benzo(a)anthracene	27.2	5.20E-03	NA	NC	8.78E-02	NA	NC	4.23E-01	NA	NC
Benzo(b)fluoranthene	28.4	6.51E-03	NA	NC	7.15E-02	NA	NC	4.97E-01	NA	NC
Benzo(k)fluoranthene	26.5	6.54E-03	NA	NC	6.50E-02	NA	NC	4.43E-01	NA	NC
Benzo(g,h,i)perylene	20.5	8.62E-03	NA	NC	4.50E-02	NA	NC	3.39E-01	NA	NC
Benzo(a)pyrene	36.8	7.62E-03	NA	NC	1.02E-01	4.0E+01	2.6E-03	6.55E-01	4.0E+01	1.6E-02
bis(2-Ethylhexyl)phthalate (BEHP)	0.127	2.30E-05	NA	NC	5.25E-04	3.5E+01	1.5E-05	2.14E-03	5.0E+01	4.3E-05
Chrysene	29.8	5.69E-03	NA	NC	9.62E-02	NA	NC	5.23E-01	NA	NC
Dibenzo(a,h)anthracene	7.38	1.79E-03	NA	NC	1.86E-02	NA	NC	1.21E-01	NA	NC
Dibenzofuran	2.51	NA	NA	NC	NA	NA	NC	NA	NA	NC
Fluoranthene	18.0	3.27E-03	NA	NC	7.79E-02	4.0E+02	1.9E-04	2.74E-01	4.0E+02	6.9E-04
Fluorene	1.30	NA	NA	NC	NA	NA	NC	NA	NA	NC
Indeno(1,2,3-cd)pyrene	17.0	2.38E-02	NA	NC	3.55E-02	NA	NC	3.14E-01	NA	NC
2-methylnaphthalene	0.524	NA	NA	NC	NA	NA	NC	NA	NA	NC
Naphthalene	1.07	NA	NA	NC	NA	NA	NC	NA	NA	NC
Phenanthrene	33.5	5.98E-03	NA	NC	NA	NA	NC	NA	NA	NC
Pyrene	41.8	7.56E-03	NA	NC	2.03E-01	NA	NC	6.93E-01	NA	NC

**Table 7-16b**  
**Hazard Quotients for Potential Sublethal Effects for Wildlife Species Associated with**  
**Maximum Exposure Concentrations of ECPCs in Soil at Subzone H-3**

Analyte	Max Conc (mg/kg)	Red-tailed Hawk			Eastern Cottontail Rabbit			Short-tailed Shrew		
		PDE	RTV	HQ	PDE	RTV	HQ	PDE	RTV	HQ
alpha-Chlordane	0.025	2.10E-05	NA	NC	9.40E-05	NA	NC	2.53E-03	NA	NC
gamma-Chlordane	0.053	4.60E-05	NA	NC	1.99E-04	NA	NC	5.35E-03	NA	NC
DDD	0.012	NA	NA	NC	NA	NA	NC	NA	NA	NC
DDE	0.020	6.50E-05	NA	NC	6.60E-05	NA	NC	2.41E-03	NA	NC
DDT	0.065	2.12E-04	NA	NC	2.43E-04	NA	NC	7.83E-03	8.1E+01	9.7E-05
Dieldrin	0.010	8.70E-06	NA	NC	5.20E-05	NA	NC	1.4E-03	NA	NC
Endosulfan II	0.006	NA	NA	NC	NA	NA	NC	NA	NA	NC
Endrin	0.066	NA	NA	NC	NA	NA	NC	NA	NA	NC
Endrin aldehyde	0.006	NA	NA	NC	NA	NA	NC	NA	NA	NC
Heptachlor	0.031	NA	NA	NC	NA	NA	NC	NA	NA	NC
Heptachlor epoxide	0.018	NA	NA	NC	NA	NA	NC	NA	NA	NC
2,3,5-TP	1.067	NA	NA	NC	NA	NA	NC	NA	NA	NC
2,3,4-T	0.107	NA	NA	NC	NA	NA	NC	NA	NA	NC
2,4-D	0.545	NA	NA	NC	NA	NA	NC	NA	NA	NC
Parathion	0.038	NA	NA	NC	NA	NA	NC	NA	NA	NC
2,3,7,8-TCDD	3.77E-06	4.40E-09	NA	NC	8.80E-09	NA	NC	2.10E-06	1.0E-05	2.1E-01
Aluminum	29,600	NA	NA	NC	NA	NA	NC	NA	NA	NC
Iron	31,800	NA	NA	NC	NA	NA	NC	NA	NA	NC

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Table 7-16b  
 Hazard Quotients for Potential Sublethal Effects for Wildlife Species Associated with  
 Maximum Exposure Concentrations of ECPCs in Soil at Subzone H-3

Analyte	Max Conc (mg/kg)	Red-tailed Hawk			Eastern Cottontail Rabbit			Short-tailed Shrew		
		PDE	RTV	HQ	PDE	RTV	HQ	PDE	RTV	HQ
Lead	20,900	1.34E+01	2.5E+02	5.4E-02	4.18E+01	5.2E+02	8.0E-02	7.88E+0 2	NA	NC
Thallium	2.9	NA	NA	NC	NA	NA	NC	NA	NA	NC
Antimony	167	NA	NA	NC	NA	NA	NC	NA	NA	NC
Arsenic	69	3.37E-02	NA	NC	1.48E+00	5.8E-01	2.6E+00	7.06E+0 0	NA	NC
Barium	121	5.68E-02	NA	NC	4.62E+00	NA	NC	1.29E+0 1	NA	NC
Beryllium	1.51	NA	NA	NC	NA	NA	NC	NA	NA	NC
Cadmium	3.6	7.74E-03	1.0E+01	7.7E-04	7.69E+00	2.2E+01	3.5E-01	2.58E+0 0	4.5E+02	5.7E-03
Cobalt	7.2	NA	NA	NC	NA	NA	NC	NA	NA	NC
Copper	79.7	5.57E-02	1.1E+01	5.1E-03	4.18E+00	1.5E+02	2.8E-02	3.52E+0 0	1.5E+02	2.3E-02
Vanadium	72	NA	NA	NC	NA	NA	NC	NA	NA	NC
Selenium	6.2	2.95E-03	1.7E+00	1.7E-03	1.60E-02	1.3E+02	1.2E-04	6.04E-01 2	1.34E+0	4.5E-03
Chromium	91	NA	NA	NC	NA	NA	NC	NA	NA	NC

**Table 7-16b**  
**Hazard Quotients for Potential Sublethal Effects for Wildlife Species Associated with**  
**Maximum Exposure Concentrations of ECPCs in Soil at Subzone H-3**

Analyte	Max Conc (mg/kg)	Red-tailed Hawk			Eastern Cottontail Rabbit			Short-tailed Shrew		
		PDE	RTV	HQ	PDE	RTV	HQ	PDE	RTV	HQ
Tin	81	NA	NA	NC	NA	NA	NC	NA	NA	NC
HI =				6.0E-02			3.1E+00			2.6E-01

- Notes:**
- maxconc = Maximum Concentration of Analyte.
  - NA = Data not available
  - NC = Not able to calculate value
  - PDE = Potential Dietary Exposure (mg/kg/BW) calculated based on equation in Table 7-7.
  - RTV = Reference Toxicity Value (mg/kg/BW/day) - 1/5 of the lowest reported LD<sub>50</sub> value from Appendix P for closest related species.
  - HQ = Hazard Quotient - PDE divided by the RTV.
  - HI = Hazard Index (HQ<sub>1</sub> + HQ<sub>2</sub> + ...HQ<sub>n</sub>).
  - a = Represent RTV values for technical chlordane (alpha- and gamma-Chlordane makeup approximately 19% and 24% of technical chlordane, respectively).
  - b = Represent RTV values for technical endosulfan.
  - ND = Not Reportable.

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**Table 7-16c**  
**Hazard Quotients for Potential Lethal Effects for Selected Wildlife Species Associated with**  
**Mean Exposure Concentrations of Selected ECPCs in Soil at Subzone H-3**

**Short-tailed Shrew**

Analyte	Mean Conc (mg/kg)	PDE	RTV	HQ
Lead	337	1.27E+01	3.0E+02	4.2E-02

**Notes:**

- meanconc = Mean Concentration of Analyte.
- PDE = Potential Dietary Exposure (mg/kg/BW) calculated based on equation in Table 7-7.
- RTV = Reference Toxicity Value (mg/kg/BW/day) - 1/5 of the lowest reported LC<sub>50</sub> value from Appendix P for closest related species.
- HQ = Hazard Quotient - PDE divided by the RTV.

**Table 7-16d**  
**Hazard Quotients for Potential Sublethal Effects for Selected Wildlife Species Associated with**  
**Mean Exposure Concentrations of Selected ECPCs in Soil at Subzone H-3**

**Eastern Cottontail Rabbit**

Analyte	Mean Conc (mg/kg)	PDE	RTV	HQ
Arsenic	12.2	2.61E-01	5.8E-01	4.5E-01

**Notes:**

- meanconc = Mean Concentration of Analyte.
- PDE = Potential Dietary Exposure (mg/kg/BW) calculated based on equation in Table 7-6.
- RTV = Reference Toxicity Value (mg/kg/BW/day) - lowest reported LOAEL value from Appendix P.
- HQ = Hazard Quotient - PDE divided by the RTV.

The risk potential produced by the model contradicts some literature information relative to metal transfer to herbivores in a terrestrial setting. Pascoe et al. (1994) found that the bioavailable fraction of metals and arsenic in soil to herbivores are limited. But results of the model agree with other studies which show that transfer of metal to herbivores via plant uptake from soils is feasible (Leita et al., 1991). Measurement of tissue concentrations or in-situ bioaccumulation studies are needed to assess the actual potential for impacts to herbivores at H-2.

For American robin in subzone H-2, all HQs and the HI value for lethal effects was less than 1. No potential lethal adverse effects to passerine bird species exists as a result of exposure to ECPCs in surface soil.

Potential sublethal effects to robins exists from exposure to ECPCs in soil based on HQ and HI values. As with rabbits, metal concentrations were most responsible for the HI value of 17. Copper and mercury were the primary constituents. For copper, the SRL of 300 mg/kg was exceeded at 12 locations (Table 7-13 and Figure 7-9). The mercury SRL (1.2 mg/kg) was exceeded at three locations. Only the mean value for copper resulted in an HQ above 1 (see Table 7-14d and Figure 7-10).

The model prediction of risks to carnivorous bird species appears to be accurate in relation to literature information. Uptake of metals by soil invertebrates, such as earthworms, to levels equal to soil concentrations has been shown (Neuhauser et al., 1985) and earthworms have been shown to be an important food item of the American robin (McDonald, 1983). Based on the maximum values observed at H-2, birds preying on soil infaunal species are likely at risk. Again, in-situ bioaccumulation studies would help to reduce any uncertainty inherent in the model prediction.

### ***Subzone H-3***

A potential lethal risk to short-tailed shrew is present based on the maximum soil concentration observed for lead (Table 15a). The maximum lead concentration (20,900 mg/kg) resulted in an HQ of 2.6, the major contributor to the overall HI value of 2.8. The lead SRL of 8,000 mg/kg (Table 7-13) was exceeded only at the location with the maximum concentration (Figure 7-11). Mean values for those ECPCs identified as major contributors to risk all produced HQs below 1 (see Table 7-16c).

A potential sublethal risk to Eastern cottontail rabbit was indicated by the model (HI=3.1), due primarily to the arsenic HQ of 2.6. The arsenic SRL of 27 mg/kg (Table 7-13) was exceeded at two locations (Figure 7-12). Mean values for those ECPCs identified as major contributors to risk all produced HQs below 1 (see Table 7-16d).

### **7.8.3 Vegetation**

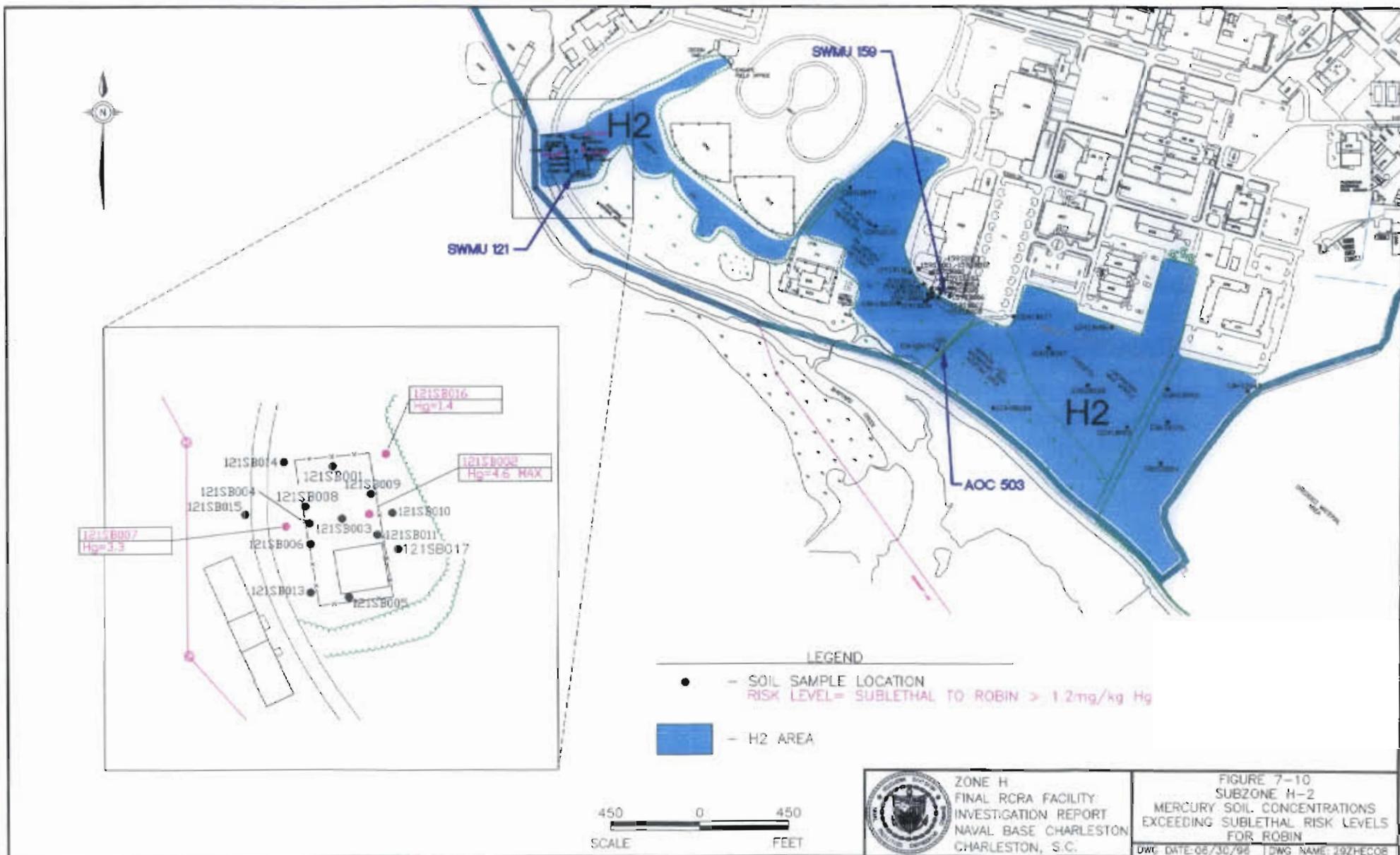
Limited information exists on toxic effects of soil contamination to plants in natural environments. Most literature containing effects information deals with herbicide or fungicide application programs. Beyer et al. (1985) demonstrated that only a small portion of all metals measured in soil became incorporated in plant foliage. In the study, the origin for plant metal residues was suggested to have come primarily from aerial deposition. Table 7-17 presents phytotoxic effects concentrations for arsenic, lead, and zinc for several species. Effects concentrations vary depending on specific soil physicochemical conditions such as pH, organic content, and CEC.

Arsenic availability to plants is typically highest in coarse-textured soil having little CEC and lowest in clay having organic material, and containing iron, calcium, and phosphate (NRCC, 1978). Cadmium appears to be taken up by plants in soil that has abnormally high cadmium residues. For chromium, Towill et al.'s (1978) study showed no phytotoxic effects to plants for elevated chromium concentrations.

Table 7-17  
 Comparison of Phytotoxic Responses to Maximum Soil Concentrations of ECPCs at Subzones H-1, H-2, and H-3

Study	Organisms	Measured Parameter	Subzone Concentration (mg/kg)				Effects Level	Measured Response
			H-1	H-2	H-3	H-4*		
USEPA (1987)	<i>Acer rubrum</i> , Red Maple	Zinc	2,800	1,500	ND	81.8	100 mg/kg	Lethal to seedlings
USEPA (1987)	<i>Quercus rubra</i> , Oak	Zinc	2,800	1,500	ND	81.8	100 mg/kg	Lethal to seedlings
NRCC (1978)	Canadian crops	Arsenic	22.1	18.7	69	7.7	25-85 mg/kg	Depressed crop yield
	<i>Oryza sativum</i> , Rice	Arsenic (disodium methylnaonate)	22.1	18.7	69	7.7	50 mg/kg	75% decrease yield
Sadiq (1985)	Corn plant	Lead	6,170	2,770	20,900		800 mg/kg	No elevated concentration in plants
Krishnappa and Bedi (1986)	<i>Cassia</i> spp., Woods	Lead	6,170	2,770	20,900		500 mg/kg	90% reduced pollen germination
Miller et al. (1985)	Radish (seed germination)	Copper	3,040	4,060	79.7	57.1	47 mg/kg	EC <sub>50</sub>
		Zinc	2,800	1,500	ND	81.8	53 mg/kg	EC <sub>50</sub>
	Cucumber (seed germination)	Copper	3,040	4,060	79.7	57.1	55 mg/kg	EC <sub>50</sub>
		Zinc	2,800	1,500	ND	81.8	61 mg/kg	EC <sub>50</sub>

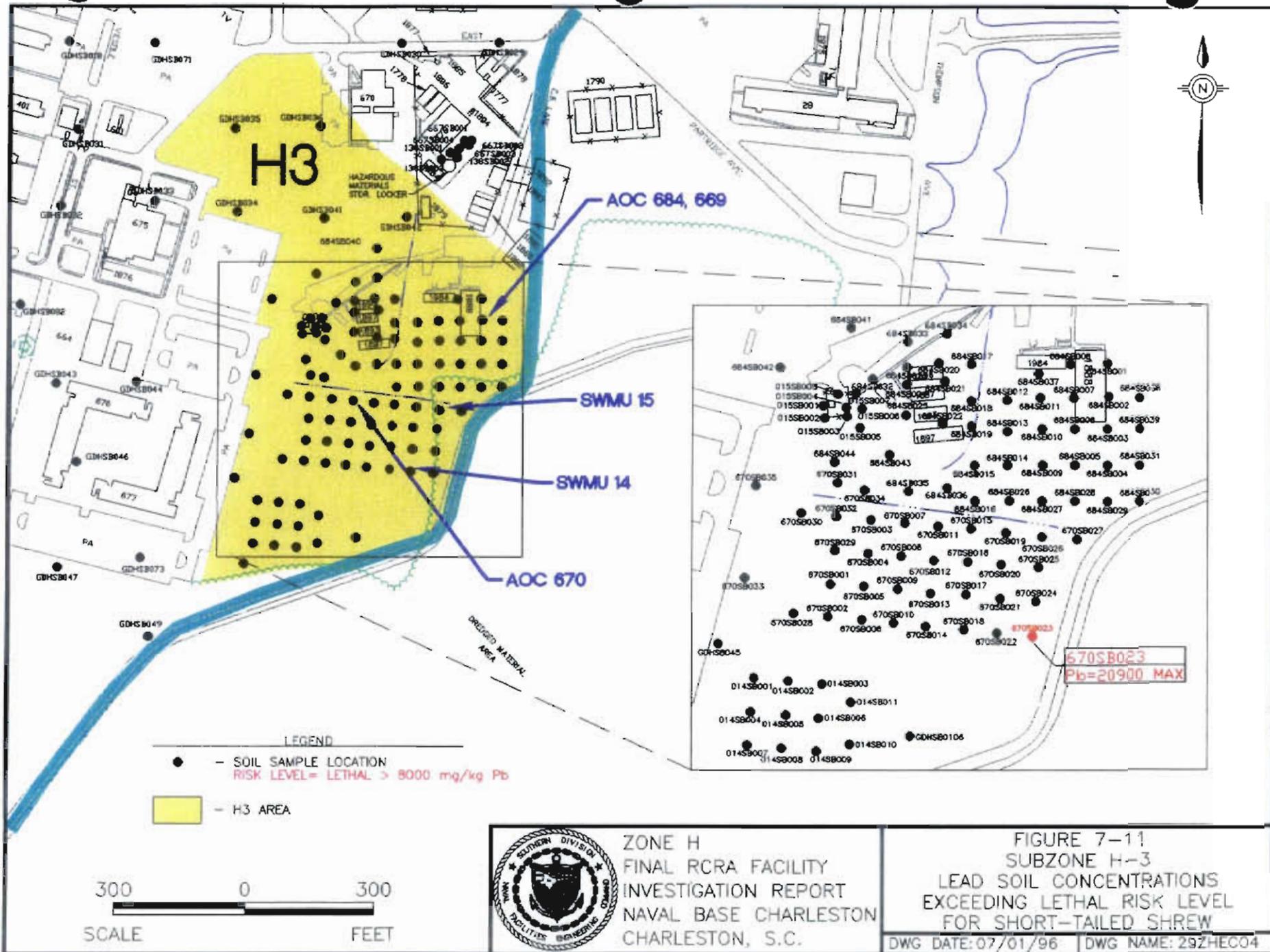
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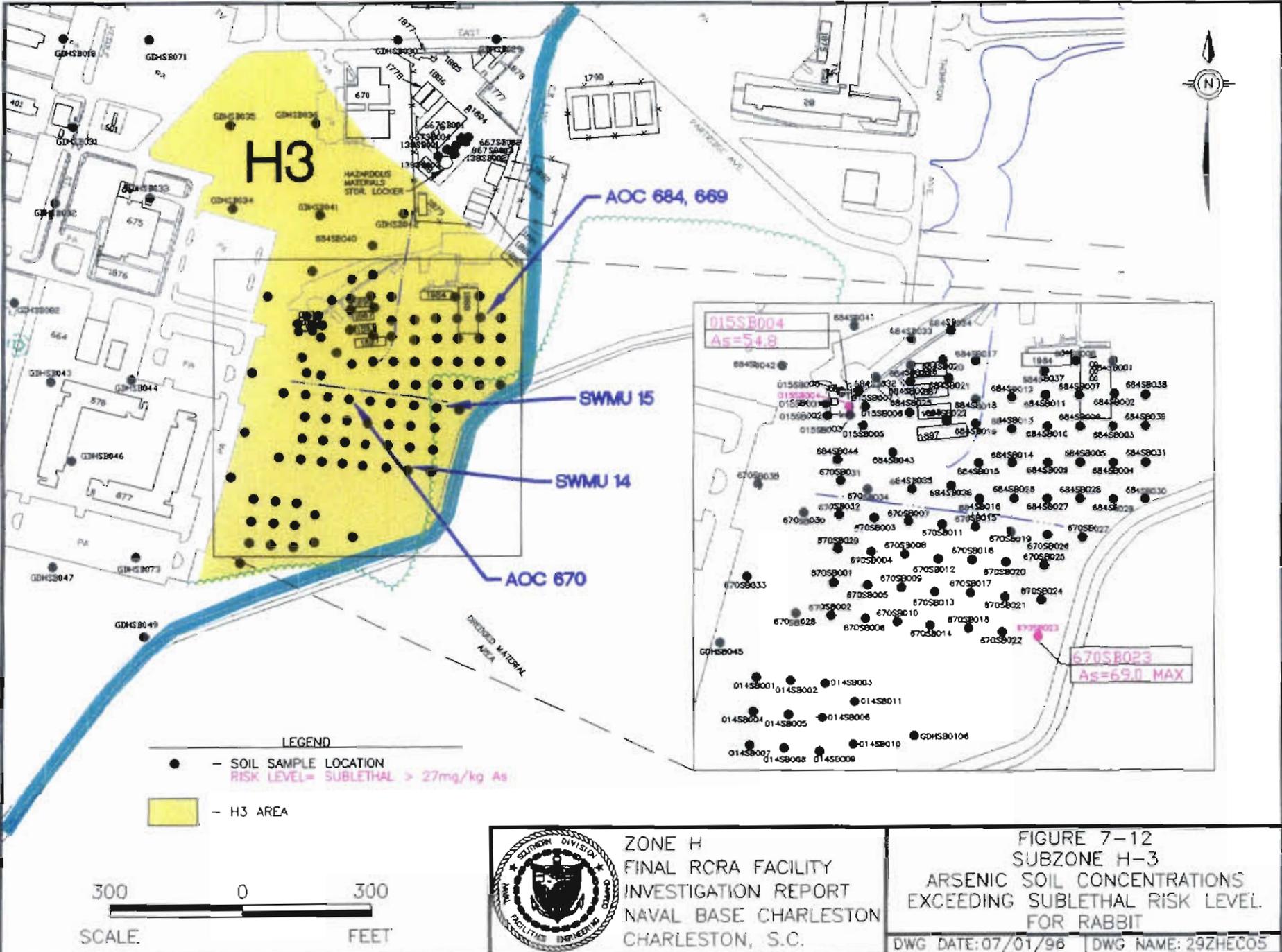



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FIGURE 7-10  
 SUBZONE H-2  
 MERCURY SOIL CONCENTRATIONS  
 EXCEEDING SUBLETHAL RISK LEVELS  
 FOR ROBIN  
 DWG. DATE: 08/30/98 DWG. NAME: 19ZHECOB

450 0 450  
 SCALE FEET





**H3**

AOC 684, 669

SWMU 15

SWMU 14

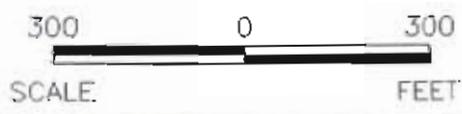
AOC 670

015S8004  
As=54.8

670S8023  
As=69.0 MAX

**LEGEND**

- - SOIL SAMPLE LOCATION  
RISK LEVEL= SUBLETHAL > 27mg/kg As
- - H3 AREA



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FIGURE 7-12  
SUBZONE H-3  
ARSENIC SOIL CONCENTRATIONS  
EXCEEDING SUBLETHAL RISK LEVEL  
FOR RABBIT  
DWG DATE: 07/01/96    DWG NAME: 29ZHEC05

Like other metals, the bioavailability of lead in soil to plants is enhanced by reduced soil pH, reduced organic matter, and reduced iron oxides and phosphorus content (NRCC, 1973). Studies have shown there is no convincing evidence that terrestrial vegetation is important in food chain biomagnification of lead (USEPA, 1980). Chang et al. (1983) observed that zinc uptake was lower in coarse loamy soil than in fine loamy soil. The phytotoxic nature of copper to crop production has been studied relative to application rates (Hirst et al., 1961). Little information exists on mercury effects to herbaceous or woody plants (Eisler, 1987b).

Studies by USEPA (1980), Lee and Grant (1981), Wang and Meresz (1982) and Edwards (1983) generally conclude five points for PAH's effects to plants. First, plants can absorb PAHs from soil through roots to other parts. Second, lower molecular weight compounds are absorbed more readily than higher molecular weight compounds. Third, aboveground parts have higher residue concentrations which are most likely attributable to airborne deposition. Fourth, PAH-induced phytotoxic effects are rare. Fifth, higher plants can catabolize benzo(a)pyrene and possibly other PAH compounds, and finally, plant uptake of PAHs is most likely not a significant pathway to terrestrial vertebrate species.

For PCBs, Klekowski (1982) suggested that there was no evidence of genetic damage to terrestrial plants at a PCB-contaminated site in Massachusetts.

For dioxins, Isensee and Jones (1971) indicated that isomer uptake by terrestrial plants was less readily comparable to uptake by aquatic plants, and studies by Blair (1973) and Ramel (1978) considered uptake of 2,3,7,8-TCDD in soil by vegetation to be negligible.

Eisler (1990) noted that there was little information available on phytotoxicity of chlordane and that there was little evidence to indicate accumulation by crop plants. In soils, chlordane is mostly immobile and there is only a limited capacity for translocation into edible portions of food crops (NRCC, 1975).

### ***Subzone H-1***

Based on detected maximum concentrations of copper (3,040 mg/kg), lead (6,170 mg/kg), and zinc (2,800 mg/kg), and considering the physical nature of soils within subzone H-1, a risk to young herbaceous species exists. Phytotoxic effects levels for organics were not available, but survey of the area did not identify any observable negative effects to vegetation.

### ***Subzone H-2***

Based on detected maximum concentrations of lead (2,770 mg/kg), copper (4,060 mg/kg), and zinc (15,100 mg/kg), and considering the physical nature of soil within subzone H-2, a risk to young herbaceous species exists. Again, effects from organic concentrations could not be assessed and man-induced modifications to the area made observable effects to vegetation from soil contamination difficult to determine.

### ***Subzone H-3***

Although lead concentrations were high (20,900 mg/kg) in soil at subzone H-3, the monotypic nature of the grass fields and the low capacity of grasses to store significant amounts of metals (Eisler, 1988b) will reduce the risk of lead phytotoxic effects in this subzone to an acceptable level. Again, organic concentrations could not be assessed.

### ***Subzone H-4***

Based on detected maximum concentrations of copper (57.1 mg/kg) and zinc (147 mg/kg), and considering the physical nature of soil/sediment within subzone H-4, a risk to young herbaceous species exists. Again, effects from organic concentrations could not be assessed and man-induced modifications to the area made observable effects to vegetation from soil contamination difficult to determine.

The reported areas of stressed or lacking vegetation in H-4 south of SWMU 9 were in the same area as remnants of an antenna field. Rather than a contamination-related effect, the lack of

vegetation is more likely attributed to the change of topography in the area of the guy anchors. Sediment/soil samples collected in these areas did not indicate higher contamination.

#### **7.8.4 Aquatic Wildlife**

Surface water and sediment were measured in Shipyard Creek (within subzone H-1) to assess potential for risks to aquatic species endemic to the waterbody. Mean concentrations of six inorganic constituents (aluminum, copper, lead, nickel, zinc, and chromium) exceeded surface water contaminant concentrations suggested for chronic effects to aquatic wildlife (Table 7-6a). Concentrations were two to 17 times above the indicated effects levels. Based on effects levels comparisons, risk to sensitive aquatic life from surface water may be high within the upper portion of Shipyard Creek.

A risk to aquatic receptors from sediment of Shipyard Creek exists based on exceedances of USEPA Region IV Sediment Screening Values (see Table 7-6b). HQ values greater than 1 for lead, nickel, arsenic, copper, chromium, zinc, mercury, PCBs, DDT, DDE, total DDT, fluoranthene, pyrene, and total PAHs were determined. As SSVs are derived from statistical interpretation of effects databases obtained from literature, actual risks to receptors within Shipyard Creek may be lower than that implied by use of the SSV in the screening assessment. Generally, organic constituent concentrations (HQs > 10 for 4,4'-DDT, 4,4'-DDE, total DDT, fluoranthene, and pyrene; HQ > 100 for total PCBs) appear to be more critical than inorganic concentrations (all HQs < 10). Because of this information, a more defined determination of risks to receptors from sediment contamination in Shipyard Creek will be conducted during the Zone J RFI.

#### ***Subzone H-2***

Two H-2 sediment samples collected in association with SWMU 159 exhibited high concentrations of metals and SVOC compounds. These sediments, however, were collected in narrow drainage ditches which, based on their size and frequent dryness, could not support nor

pose a significant risk to site-specific aquatic wildlife. Based on observed sediment concentrations and potential migration pathways, however, risk may exist to downgradient wetland communities in H-4 and possibly aquatic wildlife in Shipyard Creek. The single sediment sample collected in the small, semipermanently flooded pond north of the Building 661 parking area did not contain significant concentrations of inorganic or organic constituents. The results for these H-2 sediment samples are presented in Table 7-4c. These aquatic areas will be further assessed during the Zone J RFI, as necessary.

### ***Subzone H-3***

The sediment collected in H-3, particularly in the westernmost sample 670M000101, exhibited high concentrations of lead, PAHs, and other SVOC compounds. These sediments, however, were collected in low-lying surface depressions which, based on their frequent dryness, do not support significant communities of aquatic wildlife. These land-locked depressions also lack apparent connections to other wetlands and water bodies. With a lack of suitable habitat and the inability to convey surface water, no risk is predicted for aquatic wildlife.

### ***Subzone H-4***

Based on exceedances of USEPA Region IV SSVs, potential risk to aquatic wildlife exists from contaminant concentrations observed in surface water and sediments in subzone H-4. Although sediment HQ values for several constituents were above one (see Table 7-6c), only three organic compounds (total PCBs, 4,4'- DDT, and total DDT) had HQ values which exceeded 10. SSV exceedances for each of these three organics occurred at only a third of the stations sampled.

Overall, risks to aquatic receptors in subzone H-4 appear to be low. The findings of this screening assessment for subzone H-4 will be incorporated into the Zone J RFI.

## **7.9 Uncertainty**

General uncertainties are associated with the ecological risk assessment for Zone H.

- Degradation of chemicals has not been considered in the ECPC selection process.
- Specific effects to biota within the area are unknown.
- Acute and chronic effects data on some ECPCs were unavailable.
- Synergistic or antagonistic effects cannot be quantified.
- For some ECPCs, only assumptions relative to similar compounds or classes of elements can be made.
- Use of related species for risk determination may over- or under-estimate risk to selected representative wildlife species.
- Dermal or inhalation exposure pathways were not evaluated.
- Maximum exposure scenarios and concentrations may tend to overestimate risk potentials.
- On occasion, BAFs were assumed due to lack of information.
- Actual occurrence of selected wildlife species within the contaminated area is uncertain.
- Food ingestion rates in food chain analyses may be a source of uncertainty to exposure.

### **7.10 Ecological Risk Assessment Conclusions**

Potential risks for ecological receptors were evaluated for ECPCs in surface soil, surface water, sediment at Zone H. Risks associated with exposure to ECPCs in surface soil were evaluated for terrestrial wildlife based on a model that predicts the amount of contaminant exposure via the diet and incidental ingestion of soil. Comparison of predicted doses for representative wildlife species with doses representing thresholds for both lethal and sublethal effects (RTVs) is the basis of the risk evaluation. Risks for soil invertebrates and plants were evaluated based on qualitative comparisons to literature effects-levels for taxonomic groups similar to those potentially occurring at Zone H. Risks for aquatic organisms were evaluated by calculating HQs from benchmark values that are either promulgated or proposed by federal and state regulatory agencies.

#### **Risk Summary**

*Infaunal Invertebrates* — A high risk to soil infaunal organisms exists from inorganic constituents and low but widespread concentrations of PAH compounds detected in subzone H-1. The risk from other organic ECPCs in H-1 appears to be low. Within subzone H-2, a relatively high risk to soil infaunal organisms is also predicted from exposure to inorganic ECPCs (zinc, copper, and lead). No risk is expected from organic ECPCs in H-2 soil. A risk to infaunal organisms from soil lead concentrations at subzone H-3 is predicted. Also, low but widespread concentrations of PAH ECPCs at subzone H-3 may pose a moderate risk to soil infaunal species. No risk is predicted for other organic ECPCs in soil from subzone H-3.

*Terrestrial Wildlife* — For representative terrestrial wildlife species, mean concentration values were used to determine the soil concentration necessary to produce risk quotients (HQs) below 1. This concentration is referred to as the Significant Risk Level (SRL). Those contaminant concentrations below the respective lethal and sublethal SRLs were considered to pose negligible risk to the representative species.

Potential lethal and sublethal effects from inorganics (zinc, mercury, copper, and lead) are present in H-1 based on the HQ and HI values calculated for the rabbit, hawk, and shrew. The concentrations of inorganics in H-1 (lead, zinc, copper, and mercury) which exceeded the respective SRLs were primarily detected in SWMU 19 surface soil samples.

Within subzone H-2, copper, zinc, cadmium, and manganese concentrations contributed to an HI value predicting lethal effects to rabbits. This risk, however, is driven primarily from soil samples collected at SWMU 121. Risk for sublethal effects in H-2 are also present for the Cottontail rabbit and the American robin due to the copper, mercury, and zinc concentrations detected at SWMU 121.

The two H-3 soil samples with the highest concentrations of lead (collected from SWMU 15 and AOC 670) drive the lethal risk potential for shrews. The maximum concentration of arsenic detected in one sample at AOC 670 poses a sublethal risk to rabbits.

*Vegetation* — Risk to young herbaceous species from soil ECPCs (copper, lead, and zinc) is predicted in both subzones H-1 and H-2. While lead concentrations in H-3 were high, significant phytotoxic effects are not expected due to monotypic nature and the low storage capacity for metals within the existing vegetation (grass). Copper and zinc were present in H-4 sediments at concentrations that may also pose a risk to young herbaceous species.

*Aquatic Wildlife* — Chronic effects are predicted to aquatic wildlife from ECPCs in surface water and sediments in Shipyard Creek. For both inorganic and organic ECPCs, HQ values were above 1. Sediment concentrations from surface depressions in H-3 were high for PAHs, lead, and other SVOCs but with the absence of aquatic receptors and migration pathways, no risk is predicted.

Risks to aquatic receptors from observed sediment concentrations in H-4 appear to be moderate. Only three organic compounds had HQ values above 10, and spatial distribution was limited. SWMUs 9 and 20 should be considered likely sources of H-4 contaminants. The Zone I RFI report and subsequent sampling performed for the Zone J RFI will help further refine the source definition.

## **8.0 RECOMMENDATIONS FOR CORRECTIVE MEASURES**

According to Permit Condition IV.E., Corrective Action Plan, the SCDHEC will review the final RFI report and notify NAVBASE of the need for further investigations, corrective actions, or a corrective action study, or plan to meet the requirements of R.61-79.264.101, Corrective Action for SWMUs. Section 8 and the following section have been prepared based on SCDHEC's comment that "the RFI report should discuss whether the extent of contamination has been defined, and propose recommended actions for the SWMUs and AOCs, such as collection of additional samples, proceed into a Corrective Measures Study, or No Further Action, whichever is appropriate." Section 9.0 includes Table 9.25, Zone H RFI, Summary of Recommendations. This table summarizes site-specific information including which sites have been proposed for further action (CMS). In addition, Section 9 includes figures that delineate the extent of contamination as defined by risk.

The NAVBASE project team established ALs for assessing whether to conduct a CMS at  $10^{-6}$  residential risk and/or 100 ppm TPH. However, according to the SCDHEC, industrial cleanup levels will be acceptable if an agreement has been reached and approved by SCDHEC, and NAVBASE can demonstrate that appropriate and effective institutional controls can be maintained at the site. Ecological risk, if found to be at an unacceptable level, may also be used to initiate and drive certain CMS efforts.

The following discussions in conjunction with Section 9 address each site relative to the established ALs, the need for additional investigation, corrective actions, or a corrective action study and/or treatability study. The potential remedies listed are based on collected data and the presumptive remedies presented in the RFI work plan. The steps to be conducted during a CMS also are reviewed.

## **8.1 Introduction**

Any CMS at NAVBASE will be conducted according to standard methods presented in the USEPA guidance document *RCRA Corrective Action Plan* (USEPA, 1994g). The standard methodology will be presented in the CMS Work Plan, and will facilitate collecting necessary data, evaluating potential alternatives, and developing a final remedial alternative by establishing a set procedure for evaluation and assessment.

To establish this procedure, the CMS Work Plan will outline the CMS report, discussing basic elements. The overall structure of the plan will be explained to illustrate the decision-making process. Briefly, the report outline is as follows:

### **Report Outline**

- A. Introduction/Purpose
- B. Description of Current Conditions
- C. Corrective Action Objectives
- D. Identification, Screening, and Development of Corrective Measure Alternatives
- E. Evaluation of a Final Corrective Measure Alternative
- F. Recommendation by a Permittee/Respondent for a Final Corrective Measure Alternative
- G. Public Involvement Plan

Each required element will be discussed in detail in the CMS Work Plan. The discussion will achieve the following:

- Identify minimum requirements for CMS reports in each area.
- Define the base "pool" of technologies which will be evaluated for each medium.
- Define the evaluation process.
- Identify selection criteria for the final corrective measure alternative.

Issues to be discussed under each element are identified as follows:

- An activity-specific description of the overall purpose of the CMS for NAVBASE.

*SWMUs and AOCs at NAVBASE will be discussed in the CMS Work Plan on a zone-wide basis. Activities, contaminants, and issues specific to each zone will be discussed. The CMS Work Plan will identify: specific sites to be addressed in the CMS, any focused approach (such as naming a primary technology in lieu of the full screening), and the subsequent cleanup goals.*

- A description of the corrective action objectives for NAVBASE, including how target media cleanup standards, points of compliance, or risk assessments will be established and performed for each site, zone, and activity.

*Cleanup standards will be developed for each site, zone, or activity using the designated exposure scenario (residential, commercial, or industrial) for that area and relative to receptor type, human or ecological. BRAs, conducted in conjunction with the RFI for each zone, will be used to identify areas with unacceptable risk/hazard as per the designated exposure scenario. During the CMS, areas with unacceptable risk to human and ecological receptors will be evaluated according to media, primary contaminants contributing to risk, and the potential for groundwater contamination.*

- Identification, screening, and development of corrective measures alternatives.

*Tables similar to those presented in the NAVBASE RFI Work Plans will be used in the CMS Work Plan to present the "pool" of technologies initially evaluated in a CMS. These tables represent a range of technologies with different applications; each technology must be screened and evaluated before it is discarded from further*

*consideration. The tables, therefore, preclude any bias toward a particular technology through full-scale screening techniques.*

*Technologies will be screened using site- and waste-specific characteristics. The CMS Work Plan will identify factors to be considered, including type of media, depth of contamination, areal extent of contamination, number and type of contaminants, remedial goals, future land use scenarios, and adjacent remedial activities. In addition, the CMS Work Plan will present the requirements for implementing Corrective Action Management Units (CAMUs).*

*Once technologies have been screened, they will be assembled into corrective action alternatives. These alternatives will be evaluated according to criteria discussed as follows.*

- *A description of the general approach to investigating and evaluating potential corrective action measures.*

*Corrective measures alternatives will be evaluated using four primary and five secondary criteria, listed as follows:*

***Primary***

- 1. Protect human health and the environment.*
- 2. Attain media cleanup standards set by the implementing agency.*
- 3. Control the source of releases so as to reduce or eliminate, to the extent practicable, further releases that may pose a threat to human health and the environment.*
- 4. Comply with any applicable standards for management of wastes.*

**Secondary**

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

*Alternatives will be discussed and compared according to these criteria, which are used to gauge their relative effectiveness and implementability.*

- A detailed description of how pilot, laboratory, and/or bench-scale studies will be selected, performed, evaluated, reported, and transferred to full scale.

*Treatability studies will be implemented when more involved treatment units are being considered. For example, air stripping technologies usually do not require treatability studies to determine optimal processes for treating groundwater. However, ultraviolet (UV)/oxidation, an innovative technology, may require extensive treatability testing to determine oxidant dosages and retention times.*

*The basic structure and objectives of a treatability study will be discussed. Objectives may include: dosages, percent reduction in contaminant, treatment cost per unit volume, and implementation constraints. Study results will be used to assess the alternatives presented in the CMS and determine the optimal remedial approach for each site, zone, or activity.*

- A description of how statement of basis/response to comments or permit modifications are to be processed.

*Statement of basis/response to comments will be handled through NAVBASE and Southern Division Naval Facilities Engineering Command (SOUTHDIR). The Comprehensive Long-Term Environmental Action Navy (CLEAN) Contractor E/A&H will assist the Navy in preparing statement of basis/response to comments. Permit modifications will be managed through NAVBASE as the permit holder until the base is closed. Upon closure, SOUTHDIR and NAVBASE's caretaker will manage permit modifications. According to the existing RCRA permit issued May 4, 1990, Appendix C, Facility Submission Summary, a permit modification is required to prepare and conduct a Corrective Action Study/Plan.*

- A description of overall project management including overall approach levels of authority (including organizational chart), lines of communication, project schedules, budget, and personnel.

*The overall project management is the responsibility of SOUTHDIR for the NAVBASE. The lines of authority, communication, and project schedules have been developed and agreed upon and are provided in the Comprehensive Project Management Plan dated August 30, 1994, and amendments. In general, NAVBASE is responsible for ensuring conditions of the permit are satisfied with the ultimate responsibility held by the Commander of Charleston Naval Shipyard (CNSY). The budget for conducting CMS is defined by SOUTHDIR and funds are provided by U.S. Congress. Personnel to conduct the CMS will be assigned by E/A&H on an as-needed basis and project specific items. E/A&H will manage the CMS effort through the EnSafe Charleston, South Carolina, office.*

- Qualifications of personnel to direct or perform the work will be described.

*E/A&H will use trained and qualified registered engineers and geologists of South Carolina where required.*

## **8.2 Remedy Selection Approach**

As agreed in the Final Comprehensive Project Management Plan, remedies will be selected in accordance with statutory and RCRA CMS criteria. Particular attention will be given to the following items when evaluating alternatives:

- Background concentrations, particularly of inorganic compounds
- Land use/risk assessment
- Base-wide treatment facilities
- Presumptive remedies
- Petroleum, oils, and lubricants remedies for those type of contaminants

The use of CAMUs and temporary units (TUs) will be used where necessary to facilitate storage and treatment during remediation activities.

## **8.3 Proposed Remedy**

Before selecting and implementing corrective measures for releases, environmental and cost-effectiveness goals must be established. Typically, the environmental goal is to reduce exposure via the direct contact with air, groundwater, and surface water pathways to some level of acceptability. The cost-effectiveness goal is usually to achieve the environmental goals using the least costly alternative that is both technically feasible and reliable.

## **8.4 Development of Target Media Cleanup Goals**

Cleanup goals will be developed for each site at NAVBASE where risk exceeds acceptable levels as specified in the Part B permit. Sites requiring further remediation will undergo CMSs. During the CMS, alternatives will be developed for future residential and/or future worker uses. Two sets of alternatives may be presented for each site; they may differ due to the media cleanup standards required under residential versus site worker scenarios.

The USEPA guidance document *RCRA Corrective Action Plan* (USEPA, 1994g) outlines issues to be considered in developing cleanup goals for groundwater, soil, surface water, sediment, and air. These recommendations are outlined as follows.

#### **8.4.1 Groundwater Cleanup Goals**

The CMS will provide information to support the development of groundwater cleanup goals for all Appendix IX constituents found in groundwater during the facility investigation. The following information may be required:

- For any constituents for which a Maximum Contaminant Level (MCL) has been promulgated under the Safe Drinking Water Act, the MCL value;
- Background concentration of the constituent in groundwater; and
- An alternate standard (e.g., alternative concentration limit for a regulated unit) to be approved by the implementing agency.

Additional considerations while developing cleanup goals include the classification and primary use of the contaminated groundwater unit, proposed future uses for groundwater, proximity to surface water, etc.

#### **8.4.2 Soil Cleanup Goals**

The CMS will provide information to support the development of soil cleanup goals. The following information may be required:

- The volume and physical and chemical characteristics of the wastes in the unit;
- The effectiveness and reliability of containing, confining, and collecting systems and structures in preventing contaminant migration;
- The hydrologic characteristics of the unit and the surrounding area, including the topography of the surrounding land;
- Regional precipitation patterns;
- The current quality of surface soil, including other sources of contamination and their cumulative impacts on surface soil;
- The potential for contaminant migration and impact to the underlying groundwater;
- The patterns of land use in the region;
- The potential for health risks caused by human exposure to waste constituents; and
- The potential for damage to wildlife, food chains, and vegetation caused by exposure to waste constituents.

Damage potential to domestic animals and crops (not applicable at NAVBASE), and physical structures caused by exposure to waste constituents was not accessed during this RFI and therefore these three elements will not assist in determining soil cleanup goals. Additional information which may be considered includes background soil concentrations and regulatory guidance (e.g., UST guidance documents), among others.

### **8.4.3 Surface Water and Sediment Cleanup Goals**

The CMS will provide information to support the development of surface water and sediment cleanup goals. The following information may be required:

- The volume and physical and chemical characteristics of waste in the unit;
- The effectiveness and reliability of containing, confining, and collecting systems and structures in preventing contaminant migration;
- The hydrologic characteristics of the unit and the surrounding area, including the topography of surrounding land;
- Regional precipitation patterns;
- The quantity, quality, and direction of groundwater flow;
- The proximity of the unit to surface water;
- The current and potential uses of nearby surface water and any established water quality standards;
- The existing quality of surface water, including other sources of contamination and their cumulative impacts on surface water;
- The patterns of land use in the region;
- The potential for health risks caused by human exposure to waste constituents; and
- The potential for damage to wildlife, food chains, and vegetation caused by exposure to waste constituents.

Damage potential to domestic animals and crops (not applicable at NAVBASE), and physical structures caused by exposure to waste constituents was not accessed during this RFI and therefore these three elements will not assist in determining surface water and sediment cleanup goals. Additional data which may be considered include the presence of endangered, threatened, or ecologically sensitive species, and National Oceanic and Atmospheric Association sediment values, among others.

#### **8.4.4 Air Cleanup Goals**

The CMS will provide information to support the development of air cleanup goals. The following information may be required:

- The volume and physical and chemical characteristics of the waste in the unit, including its potential for the emission and dispersal of gases, aerosols, and particulates;
- The effectiveness and reliability of systems and structures to reduce or prevent emissions of hazardous constituents to the air;
- The operating characteristics of the unit;
- The atmospheric, meteorological, and topographic characteristics of the unit and the surrounding areas;
- The current quality of the air, including other sources of contamination and their cumulative impact on that medium;
- The potential for health risks caused by human exposure to waste constituents; and
- The potential for damage to wildlife, food chains, and vegetation caused by exposure to waste constituents.

Damage potential to domestic animals and crops (not applicable at NAVBASE), and physical structures caused by exposure to waste constituents was not accessed during this RFI and therefore these three elements will not assist in determining air cleanup goals. Other factors which may be considered include National Ambient Air Quality Standards, and state and local air quality regulations, among others.

### **8.5 Identification, Screening, and Development of Corrective Measure Technologies**

The initial step in assembling corrective measures alternatives is to identify, screen, and develop corrective measure technologies which apply to the site. Technologies are typically screened using waste-, media-, and site-specific characteristics. This section addresses the range of technologies which may be assessed for each site, the screening process, and screening criteria.

#### **8.5.1 Identification of Corrective Measure Technologies**

Each site will be assessed using the cleanup standard methodology described in Section 8.2. An initial list of impacted media and COCs have been identified in the RFI. The BRA identified soil and groundwater as the contaminated media. For each site, the major contaminants present have been grouped into one or more of the following categories:

- Chlorinated volatiles
- Nonchlorinated volatiles
- Chlorinated semivolatiles
- Nonchlorinated semivolatiles
- Pesticides/herbicides
- PCBs
- Dioxins
- Inorganic compounds (includes metals)
- TPH

These contaminant groupings and the site at which they have measured have been listed in Table 8.1 (as found in the BRA). This table lists possible remedial technologies for the site and denotes with an asterisk which sites contain TPH. Similar technologies may be used at sites containing TPH-contaminated soil. Remedial technologies in this table are described in Section 8.5.2 of this document. Table 8.2 lists nontreatment options for soil, groundwater/leachate, sediment, surface water, and air. These options include removal, containment, and disposal. Table 8.3 list types of compounds and the types of treatment for each media. These tables supply general waste management options for various situations.

It should be noted that several sites contain a combination of contaminants (i.e., inorganics, pesticides, and petroleum hydrocarbons). As a result, multiple technology types may be identified to remove these contaminants. However, some sites only contain one type of contaminant or (i.e., benzo(a)pyrene in AOC 665).

The following example presents a common situation where more than one type of contaminant exists at a site. The site contains volatile and semivolatile compounds which have been identified as slightly exceeding risk-based remediation goals. A containment alternative in this situation may include fencing to restrict unauthorized access, aerating the contaminated area, adding fertilizer and enriched soil, seeding to maintain a vegetative cover to control runoff, and monitoring. This containment approach seeks to minimize health risks through land management and natural attenuation.

As discussed in previous sections, because each site may be evaluated under both residential and site worker scenarios, COCs may vary between scenarios. Two lists of applicable technologies may be developed for each site, one for each scenario.

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**Table 8.1  
 Sites Containing COCs, Types of COCs, and Possible Remedial Technologies**

Site	Type of Compounds	Possible Remedial Technologies
SWMU 9-Soil (includes SWMUs *19, 20, *121, and AOCs *649, *650, *651, and 654)	Metals, PCBs, and SVOCs	a) No action b) Containment by capping c) Excavation, ex-situ treatment, off/onsite disposal <ol style="list-style-type: none"> <li>1) High temperature thermal desorption</li> <li>2) Incineration</li> <li>3) Soil washing/classification</li> <li>4) Bioremediation</li> </ol> d) In-situ bioremediation
SWMU 9-Shallow Groundwater (includes SWMUs 19, 20, 121, and AOCs 649, 650, 651, and 654)	Metals, VOCs, Chlorinated SVOCs, and SVOCs	a) No action, monitoring, intrinsic remediation, containment b) Extraction, chemical treatment <ol style="list-style-type: none"> <li>1) Chemical precipitation</li> <li>2) UV/ozone</li> <li>3) Air or steam strip VOCs, discharge to POTW</li> </ol>
SWMU 9-Deep Groundwater (includes SWMUs 19, 20, 121, and AOCs 649, 650, 651, and 654)	Chlorinated VOCs and Metals	a) No action, monitoring, intrinsic remediation b) Extraction, chemical treatment <ol style="list-style-type: none"> <li>1) Chemical precipitation</li> <li>2) UV/ozone</li> <li>3) Air or steam strip VOCs, discharge to POTW</li> </ol>
*SWMU 13-Soil	Metals and PCBs	a) No action b) Excavation, if nonhazardous, ex-situ treatment, off/onsited disposal <ol style="list-style-type: none"> <li>1) Solidification</li> <li>2) Thermal destruction</li> <li>3) Chemical destruction (UV/ozone)</li> </ol> c) In-situ solidification for metals
*SWMU 14-Soil (Includes SWMU 15, and AOCs 669, 670, and 684)	Metals and SVOCs	a) No action b) Excavation, ex-situ treatment, off/onsite disposal <ol style="list-style-type: none"> <li>1) Solidification</li> <li>2) Thermal destruction of PCBs</li> <li>3) Chemical destruction (UV/ozone)</li> </ol> c) In-situ solidification for metals d) In-situ bioremediation

**Table 8.1**  
**Sites Containing COCs, Types of COCs, and Possible Remedial Technologies**

Site	Type of Compounds	Possible Remedial Technologies
SWMU 14-Shallow Groundwater (Includes SWMU 15, and AOCs 669, 670, and 684)	Metals and SVOCs	a) No action, monitoring, intrinsic remediation b) Extraction, activated sludge treatment in POTW
SWMU 14-Deep Groundwater (Includes SWMU 15, and AOCs 669, 670, and 684)	SVOCs, Metals, Pesticides, and Chlorinated SVOCs	a) No action, monitoring, intrinsic remediation b) Extraction, treatment in POTW c) Chemical precipitation of metals, discharge to POTW d) Air or steam stripping, discharge to POTW
*SWMU 17-Soil	PCBs and SVOCs	a) No action b) Containment by cap c) Excavation, if nonhazardous, then landfill or ex-situ treatment, offsite disposal 1) Solidification 2) Thermal destruction 3) Chemical destruction (UV/ozone)
SWMU 17-Shallow Groundwater	PCBs and Chlorinated SVOCs	a) No action, monitoring, intrinsic remediation b) Extraction, discharge to the POTW or offsite c) Chemical oxidation (UV/ozone) d) Dechlorination e) Thermal destruction
*AOC 653-Soil	Metals and SVOCs	a) No action b) Excavation, if nonhazardous, landfill or ex-situ treatment, off/onsite disposal 1) Solidification 2) Thermal desorption 3) Bioremediation c) In-situ bioremediation

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**Table 8.1**  
**Sites Containing COCs, Types of COCs, and Possible Remedial Technologies**

Site	Type of Compounds	Possible Remedial Technologies
*AOC 655-Soil	PCBs, SVOCs, and Pesticides	a) No action b) Excavation, if nonhazardous, landfill or ex-situ treatment, off/onsite disposal 1) Solidification 2) Thermal desorption 3) Bioremediation c) In-situ bioremediation
AOC 655-Shallow Groundwater	Metals and Pesticides	a) No action, monitoring, intrinsic remediation b) Extraction, treatment, discharge to POTW 1) Chemical precipitation 2) Carbon adsorption
*AOC 656-Soil	Metals, SVOCs	a) No action b) Excavation, if nonhazardous, landfill or ex-situ treatment, off/onsite disposal 1) Thermal desorption 2) Solidification or chemical treatment 3) Bioremediation c) In-situ bioremediation
*AOC 663-Soil (Includes SWMU 136)	PCBs, SVOCs, Metals, and Pesticides	a) No action b) Excavation, if nonhazardous, landfill or ex-situ treatment, off/onsite disposal 1) Solidification 2) Thermal desorption or destruction 3) Bioremediation c) In-situ bioremediation
AOC 663-Groundwater	VOCs	a) No action, monitoring, intrinsic remediation b) Extract, air stripping or carbon, discharging to the POTW

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**Table 8.1  
Sites Containing COCs, Types of COCs, and Possible Remedial Technologies**

Site	Type of Compounds	Possible Remedial Technologies
AOC 665-Soil	SVOCs	a) No action b) Excavation, if nonhazardous, landfill or ex-situ treatment, off/onsite disposal 1) Thermal desorption 2) Bioremediation c) In-situ bioremediation
*AOC 666-Soil	SVOCs, Metals, and PCBs	a) No action b) Excavation, if nonhazardous, landfill or ex-situ treatment, off/onsite disposal 1) Thermal desorption 2) Bioremediation 3) Solidification c) In-situ bioremediation
AOC 666-Groundwater	Chlorinated VOCs	a) No action, monitoring, intrinsic remediation b) Extraction, treatment 1) Air or steam stripping, discharge to POTW 2) Carbon adsorption, discharge to POTW
*SWMU 178-Soil	Benzo(a)pyrene	a) No action b) Excavation, if nonhazardous, landfill or ex-situ treatment, off/onsite disposal 1) Thermal desorption 2) Bioremediation c) In-situ bioremediation
*AOC 667-Soil (Includes SWMU 138)	TPH	a) No action b) Excavation, if nonhazardous, landfill or ex-situ treatment, off/onsite disposal 1) Thermal desorption 2) Bioremediation c) In-situ bioremediation

**Notes:**

- \* = Site contains TPH  
 POTW = Publicly Owned Treatment Works

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**Table 8.2  
 Removal/Containment/Disposal Options**

Action	Soil	Groundwater/ Leachate	Sediment	Surface Water	Air
Removal	Excavation	Groundwater extraction Leachate collection	Dredging	Diversions Pumping	N/A
Containment	Institutional controls	Slurry wall	Berms/diversion	Diversions	N/A
	Capping	Gradient controls	Storm water controls		
	Storm water controls	Long-term monitoring			
Disposal	Long-term monitoring	Intrinsic (natural)			
	Intrinsic (natural)	bioremediation/attenuation			
	bioremediation/attenuation				
	Landfill	POTW NPDES discharge Land application	Landfill	POTW NPDES Injection	Discharge via air permit

**Notes:**  
 POTW = Publicly Owned Treatment Works  
 NPDES = National Pollutant Discharge Elimination System  
 N/A = Not Applicable

**Table 8.3**  
**Treatment Technology Options**

Contaminant Type	Soil	Groundwater/ Leachate	Sediment	Air
Chlorinated volatiles	Soil washing Incineration Thermal desorption Bioremediation	Chemical oxidation Bioremediation Adsorption Air stripping UV/ozone oxidation	Same as soil	Oxidation
Nonchlorinated volatiles	Soil washing Incineration Thermal desorption SVE Bioremediation Steam extraction	Oxidation Bioremediation Adsorption Air stripping	Same as soil	Adsorption Oxidation
Chlorinated semivolatiles	Soil washing Bioremediation Incineration Thermal desorption Solidification/stabilization	Oxidation Bioremediation Air stripping	Same as soil	Adsorption Oxidation
Nonchlorinated semivolatiles	Soil washing Incineration Thermal desorption Bioremediation Solidification/stabilization	Oxidation Bioremediation Sorption	Same as soil	Oxidation Adsorption
Pesticides/ Herbicides	Solidification/stabilization Soil washing Bioremediation Incineration Thermal desorption	Oxidation Bioremediation Sorption	Same as soil	Oxidation
PCBs	Solidification/stabilization Soil washing Dehalogenation Incineration Thermal desorption	Oxidation Dehalogenation Incineration Solidification	Solvent extraction Dehalogenation Solidification/stabilization	Oxidation
Dioxins	Incineration Solidification/stabilization	Oxidation	Same as soil	Oxidation
Inorganics	Solidification/stabilization Soil washing	Chemical precipitation Adsorption Sedimentation Filtration	Same as soil	Filtration Scrubbers Adsorption

*Note:*  
 SVE = Soil Vapor Extraction

### **8.5.2 Description of Prescreened Technologies**

The following paragraphs describes of technologies that appear to be the most feasible for the initial CMSs. These technologies are divided into four categories: in-situ soil, ex-situ soil, in-situ groundwater, and ex-situ groundwater.

#### ***In-Situ Soil***

##### **Capping of Landfills**

A layer of either clay, synthetic membrane, soil/vegetative cover, or asphalt is applied to prevent human exposure to contaminants. Capping also helps to prevent rainwater infiltration and water percolation, which may transport contaminants from the soil to the groundwater. Since SWMU 9 already is a landfill, it may be feasible to cap it in order to prevent humans from being exposed to the COCs. This solution may be the most economical and most protective of human health.

##### **Bioremediation**

This technology uses microorganisms to biologically oxidize contaminants into harmless chemicals such as carbon dioxide and water. The organisms can be naturally occurring or they can be added to the soil. In many cases, nutrients can be supplemented to enhance this process. Nitrate and phosphate are often the limiting nutrients at a site. However, insufficient electron acceptor is the greatest variable limiting bioremediation. The most common electron acceptor is oxygen for aerobic biodegradation. For these sites, it is likely that bioremediation via natural attenuation is a good candidate for some of the compounds. Typically nonchlorinated VOCs and SVOCs are good candidates for this technology.

### **Solidification/Stabilization**

This technology consists of mixing reagents with soil to prevent contaminants from leaching into the groundwater below. This technology immobilizes contaminants, preventing migration. However, this technology does not remove the contaminant.

### ***Ex-Situ Treatment of Soil***

All ex-situ soil treatments require excavation to another location or at least bringing the material to the surface. Typically heavy equipment is used to move the soil. If contaminated soil is limited in volume and considered nonhazardous, it may be feasible to dispose of it in a landfill. If sites have a limited area of contaminated soil, it may be feasible to remove the soil with heavy equipment and treat it ex-situ or, if nonhazardous, it could be disposed in the SWMU 9 landfill.

### **Soil Washing**

Soil washing physically separates soil particles by size, then treats the smaller grains with solutions which desorb the contaminants. The resulting solution containing contaminants is treated by another technology. In general, small soil particles such as clay and silt have a higher TOC, content which tends to absorb hydrophobic compounds such as chlorinated contaminants. Essentially the technology compacts soil that is contaminated, then washes it with a solvent to remove the contaminants.

### **Thermal Desorption**

Thermal desorption technologies are performed at high or low temperatures, depending on the contaminant. This technology is used in combination with incineration or some other type of offgas treatment. Soil is excavated and put in the treatment systems for both high- and low-temperature desorption to separate the contaminants from the soil, not to destroy the chemical. The volatilized contaminants enter an air stream and travel to some type of gas treatment for the contaminant destruction. Low-temperature (200 to 600°F) thermal desorption

(LTTD) is only applicable for VOCs while high-temperature (600 to 1000°F) thermal desorption (HTTD) applies to SVOCs, PAHs, PCBs, and pesticides.

### **Thermal Destruction/Incineration**

This technology is used in conjunction with ex-situ soil technologies. Typically the contaminant is removed from the soil matrix and transferred to an air stream. The air stream is treated with the thermal destruction on a catalyst or burned in an incinerator, or a combination of the two. High temperatures (1800 to 2000°F) are required to destroy organics such as PCBs, dioxins, furans, pesticides, and others.

### **Solidification/Stabilization**

This technology is similar to the in-situ methods; however, the soil is first excavated before being mixed with the chemical reagents or concrete.

### ***In-Situ Groundwater Treatment***

#### **Bioremediation**

Bioremediating contaminants in groundwater involves adding nutrients (phosphate, nitrate, etc.) and an electron acceptor (i.e., oxygen, nitrate, etc.) to the groundwater via injection wells. The most typical electron acceptor addition comes from either oxygen via air sparging, and/or nitrate with the addition of other nutrients.

#### **Intrinsic Remediation**

This technology, also called natural attenuation, simply allows natural occurring bioremediation, oxidation, hydrolysis, dispersion, and advection to occur unassisted. No nutrients or electron acceptors are added to the site. The site may be monitored to observe the contaminant reduction. Many case studies have demonstrated this technology on TPH contaminated sites.

### ***Ex-Situ Treatment of Groundwater***

Any ex-situ treatment of groundwater requires a system of extraction wells and pumps to deliver the groundwater to the treatment location.

### **Chemical Precipitation**

The solubility of many metals is a function of pH. As a result, chemical agents can be added to change the pH of the water, which results in the metals becoming insoluble. In other cases a chemical can be added to chelate the metal and precipitate it out of the solution. Either way, the contaminants then can be removed by filtering.

### **Air Stripping**

Groundwater can be extracted from the subsurface and pumped to a nearby publicly owned treatment works (POTW). While the contaminated groundwater is in the aeration basin of the water treatment plant, the volatile compounds (compounds with a high Henry's law constant) will experience mass transfer from the water to the air. Steam can be used to heat the groundwater, causing organics to volatilize. These air vapors can be treated with an appropriate technology or fall under an allowed air permit discharge.

### **Chemical Oxidation/UV-Ozone**

Ozone is one of the strongest chemical oxidizers. Almost any organic compound can be oxidized. Ozone can be generated with UV light sources. Water can pass through a flowstream surrounded by UV lights. Oxygen in the water is converted to ozone and the organics are oxidized into harmless by-products. Compounds that typically are recalcitrant to biological oxidation, such as chlorinated organics, can easily be oxidized with ozone. Good light transmission is essential; therefore, very turbid water is not a good candidate for UV ozonation.

## **Activated Sludge**

Activated sludge treatment of wastes occurs in a wastewater treatment plant. The activated sludge process uses microorganisms to convert organic wastes to inorganic wastes and/or bacterial cell mass, carbon dioxide and water.

### **8.5.3 Screening Criteria**

When more than one technology applies to a specific site, it is necessary to evaluate their limitations to show why certain CMS technologies may prove infeasible to implement given existing waste- and site-specific conditions. Therefore, for each technology, the following criteria will be discussed:

- Site characteristics
- Waste characteristics
- Technology limitations

#### **Site Characteristics**

Site characteristics define the site and any constraints that may impact selecting and implementing remedial technologies. Characteristics to be considered include primarily the current and future use of the site or SWMU. Other characteristics include type of contaminated media, areal distribution of contamination, and depth to/of contamination. Current migration pathways and the potential for intrinsic remediation will also be considered. Once again, each site may have one or two technology lists which will be evaluated for residential and Base Realignment and Closure Act (BRAC)-specified future uses.

#### **Waste Characteristics**

Waste characteristics define the nature of contamination. The primary waste characteristic to be considered is the general type of contamination — volatiles, semivolatiles,

pesticides/herbicides, PCBs, dioxins, inorganic compounds, and TPH. Also critical is the presence of halogenated compounds, such as chlorinated benzenes or trichloroethylene.

Where multiple types of contamination are present (such as PCBs and dioxins, or pesticides and volatiles), certain technologies may be eliminated from consideration due to inability to treat wastes effectively. For example, soil vapor extraction (SVE) typically is not used on pesticide sites, although it is very effective on most volatiles. If both contaminants must be treated concurrently, SVE would not be considered further.

Where appropriate, contaminant concentrations will be considered to screen remedial technologies.

### **Technology Limitations**

Technology limitations are used to assess the implementation feasibility of a particular technology. Technology limitations may include technical restrictions on application, including presence of a shallow water table, depth to bedrock, etc. Additional technology limitations include minimum or maximum process volumes, such as technologies which are cost-effective only when contaminated soil volumes are greater than 1,000 cubic yards. Other limitations to be assessed include effectiveness in meeting treatment goals and remedial time frame.

Technologies meeting this screening criterion may differ from residential to BRAC-specified use scenarios due to differences in cleanup goals for each scenario.

## **8.6 Identification of Corrective Measure Alternatives**

Once specific remedial technologies are identified for the site, they will be assembled into specific alternatives that may meet the corrective action objectives for all media. Each alternative may consist of an individual technology or a combination of technologies used in

sequence (i.e., treatment train). Depending upon site-specific situations, different alternatives may be considered for separate areas of the facility.

Less complex sites may be relatively straightforward and may only require evaluating a single or a few alternatives. Because the NAVBASE CMS will evaluate both residential and BRAC-specified future uses, two sets of alternatives may be developed for each site.

### **8.7 Evaluation of Corrective Measure Alternatives**

Each alternative proposed (including single proposed alternatives) will be evaluated according to five standards reflecting the major technical components of remedies, including cleanup of releases, source control, and management of wastes that are generated by remedial activities. The specific standards are provided as follows.

- Protect human health and the environment.
- Attain media cleanup standards set by the implementing agency.
- Control the source of releases so as to reduce or eliminate, to the extent practical, further releases that may threaten human health and the environment.
- Comply with any applicable standards for managing wastes.
- Consider other factors.

These standards are discussed in more detail in the following sections.

### **8.7.1 Protect Human Health and the Environment**

Corrective action remedies must be protective of human health and the environment. The degree of protection afforded by each alternative will be discussed in this section.

Remedies may also include those measures that are needed to be protective, but are not directly related to media cleanup, source control, or waste management. For example, access controls and deed restrictions may be implemented to prevent contact with contaminated media while intrinsic remediation or attenuation processes are monitored or augmented. This section will discuss any short-term remedies implemented to meet this standard.

### **8.7.2 Attain Media Cleanup Standards Set by the Implementing Agency**

Each alternative will be evaluated as to whether the potential remedy will achieve the remediation objective. This evaluation will estimate the time frame necessary for each alternative to meet these standards. The selected remedy will be required to attain media cleanup standards set by the implementing agency, which may be derived from current state or federal regulations or other standards. The media cleanup standard will often play a large part in determining the extent of and technical approaches to the remedy. In some cases, the practical capabilities of remedial technologies (or other technical aspects of the remedy) may influence to some degree the media cleanup standards that are established.

### **8.7.3 Control the Sources of Releases**

As part of the CMS report, source control measures will be evaluated to determine if they are necessary to control or eliminate further releases that may threaten human health or the environment. If a source control measure is proposed, it will include a discussion on how well the method is expected to work, given site conditions and the known reliability of the selected technology.

Source control measures will be considered when it is necessary to stop further environmental degradation by controlling or eliminating further releases that may threaten human health or the environment. In some cases, without source control measures, efforts to clean-up releases may be ineffective or (at best) will essentially involve a perpetual cleanup. In these cases, an effective source control program may be essential to ensure the long-term effectiveness and protectiveness of the corrective action program. Source control measures may include all protective remedies to control the source. Such remedies may include partial waste removal, capping, slurry walls, in-situ treatment and/or stabilization, and consolidation.

#### **8.7.4 Comply with Any Applicable Standards for Management of Wastes**

Each alternative will discuss how the specific waste management activities will comply with all applicable state or federal regulations, such as closure requirements, land disposal restrictions, etc.

#### **8.7.5 Other Factors**

Five general factors will be considered in selecting/approving a remedy that meets the four standards listed above. These factors combine technical measures and management controls to address the environmental problems at the facility. The five general decision factors include:

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

These factors are discussed in detail as follows.

### **Long-Term Reliability and Effectiveness**

The CMS will evaluate whether the technology or a combination of technologies has been used effectively under similar site conditions, whether failure of any one technology in the alternative would have an immediate impact on receptors, and whether the alternative would have the flexibility to deal with uncontrollable changes onsite.

This criterion will assess the proposed useful life of the overall alternative and of its component technologies. Useful life is defined as the length of time the level of effectiveness can be maintained. Typically, most corrective measure technologies deteriorate with time. Deterioration can often be slowed through proper system operation and maintenance, but the technology may eventually require replacement to maintain effectiveness. The CMS will consider these issues.

### **Reduction in the Toxicity, Mobility, or Volume of Wastes**

This criterion will be used to assess the degree to which each alternative reduces the toxicity, mobility, or volume of wastes. In general, preferred remedies employ treatment and are capable of eliminating (or substantially reducing) the potential for contaminated media to cause future environmental releases or other risks to human health and the environment. Estimates of how much the corrective measure alternatives will reduce the waste toxicity, mobility, or volume may help in assessing this criterion.

In some situations, reducing toxicity, mobility, or volume may not be practical or even desirable. For example, large municipal-type landfills or unexploded munitions may be extremely dangerous to handle. In these situations, the short-term risks of treatment outweigh the potential long-term benefits.

### **Short-Term Effectiveness**

The short-term effectiveness of each alternative will be assessed, including: the potential for fire, explosion, and exposure to hazardous substances; as well as threats associated with treatment, excavation, transportation, and re-disposal or containment of waste material. This criterion is important in densely populated areas and where waste characteristics are such that risks to workers or to the environment are high and special protective measures are needed.

### **Implementability**

Each alternative will be evaluated to assess any potential impacts on the time required to implement a given remedy. Information to consider for implementability includes:

- The administrative activities needed to implement the corrective measure alternative (e.g., permits, rights-of-way, offsite approvals, etc.) and the length of time these activities will take.
- The constructability, time for implementation, and time for beneficial results.
- The availability of adequate offsite treatment, storage capacity, disposal services, needed technical services, and materials.
- The availability of prospective technologies for each corrective measure alternative.

### **Cost**

The CMS will consider the relative cost for each remedy. This criterion is especially useful when several technologies offer the same degree of protection to human health and the environment but vary widely in cost. Cost estimates will include: engineering, site preparation, construction, materials, labor, sampling/analysis, waste management/disposal, permitting, health and safety measures, training, operations and maintenance, etc.

## **8.8 Ranking the Corrective Measure Alternatives**

Once corrective measures have been discussed for each site using each applicable scenario (residential and/or BRAC-specified future use), alternatives under each will be ranked in order of desirability. The ranking system will apply a weighting factor selected by the Navy to determine the importance of each corrective measure criterion. The weighting factors will be developed by the Navy during CMS. Table 8.4 shows the format of the ranking system.

The example presented in Table 8.4 considers a hypothetical site which has contaminated soil with relatively high (10 to 1,000 ppm) concentrations of PAHs. Three alternatives were developed: excavation and disposal in a permitted landfill, excavation and thermal treatment, and capping in-situ. The purpose of this example is to show the format and nature of comparisons.

Once weighting factors are selected, the rankings are set by multiplying the criteria values by the weighting factor. The weighted criteria values are then summed. Alternatives are ranked in order with the highest total being most preferable, and the lowest total being least preferable.

Public participation and comment is an instrumental part of the RCRA Corrective Action Process. The ranked alternatives are presented to the public by way of the Restoration Advisory Board during the public meetings process. Public input is actively requested and can become an important factor during the selection of the corrective action alternative by the permitting authority.

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Table 8.4  
 Comparison and Ranking of Alternatives

Objective & Criteria	Weighting Factor	Description	Alternative 1		Alternative 2		Alternative 3			
			Meets Criteria	Weighted Criteria Value	Description	Meets Criteria	Weighted Criteria Value	Description	Meets Criteria	Weighted Criteria Value
Protect human health and the environment		Protective of human health and the environment	3		Protective of human health and the environment	3		Protective of human health and the environment	3	
Attain media cleanup standards		Excavates soil above cleanup goals	3		Excavates soil above cleanup goals	3		No	1	
Control the sources of releases		Eliminates source material above cleanup goals	3		Eliminates source material above cleanup goals	3		Controls sources of releases through containment, reduction in leachate	3	
Comply with any applicable standards for management of wastes		Must comply with LDRs, USDOT regulations	3		Must comply with LDRs, air emissions regulations	3		Must comply with RCRA cap requirements, monitoring	3	
<b>Other Factors</b>										
Long-term reliability and effectiveness		Effective over the long-term	3		Effective over the long-term	3		Effective with regular maintenance	3	
Reduction in toxicity, mobility, and volume		Does not reduce toxicity, mobility, or volume	1		Reduces toxicity, mobility, and volume through treatment	4		Does not reduce toxicity, mobility, or volume	1	

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**Table 8.4  
 Comparison and Ranking of Alternatives**

Objective & Criteria	Weighting Factor	Alternative 1		Alternative 2		Alternative 3	
		Description	Meets Criteria	Description	Meets Criteria	Description	Meets Criteria
Short-term effectiveness		Minimal exposure to site workers during excavation	3	Minimal exposure to site workers during excavation and treatment	3	Minimal exposure to site workers during excavation	4
Implementability		Easily implemented, common approach to contaminated soil	4	Requires mobile treatment unit mobilization; may be time inefficient	2	Easily implemented, common approach to contaminated soil	3
Cost		Present worth cost = \$193,000	3	Present worth cost = \$354,000	1	Present worth cost = \$8,000	4
<b>Totals</b>			<b>XXX</b>				<b>XXX</b>

**Notes:**

Weighting Factors will be determined by NAVBASE

Meets criteria ranking values are based on the following scale

- 4 = Meets and far exceeds criteria/objectives
- 3 = Slightly exceeds criteria/objectives
- 2 = Meets only minimally the criteria/objectives
- 1 = Does not meet criteria/objectives

LDRs = Land Disposal Restrictions

USDOT = U.S. Department of Transportation

Public participation and comment will be actively solicited and has the potential for assisting in the selection of the final corrective remedy.

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## **9.0 CONCLUSIONS**

The following section includes a summary of the geologic and hydrogeologic components of the Zone H RFI and site-specific summaries. Sections 9.1 through 9.22 contain site-specific summaries of site history, the human health risk assessment, ecological risk assessment, contaminant fate and transport assessment, and CMS recommendations. Section 9.23 summarizes recommendations for the Zone H RFI.

The geology of the Zone H area consists of differentiated fine-grained sedimentary deposits extending from ground surface to the total depth of investigation (approximately 80 feet bgs). The stratigraphic sequence of these sediments generally consists of a primarily sandy layer at the surface which extends to approximately 10 to 12 feet bgs. This upper sand is underlain by a relatively uniform layer of marsh clay that is generally 15 to 30 feet thick. Underlying the marsh clay is a lower sand layer that averages 10 to 15 feet in thickness. The Ashley Formation of the Cooper Group, a tight, calcareous silty clay, was encountered in all deep borings and is thought to be present throughout Zone H at approximately 30 to 80 feet bgs.

The stratigraphic sequence overlying the Ashley Formation comprises the shallow aquifer system. The upper sand of this stratigraphic sequence is a relatively transmissive zone in which groundwater flows from a high groundwater level surface within the interior of Zone H southward and westward toward Shipyard Creek or northward and eastward toward Cooper River. The lower sand of the typical stratigraphic sequence overlying the Ashley Formation is also a relatively transmissive zone in which groundwater flow is from the interior of Zone H toward Shipyard Creek and Cooper River. Due to the relatively consistent thickness and lithology of the marsh clay which separates the upper and lower sand in Zone H, minimal hydrologic communication is expected between the two sands. Potential for groundwater contamination of the lower sand in the shallow aquifer due to past/present activities in Zone H is expected to be minimal due to the presence of the marsh clay. Analysis of samples collected

from both the upper and lower sand units indicates that groundwater salinity concentrations frequently exceed a level indicative of tidal salt waters.

Tidal influence investigations identified only minor fluctuations in groundwater levels attributable to tides. Generally, wells exhibiting the greatest water level change due to tidal influence were close to either Shipyard Creek or Cooper River. Within the interior of Zone H, fluctuation in groundwater levels that were attributable to tidal influence were minimal or not discernible. Within Zone H, the tidal influence investigation did not identify fluctuations in groundwater levels expected to be capable of directing the migration of contaminants in groundwater in any direction other than that of the natural groundwater flow gradient.

Each surface soil sample location within Zone H was assessed with respect to human health risk/hazard presented by constituents at that location. Figures 9.1 and 9.2 provide a zone-wide presentation of risk and hazard considering a residential scenario. Figures 9.3 and 9.4 provide a zone-wide presentation of risk and hazard considering an industrial scenario. Colors are used to represent the magnitude of risk/hazard at each sample location or the absence of risk/hazard relative to the analyses conducted. Site-specific risk/hazard maps are provided for sites with risk greater than  $1E-6$  or a hazard quotient greater than 1 for either the residential or industrial scenario in the site-specific Section 9 subsections. Contours, which outline individual sampling points presenting similar degrees of risk/hazard, are provided on site-specific maps where technically justified. These contours are intended to outline potential problem areas and may or may not define areas where remedial action is necessary. The magnitude of risk at each site is not necessarily reflective of a single compound; instead, it represents a summation of risk which is often based on multiple compounds. Appendix Q provides a sample-by-sample list of risk and/or hazard for each sample at each site that had significant risk/hazard. This list also provides analytical results for each site COC for each sample location. Site-specific maps are provided at the end of each subsection.

Potential risks for ecological receptors were evaluated for ECPCs in surface soil, surface water, sediment at Zone H. Risks associated with exposure to ECPCs in surface soil were evaluated for terrestrial wildlife based on a model that predicts the amount of contaminant exposure via the diet and incidental ingestion of soil. Comparison of predicted doses for representative wildlife species with doses representing thresholds for both lethal and sublethal effects is the basis of the risk evaluation. Risks for soil invertebrates and plants were evaluated based on qualitative comparisons to literature effects-levels for taxonomic groups similar to those potentially occurring at Zone H. Risks for aquatic organisms were evaluated by calculating hazard quotients from benchmark values that are either promulgated or proposed by federal and state regulatory agencies.

Second-interval samples collected during the Zone H RFI have been assessed with respect to groundwater protection and this information is summarized in the fate and transport portion of each of the following subsections. Second-interval sample data is also included in the extent of COC contamination text provided in the following subsections.

Figures 9.5 and 9.6 identify the locations of TPH detections. These maps are color-coded with respect to the magnitude of TPH detected at each sample location where TPH was an analytical parameter. Site-specific TPH maps are provided for those sites that did not have sufficient risk or hazard to result in their recommended inclusion into the CMS process, but where TPH was detected at concentrations exceeding the TPH screening level.

Maps identifying the most critical points of groundwater contamination within Zone H are provided in Section 6 (Figures 6.2.1.1 through 6.2.1.10, 6.2.4.1, and 6.2.4.2).

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**9.1 SWMU 9 (Includes Groundwater for SWMUs 19, 20, and 121, and AOCs 649, 650, 651, and 654)**

SWMU 9 is a closed landfill at the southern end of NAVBASE that is generally bounded by Shipyard Creek to the southwest, Bainbridge Avenue to the northeast, and Holland Street to the southeast. Seven additional sites were investigated concurrently with SWMU 9 during the RFI because they were physically within the landfill perimeter. These sites include SWMU 19, a solid waste transfer station currently in operation; SWMU 20, a waste disposal area which appears to have been used for disposal of industrial type materials; SWMU 121, a former satellite accumulation area now associated with a recycling operation; AOC 654, the location of a former septic tank disposal system; and AOCs 649, 650, and 651, which are areas formerly used to store ship repair supplies.

Groundwater sampling was conducted throughout the SWMU 9 area in order to identify the presence or absence of groundwater contamination associated with SWMU 9 and its associated sites. Trench sampling was conducted to identify the types and typical concentrations of contaminants associated with waste materials disposed of in the landfill.

The boundary of SWMU 9 (defined as the filled area) was delineated through the use of a geophysical survey, review of historical aerial photographs, and with borings used for the installation of wells during the investigation. The boundary is presented in Figure 4.1.1. The landfill boundary is well defined with the exception of the area that extends slightly north of Bainbridge Avenue. Aerial photos and the geophysical survey indicate that this area was disturbed during the development of the landfill; however, borings drilled for well installations along Bainbridge Avenue did not encounter any landfill type debris. Instead, the area appears to have been filled with soil and sediment. The landfill comprises two relatively distinct areas. Generally, to the southeast of Least Tern Lane, the landfill is filled primarily with industrial and domestic waste. To the northwest of Least Tern Lane, the landfill appears to contain primarily

construction type debris. A significant observation made during the trenching activities was that the landfill is not covered by a low permeability cap.

SWMU 9 shallow and deep groundwater were evaluated separately for human health risk assessment purposes. In the shallow groundwater, the future site resident risk (ingestion and inhalation pathways) was estimated at  $1E-1$  and  $2E-3$  based on first and second-quarter data, respectively. Corresponding future site worker risk projections were  $3E-2$  and  $7E-4$ . The primary change between first and second-quarter monitoring events was the disappearance of benzidine which was the primary contributor to first-quarter risk projections. Hazard indices for the future resident child were calculated as 22 and 11 for first and second-quarter. Corresponding site worker hazard indices were 4 and 3. The primary risk and hazard contributing COCs in the shallow aquifer included chlorinated benzenes (mono-, di- and tri-substituted), chlorinated alkanes/alkenes, arsenic, alkylphenols, aromatic hydrocarbons, and antimony. 2,3,7,8-TCDD equivalents were also detected in first-quarter shallow groundwater samples. Consideration of third and fourth-quarter results for dioxins will serve to confirm or refute their presence. Furthermore, the maximum 2,3,7,8-TCDD equivalent concentration reported in shallow groundwater does not exceed the MCL ( $3E-8$  mg/L).

Deep groundwater at SWMU 9 was evaluated in the same manner as shallow. The computed site resident carcinogenic risk was  $4E-6$  for first-quarter and not applicable for second-quarter. The future site worker ILCRs based on deep groundwater was  $9E-7$  for first-quarter. No carcinogenic COCs were identified in second-quarter sampling relative to nonresidential receptors. The site resident hazard indices for the respective quarterly sampling events were 138 and 17. Site worker hazard indices were computed as 21 and 3, respectively. Chloroform was the sole ILCR contributor for first-quarter, and was not detected during second-quarter sampling. Thallium, also absent in second-quarter samples, was the primary contributor to first-quarter hazard. Manganese was the sole hazard-based deep groundwater COC detected in second-quarter samples, and its absence from the list of shallow

groundwater COCs suggests that concentrations observed are representative of naturally occurring levels.

Other media (sediment and surface water) were sampled as part of RFI activities at individual SWMUs/AOCs within combined SWMU 9, and are discussed separately in subsequent sections.

SWMU 9 groundwater (shallow and deep) is proposed for inclusion in the CMS due to the projected risk and hazard under hypothetical residential and industrial use scenarios. Shallow groundwater impacts are, however, somewhat localized in nature owing to the source type (heterogeneous landfill refuse/waste). Deep groundwater was, initially, found to be impacted (1st quarter), with risk and hazard projections exceeding the most stringent risk goals and hazard thresholds. Second-quarter deep groundwater results (and significantly lower associated risk/hazard projections) indicate; however, that consideration should be given to third and fourth-quarter results prior to risk management decision-making.

The source of groundwater contamination detected in the SWMU 20 area of SWMU 9 has not been determined. Soil sampling efforts focused on the vadose zone above the areas of highest groundwater contamination did not identify the presence of contaminants similar to those found in groundwater. Extensive regrading of the site in recent years may have removed and/or redistributed the source material in such a manner that it is no longer present or detectable.

In addition, SWMU 20 is geographically within the estimated SWMU 9 boundary and therefore will be evaluated during the SWMU 9 CMS process.

SWMU 9 was included in the ERA for subzone H-1. Based on surface soil samples collected throughout H-1 (which includes SWMUs 19 and 20, and AOCs 649, 650, and 651), the primary ecological risk to infaunal and terrestrial wildlife and vegetation is from inorganic constituents (particularly mercury, zinc, and copper) and low but widespread PAH compounds (See Figures 7.4, 7.5, 7.6, and 7.7). Sediment samples collected from the headwaters of Shipyard Creek in H-1 indicated a risk to aquatic receptors from organic constituents more so than inorganic.

SWMU 9 is proposed for inclusion in the CMS due to projected soil pathway risk/hazard at SWMUs 19, 20, 121 and AOCs 649, 650, and 651. Shallow groundwater risk and hazard also exceeded the most stringent risk goals and hazard thresholds. Shallow groundwater impacts are, however, somewhat localized owing to the source type (heterogenous landfill refuse/waste). Deep groundwater was found to be impacted and risk and hazard projections exceeded the most stringent risk goals and hazard thresholds. Second-quarter deep groundwater results indicate that consideration should be given to third and fourth-quarter analytical results prior to risk management decision-making. Table 9.1 summarizes human health risk assessment results.

Figures 6.2.1.1 through 6.2.1.10 illustrate the distribution of risk in groundwater at SWMU 9.

To evaluate fate and transport, constituents detected in SWMU 9 groundwater were compared to the constituents detected in soil samples from SWMUs 19, 20, and 121, and AOCs 649, 650, 651, and 654. Maximum concentrations in groundwater and soil were compared to relevant fate and transport screening criteria to highlight potential migration pathways. The fate and transport screening process for SWMU 9 produced a list of nine constituents that were present above their fate and transport screening criteria in both soil and groundwater: benzene, chlorobenzene, methylene chloride, trichloroethene, barium, chromium, copper, lead, and vanadium. Shallow groundwater migration is a slow process in Zone H due to low hydraulic gradients. This point was illustrated with travel time analysis which estimated the quickest travel time of 20 years for

benzene to migrate in groundwater from monitoring well NBCH009014 to Shipyard Creek. For the constituents listed above, sorption (barium, chromium, copper, lead, and vanadium) and biodegradation/volatilization and/or retardation (benzene, chlorobenzene, methylene chloride, and trichloroethene) are likely to be the dominant processes affecting fate and transport rather than groundwater migration.

Each SWMU and AOC in the SWMU 9 area was also evaluated separately to provide a focused assessment of the soil-to-groundwater migration pathway. Constituents were identified for SWMU 19 (barium, benzene, and chlorobenzene), SWMU 121 (barium, copper, lead, and vanadium), and AOCs 649 and 650 (barium and lead) as soil-to-groundwater migration concerns based on soil concentrations and detections in downgradient monitoring wells. No constituents were identified as soil-to-groundwater migration concerns for SWMU 20 or AOC 654.

Evaluation of the soil-to-air migration pathway identified a single surface soil sample with 1,1-dichloroethene concentrations (0.063 mg/kg) above the screening level (0.04 mg/kg). Due to the severely limited extent of surface soil impacts, impacts to ambient air, related to 1,1-dichloroethene volatilizing from surface soil are highly unlikely to exceed acceptable risk-based air concentrations.

Qualitative evaluation of the surface soil to sediment migration pathway provided evidence that erosion is a significant process for SWMUs 19, 20, and 121, and AOC 654. Many constituents detected in surface soil were also detected in sediment. This migration pathway is significant in terms of ecological impacts to adjacent wetlands and potential ecological receptors.

**Table 9.1  
 Zone H Conclusion Summary  
 SWMU 9**

	<b>Unacceptable Risks for Human Health in Residential Scenario (Y/N)</b>	<b>Chemicals Driving Risk</b>
Surface Soil	SWMU 19, SWMU 20, SWMU 121, and AOC 649, AOC 650, AOC 651, and AOC 654 (See Individual Site Discussions)	
Shallow Groundwater	Yes ILCR 1E-1/2E-3 HI=22/11 (First/Second-quarter)	Benzidine, Chlorinated Benzenes, Chlorinated Alkanes/Alkenes, Arsenic, Dioxins, Alkylphenols, Aromatics, Antimony
Deep Groundwater	Yes ILCR 4E-6/NA HI=138/17	Tl, Chloroform, Mn
	<b>Above Levels of Concern (Y/N)</b>	<b>Total TEQ (ppb)</b>
Dioxin in Surface Soil	No (All SWMUs/AOCs)	0.716-195.37 pg/g 2,3,7,8-TCDD equivalents
Dioxin in Shallow Groundwater	Yes	1.585-2.798 pg/L 2,3,7,8-TCDD equivalents
Dioxin in Deep Groundwater	None reported	NA
	<b>TPH Present at Concentrations &gt; 100 ppm (Y/N)</b>	<b>Maximum Detected Concentration (ppm)</b>
Soil	See Individual SWMU/AOC Discussions	NA

*Note:*  
 NA = Not Applicable

### **9.3 Combined SWMU 14 (Includes SWMUs 14 and 15 and AOCs 670 and 684)**

SWMU 14 is an abandoned chemical disposal area where miscellaneous chemicals and warfare decontaminating agents and possibly industrial wastes were buried. SWMU 15 is the site of a former propane-fired incinerator reportedly used to destroy classified documents. Only the concrete slab and concrete propane tank saddles remain. AOC 670 is a former outdoor trap and skeet range operated from 1960 until the late 1970s. Lead shot and clay targets were not recovered during the operation of this facility. AOC 684 is a former outdoor pistol range in operation from the early 1960s until 1981. Firearms were discharged into a soil berm, from which no recovery was made of the spent ammunition. The area of combined SWMU 14 encompasses the areas of SWMU 15 and AOCs 670 and 684.

A 1992 geophysical and soil-gas investigation (E/A&H, 1994C) investigated the presence of buried containers and/or contaminant plumes in the SWMU 14 area. Portions of the sampling pattern were based on geophysical anomalies identified during the geophysical survey.

Soil and groundwater sampling were sampled during the RFI to identify the presence or absence of contamination resulting from the disposal of chemicals and other wastes in the SWMU 14 area and residual contamination from the discharge of firearms in the vicinity.

Canisters of decontaminating agents and other items reportedly buried in the SWMU 14 area were never found during the RFI and the chemical data for soil and groundwater samples collected in the area did not suggest that a release had occurred. However, recent interim measures activities resulted in the excavation of a number of the canisters. Results of the interim measures will be presented in a report prepared by the environmental detachment.

Most of the significant contamination detected in soil samples collected during the RFI at SWMU 14 was apparently related to the former incinerator (SWMU 15) and the former skeet range (AOC 670).

Four separate soil matrix investigations were conducted as part of the combined SWMU 14 RFI. Each is discussed separately below. Figures 9.9 and 9.10 illustrate risk and hazard in the residential scenario for the Combined SWMU 14 sampling area. Figure 9.11 illustrates hazard considering a residential scenario. Due to lack of significant hazard under the industrial scenario, an industrial hazard map was not prepared.

Figure 9.9 illustrates the distribution of risk considering a residential scenario at SWMU 14. Seven limited areas (based on individual sampling point results) were determined to pose a potential risk above  $1E-4$ . The distribution of these seven areas does not appear to fit any particular pattern. The majority of the combined SWMU 14 area is within the area which presents risk in the  $1E-5$  to  $1E-4$  range.

Figure 9.10 illustrates the distribution of risk considering an industrial scenario at SWMU 14. Results from only one sample location correlated with projected risk above  $1E-4$  (684SB035). Seven areas exhibited risk in the range of  $1E-5$  to  $1E-4$ . These areas were approximately the same as the  $1E-4$  areas identified in the residential scenario. The majority of the SWMU 14 area exhibited risk in the  $1E-6$  to  $1E-5$  range.

Figure 9.11 illustrates the distribution of hazard considering a residential scenario at SWMU 14. One sample location (670SB023) exhibited hazard at a HI of 3.0 to 10.0. Four other areas exhibited hazard in the HI range of 0.1 to 1.0.

Due to lack of significant hazard in the industrial scenario at SWMU 14, no industrial hazard map was produced.

Shallow and deep groundwater, as well as sediment and surface water, were also sampled at Combined SWMU 14. Table 9.3 summarizes human health risk assessment results.

TPH contamination, as evidenced by soil sample results, is present in the Combined SWMU 14 area at concentrations exceeding the screening level (Figure 9.5 and 9.6). The area exhibiting the highest TPH contamination was approximately 50 feet to 150 feet south of Building 1984. This "hot spot" is encircled by sample data points with significantly lower or nondetect TPH concentrations.

These sites were included in the ERA for subzone H-3. Based on surface soil samples collected throughout H-3, the primary ecological risk to infaunal and terrestrial organisms is from inorganic constituents (lead and arsenic) and low but widespread concentrations of BEQ compounds (Figures 7.11 and 7.12).

#### **SWMU 14**

Six COCs were identified in the samples collected from the SWMU 14 portion of the Combined SWMU 14 sampling area: 1,2,3-trichloropropane, BEQ, aluminum, arsenic, beryllium, and vanadium.

Trichloropropane was detected at 91.2  $\mu\text{g}/\text{kg}$  at sample location 014SB008. This concentration did not exceed the RBSL for this compound; however, the concentration did exceed the soil-to-air volatilization screening level and as a result is considered a site COC. No trichloropropane was detected in the second-interval samples at the SWMU 14 subarea. Due to the severely limited extent of surface soil impacts, impacts to ambient air, related to trichloropropane volatilizing from surface soil are highly unlikely to exceed acceptable risk-based air concentrations.

BEQ concentrations of PAH were identified in the SWMU 14 sampling subarea. The RBSL for BAP was exceeded at only one sample location (014SB106). No BEQ concentrations were detected in the second-interval soil samples at RBSL-exceeding concentrations.

Aluminum was only analyzed at three locations within the SWMU 14 portion of the Combined SWMU 14 sampling area. One of these locations (014SB010) contained aluminum over its respective RBSL and UTL. Aluminum was included in the SW-846 group of metals but not in the Appendix IX group of metals. The three locations in the SWMU 14 subarea with aluminum results were submitted for SW-846 rather than the Appendix IX analyses. No second-interval samples were analyzed for aluminum at the SWMU 14 subarea.

Arsenic was detected at two of the SWMU 14 subarea sampling locations (014SB004 and 014SB106). The concentration for both samples was less than the RBSL/UTL for arsenic; however, the Wilcoxon rank sum test determined that the concentration of the site samples as a group were significantly higher than the corresponding group of background concentrations for arsenic. Arsenic was not detected in the second-interval soil samples collected in the SWMU 14 subarea.

Beryllium was detected at eight of 12 SWMU 14 subarea sampling locations; however, the concentration of beryllium at each of these locations was less than its RBSL/UTL. As with arsenic, the Wilcoxon rank sum test determined that the concentrations in site samples as a group were significantly higher than the corresponding group of background concentrations for beryllium. There were no detections of beryllium at interval-specific UTL-exceeding concentrations in the second-interval samples collected at the SWMU 14 subarea.

Vanadium was detected in all upper-interval SWMU 14 subarea sampling locations and in the majority of the second-interval samples. None of the vanadium detections were higher than the element's UTL; however, as with arsenic and beryllium, the Wilcoxon rank sum test determined that the concentration in site samples as a group were significantly higher than the corresponding group of background concentrations for vanadium. There were no detections of vanadium at interval-specific UTL-exceeding concentrations in the second-interval samples collected at the SWMU 14 subarea.

The total soil pathway risk for site residents and site workers was calculated as  $6E-5$  and  $9E-6$ , respectively. The resident child hazard index was 1. Adult resident and site worker hazard indices were below 0.1. The primary contributors to surface soil risk were arsenic, BEQs, and beryllium. The primary hazard contributors were aluminum, arsenic and vanadium. SWMU 14 surface soil is recommended for inclusion in the CMS process on the basis of projected resident and worker risk, potential resident child hazard, and TPH concentrations.

### **SWMU 15**

Arsenic and BEQ were identified as COCs in the SWMU 15 portion of the Combined SWMU 14 sampling area.

Sample location 015SB004 contained the highest concentration ( $53.1 \mu\text{g}/\text{kg}$ ) of arsenic in the SWMU 15 samples. The only other arsenic detection was at 015SB003, adjacent to the 015SB004 sample location; however, this detection was only slightly over the UTL. No interval-specific UTL-exceeding concentrations of arsenic were detected in the second-interval samples collected in the SWMU 15 subarea.

All BEQs for PAH detected at the SWMU 15 soil sampling subarea exceeded the RBSL for BAP. The highest BEQ concentration ( $2,028.44 \mu\text{g}/\text{kg}$ ) was detected at 015SB004. Other BEQ concentrations at the SWMU 15 sampling area were less than one-half the 015SB004 concentration. No BEQs were detected in the second-interval soil samples from the SWMU 15 subarea.

The total soil pathway risk for site residents and site workers was calculated as  $2E-4$  and  $3E-5$ , respectively. The resident child hazard index was 2. Adult resident and site worker hazard indices were below 0.3. The primary contributors to surface soil risk were arsenic and BEQs. The sole hazard contributor was arsenic. SWMU 15 surface soil is recommended for inclusion

in the CMS process on the basis of projected resident and worker risk, and potential resident child hazard.

#### **AOC 670 and AOC 684**

Aluminum, antimony, thallium, beryllium, arsenic, Aroclor-1254, Aroclor-1260, and BEQ were identified as COCs in the AOC 670 and 684 portion of the Combined SWMU 14 sampling area.

Aluminum was analyzed in a portion of the AOC 670 soil samples. While no single detection of aluminum exceeded the element's RBSL/UTL, the Wilcoxon rank sum test determined that the concentration of aluminum in site samples as a group were significantly higher than the corresponding group of background concentrations for aluminum. Aluminum was detected at all second-interval sample locations where analyzed. All detections of aluminum in the second-interval were below the interval-specific UTL for aluminum.

Antimony was detected at 10 surface soil sample locations in the AOC 670 and 684 subareas. All detections were over the element's RBSL. No UTL was computed for the element due to low number of detections. The majority of the detections for antimony were in the north-central portion of the sampled area in the vicinity of 684SB018 and 684SB014; however, the highest antimony detection was an isolated hit at 670SB023. Antimony was detected in nine second-interval sample locations at somewhat lower concentrations. The second-interval detections were in the same general area as the surface-interval detections. No antimony was detected in the second-interval at 670SB023.

Thallium was detected at seven surface soil sample locations in the AOC 670 and 684 subareas. Five of these detections exceeded thallium's RBSL/UTL. These five locations were 684SB016, 684SB015, 684SB026, 684SB027, and 670SB023. Thallium was detected in four of the second-interval soil samples collected in the AOC 670 and 684 subareas. None exceeded the second-interval UTL for thallium.

Beryllium was identified in the AOC 684 subarea as a COC. It was detected at one surface-interval sample location (684SB009) at an RBSL/UTL exceeding concentration. This detection was only slightly above the UTL. Beryllium was also detected in the majority of the second-interval soil samples from AOC 684; however, none of the detections were above beryllium's interval-specific UTL.

Five locations within the AOC 670 and 684 subareas produced samples with concentrations of arsenic that exceeded its RBSL/UTL. There was no apparent pattern to the distribution of arsenic in this area. The majority of second-interval samples contained arsenic; however, no detections of arsenic were above the interval-specific UTL.

Aroclor-1254 was detected in two samples (684SB03201 and 684SB03301) at AOC 684 where it was identified as a COC. The 684SB03301 sample was the only detection (160  $\mu\text{g}/\text{kg}$ ) which exceeded the RBSL for Aroclor-1254 (83  $\mu\text{g}/\text{kg}$ ).

Aroclor-1260 was detected in three samples (684SB00701, 684SB03201, and 684SB03301) at AOC 684 where it was identified as a COC. Only one sample (684SB00701) contained Aroclor-1260 at a concentration (376  $\mu\text{g}/\text{kg}$ ) which exceeded the RBSL of 83  $\mu\text{g}/\text{kg}$ .

BEQs were identified as COCs at the AOC 670 and 684 subareas. The highest concentrations of BEQs were east and south of the SWMU 15 area. SWMU 15 was a paper incinerator and may account for the presence of high concentrations of BEQs in AOC 670 and 684 sampling areas. BEQs were detected in seven second-interval samples. Six of these seven detections were along the border between the AOC 670 and AOC 684 sampling areas. The BEQs for three of these samples exceeded the RBSL for BAP. The only other detection of BEQ in the second-interval was at 684SB040 on the northern edge of the AOC 684 sampling pattern.

The AOC 670 total soil pathway risk for site residents and site workers was calculated as  $7E-5$  and  $1E-5$ , respectively. The resident child hazard index was 1. Adult resident and site worker hazard indices were below 0.2. The primary contributors to surface soil risk were arsenic and BEQ. The hazard contributors included arsenic, aluminum, antimony, and thallium. AOC 670 surface soil is recommended for inclusion in the CMS process on the basis of projected resident and worker risk, potential resident child hazard, and TPH concentrations.

The AOC 684 total soil pathway risk for site residents and site workers was calculated as  $1E-4$  and  $2E-5$ , respectively. The resident child hazard index was 1. Adult resident and site worker hazard indices were below 0.1. The primary contributors to surface soil risk were arsenic, BEQs, and beryllium. The hazard contributors included arsenic, antimony, and thallium. AOC 684 surface soil is recommended for inclusion in the CMS process on the basis of projected resident and worker risk, potential resident child hazard, and TPH concentrations.

#### **SWMU 14 Shallow Groundwater**

The total shallow groundwater pathway risk for site residents and site workers was calculated as  $3E-5$  and  $7E-6$ , respectively. The resident child hazard index was 2. Adult resident and site worker hazard indices were below 0.7. The primary contributors to shallow groundwater risk were BEHP and 2,3,7,8-TCDD equivalents; both detected in first-quarter samples only. The hazard contributors included aluminum and vanadium. SWMU 14 shallow groundwater is recommended for inclusion in the CMS process on the basis of projected resident and worker risk, and potential resident child hazard. Due to the hydrophobic nature of dioxins, they are not expected to migrate from soil to groundwater. It has been suspected that first-quarter results for dioxins may reflect the influence of sediment entrained in the monitored zone during well installation. Consideration of third and fourth-quarter results will confirm or refute the presence of both 2,3,7,8-TCDD equivalents and BEHP in shallow groundwater. This review will facilitate responsible and sound risk-management decisions. Furthermore, the maximum

2,3,7,8-TCDD equivalent concentration reported in shallow groundwater does not exceed the MCL (3E-8 mg/L).

#### **SWMU 14 Deep Groundwater**

The total deep groundwater pathway risk for site residents and site workers was calculated as 5E-4 and 1E-4, respectively. The resident child hazard index was 17. Adult resident and site worker hazard indices were calculated at 8 and 3, respectively. The primary contributors to deep groundwater risk were heptachlor epoxide, BEHP and 2,3,7,8-TCDD equivalents; each was detected in first-quarter samples only. The hazard contributors included cadmium and thallium. Thallium was also detected exclusively in first-quarter samples. SWMU 14 deep groundwater is recommended for inclusion in the CMS process on the basis of projected resident and worker risk and hazard for all potential receptors. Due to the hydrophobic nature of dioxins and heptachlor epoxide, neither would be expected to migrate from soil to groundwater. It has been suspected that first-quarter results for these compounds may reflect the influence of sediment entrained in the monitored zone during well installation. Consideration of third and fourth-quarter results will confirm or refute the presence of heptachlor epoxide, 2,3,7,8-TCDD equivalents and BEHP in deep groundwater. This review will facilitate responsible and sound risk management decisions. Furthermore, the maximum 2,3,7,8-TCDD equivalent concentration reported in deep groundwater does not exceed the MCL (3E-8 mg/L).

To evaluate fate and transport, constituents detected in Combined SWMU 14 groundwater were compared to the constituents detected in soil samples collected from SWMUs 14 and 15, and AOCs 670 and 684. Maximum concentrations in groundwater and soil were compared to relevant fate and transport screening criteria to highlight potential migration pathways. The fate and transport screening process for Combined SWMU 14 identified chromium and lead present above their fate and transport screening criteria in both soil and groundwater. Shallow groundwater migration is a slow process for Zone H due to low hydraulic gradients. This point was illustrated with travel time analysis which estimated a travel time of 200 to 300 years for

groundwater to migrate from the SWMU 14 area to the Cooper River. Sorption is likely to be the dominant process affecting fate and transport rather than groundwater migration for lead and chromium.

Each SWMU and AOC in Combined SWMU 14 area were also evaluated separately to provide a focused assessment of the soil-to-groundwater migration pathway. Lead was identified for SWMU 14 as a soil-to-groundwater migration concern based on soil concentrations and detections in a downgradient monitoring well. No constituents were identified as soil-to-groundwater migration concerns for SWMU 15, AOC 670, and AOC 684.

Evaluation of the soil-to-air migration pathway identified a single surface soil sample with 1,2,3-trichloropropane concentrations (0.0912 mg/kg) above the screening level (0.00003 mg/kg). Due to the limited extent of surface soil impacts, impacts to ambient air, related to 1,2,3-trichloropropane volatilizing from surface soil, are unlikely to exceed acceptable risk-based air concentrations. Limited supplemental soil and/or air sampling during the CMS would assist in confirming that 1,2,3-trichloropropane concentrations are not actionable relative to the soil-air pathway.

Qualitative evaluation of the surface soil-to-sediment migration pathway provided evidence that erosion is a significant process for AOCs 670 and 684. Many constituents detected in surface soil were also detected in sediment. This migration pathway is potentially significant relative to ecological impacts to the drainage features located at these AOCs. Table 9.3 summarizes the human health risk assessment (residential scenario) for the Combined SWMU 14 area.

**Table 9.3**  
**Zone H Conclusion Summary**  
**Combined SWMU 14 (Includes SWMUs 14 and 15 and AOCs 670 and 684)**

	<b>Unacceptable Risks for Human Health in Residential Scenario (Y/N)</b>	<b>Chemicals Driving Risk</b>
Surface Soil	SWMU 14 Yes, ILCR 6E-5, HI=1 SWMU 15 Yes, ILCR 2E-4, HI=2 AOC 670 Yes, ILCR 7E-5, HI=1 AOC 684 Yes, ILCR 1E-4, HI=1	Al, As, BEQ, Be, V, As, BEQ BEQ, As, Tl, Al, Sb, Aroclor-1254, Aroclor-1260, BEQ, As, Tl, Be, Sb,
Shallow Groundwater	Yes ILCR 3E-5, HI=2	BEHP, 2,3,7,8-TCDD equivalents, Al, V
Deep Groundwater	Yes ILCR 5E-4, HI=17	Heptachlor epoxide, 2,3,7,8-TCDD equivalents, Chloroform, Cd, Tl
	<b>Above Levels of Concern (Y/N)</b>	<b>Total TEQ (ppb)</b>
Dioxin in Surface Soil	No	0.831-22.357 pg/g 2,3,7,8-TCDD equivalents
Dioxin in Shallow Groundwater	Yes	2.038-11.368 pg/l 2,3,7,8-TCDD equivalents
Dioxin in Deep Groundwater	Yes	1.061-2.285 pg/l 2,3,7,8-TCDD equivalents
	<b>TPH Present at Concentrations &gt;100 ppm (Y/N)</b>	<b>Maximum Detected Concentration (ppm)</b>
Soil	Y	13,400

*Note:*  
 NA = Not Applicable

*Final RCRA Facility Investigation Report for Zone H*  
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*June 24, 1997*

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#### **9.4 SWMU 17**

SWMU 17 is the site of an oil spill from a ruptured underground fuel pipe beneath Building FBM 61. The 1987 rupture released approximately 14,000 gallons of fuel oil beneath the north-central extension of the building. Soil sampling identified the presence of SVOCs and PCBs in the soil adjacent to the building and extrapolation of the data indicates a high probability that contamination exists beneath the building. Contaminants have leached into shallow groundwater as evidenced by results of the groundwater sample analyses.

Two organic compounds or compound groups were identified through soil sampling and subsequent risk assessment as COCs in surface soil at SWMU 17: Aroclor-1260 and BEQs.

BEQs were present in soil samples collected from SWMU 17 at concentrations resulting in their identification as site COCs with regard to a residential scenario. The concentration of these compounds, when equated to BAP, exceeded the RBSL for BAP. BEQs for PAH at BAP RBSL-exceeding concentrations were present along the eastern side of the building appendage on the north side of Building 61. The only BEQ detection in the second-interval was at location 017SB011. The BEQ for this sample was 0.13  $\mu\text{g}/\text{kg}$ . Based on the current sampling pattern, the extent of BEQ contamination is confined to the above-described area.

Aroclor-1260 contamination was present on the west and east sides of the building appendage on the north side of Building 61. The soil boring with the highest Aroclor-1260 contamination in the upper sampling-interval was 017SB020. The second highest Aroclor-1260 contamination in the upper sampling-interval was from soil boring 017SB002. Lower-interval samples with Aroclor-1260 contamination were obtained from borings 017SB006 and 017SB004. Aroclor-1260 contamination of soil at SWMU 17 is centered on the north side of Building 61.

The area of SWMU 17 exhibiting the most impact from TPH contamination, as evidenced by soil sample results, was in the vicinity of soil borings 017SB001, 017SB002, 017SB003, and

017SB006 in the indented, open area of the north side of Building 61. TPH contamination at concentrations exceeding the screening level were also detected at 017SB011. The presence of TPH under Building 61 has not been assessed.

The total soil pathway risk for site residents and site workers was calculated as  $4E-4$  and  $8E-5$ , respectively. The primary contributors to surface soil risk were BEQs and Aroclor-1260. SWMU 17 surface soil is recommended for inclusion in the CMS process on the basis of projected resident and worker risk, as well as TPH concentrations.

Figure 9.12 illustrates the distribution of risk at SWMU 17 considering a residential scenario. An area encompassing sample locations 017SB002, 017SB009, and 017SB023 and an area around 017SB006 represent the presence of potential individual point risk greater than  $1E-4$ . This area is apparently the source area for Aroclor-1260.

Aroclor-1260 was the sole carcinogenic COC with regard to the industrial scenario (Figure 9.13). The distribution of risk in the industrial scenario was similar to the distribution of risk in the residential scenario with the same primary  $1E-4$  risk locations.

No hazard maps were prepared due to lack of significant hazard at SWMU 17.

No ecological risk is anticipated for SWMU 17 due to the lack of suitable habitat and lack of ecological receptors.

Groundwater contamination is present in the area immediately surrounding NBCH017002 and appears to be moving in the northeast direction as evidenced by the lower level of contamination identified in NBCH017005. SWMU 17 shallow groundwater is recommended for inclusion in the CMS process on the basis of projected resident and worker risk and hazard. Although proof that the single benzidine hit was a well installation artifact would result in a considerable

reduction in projected shallow groundwater risk, the chlorinated benzenes detected on a limited basis at NBCH017002 would remain problematic with associated risk projections above 1E-4.

The total shallow groundwater pathway risk for site residents and site workers were calculated as 2E-1 and 6E-2, respectively. The hazard indices for resident children, resident adults and site worker's were 79, 34 and 12, respectively. The primary contributors to shallow groundwater risk and hazard were benzidine (detected in one first-quarter sample only) and chlorinated benzenes (mono-, di-, and tri-). Table 9.4 summarizes human health risk assessment results.

To evaluate fate and transport, constituents detected in SWMU 17 groundwater were compared to the constituents detected in soil samples. Maximum concentrations in groundwater and soil were compared to relevant fate and transport screening criteria to highlight potential migration pathways. The fate and transport screening process for SWMU 17 identified chlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, and 1,2,4-trichlorobenzene above their fate and transport screening criteria in both soil and groundwater. A dense nonaqueous phase liquid was reported in the NBCH017002 monitoring well during the third round of groundwater sampling. In addition, benzidine, chromium, and 1,2-dichlorobenzene were detected in SWMU 17 shallow groundwater above their tap water RBCs.

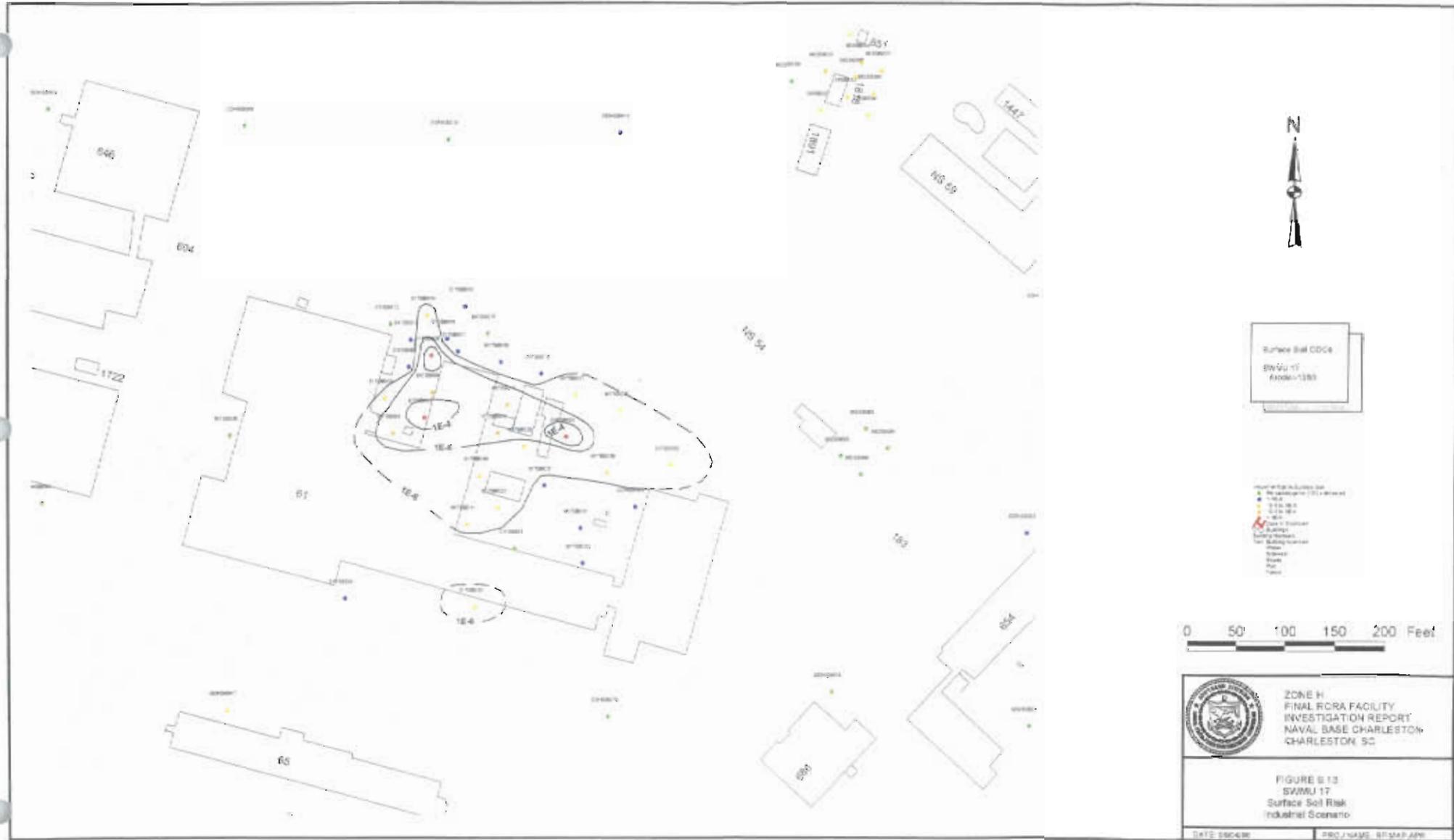
Groundwater migration is a slow process for Zone H due to low hydraulic gradients. This point was illustrated with travel time analysis which estimated a travel time of 176 years for benzidine to migrate in groundwater from monitoring well NBCH017002 to the Cooper River. For the constituents listed above, biodegradation/volatilization are likely to be the dominant processes affecting fate and transport rather than groundwater migration.

**Table 9.4  
 Zone H Conclusion Summary  
 SWMU 17**

	<b>Unacceptable Risks for Human Health in Residential Scenario (Y/N)</b>	<b>Chemicals Driving Risk</b>
Surface Soil	Yes, ILCR 4E-4	BEQs, Aroclor-1260
Shallow Groundwater	Yes, ILCR 1E-1	Benzidine, Mono, Di, and Tri chlorobenzenes
Deep Groundwater	NA	
	<b>Above Levels of Concern (Y/N)</b>	<b>Total TEQ (ppb)</b>
Dioxin in Surface Soil	No	1.106-127.031 pg/g 2,3,7,8-TCDD equivalents
Dioxin in Shallow Groundwater	No	ND
Dioxin in Deep Groundwater	NA	
	<b>TPH Present at Concentrations &gt; 100 ppm (Y/N)</b>	<b>Maximum Detected Concentration (ppm)</b>
Soil	Y	1,200

*Note:*  
 NA = Not Applicable





Surface Soil COCs  
 SWMU 17  
 F00001380

- Legend
- Sampling Location
  - 10.4
  - 15.4
  - 20.4
  - ▲ Area of Concern
  - ▲ Building
  - ▲ Building Footprint
  - ▲ Road
  - ▲ Stream
  - ▲ Well

0 50 100 150 200 Feet

 ZONE H  
 FINAL RCRA FACILITY  
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 CHARLESTON, SC

FIGURE S 13  
 SWMU 17  
 Surface Soil Risk  
 Industrial Scenario

DATE: 08/04/08 PROJ NAME: 87343-AP1

## **9.5 SWMU 19**

SWMU 19 is a solid waste transfer station. It was used for the temporary storage of solid waste prior to transport offsite. Wastes were stored on bare ground prior to transport and included dry trash, tires, and empty 55-gallon drums. Soil sampling was conducted at SWMU 19 to evaluate whether residual contamination remains at the site as a result of previous solid waste management activities. Only two second-interval soil samples were collected at SWMU 19 due to the shallow depth to groundwater. These were collected at locations 019SB001 and 019SB004.

Three organic compounds or compound groups (BEQs, Aroclor-1254, and Aroclor-1260) and six inorganic elements (antimony, arsenic, beryllium, copper, nickel, and zinc) were determined to be COCs in the surface soil at SWMU 19.

BEQs were present in soil samples collected from SWMU 19. The concentration of these compounds, when equated to BAP, exceeded the RBSL for BAP. Soil sample locations exhibiting BEQ contamination at concentrations exceeding the RBSL for BAP were present within and around the perimeter of the SWMU 19 sampling pattern. BEQs were detected in one of the two second-interval samples collected at SWMU 19. The BEQs for this sample was 2062.6  $\mu\text{g}/\text{kg}$ , which made it the most heavily contaminated BEQ sample in the SWMU 19 area. This sample was collected at location 019SB004.

Aroclor-1254 was detected at only one sample location at SWMU 19 (the upper-interval sample at 019SB007). This detection of Aroclor-1254 was 2,300  $\mu\text{g}/\text{kg}$ , which exceeds the compound's RBSL (83  $\mu\text{g}/\text{kg}$ ). Aroclor-1254 was not detected in either second-interval sample.

Aroclor-1260 was detected in 11 samples at SWMU 19. Eight of these detections exceeded the compound's RBSL (83  $\mu\text{g}/\text{kg}$ ). These detections were distributed throughout the SWMU 19 sampling pattern. Aroclor-1260 was not detected in either second-interval sample.

Antimony was detected at one sample location (019SB002) at a concentration which exceeded its RBSL. Antimony was detected at two other upper-interval sample locations and at one of the two second-interval sample locations. All detections for antimony were within the fenced area of SWMU 19.

Arsenic was present at UTL-exceeding concentrations at three upper-interval soil sample locations (019SB013, 019SB009, and 019SB001). Two of these sample locations are on the perimeter of the current sampling pattern. Arsenic was detected in both lower-interval sample locations. Both second-interval detections were below the interval-specific UTL.

Beryllium was detected in one soil sample (019SB00401) at a concentration that exceeded the RBSL and interval-specific UTL. This sample location is surrounded with samples that contained background concentrations of beryllium. Beryllium was detected in both lower-interval samples at concentrations below the interval-specific UTL.

Copper was detected at RBSL/UTL-exceeding concentrations at nine soil sample locations. These locations were distributed throughout the SWMU 19 sampling pattern. The highest detected concentration of copper was at sample location 019SB007. Copper, at above-UTL concentrations, was detected in both second-interval sample locations.

Nickel was detected at one soil sample location (019SB004) at a RBSL/UTL-exceeding concentration. Detections of nickel below the RBSL and UTL were distributed throughout the SWMU 19 sampling pattern. Nickel was detected in one (019SB004) of the two second-interval samples. The concentration of nickel in this sample was below the interval-specific UTL.

Zinc was only detected at one SWMU 19 sample location (019SB004) at a RBSL/UTL-exceeding concentration. However, zinc was present at UTL-exceeding concentrations throughout the SWMU 19 sampling pattern. Zinc was detected in both lower-interval soil samples. Both

detections exceeded zinc's lower-interval UTL; however, they did not exceed the element's RBSL.

The total soil pathway risk for site residents and site workers was calculated as  $7E-5$  and  $1E-5$ , respectively. The child hazard index computed for soil pathways was 3. The hazard indices for adult residents and site workers were 0.4 and 0.2, respectively. The primary contributors to surface soil risk were arsenic, beryllium, BEQ and Aroclor-1254 and -1260. Table 9.5 summarizes human health risk assessment results.

SWMU 19 was included in the ERA for subzone H-1. Of the surface soil samples collected throughout H-1 (which also includes SWMUs 9 and 20 and AOCs 649, 650, and 651) most of the samples with the highest potential for lethal and sublethal risk to infaunal invertebrates, terrestrial organisms, and herbaceous vegetation were collected from SWMU 19 (see Figures 7-4, 7-5, 7-6, and 7-7). The primary ecological risk is related to inorganic constituents (particularly zinc, copper, mercury, arsenic, and lead) and low but widespread BEQ compounds.

Figure 9.14 illustrates the distribution of risk considering a residential scenario. The majority of the SWMU 19 site exhibits risk between the  $1E-5$  and  $1E-4$  range.

Figure 9.15 illustrates the distribution of risk considering an industrial scenario. The majority of the SWMU 19 site poses risk in the range of  $1E-6$  to  $1E-5$ .

Figure 9.16 illustrates the distribution of hazard considering a residential scenario. The vicinity of sample location 019SB009 is an area of hazard between a HI of 1.0 and 3.0. The area around sample locations 019SB003, 019SB004, and 019SB007 represents an area of HI between 1.0 and 10.0.

Due to lack of significant industrial hazard, no industrial hazard map was prepared.

Given the sample location distribution, it is not apparent whether the hazard at either of the above-mentioned areas is due to SWMU 19 activities. It is apparent from the data that the risk identified at SWMU 19 is not confined to the fenced SWMU 19 area. The widespread nature of organic COCs suggests a source other than past SWMU 19 operations.

TPH analysis was conducted on two samples collected in the SWMU 19 area (the upper-interval sample at 019SB002 and the upper-interval sample at 019SB014). The concentration of TPH in both samples exceeded the screening level for TPH. No additional TPH analyses were conducted on SWMU 19 samples.

SWMU 19 surface soil is recommended for inclusion in the CMS process on the basis of projected resident and worker risk, and resident child hazard as well as TPH concentrations. Table 9.5 summarizes unacceptable risks for human health at SWMU 19.

In addition, SWMU 19 is geographically within the estimated SWMU 9 boundary and therefore will be evaluated during the SWMU 9 CMS process.

**Table 9.5  
 Zone H Conclusion Summary  
 SWMU 19**

	<b>Unacceptable Risks for Human Health in Residential Scenario (Y/N)</b>	<b>Chemicals Driving Risk</b>
Surface Soil	Yes, ILCR 7E-5, HI=3	Aroclor-1254 and 1260, BEQs, As, Be, Cu, Ni, Zn
Shallow Groundwater	See SWMU 9	NA
Deep Groundwater	See SWMU 9	NA
	<b>Above Levels of Concern (Y/N)</b>	<b>Total TEQ (ppb)</b>
Dioxin in Surface Soil	No	1.058-45.608 pg/g 2,3,7,8-TCDD equivalents
Dioxin in Shallow Groundwater	See SWMU 9	NA
Dioxin in Deep Groundwater	See SWMU 9	NA
	<b>TPH Present at Concentrations &gt; 100 ppm (Y/N)</b>	<b>Maximum Detected Concentration (ppm)</b>
Soil	Y	189

*Note:*

NA = Not Applicable

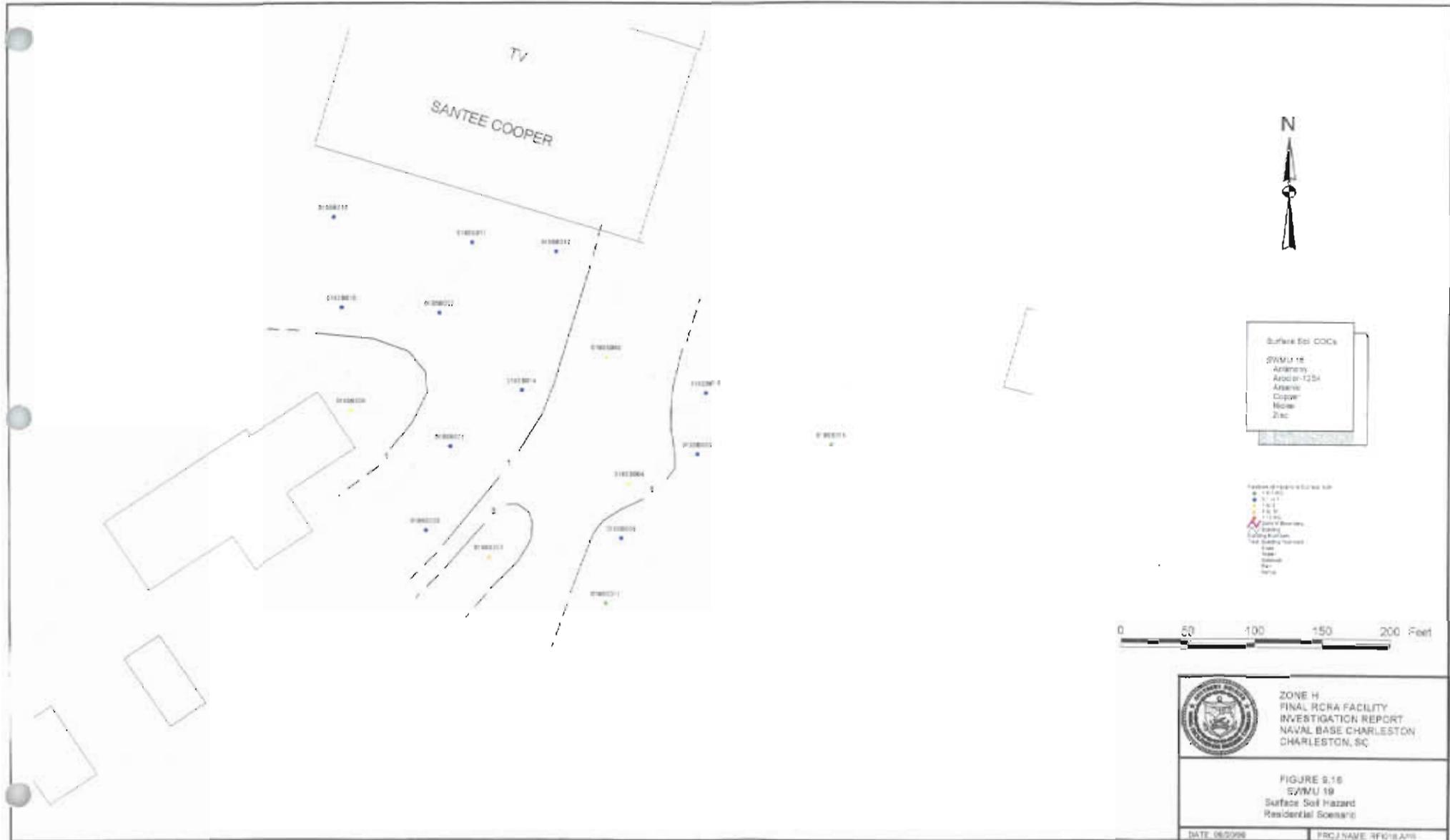
*Final RCRA Facility Investigation Report for Zone H*  
*NAVBASE Charleston*  
*Section 9: Conclusions*  
*June 24, 1997*

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**ZONE H**  
**FINAL RCRA FACILITY**  
**INVESTIGATION REPORT**  
**NAVAL BASE CHARLESTON**  
**CHARLESTON, SC**

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**FIGURE 9.16**  
**25MU 18**  
**Surface Soil Hazard**  
**Residential Scenario**

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DATE: 06/2008      PROJ NAME: RFG18A18

## **9.6 SWMU 20**

SWMU 20 is the site of previous construction waste disposal/storage. Beginning in 1985, waste materials, such as batteries, concrete, wood, and sand blasting residue were stored on the ground at SWMU 20. No containment was provided around the waste storage area. Soil sampling was conducted at SWMU 20 to evaluate whether residual contamination remains at the site as a result of the previous waste management activities which occurred there. Due to shallow depth to groundwater, only one lower-interval sample (020SB011) was collected at SWMU 20.

BEQs were present in soil samples collected from SWMU 20 at concentrations resulting in their identification as site COCs. BEQs were detected at each of the 11 soil boring locations at SWMU 20. All of the BEQ concentrations exceeded the RBSL for BAP with the exception of the upper-interval sample collected at 020SB002. BEQ were detected in the second-interval soil sample (020SB011) at a concentration which exceeded the RBSL for BAP.

SWMU 20 was also included in the ERA for subzone H-1. Based on surface soil samples collected throughout H-1 (which included SWMUs 9 and 19 and AOCs 649, 650, and 651), the primary ecological risk to infaunal and terrestrial organisms is from inorganic constituents (particularly mercury, zinc, and copper) and low but widespread PAH compounds (see Figures 7.4, 7.5, 7.6, and 7.7). Inorganic analysis was not included in the sampling plan for SWMU 20. Concentrations of organic ECPCs indicated low ecological risk.

The total soil pathway risk for site residents and site workers was calculated as  $1E-5$  and  $3E-6$ , respectively. No noncarcinogenic COCs were identified for soil pathways. The primary contributors to surface soil risk were BEQs. SWMU 20 surface soil is recommended for inclusion in the CMS process on the basis of projected resident and worker risk. Table 9.6 summarizes human health risk assessment results.

In addition, SWMU 20 is geographically within the estimated SWMU 9 boundary and therefore will be evaluated during the SWMU 9 CMS process.

Figure 9.17 illustrates the distribution of risk in surface soil at SWMU 20 considering a residential scenario. Individual locations in the southern portion of the SWMU 20 sampling area exhibited risk in excess of 1E-5, while those in the northern portion of the SWMU 20 sampling area exhibited risk in the range of 1E-5 and 1E-4. On the eastern and western edges of the SWMU 20 sampling pattern, risk dropped to below 1E-6.

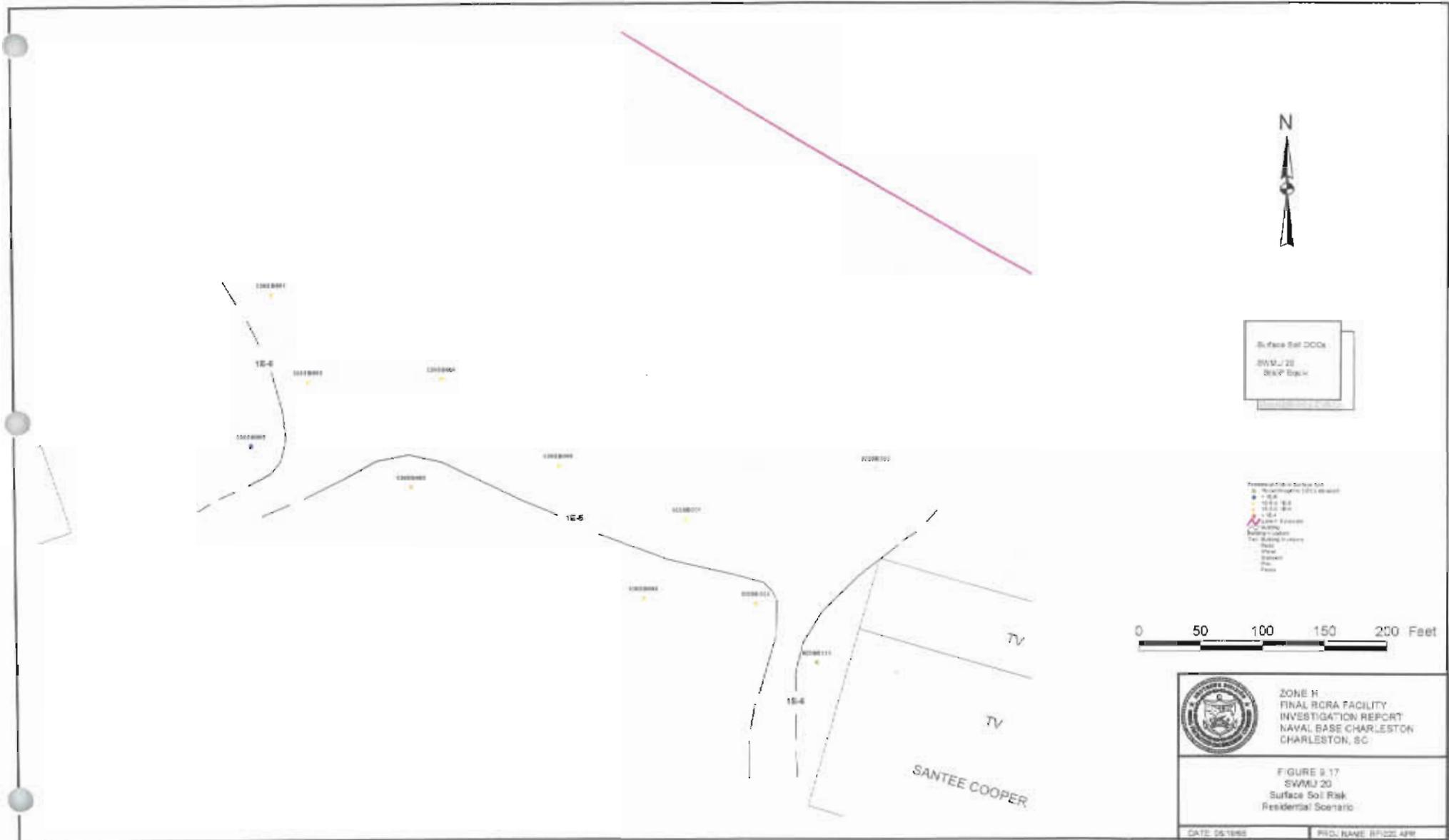
Figure 9.18 illustrates the distribution of risk in surface soil at SWMU 20 considering an industrial scenario. The southern portion of the sampled area exhibited risk exceeding 1E-6. The remainder of the sampled area (the northern portion) did not exhibit risk above 1E-6.

No hazard maps were prepared for the SWMU 20 area because no hazard-based COCs were identified.

**Table 9.6**  
**Zone H Conclusion Summary**  
**SWMU 20**

	<b>Unacceptable Risks for Human Health in Residential Scenario (Y/N)</b>	<b>Chemicals Driving Risk</b>
Surface Soil	Yes, ILCR 1E-5	BEQ
Shallow Groundwater	See SWMU 9	NA
Deep Groundwater	See SWMU 9	NA
	<b>Above Levels of Concern (Y/N)</b>	<b>Total TEQ (ppb)</b>
Dioxin in Surface Soil	No	1.34-6,308 pg/g 2,3,7,8-TCDD equivalents
Dioxin in Shallow Groundwater	See SWMU 9	NA
Dioxin in Deep Groundwater	See SWMU 9	NA
	<b>TPH Present at Concentrations &gt; 100 ppm (Y/N)</b>	<b>Maximum Detected Concentration (ppm)</b>
Soil	None Collected	NA

*Note:*  
 NA = Not Applicable





## **9.7 SWMU 121**

SWMU 121 is the site of Building 801 and associated SAA. Since 1990, Building 801 has been used for collection, sorting, and storage of recyclable material. The associated SAA was an 8-foot by 8-foot sheet metal building with a concrete floor on which hazardous waste was accumulated. The SAA had no secondary containment structures. Soil sampling was conducted at SWMU 121 to evaluate the potential presence of contamination associated with Building 801 and the SAA. Only one second-interval sample (121SB00702) was collected at SWMU 121 due to shallow groundwater.

BEQs, Aroclor-1248, Aroclor-1254, and Aroclor-1260 (organic), and antimony, arsenic, beryllium, copper, mercury, nickel, thallium, vanadium, and zinc (inorganic) were determined to be COCs in surface soil at SWMU 121.

BEQs were present in soil samples collected from SWMU 121 at concentrations which identified them as site COCs. The concentration of these compounds, when equated to BAP, exceeded the RBSL for BAP. The highest BEQ for soil samples collected at SWMU 121 was 2,525  $\mu\text{g}/\text{kg}$  (121SB011). The second highest BEQ concentration was at 121SB013 (2,106.7  $\mu\text{g}/\text{kg}$ ). The remainder of the detected BEQ concentrations exceeded the RBSL for BAP with the exception of the sample collected at 121SB006. BEQs were prevalent across the SWMU 121 area. The one SWMU 121 second-interval sample also contained RBSL-exceeding BEQ concentrations.

Aroclor-1248 was present at RBSL-exceeding concentrations at three soil boring locations along the center of the eastern side of the SWMU 121 fenced area. Concentrations of Aroclor-1248 were within a factor of two of the RBSL (83  $\mu\text{g}/\text{kg}$ ). Aroclor-1248 was also detected in the one second-interval sample at a less-than-RBSL concentration.

Aroclor-1254 was present at RBSL-exceeding concentrations at seven surface soil sample locations at SWMU 121. The highest detected Aroclor-1254 concentration was at the northeast

corner of the current sampling pattern. The remainder of the Aroclor-1254 RBSL-exceeding detections were concentrated in the center of the SWMU 121 sampling pattern. Aroclor-1254 was also detected in the one second-interval sample at a less-than-RBSL concentration.

Aroclor-1260 was present at RBSL-exceeding concentrations in 12 surface soil samples collected at SWMU 121. As with Aroclor-1254, the highest detected Aroclor-1260 concentration was at the northeast corner of the current SWMU 121 sampling pattern. The remainder of the RBSL-exceeding detections were in the center of the SWMU 121 sampling pattern both inside and outside of the fenced area. Aroclor-1260 was also detected in the one second-interval sample at a greater-than-RBSL concentration.

Antimony was present at RBSL-exceeding concentrations at three surface soil sample locations within the SWMU 121 sampling pattern. Antimony was only detected at one other surface soil sample location. All antimony detections were within the fenced area of SWMU 121. Antimony was not detected in the second-interval soil sample.

Arsenic was present in one upper-interval soil sample (121SB004) at an RBSL/UTL-exceeding concentration. This sample location is surrounded by samples with less-than-RBSL concentrations of arsenic. Arsenic was detected at a less-than-UTL concentration in the second-interval soil sample.

Beryllium was present at RBSL/UTL-exceeding concentrations at nine surface soil and one second-interval soil sampling locations at SWMU 121. The highest two detected concentrations of beryllium were in the surface-interval samples at 121SB007 and 121SB004 (14  $\mu\text{g}/\text{kg}$  and 4.8  $\mu\text{g}/\text{kg}$ , respectively). The third and fourth highest detected concentrations of beryllium were in the surface-interval samples at 121SB014 and 121SB016 (4.1  $\mu\text{g}/\text{kg}$  and 4.6  $\mu\text{g}/\text{kg}$ , respectively). These two samples are at the northern end of the current SWMU 121 sampling pattern. The presence of beryllium appears to be relatively consistent across the SWMU 121

area. Beryllium was detected in the second-interval sample at a concentration which exceeded the second-interval UTL.

Copper was detected in all but one soil sample collected at SWMU 121. Thirteen soil samples contained RBSL/UTL-exceeding concentrations of copper. The highest detected concentration of copper was in the surface soil sample collected at 121SB007. Copper was detected in the second-interval soil sample at a concentration which exceeded the second-interval UTL.

Mercury was present in all soil samples collected at SWMU 121. However, it was only detected at two sample locations (121SB007 and 121SB002) at RBSL/UTL-exceeding concentrations. Mercury was detected at seven soil sample locations at concentrations that exceeded the interval-specific UTL but not the RBSL. Mercury was detected in the second-interval sample at a concentration which was only slightly below the second-interval UTL.

Nickel was present at eight SWMU 121 soil sample locations at RBSL/UTL-exceeding concentrations. The highest detected concentration of nickel was in the upper-interval sample at 121SB007. The remainder of the RBSL/UTL-exceeding concentrations were distributed through the central and northern area of the current SWMU 121 sampling pattern. Nickel was detected in the second-interval soil sample at a concentration which exceeded the second-interval UTL.

Thallium was present in only one soil sample collected at SWMU 121. The concentration of thallium in this sample (121SB00101) exceeded both the RBSL and interval-specific UTL. The 121SB001 sample location is surrounded by sample locations that were non-detect for thallium. Thallium was not detected in the second-interval sample.

Vanadium was present in all soil samples collected at SWMU 121. At five soil sample locations vanadium was present at RBSL/UTL-exceeding concentrations. The highest detected

concentration was in the upper-interval sample at 121SB007. The remainder of the RBSL/UTL-exceeding detections were in the central and northern areas of the SWMU 121 sampling pattern. Vanadium was detected in the one second-interval soil sample at a concentration that was less than the second-interval UTL.

Zinc was present in all soil samples collected at SWMU 121. Zinc was present at RBSL/UTL-exceeding concentrations at six soil sample locations. The highest detected concentration was in the upper-interval sample at 121SB007. The remainder of the RBSL/UTL-exceeding detections were in the central and northern area of the SWMU 121 sampling pattern. Zinc was present in the second-interval soil sample at a concentration that was greater than the second-interval UTL, but less than the RBSL.

This SWMU was included in the ERA for subzone H-2. Of the surface soil samples collected throughout H-2 (which also includes SWMU 159 and AOC 503), most of the samples with the highest potential for lethal and sublethal risk to infaunal and terrestrial organisms originated from SWMU 121 (See Figures 7.8, 7.9, and 7.10). The primary ecological risk to infaunal and terrestrial organisms in H-2 is from inorganic constituents (zinc, copper, mercury, cadmium, manganese, and lead).

The total soil pathway risk for site residents and site workers was calculated as  $1E-4$  and  $2E-5$ , respectively. The child hazard index computed for soil pathways was 5. The hazard indices for adult residents and site workers were 0.6 and 0.3, respectively. The primary contributors to surface soil risk were arsenic, beryllium, BEQs, and Aroclor-1254. Table 9.7 summarizes human health risk assessment results.

Figure 9.19 illustrates the distribution of risk considering a residential scenario in the vicinity of SWMU 121. The majority of the SWMU 121 area is within the risk range of  $1E-5$  to  $1E-4$ .

Two sample locations (121SB007 and 121SB016) present risk in the  $> 1E-4$  risk range. There is no apparent pattern to the distribution of risk in the vicinity of SWMU 121.

Figure 9.20 illustrates the distribution of risk considering an industrial scenario. No point risk estimate above  $1E-4$  was identified.

Figure 9.21 illustrates the distribution of hazard considering a residential scenario in the vicinity of SWMU 121. The majority of the SWMU 121 area is within the HI range of 0.1 to 3.0 with the central area of SWMU 121 area in the 1.0 to 3.0 HI range. Two sample locations (121SB007 and 121SB016) exceeded the HI of 3.0. There is no apparent pattern to the distribution of hazard in the vicinity of SWMU 121.

Due to lack of significant hazard identified considering an industrial scenario, no map was prepared.

Risk and hazard identified at SWMU 121 are likely due to the presence of the landfill and associated activities, as well as the recycling activities at SWMU 121.

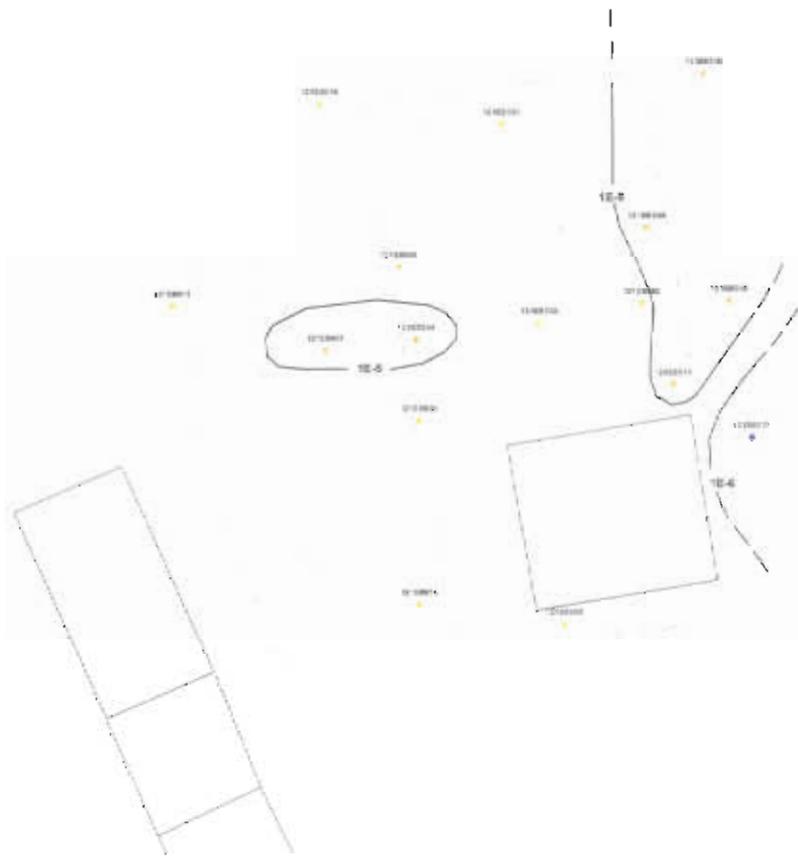
One sample at SWMU 121 (121SB002, upper-interval) was analyzed for TPH. The concentration of TPH in this sample was 150 mg/kg, which exceeds the screening level. SWMU 121 surface soil is recommended for inclusion in the CMS process on the basis of projected resident and worker risk, and resident child hazard, as well as TPH concentration.

In addition, SWMU 121 is geographically within the estimated SWMU 9 boundary and therefore will be evaluated during the SWMU 9 CMS process.

**Table 9.7  
 Zone H Conclusion Summary  
 SWMU 121**

	<b>Unacceptable Risks for Human Health in Residential Scenario (Y/N)</b>	<b>Chemicals Driving Risk</b>
Surface Soil	Yes, ILCR 2E-4, HI=5	Aroclor-1254, As, Be, BEQ
Shallow Groundwater	See SWMU 9	NA
Deep Groundwater	See SWMU 9	NA
	<b>Above Levels of Concern (Y/N)</b>	<b>Total TEQ (ppb)</b>
Dioxin in Surface Soil	No	17.818-195.637 pg/g 2,3,7,8-TCDD equivalents
Dioxin in Shallow Groundwater	See SWMU 9	NA
Dioxin in Deep Groundwater	See SWMU 9	NA
	<b>TPH Present at Concentrations &gt;100 ppm (Y/N)</b>	<b>Maximum Detected Concentration (ppm)</b>
Soil	Y	150

*Note:*  
 NA = Not Applicable



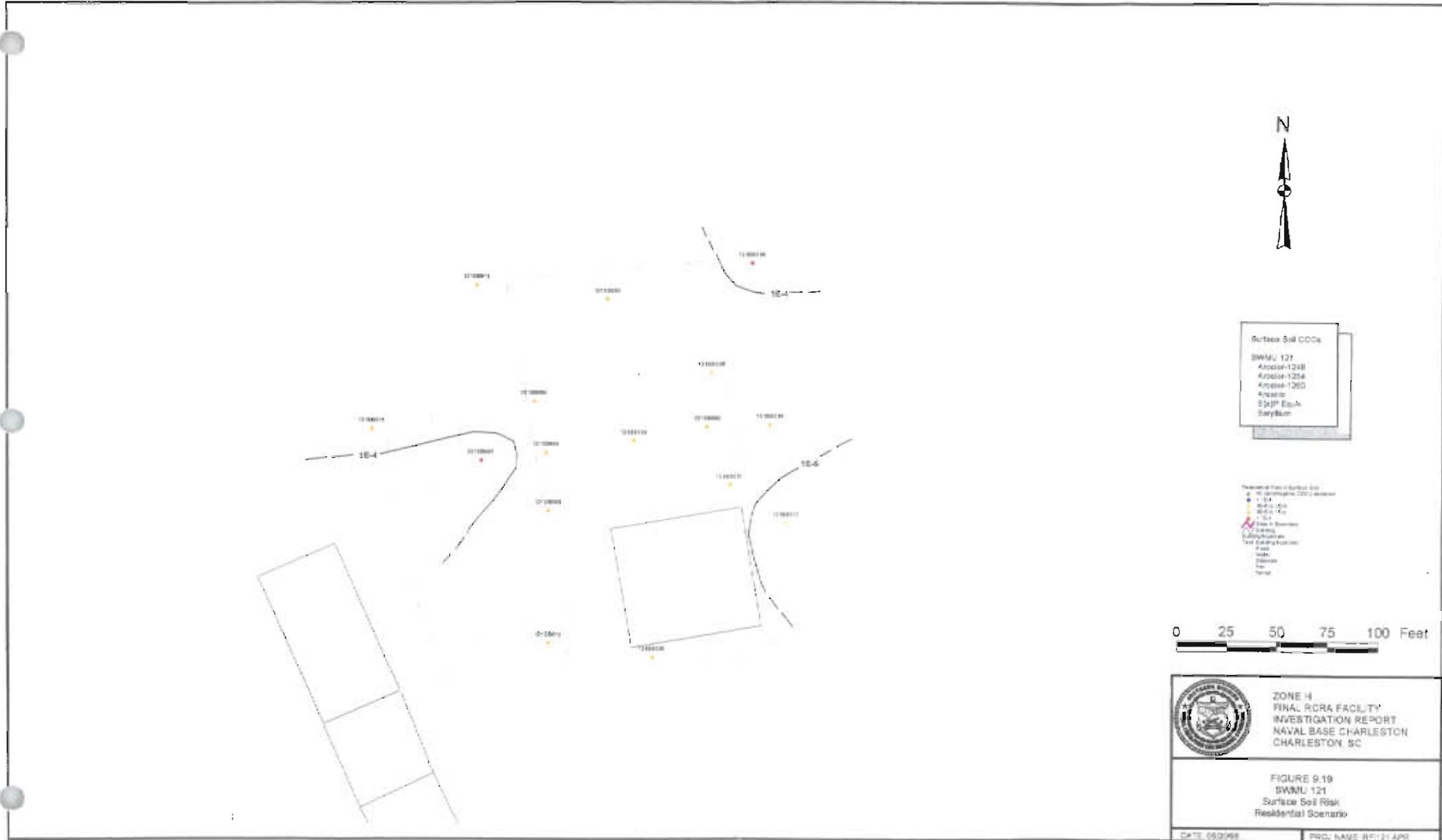
Surface Soil COCs  
 SWMU 121  
 Aroclor-1248  
 Aroclor-1260  
 PCBs  
 Dieldrin  
 DDTs

- Monitoring Point Location
- Monitoring Point ID
- Monitoring Point Risk
- Monitoring Point Risk Level
- Monitoring Point Risk Category
- Monitoring Point Risk Description
- Monitoring Point Risk Reference
- Monitoring Point Risk Source
- Monitoring Point Risk Pathway
- Monitoring Point Risk Exposure
- Monitoring Point Risk Assessment
- Monitoring Point Risk Mitigation
- Monitoring Point Risk Management
- Monitoring Point Risk Reporting
- Monitoring Point Risk Review
- Monitoring Point Risk Update



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FIGURE 6.20  
 SWMU 121  
 Surface Soil Risk  
 Industrial Scenario



Surface Soil COCs

- SWMU 121
- Arceuth-1248
- Arceuth-1254
- Arceuth-1260
- Arceuth
- EqIP Eq-A
- EqIP Eq-B

Location of Sites in Surface Soil

- 1210004
- 1210005
- 1210006
- 1210007
- 1210008
- 1210009
- 1210010
- 1210011
- 1210012
- 1210013
- 1210014
- 1210015
- 1210016
- 1210017
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- 1210099
- 1210100

0 25 50 75 100 Feet


**ZONE H**  
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**CHARLESTON, SC**

**FIGURE 9-19**  
**SWMU 121**  
**Surface Soil Risk**  
**Residential Scenario**

DATE: 09/20/98      PROJ. NAME: 87F-21-APR



- Surface Soil COCs
- SWMU 121
  - Arsenic
  - Arsenic-1254
  - Zinc
  - Beryllium
  - Copper
  - Manganese
  - Nickel
  - Thallium
  - Vanadium
  - Zinc

- Residential Areas of Surface Soil
- 100-150
  - 150-200
  - 200-250
  - 250-300
  - 300-350
  - 350-400
  - 400-450
  - 450-500
  - 500-550
  - 550-600
  - 600-650
  - 650-700
  - 700-750
  - 750-800
  - 800-850
  - 850-900
  - 900-950
  - 950-1000

0 25 50 75 100 Feet


 ZONE H  
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FIGURE 9.21  
 SWMU 121  
 Surface Soil Hazard  
 Residential Scenario

DATE: 06/03/00 PROJ NAME: 9F1121.APR

## **9.8 SWMU 178**

SWMU 178 is the site of a transformer-oil leak from a transformer vault approximately 50 feet south of Building X33-A. The leak was discovered in 1994. Soil and groundwater sampling were completed at SWMU 178 to investigate the presence, if any, of residual contamination resulting from the previous oil leak and other possible spills or leaks.

BEQs were present in soil samples collected at SWMU 178 at concentrations which identified them as site COCs. However, the BEQ for only one sample exceeded the RBSL for BAP (178SB00501). This sample was collected at the north end of the current sampling pattern in the vicinity of the UST which is located just north of the transformer vault. No BEQs were detected in the second-interval samples.

The total soil pathway risk for site residents and site workers was calculated as  $3E-6$  and  $6E-7$ , respectively. No noncarcinogenic COCs were identified for the soil pathways. The sole contributors to surface soil risk were BEQs. Table 9.8 summarizes human health risk assessment results.

Figure 9.22 illustrates the distribution of risk in surface soil considering a residential scenario. Only one sample location exhibited risk above  $1E-6$ . Due to lack of significant risk in the industrial scenario and hazard in both the residential and industrial scenarios, none of these maps were prepared for SWMU 178.

TPH, at concentrations greater than the screening level, was present in all soil samples collected at SWMU 178 except the upper and lower-interval samples from location 178SB006. No TPH was detected at this location. The highest concentrations of TPH were detected in the lower-interval soil samples at 178SB001 and 178SB005. Groundwater contamination was not apparent in the vicinity of the petroleum contamination of soil evidenced by the VOC, SVOC, and TPH analyses for groundwater.

No ecological risk is anticipated for SWMU 178 due to the lack of suitable habitat, and lack of ecological receptors.

No shallow groundwater COCs were identified for either receptor group. SWMU 178 surface soil is recommended for inclusion in the CMS process on the basis of projected resident risk, and TPH concentrations.

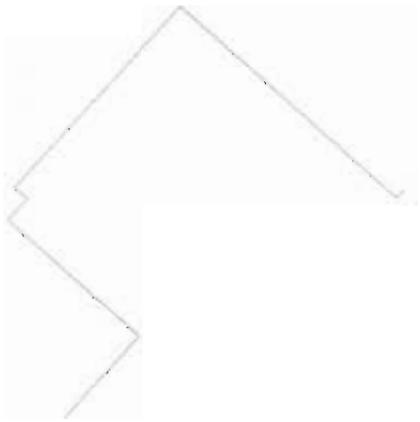
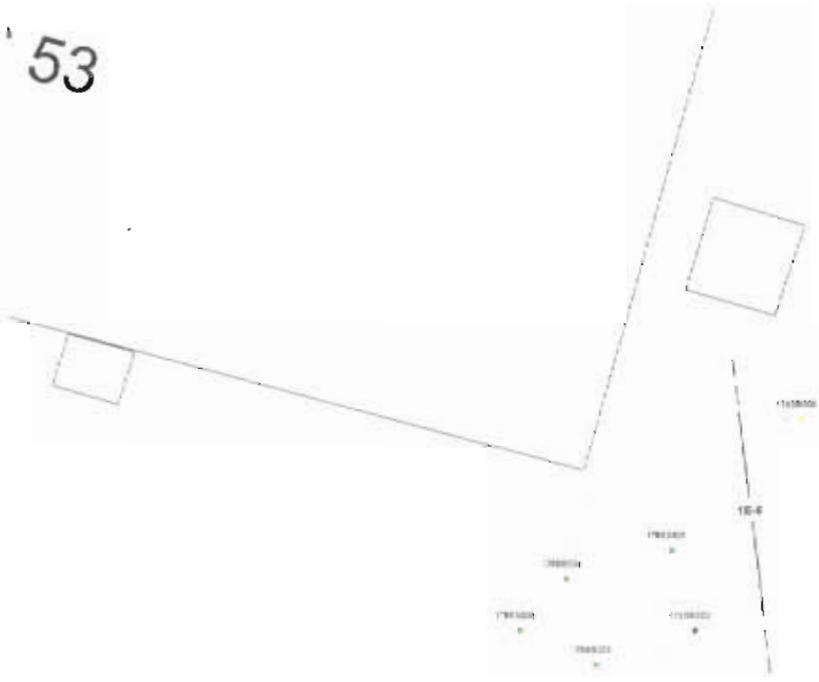
No fate and transport concerns were identified for SWMU 178. Table 9.8 summarizes unacceptable risks for human health at SWMU 178.

**Table 9.8**  
**Zone H Conclusion Summary**  
**SWMU 178**

	<b>Unacceptable Risks for Human Health in Residential Scenario (Y/N)</b>	<b>Chemicals Driving Risk</b>
Surface Soil	Yes, ILCR 3E-6	BEQs
Shallow Groundwater	No	
Deep Groundwater	NA	NA
	<b>Above Levels of Concern (Y/N)</b>	<b>Total TEQ (ppb)</b>
Dioxin in Surface Soil	No	NA
Dioxin in Shallow Groundwater	No	NA
Dioxin in Deep Groundwater	NA	NA
	<b>TPH Present at Concentrations &gt; 100 ppm (Y/N)</b>	<b>Maximum Detected Concentration (ppm)</b>
Soil	Y	37,000

**Note:**  
 NA = Not Applicable

53



Surface Soil: C0C0  
SWMU 178  
S01F 0040

- Legend:
- Boundary Line in Surface Soil
  - Soil Contaminant (C0C0) Location
  - SWMU 178
  - S01F 0040
  - 1E-4
  - Zone H Boundary
  - Building Footprint
  - Line: Building Footprint
  - Point: SWMU 178
  - Point: S01F 0040
  - Point: 1E-4



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FIGURE B.22  
SWMU 178  
Surface Soil Risk  
Residential Scenario

DATE: 06/1998 PROJ NAME: PF178-AP0

### **9.9 AOCs 649, 650, and 651**

AOC 649, the former Braswell Storage Area, is located east of Building 672. It was used to store sandblast media, welding supplies, and other various supplies used in ship repair. Material was stored for an unknown length of time during the 1970s. AOC 650, the former Metal Trades storage area, is also located east of Building 672. It was used to store unknown supplies used in ship repair. The exact dates of operation are unknown but maps indicate that the area was in operation during the 1970s. AOC 651, the former Sandblaster's storage area, is also located east of Building 672. It was used to store sandblast media presumably resulting from ship repair. The area was in operation from the 1970s until 1991. Soil sampling was conducted in order to assess the presence of residual contamination from the former storage area. Due to shallow depth to groundwater, only one second-interval sample was collected (650SB010) in the AOC 649, 650, and 651 area.

Aroclor-1254 and BEQs were identified as COCs in the surface soil samples collected at AOCs 649, 650, and 651: Aroclor-1254, and BEQs.

Aroclor-1254 was present at one upper-interval sampling location (650SB002) at a RBSL-exceeding concentration. This sample was surrounded by samples that were nondetect for Aroclor-1254. Aroclor-1254 was detected in the second-interval soil sample at a concentration lower than its RBSL.

BEQs were present in soil samples collected at AOC 649, 650, and 651 at concentrations which identified them as site COCs. The concentration of these compounds, when equated to BAP, exceeded the RBSL for BAP. The highest detected BEQ concentration (3,073  $\mu\text{g}/\text{kg}$ ) was detected at sample location 650SB006. The BEQ concentrations of PAH decrease away from this central sample location. BEQs were not detected in the second-interval sample at any location.

The total soil pathway risk for site residents and site workers was calculated as  $3E-6$  and  $7E-7$ , respectively at AOC 649. The child hazard index computed for soil pathways was 0.3. The hazard indices for adult residents and site workers were below 0.4. The primary contributors to surface soil risk were BEQs.

TPH analysis was conducted on two surface soil samples collected in the AOC 649, 650, and 651 area (649SB001 and 650SB003). The concentration of TPH detected in both of these samples exceeded the screening level for TPH.

This group of four AOCs was included in the ERA for subzone H-1. Based on surface soil samples collected throughout H-1, the primary ecological risk to infaunal and terrestrial organisms is from inorganic constituents (particularly zinc, copper, mercury, arsenic, and lead) and low but widespread PAH compounds. One sample at AOC 649 exhibited the highest concentration of mercury in subzone H-1, which increased the respective risk potential for that constituent.

AOC 649 surface soil is recommended for inclusion in the CMS process on the basis of projected resident risk, and TPH concentrations. In addition, AOC 649 is geographically within the estimated SWMU 9 boundary and therefore will be evaluated during the SWMU 9 CMS process. Table 9.9 summarizes human health risk assessment results.

Figure 9.23 illustrates the distribution of risk in surface soil at AOCs 649, 650, and 651 considering a residential scenario. A relatively small area in the central portion of the sample pattern exhibited risk between  $1E-5$  and  $1E-4$ . The remainder of the area exhibited risk less than  $1E-5$ .

Figure 9.24 illustrates the distribution of risk considering an industrial scenario.

Due to the lack of significant hazard in both the residential and industrial scenarios, neither of these maps was prepared for AOCs 649, 650, and 651.

At AOC 650, the total soil pathway risk for site residents and site workers was calculated as  $6E-5$  and  $1E-5$ , respectively. The child hazard index computed for soil pathways was 0.4. The hazard indices for adult residents and site workers were below 0.05. The primary contributors to surface soil risk were BEQ and Aroclor-1254. AOC 650 surface soil is recommended for inclusion in the CMS process on the basis of projected resident and site worker risk, as well as TPH concentrations. In addition, AOC 650 is geographically within the estimated SWMU 9 boundary and therefore will be evaluated during the SWMU 9 CMS process. Table 9.9 summarizes human health risk assessment results.

No soil investigations were performed at AOC 651 as it was sufficiently covered under the scope of the AOC 649 and 650 sampling efforts.

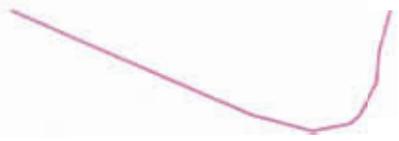
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**Table 9.9**  
**Zone H Conclusion Summary**  
**AOC 649, 650, and 651**

	<b>Unacceptable Risks for Human Health in Residential Scenario (Y/N)</b>	<b>Chemicals Driving Risk</b>
Surface Soil	AOC 649 Yes, ILCR 3E-6	BEQs
	AOC 650 Yes, ILCR 6E-5	BEQs, Aroclor-1254
Shallow Groundwater	See SWMU 9	NA
Deep Groundwater	See SWMU 9	NA
	<b>Above Levels of Concern (Y/N)</b>	<b>Total TEQ (ppb)</b>
Dioxin in Surface Soil	AOC 649, No AOC 650, No	8.381 pg/g 1.061-4.907 pg/g 2,3,7,8-TCDD equivalents
Dioxin in Shallow Groundwater	See SWMU 9	NA
Dioxin in Deep Groundwater	See SWMU 9	NA
	<b>TPH Present at Concentrations &gt;100 ppm (Y/N)</b>	<b>Maximum Detected Concentration (ppm)</b>
Soil	Y	980

*Note:*  
 NA = Not Applicable





Surface Soil COCs  
 AOCs 649, 650 and 651  
 And/or 1254  
 Btu/F Boats

- Residential Risk in Surface Soil
- No Contaminants (R100 - Minimal)
  - R100-1
  - R100-2
  - R100-3
  - R100-4
  - R100-5
  - R100-6
  - R100-7
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  - R100-100



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FIGURE 9.23  
 AOCs 649, 650 and 651  
 Surface Soil Risk  
 Residential Scenario

### **9.10 AOC 656**

AOC 656 is the site of an oil spill which occurred in 1974 between Buildings 602 and NS-71. This spill occurred as the result of a ruptured underground line connecting an 8,000-gallon AST to a boiler in Building NS-71. Of the 285 gallons released during the spill, 275 gallons were reportedly recovered. Soil sampling and groundwater sampling were completed at AOC 656 to determine the presence or absence of residual contamination resulting from the previous oil spill and other possible spills which may have occurred at the AST.

BEQs were present in soil samples collected from AOC 656 at concentrations which identified them as site COCs. The concentration of these compounds, when equated to BAP, exceeded the RBSL for BAP. These concentrations were present around the perimeter of the current AOC 656 sampling pattern. The highest detected BEQ for PAHs (594  $\mu\text{g}/\text{kg}$ ) was at sample location 656SB001. Two other RBSL-exceeding detections for BEQs were at 656SB011 and 656SB009. BEQs were detected in one second-interval soil sample (656SB003). The BEQ concentration in this sample was below the RBSL for BAP.

The total soil pathway risk for site residents and site workers was calculated as  $4\text{E-}6$  and  $8\text{E-}7$ , respectively. The hazard index for surface soil pathways was below 1 for all receptor groups. The sole contributors to surface soil risk were BEQs. Table 9.10 summarizes human health risk assessment results.

TPH contamination at AOC 656 is present at concentrations greater than the screening level in the immediate vicinity of the fuel oil AST. No TPH was detected between the AST and Building NS 71. The most heavily TPH-contaminated samples were collected within the berm around the AST. No TPH were detected in the second-interval samples. However, no second-interval samples were collected within the bermed area.

No ecological risk is anticipated for AOC 656 due to the lack of suitable habitat, and lack of ecological receptors.

AOC 656 surface soil is recommended for inclusion in the CMS process on the basis of projected resident risk, and TPH concentrations.

Figure 9.25 illustrates the distribution of risk in surface soils considering a residential scenario.

Due to lack of significant risk in the industrial scenario and hazard in both the residential and industrial scenarios, none of these maps were prepared for AOC 656.

The total shallow groundwater pathway risk at AOC 656 for site residents and site workers was calculated as  $8E-6$  and  $9E-7$ , respectively. No noncarcinogenic COCs were identified for the shallow groundwater pathways. The sole contributors to shallow groundwater risk were 2,3,7,8-TCDD equivalents; detected exclusively in (NBCH656001) first-quarter samples only. AOC 656 shallow groundwater is recommended for inclusion in the CMS process on the basis of projected resident and worker risk, and potential resident child hazard. Due to the hydrophobic nature of dioxins, they are not expected to migrate from soil to groundwater. It has been suspected that first-quarter results for dioxins may reflect the influence of sediment entrained in the monitored zone during well installation. Consideration of third and fourth-quarter results will confirm or refute the presence of both 2,3,7,8-TCDD equivalents in shallow groundwater. This review will facilitate responsible and sound risk management decisions. Furthermore, the maximum 2,3,7,8-TCDD equivalent concentration reported in shallow groundwater does not exceed the MCL ( $3E-8$  mg/L).

No fate and transport concerns were identified for AOC 656.

**Table 9.10**  
**Zone H Conclusion Summary**  
**AOC 656**

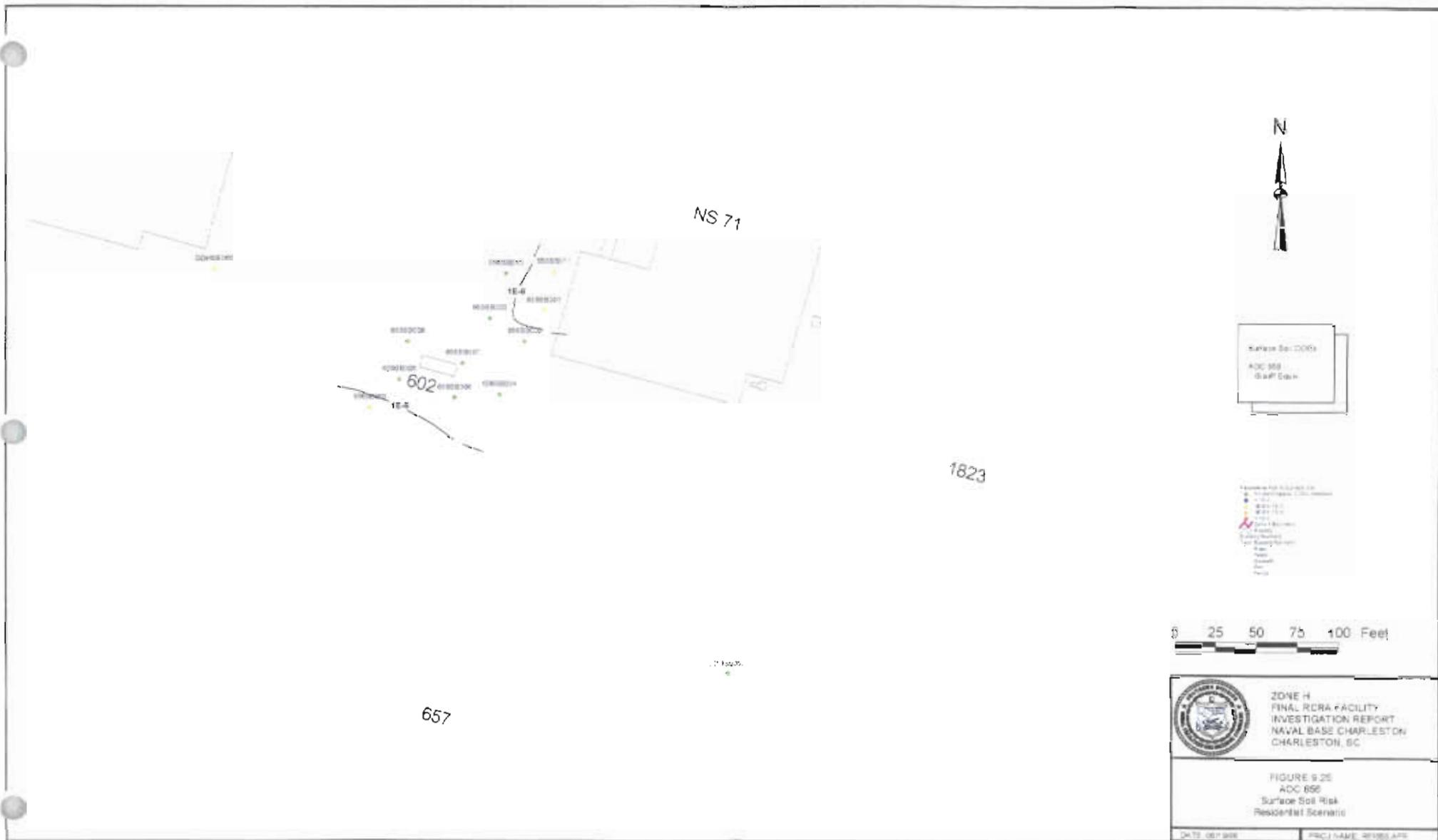
	<b>Unacceptable Risks for Human Health in Residential Scenario (Y/N)</b>	<b>Chemicals Driving Risk</b>
Surface Soil	Yes, ILCR 4E-6	BEQs
Shallow Groundwater	Yes, ILCR 8E-6	2,3,7,8-TCDD equivalents
Deep Groundwater	NA	
	<b>Above Levels of Concern (Y/N)</b>	<b>Total TEQ (ppb)</b>
Dioxin in Surface Soil	No	ND
Dioxin in Shallow Groundwater	No	ND
Dioxin in Deep Groundwater	NA	
	<b>TPH Present at Concentrations &gt; 100 ppm (Y/N)</b>	<b>Maximum Detected Concentration (ppm)</b>
Soil	Y	1,900

*Note:*  
 NA = Not Applicable

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Surface Soil Risk  
 ADC 856  
 Garf

- Legend
- Zone H
- Zone I
- Zone II
- Zone III
- Zone IV
- Zone V
- Zone VI
- Zone VII
- Zone VIII
- Zone IX
- Zone X
- Zone XI
- Zone XII
- Zone XIII
- Zone XIV
- Zone XV
- Zone XVI
- Zone XVII
- Zone XVIII
- Zone XIX
- Zone XX
- Zone XXI
- Zone XXII
- Zone XXIII
- Zone XXIV
- Zone XXV
- Zone XXVI
- Zone XXVII
- Zone XXVIII
- Zone XXIX
- Zone XXX

0 25 50 75 100 Feet

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	FIGURE 9.25 ADC 856 Surface Soil Risk Residential Scenario
DATE: 08/19/08	PROJECT NAME: 081908LAF0

### **9.11 AOC 653**

AOC 653 is in the vicinity of a hydraulic fluid storage tank located at the west end of Building 1508 (one of the four buildings which make up the automotive hobby shop complex). The tank is no longer in use due to suspected leakage. In addition to fluids in the tank, various paints, solvents, thinners, and petroleum products have been used and stored at the site and may also have been released. Soil and groundwater sampling were conducted at AOC 653 to investigate the presence of residual contamination resulting from the leaking tank and other possible spills.

Results of TPH analysis for samples collected in the vicinity of the leaking hydraulic fluid storage tank indicate that petroleum hydrocarbon contamination is present at AOC 653. The highest concentration of TPH (42,000 mg/kg) was at sample location 653SB003. The degree of contamination indicated by the concentration of petroleum hydrocarbon compounds was not reflected in the results of SW-846 method analyses for SVOCs and VOCs. Groundwater contamination was not apparent in the vicinity of the petroleum contamination of soil as evidenced by the VOC, SVOC, and TPH analyses. Apparently, little contamination from soil has migrated into the groundwater of the area. Figure 9.26 illustrates the distribution of TPH detected in surface soil samples collected at AOC 653. The screening level was exceeded in all four surface-interval samples. Only two second-interval samples were analyzed for TPH. Both samples contained TPH over the screening level (Figure 9.27).

No ecological risk is anticipated for AOC 653 due to the lack of suitable habitat, and lack of ecological receptors.

At AOC 653, the total soil pathway risk for site residents and site workers was calculated as  $9E-7$  and  $2E-7$ , respectively. No noncarcinogenic COCs were identified for soil pathways. AOC 653 surface soil is recommended for inclusion in the CMS process solely on the basis of

TPH concentrations. Table 9.11 summarizes human health risk assessment results. Due to the minimal risk/hazard identified at AOC 653, no risk/hazard maps have been prepared.

The total shallow groundwater pathway risk for site residents and site workers was calculated as  $8E-4$  and  $2E-4$ , respectively. The child resident hazard index was computed as 7, and the adult resident and site worker hazard indices were 3 and 1. The sole contributor to shallow groundwater risk and hazard was arsenic in NBCH653001. However, no arsenic hit was reported above the corresponding MCL. AOC 653 shallow groundwater is recommended for inclusion in the CMS process on the basis of projected resident and worker risk. However, if MCLs are strictly followed with respect to establishing groundwater remedial goals, no corrective measure would be required.

No fate and transport concerns were identified for AOC 653.

An interim measure, which involved the removal of the hydraulic fluid storage tank and associated impacted soil has been completed. The details of this interim action will be provided in a report prepared by the environmental detachment.

**Table 9.11  
 Zone H Conclusion Summary  
 AOC 653**

	<b>Unacceptable Risks for Human Health in Residential Scenario (Y/N)</b>	<b>Chemicals Driving Risk</b>
Surface Soil	No, ILCR <1E-6	NA
Shallow Groundwater	Yes, ILCR 8E-4, HI=7	As
Deep Groundwater	NA	NA
	<b>Above Levels of Concern (Y/N)</b>	<b>Total TEQ (ppb)</b>
Dioxin in Surface Soil	No	3.071-43.571 pg/g 2,3,7,8-TCDD equivalents
Dioxin in Shallow Groundwater	No	ND
Dioxin in Deep Groundwater	NA	NA
	<b>TPH Present at Concentrations &gt; 100 ppm (Y/N)</b>	<b>Maximum Detected Concentration (ppm)</b>
Soil	Y	42,000

**Note:**

NA = Not Applicable

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### **9.12 AOC 654**

AOC 654 is an abandoned septic tank and associated drain field connected to Building 661. It was used from 1968 until 1978 and was known to back up during periods of high use, resulting in the release of raw sewage. Soil sampling was conducted to determine the presence of contamination associated with materials possibly disposed of in the septic system.

No formal human health risk assessment was warranted at AOC 654 because no CPSS was detected in site soil above both residential RBSLs and background concentrations. No hazard/risk maps were prepared for AOC 654 surface soils. Table 9.12 summarizes the human health risk assessment results.

AOC 654 is located in the only developed, non-inundated portion of subzone H-4. Therefore, most of the surface soils collected in H-4 were all located near AOC 654. Based on these surface soil samples and several sediment samples throughout the subzone, the primary ecological risk is to young, herbaceous vegetation from slightly elevated concentrations of inorganic constituents (primarily copper and zinc).

**Table 9.12  
 Zone H Conclusion Summary  
 AOC 654**

	<b>Unacceptable Risks for Human Health in Residential Scenario (Y/N)</b>	<b>Chemicals Driving Risk</b>
Surface Soil	No	NA
Shallow Groundwater	See SWMU 9	NA
Deep Groundwater	See SWMU 9	NA
	<b>Above Levels of Concern (Y/N)</b>	<b>Total TEQ (ppb)</b>
Dioxin in Surface Soil	No	0.716 pg/g 2,3,7,8-TCDD equivalents
Dioxin in Shallow Groundwater	See SWMU 9	NA
Dioxin in Deep Groundwater	See SWMU 9	NA
	<b>TPH Present at Concentrations &gt; 100 ppm (Y/N)</b>	<b>Maximum Detected Concentration (ppm)</b>
Soil	N	Not Detected

*Note:*  
 NA = Not Applicable

### **9.13 AOC 655**

AOC 655 is the site of a spill of approximately 300 gallons of No. 2 fuel oil. The spill occurred in 1985 when a fuel line within the boiler room of Building 656 ruptured. Approximately 150 gallons of the spilled fuel escaped through a seam in the concrete floor of the building to the underlying soil. Fuel oil was supplied to the boiler room from a nearby 5,800-gallon UST which is also within the subject AOC. Soil and groundwater sampling were conducted at AOC 655 to assess the presence or absence of residual contamination resulting from the previous oil spill and other possible releases which may have occurred in the vicinity.

As determined by soil sampling and subsequent risk assessment, four compounds or compound groups were responsible for risk present in surface soil at AOC 655. These compounds were Aroclor-1254, Aroclor-1260, dieldrin, and BEQs.

Aroclor-1260 was present at AOC 655 at RBSL-exceeding concentrations. The majority of the detections of Aroclor-1260 are centered in the area of the UST and the transformer vault adjacent to Building 656 where piping from the UST enters the building. The highest concentration of Aroclor-1260 was at the UST in both the upper and lower-interval samples collected from boring 656SB001. No other Aroclor-1260 was detected in the second-interval samples. Concentrations of Aroclor-1260 decrease at surface soil sample locations away from the UST.

Aroclor-1254 was detected at two soil borings at RBSL-exceeding concentrations (655SB005 and 655SB004). The 655SB005 detection of Aroclor-1254 is only slightly above the RBSL of 83  $\mu\text{g}/\text{kg}$ . At soil boring 655SB004, immediately adjacent to the transformer vault, Aroclor-1254 was present in the upper and lower-interval at 110  $\mu\text{g}/\text{kg}$  and 180  $\mu\text{g}/\text{kg}$ , respectively. This soil boring is surrounded by sample locations where no Aroclor-1254 was detected. No other second-interval samples contained Aroclor-1254.

Dieldrin was present in two soil samples at RBSL-exceeding concentrations (655SB00502 and 655SB00701). The dieldrin concentration in the second-interval sample at 655SB005 was only slightly above dieldrin's RBSL (44  $\mu\text{g}/\text{kg}$ ). The concentration of dieldrin in the upper-interval sample at 655SB007 was considerably higher (360  $\mu\text{g}/\text{kg}$ ). However, this detection was in the open-air alcove of Building 656 where it was likely used as an insecticide. No other soil sample collected at AOC 655 contained RBSL-exceeding concentrations of dieldrin.

BEQs were present in one soil sample (655SSGC9) collected from AOC 655 at concentrations which resulted in their identification as site COCs. The concentration of these compounds, when equated to BAP, exceeded the RBSL for BAP. The 655SSGC9 sample contained a BEQ concentration of 3,590  $\mu\text{g}/\text{kg}$ . The sample location is at the edge of the current sampling pattern. BEQs were not detected in any second-interval sample collected at AOC 655.

At AOC 655, the total soil pathway risk for site residents and site workers was calculated as 3E-5 and 6E-6, respectively. The soil pathway hazard indices for all receptor groups were below 0.1. The primary contributors to surface soil risk were BEQs, Aroclor-1254, Aroclor-1260, and dieldrin. Table 9.13 summarizes human health risk assessment results.

Figure 9.28 illustrates the distribution of risk considering a residential scenario for AOC 655. Three areas (based on three sample locations) were identified that presented risk in the range between 1E-5 and 1E-4. The majority of the sampled area presented a risk of between 1E-6 and 1E-5.

Considering an industrial scenario at AOC 655 (Figure 9.29), only one sample location presented risk in the 1E-5 to 1E-4 range and only a small portion of the sampled area presented risk in the 1E-6 to 1E-5 range.

Due to lack of significant hazard in both the residential and industrial scenarios, no hazard maps for AOC 655 were prepared.

TPH contamination in excess of the screening level is present in the vicinity of the fuel oil UST and the piping leading from the UST into Building 656. The highest concentration of TPH detected at AOC 655 was 120 mg/kg. TPH concentrations drop to below the screening level in all directions away from the fuel oil UST. TPH was detected in three second-interval soil samples collected at AOC 655. One second-interval sample (655SB00402) contained TPH at a concentration which exceeded the screening level.

No ecological risk is anticipated for AOC 655 due to the lack of suitable habitat and lack of ecological receptors.

AOC 655 surface soil is recommended for inclusion in the CMS process on the basis of site resident and site worker risk as well as TPH concentrations.

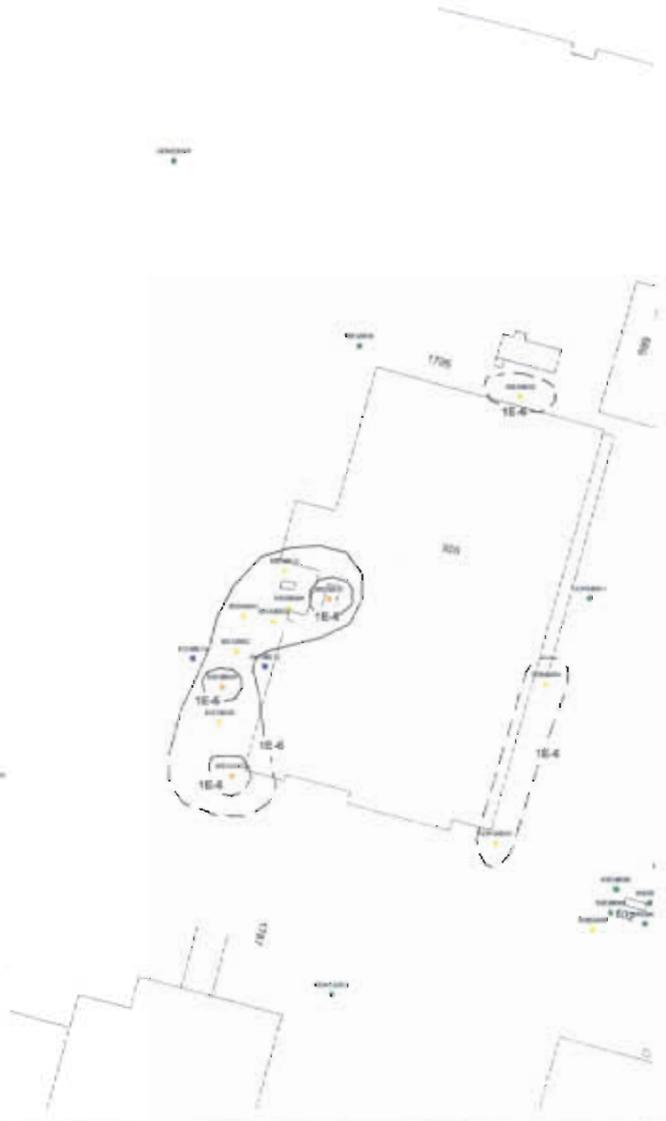
The total shallow groundwater pathway risk for site residents and site workers was calculated as 1E-3 and 2E-4, respectively. The child resident hazard index was computed as 9, and the adult resident and site worker hazard indices were 4 and 1. The contributors to shallow groundwater risk and hazard were arsenic (NBCH655002 and NBCH655003) and chlordane (NBCH655002). Each was detected in at least one well during both quarterly sampling events. No arsenic or chlordane (sum of alpha and gamma isomers) was reported above their corresponding MCLs (0.05 and 0.002  $\mu\text{g/l}$ ). AOC 655 shallow groundwater is recommended for inclusion in the CMS process on the basis of projected resident and worker risk and hazard. However, if MCLs are strictly followed with respect to establishing groundwater remedial goals, no corrective measures would be required.

No fate and transport concerns were identified for AOC 655.

**Table 9.13  
 Zone H Conclusion Summary  
 AOC 655**

	<b>Unacceptable Risks for Human Health in Residential Scenario (Y/N)</b>	<b>Chemicals Driving Risk</b>
Surface Soil	Yes, ILCR 3E-5	BEQ, Aroclor-1254 and 1260, Dieldrin
Shallow Groundwater	Yes, ILCR 1E-3	As, Chlordane
Deep Groundwater	NA	NA
	<b>Above Levels of Concern (Y/N)</b>	<b>Total TEQ (ppb)</b>
Dioxin in Surface Soil	No	0.81 pg/g 2,3,7,8-TCDD equivalents
Dioxin in Shallow Groundwater	No	ND
Dioxin in Deep Groundwater	NA	NA
	<b>TPH Present at Concentrations &gt; 100 ppm (Y/N)</b>	<b>Maximum Detected Concentration (ppm)</b>
Soil	Y	120

*Note:*  
 NA = Not Applicable



Surface Soil DOOs  
 AOC 855  
 AOC 1254  
 AOC 1280  
 EOP Entry  
 Data

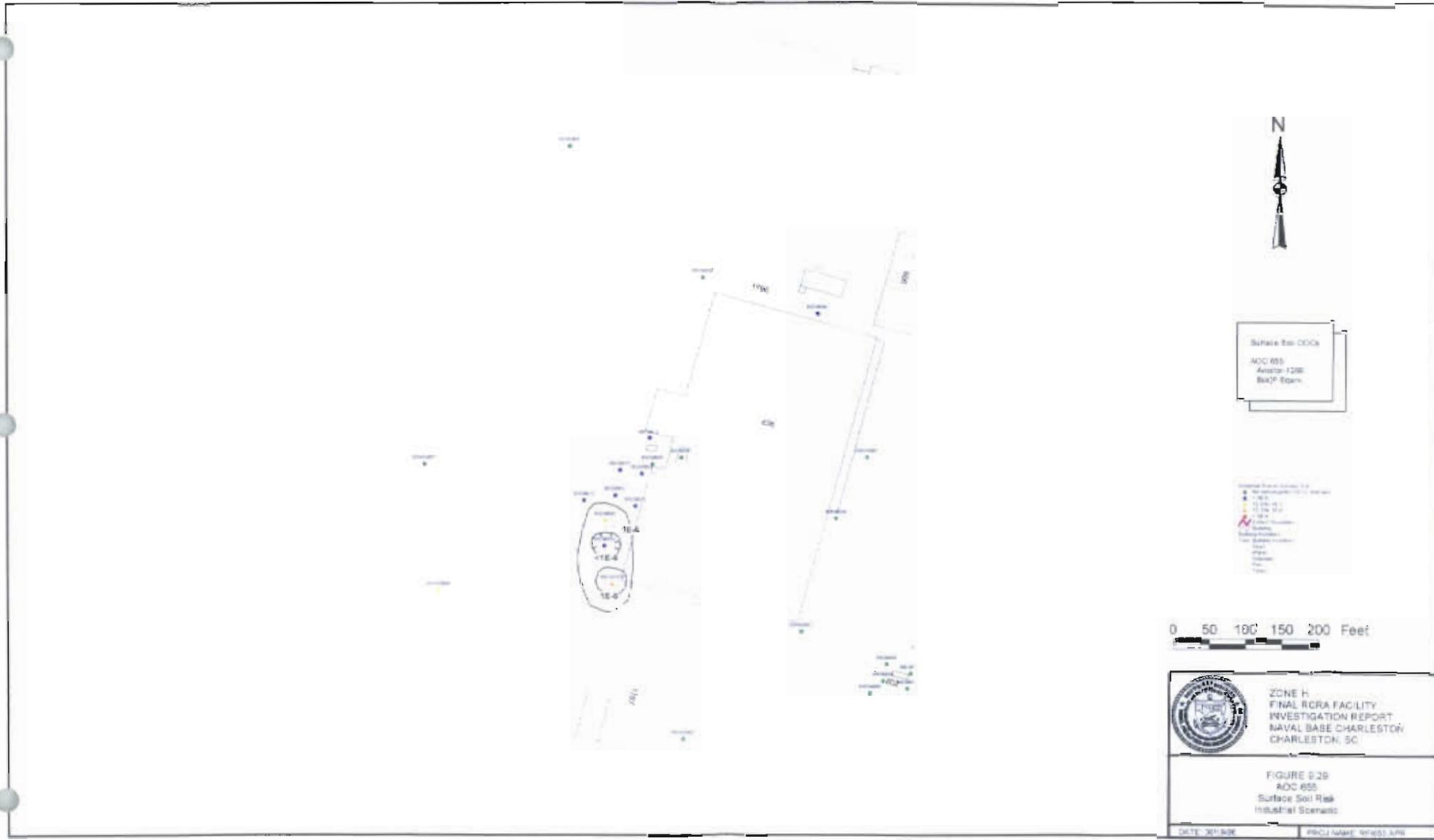
Investigation & Control Unit  
 1E-4  
 1E-5  
 1E-6  
 1E-7  
 1E-8  
 1E-9  
 1E-10  
 1E-11  
 1E-12  
 1E-13  
 1E-14  
 1E-15  
 1E-16  
 1E-17  
 1E-18  
 1E-19  
 1E-20

0 50 100 150 200 Feet



ZONE H  
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 NAVAL BASE CHARLESTON  
 CHARLESTON, SC

FIGURE 9.2B  
 AOC 855  
 Surface Soil Risk  
 Residential Scenario



0 50 100 150 200 Feet


**ZONE H**  
**FINAL RCRA FACILITY**  
**INVESTIGATION REPORT**  
**NAVAL BASE CHARLESTON,**  
**CHARLESTON, SC**

**FIGURE 0-29**  
**ADC 655**  
**Surface Soil Risk**  
**Industrial Scenarios**

DATE: 08/08/08 PROJECT: W8551-01-0000

#### **9.14 AOC 659**

AOC 659 is the site of a 30,000-gallon steel AST used to store diesel fuel from 1958 until 1990. The tank, located between Hobson Avenue and Dyess Avenue, is surrounded by a 5-foot-high earthen berm. The tank is no longer in service. Soil sampling was conducted at AOC 659 to evaluate the presence or absence of contamination associated with the AST.

TPH contamination was present within the bermed area surrounding the AST. The higher concentrations of TPH were detected in three of the four lower-interval samples. No samples were collected outside of the bermed area.

Figure 9.30 illustrates the distribution of TPH in the surface soil samples collected at AOC 659. The northern two of the four samples contained TPH at concentrations over the screening level. Three of the locations produced second-interval samples that contained greater than screening levels of TPH (Figure 9.31).

No ecological risk is anticipated for AOC 659 due to the lack of suitable habitat and lack of ecological receptors.

No risk or hazard based surface soil COCs were identified at AOC 659. No hazard/risk maps were prepared for AOC 659. AOC 659 surface soil is recommended for inclusion in the CMS process on the basis of the TPH screening level exceedance. No groundwater monitoring was performed in conjunction with the AOC 659 RFI. Table 9.14 summarizes human health risk assessment results.

Additional soil sampling will be necessary in the vicinity of the AST to define the extent of petroleum hydrocarbon contamination.

No fate and transport concerns were identified for AOC 659.

**Table 9.14**  
**Zone H Conclusion Summary**  
**AOC 659**

	<b>Unacceptable Risks for Human Health in Residential Scenario (Y/N)</b>	<b>Chemicals Driving Risk</b>
Surface Soil	No	NA
Shallow Groundwater	NA	NA
Deep Groundwater	NA	NA
	<b>Above Levels of Concern (Y/N)</b>	<b>Total TEQ (ppb)</b>
Dioxin in Surface Soil	No	0.738 pg/g 2,3,7,8-TCDD equivalents
Dioxin in Shallow Groundwater	NA	
Dioxin in Deep Groundwater	NA	
	<b>TPH Present at Concentrations &gt;100 ppm (Y/N)</b>	<b>Maximum Detected Concentration (ppm)</b>
Soil	Y	15,000

*Note:*  
 NA = Not Applicable



1819

1351

14



- 100-150 mg/kg
- 150-200 mg/kg
- 200-250 mg/kg
- 250-300 mg/kg
- 300-350 mg/kg
- 350-400 mg/kg
- 400-450 mg/kg
- 450-500 mg/kg
- 500-550 mg/kg
- 550-600 mg/kg
- 600-650 mg/kg
- 650-700 mg/kg
- 700-750 mg/kg
- 750-800 mg/kg
- 800-850 mg/kg
- 850-900 mg/kg
- 900-950 mg/kg
- 950-1000 mg/kg
- 1000-1050 mg/kg
- 1050-1100 mg/kg
- 1100-1150 mg/kg
- 1150-1200 mg/kg
- 1200-1250 mg/kg
- 1250-1300 mg/kg
- 1300-1350 mg/kg
- 1350-1400 mg/kg
- 1400-1450 mg/kg
- 1450-1500 mg/kg
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- 1750-1800 mg/kg
- 1800-1850 mg/kg
- 1850-1900 mg/kg
- 1900-1950 mg/kg
- 1950-2000 mg/kg
- 2000-2050 mg/kg
- 2050-2100 mg/kg
- 2100-2150 mg/kg
- 2150-2200 mg/kg
- 2200-2250 mg/kg
- 2250-2300 mg/kg
- 2300-2350 mg/kg
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- 2450-2500 mg/kg
- 2500-2550 mg/kg
- 2550-2600 mg/kg
- 2600-2650 mg/kg
- 2650-2700 mg/kg
- 2700-2750 mg/kg
- 2750-2800 mg/kg
- 2800-2850 mg/kg
- 2850-2900 mg/kg
- 2900-2950 mg/kg
- 2950-3000 mg/kg
- 3000-3050 mg/kg
- 3050-3100 mg/kg
- 3100-3150 mg/kg
- 3150-3200 mg/kg
- 3200-3250 mg/kg
- 3250-3300 mg/kg
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- 3900-3950 mg/kg
- 3950-4000 mg/kg
- 4000-4050 mg/kg
- 4050-4100 mg/kg
- 4100-4150 mg/kg
- 4150-4200 mg/kg
- 4200-4250 mg/kg
- 4250-4300 mg/kg
- 4300-4350 mg/kg
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- 4950-5000 mg/kg
- 5000-5050 mg/kg
- 5050-5100 mg/kg
- 5100-5150 mg/kg
- 5150-5200 mg/kg
- 5200-5250 mg/kg
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- 6000-6050 mg/kg
- 6050-6100 mg/kg
- 6100-6150 mg/kg
- 6150-6200 mg/kg
- 6200-6250 mg/kg
- 6250-6300 mg/kg
- 6300-6350 mg/kg
- 6350-6400 mg/kg
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- 6500-6550 mg/kg
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- 6650-6700 mg/kg
- 6700-6750 mg/kg
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- 6850-6900 mg/kg
- 6900-6950 mg/kg
- 6950-7000 mg/kg
- 7000-7050 mg/kg
- 7050-7100 mg/kg
- 7100-7150 mg/kg
- 7150-7200 mg/kg
- 7200-7250 mg/kg
- 7250-7300 mg/kg
- 7300-7350 mg/kg
- 7350-7400 mg/kg
- 7400-7450 mg/kg
- 7450-7500 mg/kg
- 7500-7550 mg/kg
- 7550-7600 mg/kg
- 7600-7650 mg/kg
- 7650-7700 mg/kg
- 7700-7750 mg/kg
- 7750-7800 mg/kg
- 7800-7850 mg/kg
- 7850-7900 mg/kg
- 7900-7950 mg/kg
- 7950-8000 mg/kg
- 8000-8050 mg/kg
- 8050-8100 mg/kg
- 8100-8150 mg/kg
- 8150-8200 mg/kg
- 8200-8250 mg/kg
- 8250-8300 mg/kg
- 8300-8350 mg/kg
- 8350-8400 mg/kg
- 8400-8450 mg/kg
- 8450-8500 mg/kg
- 8500-8550 mg/kg
- 8550-8600 mg/kg
- 8600-8650 mg/kg
- 8650-8700 mg/kg
- 8700-8750 mg/kg
- 8750-8800 mg/kg
- 8800-8850 mg/kg
- 8850-8900 mg/kg
- 8900-8950 mg/kg
- 8950-9000 mg/kg
- 9000-9050 mg/kg
- 9050-9100 mg/kg
- 9100-9150 mg/kg
- 9150-9200 mg/kg
- 9200-9250 mg/kg
- 9250-9300 mg/kg
- 9300-9350 mg/kg
- 9350-9400 mg/kg
- 9400-9450 mg/kg
- 9450-9500 mg/kg
- 9500-9550 mg/kg
- 9550-9600 mg/kg
- 9600-9650 mg/kg
- 9650-9700 mg/kg
- 9700-9750 mg/kg
- 9750-9800 mg/kg
- 9800-9850 mg/kg
- 9850-9900 mg/kg
- 9900-9950 mg/kg
- 9950-10000 mg/kg



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CHARLESTON, SC

FIGURE B-31  
AOC 659  
Subsurface Soil  
TTH Concentrations

DATE: 09/13/96

PROJECT: 96-004-002

### **9.15 AOC 660**

In the 1950s, AOC 660 was an area used for the storage, mixing, and rinsing of pesticides associated with mosquito control activities. AOC 660 is currently an asphalt parking lot immediately west of Building NS-53. Soil and groundwater sampling were conducted at AOC 660 to determine the presence or absence of contamination resulting from pesticide handling activities or other releases at the site.

No risk or hazard based surface soil or shallow groundwater COCs were identified at AOC 660. No risk/hazard maps were prepared for AOC 660. Table 9.15 summarizes human health risk assessment results.

No fate and transport concerns were identified for AOC 660.

No ecological risk is anticipated for AOC 660 due to the lack of suitable habitat, and lack of ecological receptors.

**Table 9.15  
 Zone H Conclusion Summary  
 AOC 660**

	<b>Unacceptable Risks for Human Health in Residential Scenario (Y/N)</b>	<b>Chemicals Driving Risk</b>
Surface Soil	No	NA
Shallow Groundwater	No	NA
Deep Groundwater	NA	NA
	<b>Above Levels of Concern (Y/N)</b>	<b>Total TEQ (ppb)</b>
Dioxin in Surface Soil	No	2.61 pg/g 2,3,7,8-TCDD equivalents
Dioxin in Shallow Groundwater	No	NA
Dioxin in Deep Groundwater	No	NA
	<b>TPH Present at Concentrations &gt; 100 ppm (Y/N)</b>	<b>Maximum Detected Concentration (ppm)</b>
Soil	N	Not Detected

**Note:**

NA = Not Applicable

### **9.16 AOC 662**

AOC 662 is the site of a former gasoline service station and possible billeting office. The site was used as a service station for an unknown duration beginning in 1958. The site was subsequently converted and is currently a non-hazardous material storage area. Two unregistered steel USTs may remain at the site. Soil and groundwater sampling were completed at AOC 662 to determine the presence or absence of contamination resulting from gasoline storage and dispensing from the USTs or other releases at the site.

No risk or hazard based surface soil or shallow groundwater COCs were identified at AOC 662. No risk/hazard maps were prepared for AOC 662. Table 9.16 summarizes the results of the AOC 662 human health risk assessment.

No fate and transport concerns were identified for AOC 662.

No ecological risk is anticipated for AOC 662 due to the lack of suitable habitat, and lack of ecological receptors.

An interim measure, which involved the removal of an underground storage tank has been completed. The details of this interim action will be provided in a report prepared by the environmental detachment.

**Table 9.16**  
**Zone H Conclusion Summary**  
**AOC 662**

	<b>Unacceptable Risks for Human Health in Residential Scenario (Y/N)</b>	<b>Chemicals Driving Risk</b>
Surface Soil	No	NA
Shallow Groundwater	No	NA
Deep Groundwater	NA	NA
	<b>Above Levels of Concern (Y/N)</b>	<b>Total TEQ (ppb)</b>
Dioxin in Surface Soil	No	0.66 pg/g 2,3,7,8-TCDD equivalents
Dioxin in Shallow Groundwater	No	NA
Dioxin in Deep Groundwater	No	NA
	<b>TPH Present at Concentrations &gt; 100 ppm (Y/N)</b>	<b>Maximum Detected Concentration (ppm)</b>
Soil	N	Not Detected

*Note:*  
 NA = Not Applicable

### **9.17 AOC 663 and SWMU 136**

AOC 663 and SWMU 136, because of their proximity, have been investigated together. AOC 663 is an active diesel pumping station at Building 851. It has been active since 1983 and contains two 500-gallon USTs and five flammable storage lockers. The flammable lockers located along the west side of the facility store hazardous material from adjacent buildings. SWMU 136 is a SAA that receives hazardous waste from both Buildings 851 and NS-53. Soil and groundwater sampling were conducted at AOC 663 and SWMU 136 to determine the presence or absence of contamination resulting from diesel fuel storage and dispensing from the USTs or other releases at the sites.

Three inorganic elements were identified as COCs at AOC 663/SWMU 136: aluminum, arsenic, and vanadium. Three organic compounds or compound groups were identified as COCs: 4,4'-DDE, Aroclor-1254, and BEQs.

The upper-interval soil sample at boring location 136SB004 was the only location that RBSL/UTL-exceeding concentrations of aluminum and vanadium were present. Neither of these elements were present in other AOC 663/SWMU 136 samples at RBSL/UTL-exceeding concentrations. The 136SB004 soil boring location is at the southeastern corner of the current sampling pattern. Aluminum was detected in three second-interval samples at less than RBSL/UTL concentrations. Vanadium was detected in three second-interval samples at less than RBSL/UTL concentrations.

Arsenic was present in UTL-exceeding concentrations in two soil samples (136SB004 and 663SB007). The 136SB004 sample location is on the edge of the current sampling pattern. Arsenic was detected in three second-interval samples at less than RBSL/UTL concentrations.

One sample contained 4,4'-DDE at a RBSL-exceeding concentration (663SB004). Soil samples collected at locations surrounding 663SB004 contained less-than-RBSL concentrations or were non-detect for 4,4'-DDE. 4,4'-DDE was not detected in any second-interval sample.

Aroclor-1254 was present in only one soil sample collected at AOC 663/SWMU 136. This detection for Aroclor-1254 was for 695  $\mu\text{g}/\text{kg}$  in the upper-interval sample at 136SB002. The extent of Aroclor-1254 is confined to the immediate vicinity of 136SB002 since none of the samples from adjacent borings contained Aroclor-1254. Aroclor-1254 was not detected in any second-interval sample.

BEQs were present in soil samples collected from AOC 663 and SWMU 136 at concentrations which resulted in their identification as site COCs. The concentration of these compounds, when equated to BAP, exceeded the RBSL for BAP. BEQs were present at five sampling locations at BEQ concentrations exceeding the RBSL for BAP. Two samples contained considerably higher BEQ concentrations (663SB007 and 136SB002). These sample locations were along the fence east of Building 1818. BEQs were only detected in one second-interval sample. The BEQ concentration in this deeper sample was considerably lower than the RBSL for BAP.

At combined AOC 663/SWMU 136, the total soil pathway risk for site residents and site workers was calculated as  $1\text{E-}4$  and  $2\text{E-}5$ , respectively. The child hazard index computed for soil pathways was 2. The hazard indices for adult residents and site workers were below 0.3. The primary contributors to surface soil risk were BEQs and arsenic. Other contributors included Aroclor-1254 and 4,4'-DDE. Table 9.17 summarizes human health risk assessment results.

Figure 9.32 illustrates the distribution of risk in surface soil considering a residential scenario at AOC 663/SWMU 136. Risk at one sample location (663SB007) exceeded  $1\text{E-}4$  (driven by BEQs). The remainder of the sampled area exhibited risk in the range of  $1\text{E-}5$  to  $1\text{E-}4$ .

Figure 9.33 illustrates the distribution of risk in surface soil considering an industrial scenario. Risk at one sample location (663SB007) exceeded  $1E-5$ . The remainder of the sampled area exhibited risk in the range of  $1E-5$  to  $1E-6$ .

Figure 9.34 illustrates the distribution of hazard in surface soil considering a residential scenario. Two sample locations (136SB002 and 136SB004) identified hazard greater than an HI of 1.0. The HI for the remainder of the sampled area was below 1.0.

TPH contamination is present at concentrations exceeding the screening level in the vicinity of Building 1818. TPH in this area is apparently concentrated in the upper soil sampling-interval; however, lower-interval samples were collected from only 2 of the 5 soil sample locations with TPH analysis. TPH concentrations decreased in the east and west directions away from Building 1818. TPH presence was not assessed in the north and south directions away from the Building 1818 area. No detections of TPH at AOC 663 and SWMU 136 exceeded the screening level by more than a factor of two.

No ecological risk is anticipated for AOC 663/SWMU 136 due to the lack of suitable habitat, and lack of ecological receptors.

Combined AOC 663/SWMU 136 surface soil is recommended for inclusion in the CMS process on the basis of projected resident and site worker risk, child resident hazard and TPH concentrations.

The total shallow groundwater pathway risk for site residents and site workers were calculated as  $1E-4$  and  $4E-5$ , respectively. The hazard indices for resident children, resident adults and site worker were 40, 18, and 6, respectively. The primary contributors to shallow groundwater risk and hazard were benzene (NBCH663002), and 2,3,7,8-TCDD equivalents (NBCH663001). AOC 663/SWMU 136 shallow groundwater is recommended for inclusion in the CMS process

on the basis of projected resident and worker risk and hazard. Due to the hydrophobic nature of dioxins, they would not be expected to migrate from soil to groundwater. It has been suspected that first-quarter results for these compounds may reflect the influence of sediment entrained in the monitored zone during well installation. Consideration of third and fourth-quarter results will confirm or refute the presence of 2,3,7,8-TCDD equivalents in deep groundwater. This review will facilitate responsible and sound risk management decisions. Furthermore, the maximum 2,3,7,8-TCDD equivalent concentration reported in shallow groundwater does not exceed the MCL (3E-8 mg/L).

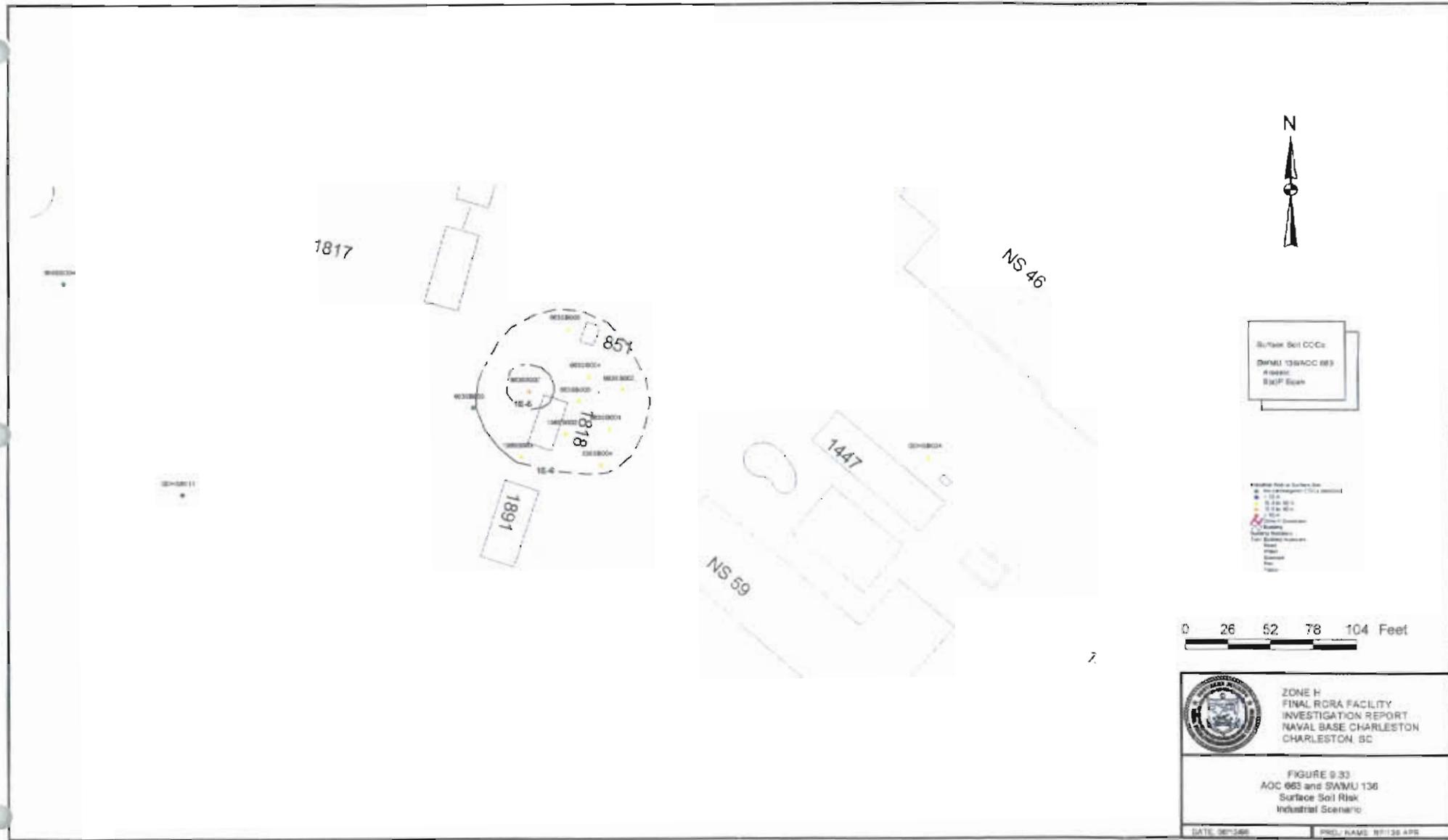
No fate and transport concerns were identified for AOC 663 and SWMU 136.

Table 9.17  
 Zone H Conclusion Summary  
 AOC 663 and SWMU 136

	Unacceptable Risks for Human Health in Residential Scenario (Y/N)	Chemicals Driving Risk
Surface Soil	Yes, ILCR 1E-4, HI=2	BEQ, As, Aroclor-1254, 4,4'-DDE, Al
Shallow Groundwater	Yes, ILCR 1E-4, HI=34	Benzene, 2,3,7,8-TCDD equivalents
Deep Groundwater	NA	NA
	Above Levels of Concern (Y/N)	Total TEQ (ppb)
Dioxin in Surface Soil	No	4.929 pg/g 2,3,7,8-TCDD equivalents
Dioxin in Shallow Groundwater	Yes	1.328 pg/l 2,3,7,8-TCDD equivalents
Dioxin in Deep Groundwater	NA	NA
	TPH Present at Concentrations >100 ppm (Y/N)	Maximum Detected Concentration (ppm)
Soil	Y	190

Note:  
 NA = Not Applicable





Outside Soil COCs  
 DPMU 138AOC 863  
 4 ppm  
 5x10<sup>7</sup> Sp/m<sup>3</sup>

Available Risk on Surface Soil  
 0 - 1.0  
 1.0 - 2.0  
 2.0 - 3.0  
 3.0 - 4.0  
 4.0 - 5.0  
 5.0 - 6.0  
 6.0 - 7.0  
 7.0 - 8.0  
 8.0 - 9.0  
 9.0 - 10.0

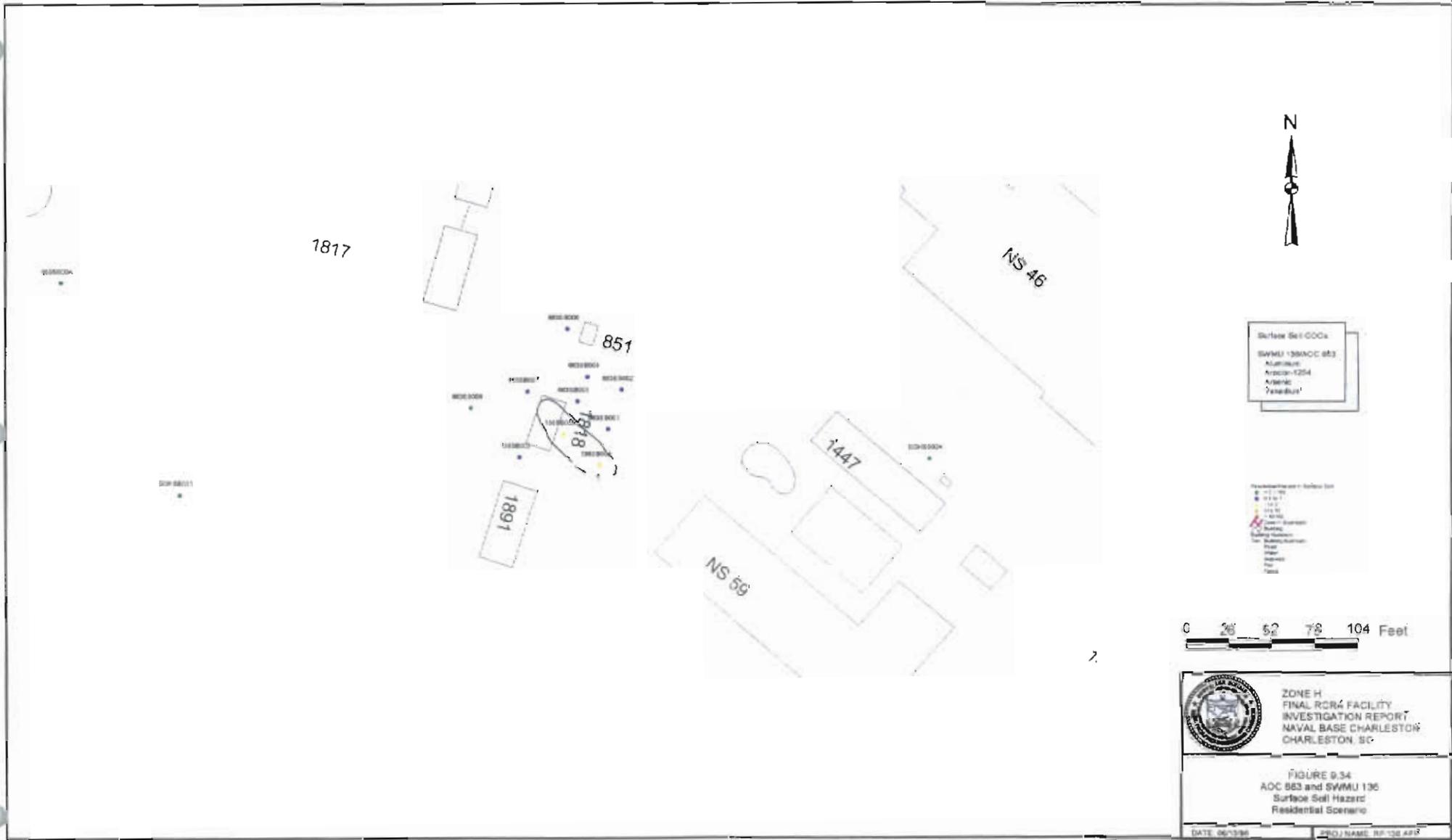
0 26 52 78 104 Feet



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 CHARLESTON, SC

FIGURE 9.33  
 AOC 863 and SAMU 138  
 Surface Soil Risk  
 Industrial Scenario

DATE: 08/14/08 PROJ. NAME: 07138 AFR



Surface Soil COCs  
 SWMU 136/AOC 883  
 ALUMINUM  
 ARSENIC-1254  
 CHROMIUM  
 ZINC/NICKEL

Investigation of Surface Soil  
 0 - 100  
 100 - 200  
 200 - 300  
 300 - 400  
 400 - 500  
 500 - 600  
 600 - 700  
 700 - 800  
 800 - 900  
 900 - 1000  
 1000 - 1100  
 1100 - 1200  
 1200 - 1300  
 1300 - 1400  
 1400 - 1500  
 1500 - 1600  
 1600 - 1700  
 1700 - 1800  
 1800 - 1900  
 1900 - 2000

0 26 52 78 104 Feet


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**FIGURE 9.34  
 AOC 883 and SWMU 136  
 Surface Soil Hazard  
 Residential Scenario**

DATE: 06/13/99      PROJ NAME: NP-136-APP

### **9.18 AOC 665**

AOC 665 is a former shed used to store unknown pyrotechnics from 1943 until its demolition at an unknown date. Currently Buildings 1889 and NS-46 are on the site where the pyrotechnic shed was located. Soil sampling was completed at AOC 665 to determine the presence or absence of residual contamination associated with the former storage facility.

BEQs were present in one soil sample (665SB002) collected at AOC 665 at concentrations which resulted in their identification as site COCs. The concentration of these compounds, when equated to BAP, exceeded the RBSL for BAP. The BEQ concentration of this sample was less than twice the RBSL. No BEQs were detected in second-interval samples.

No ecological risk is anticipated for AOC 665 due to the lack of suitable habitat, and lack of ecological receptors.

At AOC 665, the total soil pathway risk for site residents and site workers was calculated as  $2E-6$  and  $5E-7$ , respectively. No noncarcinogenic COCs were identified for soil pathways. The sole contributors to surface soil risk were BEQs. Table 9.18 summarizes human health risk assessment results.

Figure 9.35 illustrates the distribution of risk considering a residential scenario at AOC 665. Given the minimal sampling pattern, there was little potential to map distribution of risk. However, at two locations there were carcinogenic COCs identified, and at the other two locations, no carcinogenic COCs were identified.

Due to lack of significant risk in the industrial scenario and hazard in both the residential and industrial scenarios, none of these maps were prepared for AOC 665.

TPH contamination is present at greater than the screening level of 100 mg/kg in the upper-interval sample from one soil boring at AOC 665 (665SB002). The concentration of TPH contamination in this sample was 200 mg/kg. No additional samples for TPH analysis were collected. TPH was not detected in second-interval samples.

No groundwater monitoring was performed in conjunction with the AOC 665 RFI. AOC 665 surface soil is recommended for inclusion in the CMS process on the basis of projected resident risk, and TPH concentration.

No fate and transport concerns were identified for AOC 665.

Subsequent to initial RFI review, additional samples have been proposed for collection. Final conclusions for this site are pending. An addendum to this report will be submitted which contains the results of the additional sampling and CMS recommendations.

**Table 9.18  
 Zone H Conclusion Summary  
 AOC 665**

	<b>Unacceptable Risks for Human Health in Residential Scenario (Y/N)</b>	<b>Chemicals Driving Risk</b>
Surface Soil	Yes, ILCR 2E-6	BEQ
Shallow Groundwater	NA	NA
Deep Groundwater	NA	NA
	<b>Above Levels of Concern (Y/N)</b>	<b>Total TEQ (ppb)</b>
Dioxin in Surface Soil	No	ND
Dioxin in Shallow Groundwater	NA	NA
Dioxin in Deep Groundwater	NA	NA
	<b>TPH Present at Concentrations &gt;100 ppm (Y/N)</b>	<b>Maximum Detected Concentration (ppm)</b>
Soil	Y	200

*Note:*  
 NA = Not Applicable

*Final RCRA Facility Investigation Report for Zone H  
NAVBASE Charleston  
Section 9: Conclusions  
June 24, 1997*

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1889



Surface Soil COCs  
ADC 605  
RSP Scenario

- Residential Scenario Surface Soil
- 100 mg/kg (COC) & above
  - 10.0 mg/kg
  - 1.0 mg/kg
  - 0.1 mg/kg
  - 0.01 mg/kg
- Other Symbols
- Building Footprint
  - Building
  - Surface Water
  - Road
  - Fence

0 26 52 Feet



ZONE H  
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FIGURE 9-35  
ADC 605  
Surface Soil Risk  
Residential Scenario

### **9.19 AOC 667 and SWMU 138**

AOC 667 and SWMU 138, because of their proximity, were investigated as one site. AOC 667, the vehicle maintenance area, is a two-story brick structure (Building 1776) which houses an oil-water separator. The site is used for the routine maintenance of automobiles and heavy equipment, including oil changes and repairing hydraulic parts from the equipment. The site uses a 550-gallon portable storage tank to store waste oil. Numerous oil stains have been noted around the building. SWMU 138, the SAA related to Building 1776, is used to store hazardous waste in 55-gallon drums which are transferred to a permitted hazardous waste storage facility. Soil and groundwater sampling were completed at AOC 667 and SWMU 138 to determine the presence or absence of contamination resulting from petroleum product storage and dispensing, or from other releases at the sites.

At AOC 667/SWMU 138, the total soil pathway risk for site residents and site workers was calculated as  $6E-7$  and  $1E-7$ , respectively. No noncarcinogenic COCs were identified for soil pathways. The sole contributors to surface soil risk were BEQs. No risk/hazard maps were prepared for AOC 667/SWMU 138.

TPH analysis was conducted on two samples (667SB00201 and 138SB00201) from the AOC 667 and SWMU 138 area. Both samples contained TPH at concentrations which exceeded the screening level.

Figure 9.36 illustrates the distribution of TPH detected in surface soil at AOC 667 and SWMU 138. Both samples contained TPH at concentrations above the screening level. No second-interval samples were analyzed for TPH.

No ecological risk is anticipated for AOC 667 and SWMU 138 due to the lack of suitable habitat, and lack of ecological receptors.

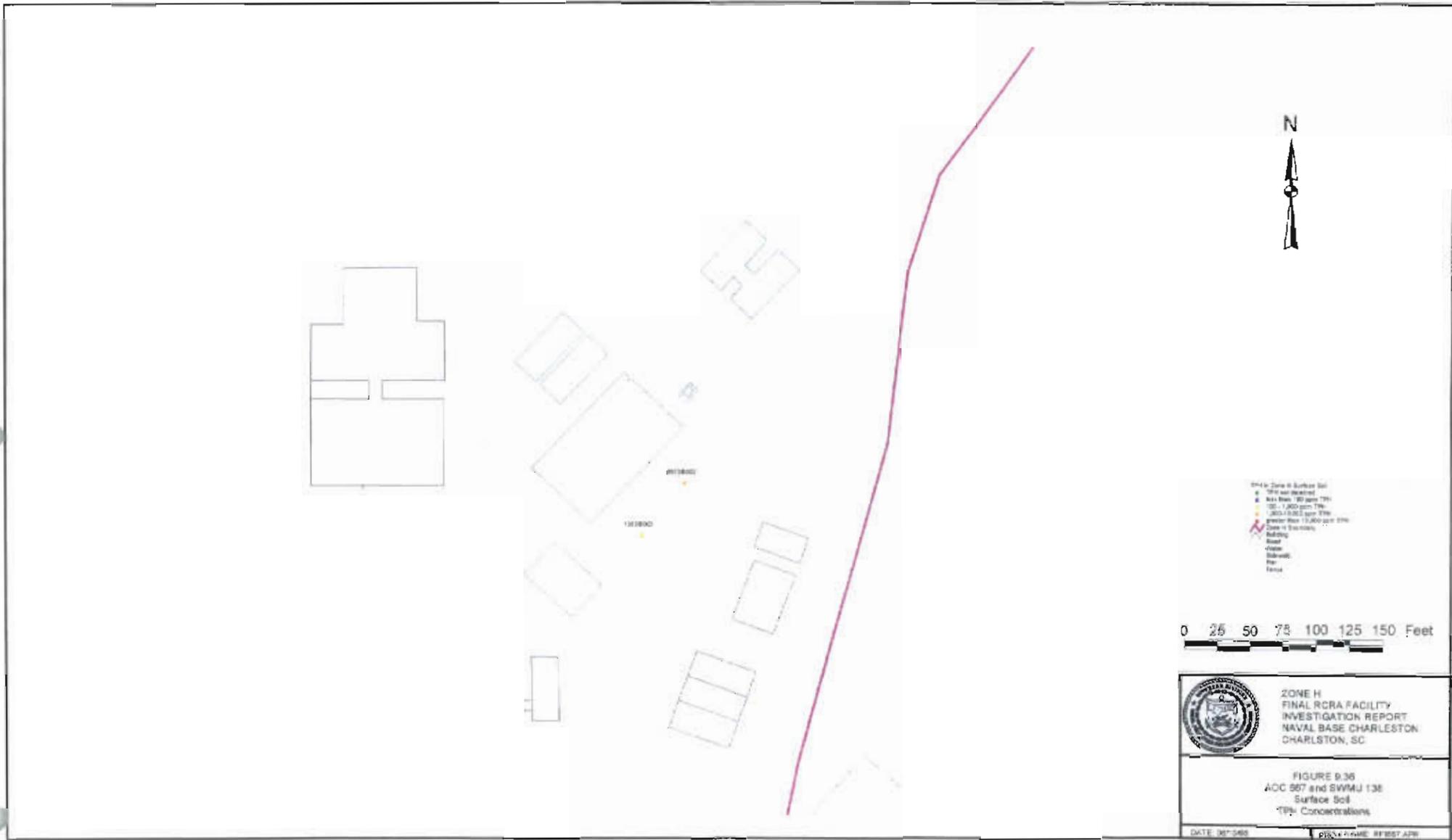
No groundwater COPCs were identified based on tap water RBSL and background comparison. Combined AOC 667/SWMU 138 surface soil is recommended for inclusion in the CMS process solely on the basis of TPH concentrations. Table 9.19 summarizes human health risk assessment results.

No fate and transport concerns were identified for AOC 667 and SWMU 138. However, additional groundwater data is to be collected in the AOC 667/SWMU 138 area. This decision was made subsequent to the RFI when it was observed that a downgradient well in Zone I contained a contaminant that was detected in an AOC 667/SWMU 138 well. Direct push technology samples are to be collected downgradient of AOC 667/SWMU 138 during the Zone L RFI. The final results of this additional sampling effort and resultant CMS recommendations will be submitted in an addendum to this RFI report.

**Table 9.19  
 Zone H Conclusion Summary  
 AOC 667 and SWMU 138**

	<b>Unacceptable Risks for Human Health in Residential Scenario (Y/N)</b>	<b>Chemicals Driving Risk</b>
Surface Soil	No	NA
Shallow Groundwater	No	NA
Deep Groundwater	NA	NA
	<b>Above Levels of Concern (Y/N)</b>	<b>Total TEQ (ppb)</b>
Dioxin in Surface Soil	No	2.041-6.689 pg/g 2,3,7,8-TCDD equivalents
Dioxin in Shallow Groundwater	No	NA
Dioxin in Deep Groundwater	No	NA
	<b>TPH Present at Concentrations &gt;100 ppm (Y/N)</b>	<b>Maximum Detected Concentration (ppm)</b>
Soil	Y	1,800

*Note:*  
 NA = Not Applicable



Zone H Boundary  
 Sampling Point  
 Building  
 Road  
 Other  
 Railroad  
 River  
 Canal

0 25 50 75 100 125 150 Feet


 ZONE H  
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 CHARLSTON, SC

FIGURE 9.36  
 ACC 967 and SWMU 138  
 Surface Soil  
 TPH Concentrations

DATE: 08/14/08 PWS: P:\NAME: 8F087.APR

## **9.20 AOC 666**

AOC 666 is the area around a UST (NS-45) which supplies fuel oil to the adjacent heating plant (NS-44). The exact capacity of the UST is unknown. The site was constructed in 1958 and the surrounding area was an airstrip prior to that date. AOC 666 is approximately 10 feet by 30 feet, surrounded by railroad ties. Soil and groundwater sampling were completed at AOC 666 to determine the presence or absence of contamination resulting from fuel oil storage and dispensing from the UST or other releases at the site.

Arsenic, vanadium, Aroclor-1260, N-nitroso-di-n-propylamine, and BEQs were identified as COCs in surface soil at AOC 666.

BEQs were present in soil samples collected at AOC 666 at concentrations which resulted in their identification as site COCs. The concentration of these compounds, when equated to BAP, exceeded the RBSL for BAP. BEQs were detected at two soil boring locations at AOC 666. A BEQ concentration of 214  $\mu\text{g}/\text{kg}$  was present in the upper-interval sample from 666SB001. At sample location 666SB002 BEQ concentrations of 1,469  $\mu\text{g}/\text{kg}$  and 1,750  $\mu\text{g}/\text{kg}$  were present in the upper and lower-interval samples, respectively. Both soil sample locations with BEQ detections are on the eastern edge of the current sampling pattern.

N-nitroso-di-n-propylamine was only detected in the upper-interval at soil boring 666SB007. This sample location is on the north corner of the current sampling pattern.

Aroclor-1260 was detected in one soil sample (666SB005) collected at AOC 666. The concentration of Aroclor-1260 in this sample (88.4  $\mu\text{g}/\text{kg}$ ) was only slightly above the RBSL (83  $\mu\text{g}/\text{kg}$ ).

Arsenic was detected at RBSL/UTL-exceeding concentrations at two AOC 666 surface soil sample locations (666SB002 and 666SB004). Both sample locations are on the edge of the

current sampling pattern. Arsenic was detected in three second-interval samples; however, the concentration of arsenic in these samples was less than the RBSL and interval-specific UTL.

Vanadium was detected at RBSL/UTL-exceeding concentrations at four of seven soil boring locations. The highest detected vanadium concentration was at soil boring location 666SB007. Vanadium was detected in six second-interval soil samples. The vanadium detection in the second-interval sample at 666SB007 exceeded the RBSL and interval-specific UTL. The vanadium detection in the second-interval sample at 666SB005 exceeded the RBSL but not the interval-specific UTL. All other second-interval vanadium detections were less than the RBSL and interval-specific UTL.

At AOC 666, the total soil pathway risk for site residents and site workers was calculated as  $1E-4$  and  $2E-5$ , respectively. The child hazard index computed for soil pathways was 2. The hazard indices for adult residents and site workers were below 0.3. The primary contributors to surface soil risk were BEQs, N-nitroso-di-n-propylamine, and arsenic. The only other significant contributor was Aroclor-1260. Table 9.20 summarizes human health risk assessment results.

Figure 9.37 illustrates the distribution of risk in surface soil considering a residential scenario at AOC 666. Soil samples collected from locations 666SB004 and 666SB002 resulted in the identification of risk above  $1E-4$ . Sample locations 666SB001 and 666SB005 produced samples which identified presence of risk in the range of  $1E-5$  to  $1E-4$ . Risk identified at the remaining sample locations was below  $1E-5$ .

Figure 9.38 illustrates the distribution of risk in surface soil considering an industrial scenario at AOC 666. An area in the central portion of the sampled area exhibits risk in the range of  $1E-5$  to  $1E-4$ . The remainder of the site exhibits risk below  $1E-5$ .

Figure 9.39 illustrates the distribution of hazard in surface soil considering a residential scenario at AOC 666. Sample location 666SB004 presented the most significant hazard (HI between 3.0 and 10.0). Sample location 666SB002 was the only other location exhibiting hazard above a HI of 1.0.

Due to lack of significant hazard identified in the industrial scenario at AOC 666, no industrial hazard map was prepared.

TPH contamination was present at concentrations exceeding the screening levels in the vicinity of the UST at AOC 666. The highest TPH detections were in the lower-interval samples at 666SB002 (16,000 mg/kg) and 666SB004 (2,100 mg/kg).

No ecological risk is anticipated for AOC 666 due to the lack of suitable habitat, and lack of ecological receptors.

AOC 666 surface soil is recommended for inclusion in the CMS process on the basis of projected resident and site worker risk, child resident hazard, and TPH concentrations.

No fate and transport concerns were identified for AOC 666.

The total shallow groundwater pathway risk for site residents and site workers were calculated as  $7E-5$  and  $2E-5$ , respectively. No hazard indices were computed for the groundwater pathways. The primary contributors to shallow groundwater risk were chloromethane and vinyl chloride. Both were detected exclusively in one first-quarter shallow groundwater sample (NBCH666001). AOC 666 shallow groundwater is recommended for inclusion in the CMS process on the basis of projected resident and worker risk. Because neither shallow groundwater COC was detected in second-quarter groundwater samples, uncertainty remains regarding the potential chronicity of exposure through shallow groundwater pathways. Consideration of third

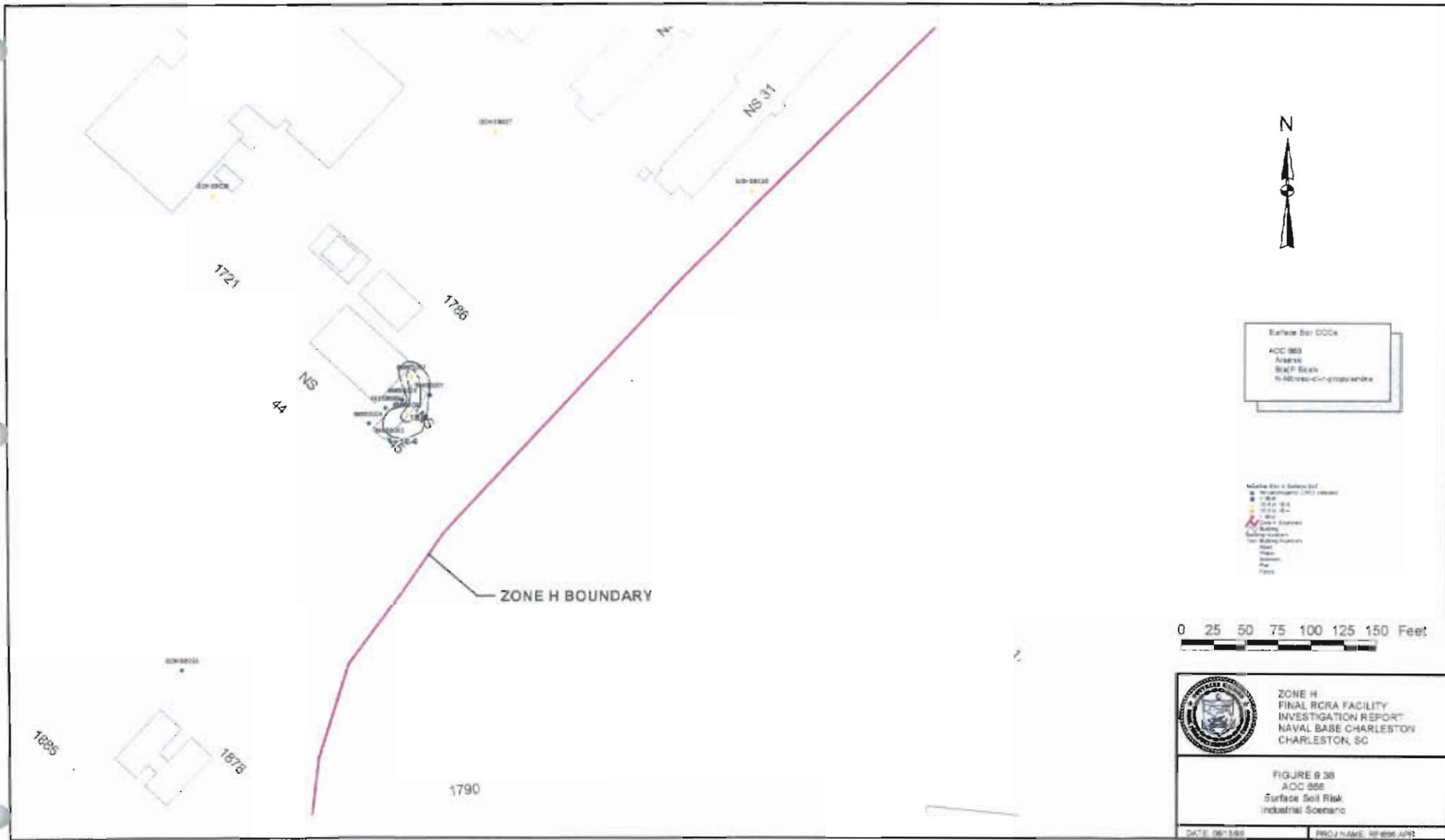
and fourth-quarter results will confirm or refute the presence of chloromethane and vinyl chloride in shallow groundwater. This review will facilitate responsible and sound risk management decisions.

**Table 9.20**  
**Zone H Conclusion Summary**  
**AOC 666**

	<b>Unacceptable Risks for Human Health in Residential Scenario (Y/N)</b>	<b>Chemicals Driving Risk</b>
Surface Soil	Yes, ILCR 1E-4, HI=2	BEQ, N-nitroso-di-n-propylamine, As, Aroclor-1260, V
Shallow Groundwater	Yes, ILCR 7E-5	Vinyl chloride, chloromethane
Deep Groundwater	NA	NA
	<b>Above Levels of Concern (Y/N)</b>	<b>Total TEQ (ppb)</b>
Dioxin in Surface Soil	No	5.42 pg/g 2,3,7,8-TCDD equivalents
Dioxin in Shallow Groundwater	No	NA
Dioxin in Deep Groundwater	NA	NA
	<b>TPH Present at Concentrations &gt; 100 ppm (Y/N)</b>	<b>Maximum Detected Concentration (ppm)</b>
Soil	Y	16,000

*Note:*  
 NA = Not Applicable





Surface Soil Code

ACC 855
Aroclor
BzP/BzA
N-Nitroso-dimethylamine

Analyte Risk in Surface Soil

■	High
●	Medium
○	Low
□	Very Low
△	Not Sampled
○	Blank
○	Sampling Method
○	Grab
○	Walk
○	Drive

0 25 50 75 100 125 150 Feet


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**FIGURE B 38  
AOC 855  
Surface Soil Risk  
Industrial Scenario**

DATE: 08/19/95      PROJECT NAME: 950001.APR



### **9.21 SWMU 159**

SWMU 159, located near Building 665 in the south-central portion of Zone H, is a former SAA which temporarily accumulated and stored hazardous materials. Materials stored at the site included batteries, aerosol cans, and paint waste. An AST containing diesel fuel, a can crusher, and scattered debris are also at the SWMU.

Soil, sediment, and surface water were sampled to assess any residual contamination from the former storage area.

BEQs were present in one soil sample (159SB011) collected from SWMU 159 at concentrations which resulted in their identification as site COCs. The concentration of BEQs, when equated to BAP, exceeded the RBSL for BAP. The BEQ concentration in the upper-interval sample at this location was 127  $\mu\text{g}/\text{kg}$ , less than twice the RBSL of 88  $\mu\text{g}/\text{kg}$ . This soil boring location is surrounded by boring locations which yielded samples with less-than-RBSL BEQ concentrations or were nondetect for BEQs. BEQs were detected in one second-interval sample; however, the BEQ concentration in this sample was less than the RBSL for BAP.

At SWMU 159, the total soil pathway risk for site residents and site workers was calculated as 2E-6 and 5E-7, respectively. The child hazard index computed for soil pathways was 0.4. The hazard indices for adult residents and site workers were below 0.1. The sole contributors to surface soil risk were BEQs. Table 9.21 summarizes human health risk assessment results.

Figure 9.40 illustrates the distribution of risk in surface soil considering a residential scenario. Only one sample location presented risk above 1E-6 (159SB008). Due to lack of significant risk in the industrial scenario and hazard in both the residential and industrial scenarios, none of these maps were prepared for SWMU 159.

TPH contamination was present at SWMU 159 at concentrations exceeding the screening level. Samples with TPH concentrations exceeding the screening level were concentrated in the vicinity of 159SB012, 159SB008, and 159SB010. Sample data points away from the above-listed soil borings exhibited TPH concentrations less than the screening level.

This SWMU is included in the ERA for subzone H-2. Based on surface soil and sediment samples collected throughout H-2 (which also includes SWMU 121 and AOC 503), the primary ecological risk to infaunal invertebrates, terrestrial organisms, vegetation and aquatic wildlife is from inorganic constituents (zinc, arsenic, copper, mercury, cadmium, manganese, and lead) (See Figures 7.8, 7.9, and 7.10). The two sediment samples collected in association with this SWMU also exhibited high concentrations of metals as well as SVOCs. These sediments were collected in drainage ditches which, based on their size and frequent dryness, could not support nor pose a significant risk to site-specific aquatic wildlife. Based on observed concentrations, however, risk may exist to downgradient communities in H-2 and H-4, and possibly aquatic wildlife in Shipyard Creek.

SWMU 159 surface soil is recommended for inclusion in the CMS process on the basis of projected resident risk and TPH concentrations. No groundwater monitoring was performed in conjunction with the SWMU 159 RFI.

Sediment exposures were evaluated based on an adolescent trespasser scenario. The total sediment pathway risk for the adolescent trespasser was calculated at  $9E-7$ . Arsenic was the primary contributor for both pathways.

Petroleum hydrocarbons (as indeterminate lubricating oil) were detected in SWMU 159 sediment above the screening level of 100 mg/kg. SWMU 159 sediment is recommended for inclusion in the CMS process solely on the basis of TPH concentrations.

Qualitative evaluation of the surface soil to sediment migration pathway provided evidence that an erosion mechanism is a significant process for SWMU 159. Many constituents detected in surface soil were also detected in sediment. This migration pathway is significant relative to ecological impacts to the tidal estuary located adjacent to this site.

An interim measure has been conducted to remove surface soil and mitigate the impact to sediment. The details of this interim measure will be included in a report prepared by the environmental detachment.

Even though contaminant levels were below generic soil screening levels, groundwater sampling will be performed as part of the SWMU 159 CMS to ascertain whether there has been impact to groundwater.

**Table 9.21  
 Zone H Conclusion Summary  
 SWMU 159**

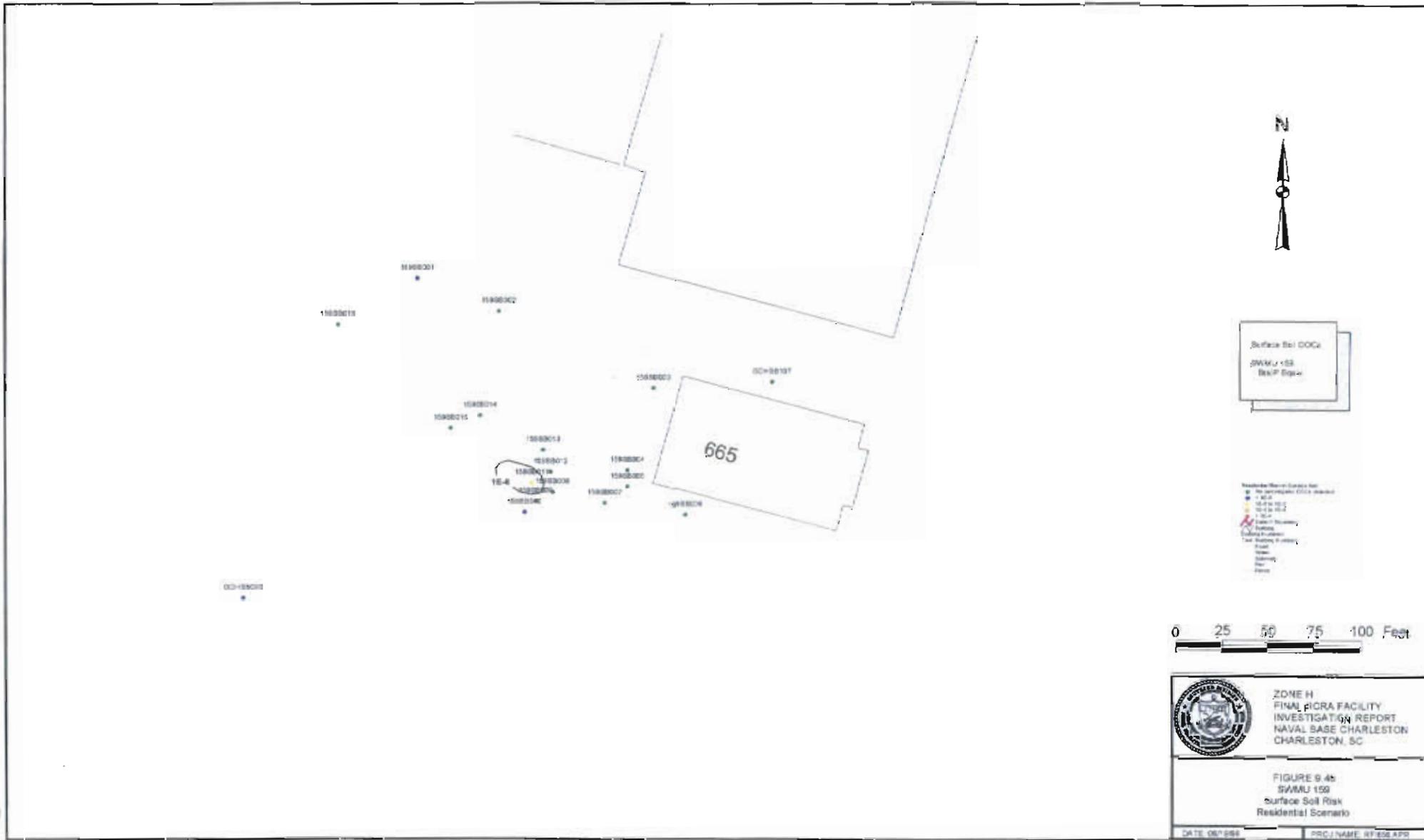
	<b>Unacceptable Risks for Human Health in Residential Scenario (Y/N)</b>	<b>Chemicals Driving Risk</b>
Surface Soil	Yes, ILCR 2E-6	BEQ
Sediment	No	NA
Shallow Groundwater	NA	NA
Deep Groundwater	NA	NA
	<b>Above Levels of Concern (Y/N)</b>	<b>Total TEQ (ppb)</b>
Dioxin in Surface Soil	No	3.887-9.014 $\mu\text{g/g}$ 2,3,7,8-TCDD equivalents
Dioxin in Shallow Groundwater	NA	NA
Dioxin in Deep Groundwater	NA	NA
	<b>TPH Present at Concentrations &gt; 100 ppm (Y/N)</b>	<b>Maximum Detected Concentration (ppm)</b>
Soil	Y	170

*Note:*  
 NA = Not Applicable

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0 25 50 75 100 Feet


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**FIGURE 9.4b**  
 SWMU 159  
 Surface Soil Risk  
 Residential Scenario

DATE: 05/19/14      PROJ NAME: RT208 APP

## **9.22 Other Impacted Areas**

### **G07 and G38**

The grid based soil samples GDHSB00701 and GDHSB03801 contained 2,600 and 4,000  $\mu\text{g}/\text{kg}$  of Aroclor-1260, respectively. The GDHSB038 sample from the second-interval also contained Aroclor-1260 at a concentration (290  $\mu\text{g}/\text{kg}$ ) above the RBSL. Sample GDHSB00701 was collected from an area approximately 70 feet northwest of Building 644 and sample GDHSB03801 was collected from an area approximately 85 feet southeast of Building 84. Additional sampling performed in the immediate vicinity of these two grid samples also yielded detections of Aroclor-1260 which exceeded the RBSL.

Three soil boring locations (GDHSB007, G38SB003, and G07SB001) within the sampling pattern of the G38 and G07 area yielded samples with RBSL-exceeding BEQ concentrations.

No ecological risk is anticipated for OIA G07 and G38 due to the lack of suitable habitat, and lack of ecological receptors.

For the area of G07, total soil pathway risk for site residents and site workers was calculated as  $6\text{E-}5$  and  $1\text{E-}5$ , respectively. No noncarcinogenic COCs were identified for the surface soil pathways. The primary contributor to risk was Aroclor-1260 with BEQ responsible for the remainder. Area G07 surface soil is recommended for inclusion in the CMS process on the basis of projected resident and site worker risk.

For the area of G38, total soil pathway risk for site residents and site workers was calculated as  $7\text{E-}5$  and  $2\text{E-}5$ , respectively. No hazard indices were computed for the surface soil COPCs. The primary contributor to risk was Aroclor-1260 with BEQ responsible for the remainder. Area G38 surface soil is recommended for inclusion in the CMS process on the basis of projected resident and site worker risk.

Figure 9.41 illustrates the distribution of risk in surface soil considering a residential scenario in the vicinity of OIAs G07 and G38. The central portion of the sampled area exhibits risk between  $1E-5$  and  $1E-4$ . The remainder of the sampled area exhibits risk less than  $1E-6$ .

Figure 9.42 illustrates the distribution of risk in surface soil considering an industrial scenario. This distribution is similar to the residential scenario except that the risk present at G38SB003 drops down to the  $1E-6$  to  $1E-5$  range resulting in two separate areas exhibiting risk in the range of  $1E-5$  to  $1E-4$ .

No hazard was identified in the OIA G07 and G38 area; therefore, no hazard maps were produced.

### **G80**

During the construction of deep monitoring well NBCHGDH04D, which is located approximately 70 feet south of the intersection of Hobson Avenue and West Osprey Street, a piece of treated timber (possibly old piling) was removed from the borehole. Analytical results for the soil sample collected from this borehole reflected significant concentrations of SVOCs. Additional soil samples collected in the vicinity of the borehole did not reflect the degree of contamination identified in the borehole. However, the soil samples were not collected at the same depth as the sample from the borehole. Analysis of groundwater from the shallow well located approximately 10 feet from the borehole that was the source of the contaminated soil sample also did not report the chemicals identified in the soil sample, nor did groundwater analysis from the deep well. Apparently, the analytical results for the soil sample collected while drilling the deep borehole represent a very isolated area of contamination, likely centered around an old treated piling. Furthermore, as evidenced by the shallow groundwater sample results, contamination has apparently not significantly migrated from the piling into the surrounding groundwater.

Two soil boring locations within the sampling pattern of the G80 area, which was established around the location where the heavily contaminated sample was collected, yielded samples with RBSL-exceeding BEQ concentrations. However, both BEQs were within two times the RBSL for BAP.

No ecological risk is anticipated for OIA G80 due to the lack of suitable habitat, and lack of ecological receptors.

For the G80 area total soil pathway risk for site residents and site workers was calculated as  $4E-6$  and  $9E-7$ , respectively. No noncarcinogenic COCs were identified for the surface soil pathways. The sole contributors to risk were BEQs. Area G80 surface soil is recommended for inclusion in the CMS process on the basis of projected resident risk. Figure 9.43 illustrates the risk identified through samples collected in the vicinity of OIA G80. Given the minimal sampling pattern, there was little potential to map distribution of risk. However, at three locations there were carcinogenic COCs identified that produced risk greater than  $1E-6$ . At the remaining two, either no carcinogenic COCs were identified or risk was less than  $1E-6$ .

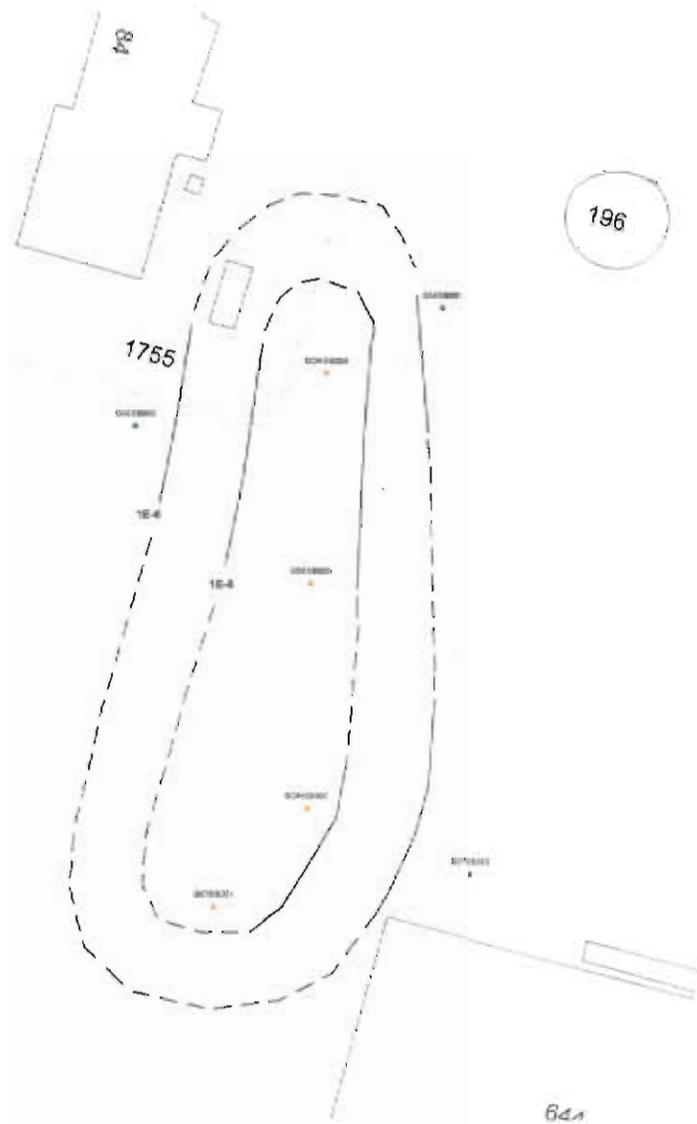
Due to lack of significant risk in the industrial scenario and hazard in the residential and industrial scenarios, none of the maps were produced for OIA G80.

No fate and transport concerns were identified for OIAs G07/G38 and G80.

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Surface Soil COCs  
 OIA G07 and G36  
 Aerial-1280  
 3x37' Grid

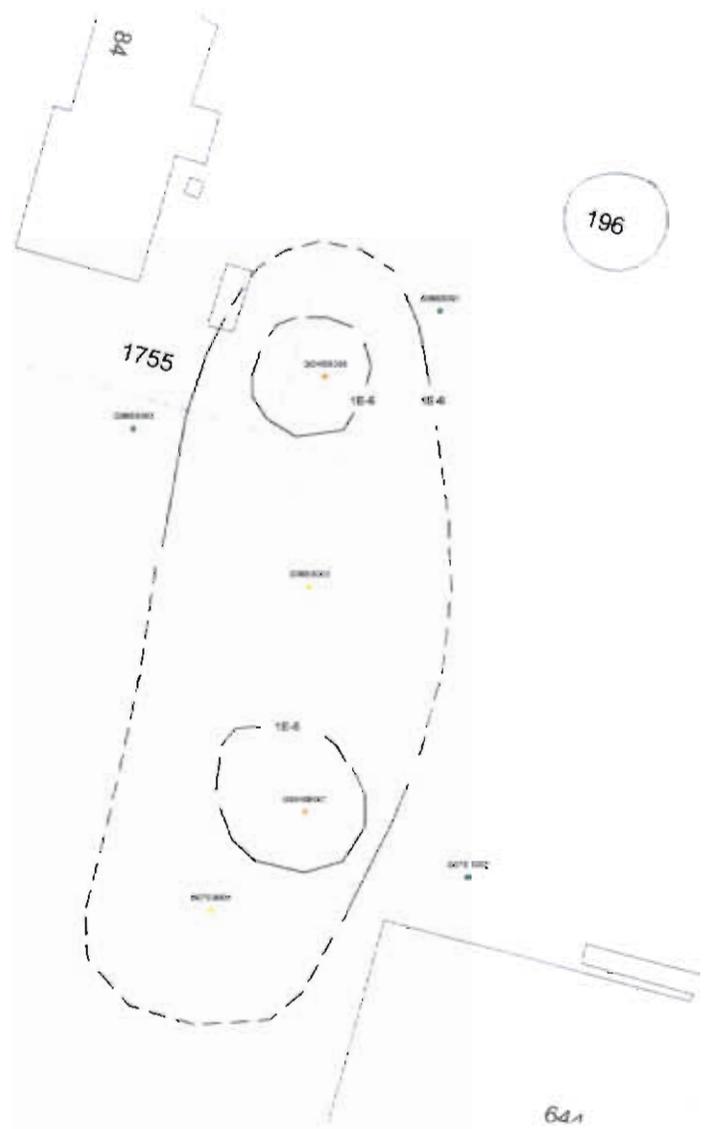
Residential Risk of Contaminant  
 ● High (100-1000) (1000-10000)  
 ● Medium (100-1000)  
 ● Low (100-1000)  
 ● Very Low (100-1000)  
 ● None

0 25 50 75 100 Feet

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FIGURE B-41  
 OIA G07 and G36  
 Surface Soil Risk  
 Residential Scenario

DATE: 04/18/04 PROJ. NAME: BT/DC/AFB

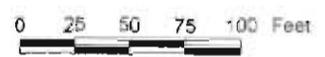


Surface Soil COCs

- OIA G07  
AR001-1280
- OIA G38  
AR001-1280  
Bo/F Equiv

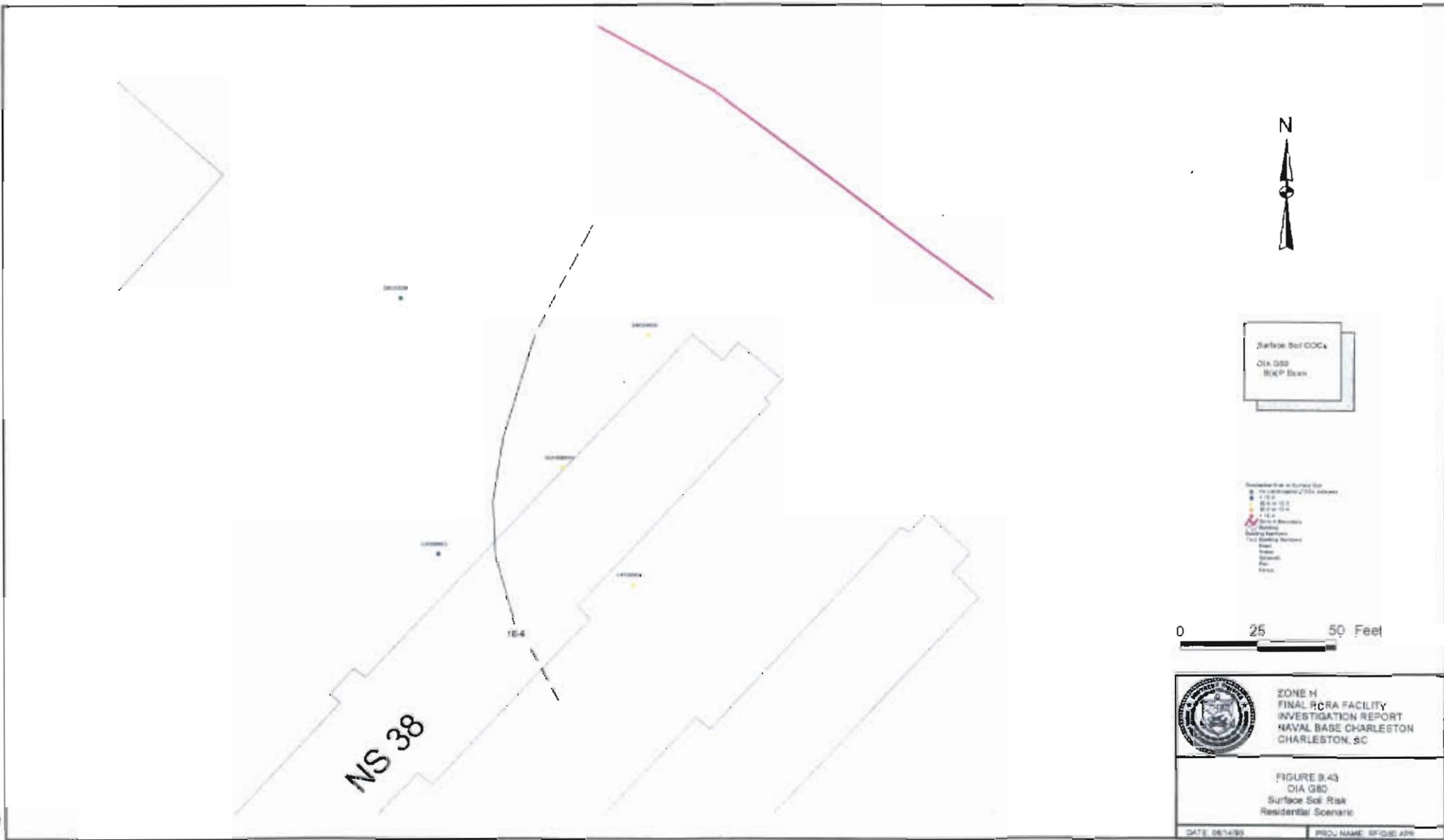
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FIGURE B-42  
OIA G07 and G38  
Surface Soil Risk  
Industrial Scenario



### **9.23 AOC 503 and AOC 661**

AOC 503 (Unexploded Ordnance Site south of Building 665) is at the southern boundary of Zone H in a wooded area approximately 300 feet from Shipyard Creek. Two Mark-17 depth bombs were reportedly jettisoned in this area from a Naval vessel in 1943. An EOD survey of the AOC 503 area has been completed by the environmental detachment. The findings of this survey will be presented in a report prepared by the environmental detachment.

AOC 661 (Explosives Storage) is an area where explosives were stored during the 1950s in a now demolished building. Currently, the area of AOC 661 is a grassy area south of Building 601 and north of Building 675. The environmental detachment has completed additional research and concluded that AOC 661 was a small shed on a paved runway. Based on these findings, the proposed EOD survey for this site has been canceled. However, soil samples will be collected at the site. The final results and CMS recommendations for AOC 661 will be submitted as an addendum to the final report.

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#### **9.24 Zone H RFI Summary of Recommendations**

The Naval Base Charleston Project Team has agreed upon three possible courses of action for sites determined to be adequately characterized for decision-making purposes. These alternatives are NFA, CMS, or transfer to the South Carolina UST program.

The risk management decision making process of determining whether a site was recommended for NFA or CMS was based on risk/hazard to human health or ecological receptors. The criteria for making this decision with respect to human health were the USEPA and SCDHEC standard limits (or points of departure) for carcinogens and noncarcinogens. For carcinogens, the point-of-departure range is  $1E-6$ , with a generally accepted range of  $1E-6$  to  $1E-4$ . For noncarcinogens, other toxic effects are generally considered possible if the HQ or sum of HQs is greater than 1. Risks for soil invertebrates and plants were evaluated based on qualitative comparisons to literature effects-levels for taxonomic groups similar to those potentially occurring at Zone H. Risks for aquatic organisms were evaluated by calculating HQs from benchmark values that are either promulgated or proposed by federal and state regulatory agencies.

Sites investigated in the Zone H RFI that have already been transferred or are recommended for transfer to the UST program meet the following criteria. The data generated during the RFI supported the conclusion that releases at the site(s) consisted of virgin petroleum and groundwater beneath the site had not been impacted by other nearby sites with RCRA concerns.

The purpose of the CMS is to identify, screen and evaluate potential remedial alternatives for releases that have been identified at a facility. A potential remedy can range from engineering and institutional controls to a full scale clean-up. Depending on final action levels, and CMS needs, additional sampling may be necessary at some sites to more accurately define the extent of contamination. These sites are identified in the comments column of Table 9.22. Additional

samples may also be collected at some sites to satisfy CMS data requirements with respect to ecological and human health risk assessment data gaps.

During the corrective action process, the project team will be responsible and instrumental in determining unacceptable risks and the ensuing appropriate clean-up response, if warranted, at NAVBASE.

Table 9.22 lists the sites and their corresponding recommendations as determined by consensus agreement of the Project Team.

Table 9.22  
 Zone H RFI  
 Summary of Recommendations

Site #	Site Description	Further Action						Comments	
		TPH <sup>a</sup>	BRA <sup>b</sup>				Ecological Concern (Y/N)		
			Soil (Y/N)	Soil (Y/N)		Groundwater (Y/N)			
				R <sup>c</sup>	I <sup>d</sup>	R <sup>c</sup>			I <sup>d</sup>
SWMU 9	Closed Landfill	NA <sup>a</sup>	NA <sup>e</sup>	NA <sup>e</sup>	Y	Y	Y	Recommended for CMS.	
SWMU 13	Current Fire Fighting Training Area	Y	N	N	Y	Y	N	The site has been transferred to the UST program. Additional soil sampling may be necessary to further define extent of TPH contamination. The site has been transferred into the UST program.	
SWMU 14	Chemical Disposal Area	Y	Y	Y	Y	Y	N	Continued groundwater monitoring for BEHP is recommended as part of the CMS. Interim measures directed toward excavation of geophysical anomalies are in process. Lead shot may also be removed as part of the interim measures.	
SWMU 15	Incinerator	Y	Y	Y	NA <sup>f</sup>	NA <sup>f</sup>	Y	To be included in the SWMU 14 CMS.	
SWMU 17	Oil Spill Area	Y	Y	Y	Y	Y	N	Data gaps are to be addressed, as required, for the SWMU 17 CMS.	
SWMU 19	Solid Waste Transfer Station	Y	Y	Y	NA <sup>g</sup>	NA <sup>g</sup>	Y	SWMU 19 data and data gaps should be considered, as required, in the SWMU 9 CMS.	
SWMU 20	Waste Disposal Area	NA	Y	Y	NA <sup>g</sup>	NA <sup>g</sup>	Y	SWMU 20 data and data gaps should be considered, as required, in the SWMU 9 CMS.	
SWMU 121	Satellite Accumulation Area	Y	Y	Y	NA <sup>g</sup>	NA <sup>g</sup>	Y	SWMU 121 data and data gaps should be considered, as required, in the SWMU 9 CMS.	
SWMU 159	Satellite Accumulation Area	Y	Y	N	N	NA	Y	Interim measures have been implemented. Groundwater monitoring will be conducted as part of the SWMU 159 CMS.	

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Table 9.22  
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 Summary of Recommendations

Site #	Site Description	Further Action						Comments
		TPH <sup>a</sup>  Soil (Y/N)	BRA <sup>b</sup>				Ecological Concern (Y/N)	
			Soil (Y/N)		Groundwater (Y/N)			
			R <sup>c</sup>	I <sup>d</sup>	R <sup>c</sup>	I <sup>d</sup>		
SWMU 178	Apparent Transformer Fire Site	Y	Y	N	N	N	N	The site has been transferred to the UST program and a tank removal and subsequent sampling has been conducted. Groundwater is to be monitored during the CMS effort for SWMU 136 and AOC 663.
AOCs 649, 650, and 651	Ship Painting and Repair Storage Areas	Y	Y	Y	NA <sup>e</sup>	NA <sup>e</sup>	Y	AOCs 649, 650, and 651 data should be considered, as required, in the SWMU 9 CMS.
AOC 653	Hobby Shop	Y	N	N	Y	Y	N	Interim measures have been completed. However, the site is still recommended for CMS.
AOC 654	Septic Tank and Drainfield	N	N	N	NA <sup>e</sup>	NA <sup>e</sup>	Y	No further action is necessary. Monitoring wells in the vicinity of AOC 654 are to be considered part of the SWMU 9 groundwater monitoring network.
AOC 655	Oil Spill Area	Y	Y	Y	Y	Y	N	Interim measures have been implemented. No further action is recommended.
AOC 656	Petroleum Spill	Y	Y	Y	Y	N	N	The site has been transferred to the UST program. Groundwater is to be monitored as part of the CMS.
AOC 659	Diesel Storage	Y	N	N	NA	NA	N	The AST has been removed from the site. Candidate site for inclusion into the UST program. Temporary monitoring wells will be installed inside the bermed area to ascertain whether methylene chloride is present in groundwater. Final results and CMS recommendations will be submitted as an addendum to the RFI report.
AOC 660	Mosquito Control	N	N	N	N	N	N	No further action necessary.
AOC 662	Former Gasoline Station	N	N	N	N	N	N	This site has been recommended for transfer to the UST program.

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		TPH <sup>a</sup>	BRA <sup>b</sup>				Ecological Concern (Y/N)		
			Soil (Y/N)	Soil (Y/N)		Groundwater (Y/N)			
				R <sup>c</sup>	I <sup>d</sup>	R <sup>c</sup>			I <sup>d</sup>
AOC 663 and SWMU 136	Gas/Diesel Pumping Station and Satellite Accumulation Area	Y	Y	Y	Y	Y	N	Groundwater is to be monitored for benzene and BEHP.	
AOC 665	Pyrotechnic Storage Area	Y	Y	N	NA	NA	N	Additional samples, to be analyzed for pyrotechnics, are to be collected at new suspect locations. Final results and CMS recommendations will be submitted as an addendum to the RFI report.	
AOC 666	Fuel Storage	Y	Y	Y	Y	Y	N	Interim measures involving UST removal have been completed. However, inclusion into the CMS is still recommended.	
AOC 667 and SWMU 138	Vehicle Maintenance Area and Satellite Accumulation Area	Y	N	N	N	N	N	DPT sampling is proposed to assess potential groundwater contamination. Final results and CMS recommendations will be submitted as an addendum to the RFI report.	
AOC 670	Former Skeet Range	Y	Y	Y	NA	NA <sup>e</sup>	Y	To be included in the SWMU 14 CMS.	
AOC 684	Former Outdoor Pistol Range	Y	Y	Y	NA	NA <sup>f</sup>	N	To be included in the SWMU 14 CMS.	
OIA G07 and G38	PCB contamination in the area of grid samples GDHSB007 and GDHSB038	NA	Y	Y	NA	NA	N	No further action necessary per risk management decisions.	
OIA G80	BEQ contamination in the borehole of NBCHGDH04D	NA	Y	N	NA	NA	N	No further action necessary per risk management decisions.	

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Site #	Site Description	Further Action				Comments
		TPH <sup>a</sup>  Soil (Y/N)	BRA <sup>b</sup>		Ecological Concern (Y/N)	
			Soil (Y/N)	Groundwater (Y/N)		
		R <sup>c</sup>	I <sup>d</sup>	R <sup>c</sup>	I <sup>d</sup>	
AOC 503	Unexploded Ordnance Site					Recommended for inclusion into the CMS per-risk management decisions.
AOC 661	Explosives Storage					Soil sampling is proposed. Final results and CMS recommendations will be submitted as an addendum to the RFI report.

Notes:

- NA = Not Assessed
- <sup>a</sup> = Total Petroleum Hydrocarbons (TPH) were not detected in first or second round groundwater samples. Sites with presence of TPH in soil exceeding 100 mg/kg are identified with a "Y" in the Further Action column.
- <sup>b</sup> = Sites which were determined to have excessive risk for soil and/or groundwater, as determined by the BRA, are identified with a "Y" in the Further Action column.
- <sup>c</sup> = Residential Risk Assessment Scenario
- <sup>d</sup> = Industrial Risk Assessment Scenario
- <sup>e</sup> = Soil within SWMU 9 was assessed as SWMUs 19, 20, and 121, and AOCs 649, 650, and 651.
- = Groundwater at SWMUs 14 and 15 and AOCs 670 and 684 was assessed as SWMU 14.
- = Groundwater at SWMUs 20, 19, and 121, and AOCs 649, 650, 651, and 654 was assessed as SWMU 9.

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*Final RCRA Facility Investigation Report for Zone H  
NAVBASE Charleston  
Section 10: References  
July 5, 1996*

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## 11.0 SIGNATORY REQUIREMENT

Condition I.E. of the Hazardous and Solid Waste Amendments (HSWA) portion of 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 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.*

  
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Caretaker Site Officer

7/9/96  
Date