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Norfolk Naval Base

Norfolk, Virginia
CERCLIS #VA6170061463

Site Exposure Potential

Norfolk Naval Base, part of the Sewells Point Naval Complex, occupies approximately 1900 ha directly northwest of Norfolk, Virginia (Figure 1). Mason Creek borders the area along the base's eastern boundary; the junction of the Elizabeth and James rivers (Hampton Roads) borders the site on the west; and the remnants of Bousch Creek and a network of ditches drain the central portion of the facility (Figure 2). Willoughby Bay forms the northern border of the site and enters Chesapeake Bay approximately 1.5 km northeast of Norfolk Naval Base.

Norfolk Naval Base began operating in 1917 as a support base for World War I activities. The base provides fleet support for the U.S. Atlantic fleet, shore facilities and support for U.S. military vessels and aircraft, and service and maintenance for ships and aircraft. Many hazardous substances have been used, generated, and discarded at the property. These substances include various chlorinated organic solvents, sludges from metal plating processes, parts cleaning and paint stripping wastes, acids, heavy metals, and pesticides (Baker Environmental, Inc. 1994).

Under the Department of Defense Installation Restoration Program, 22 sites on the base were identified as potentially contaminated. Data were available for four source areas: the Camp Allen

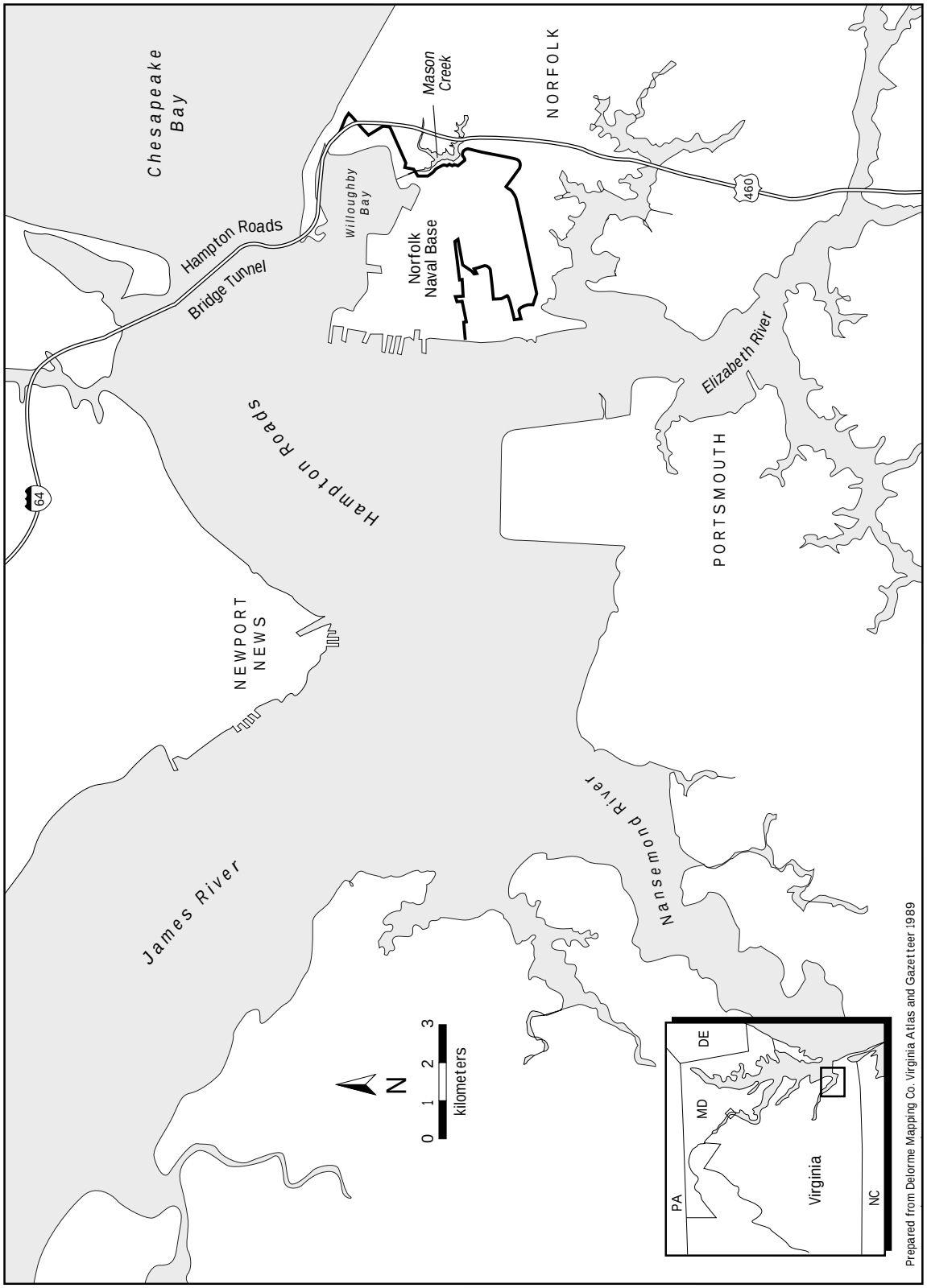

Figure 1. Location of Norfolk Naval Base in Norfolk, Virginia.

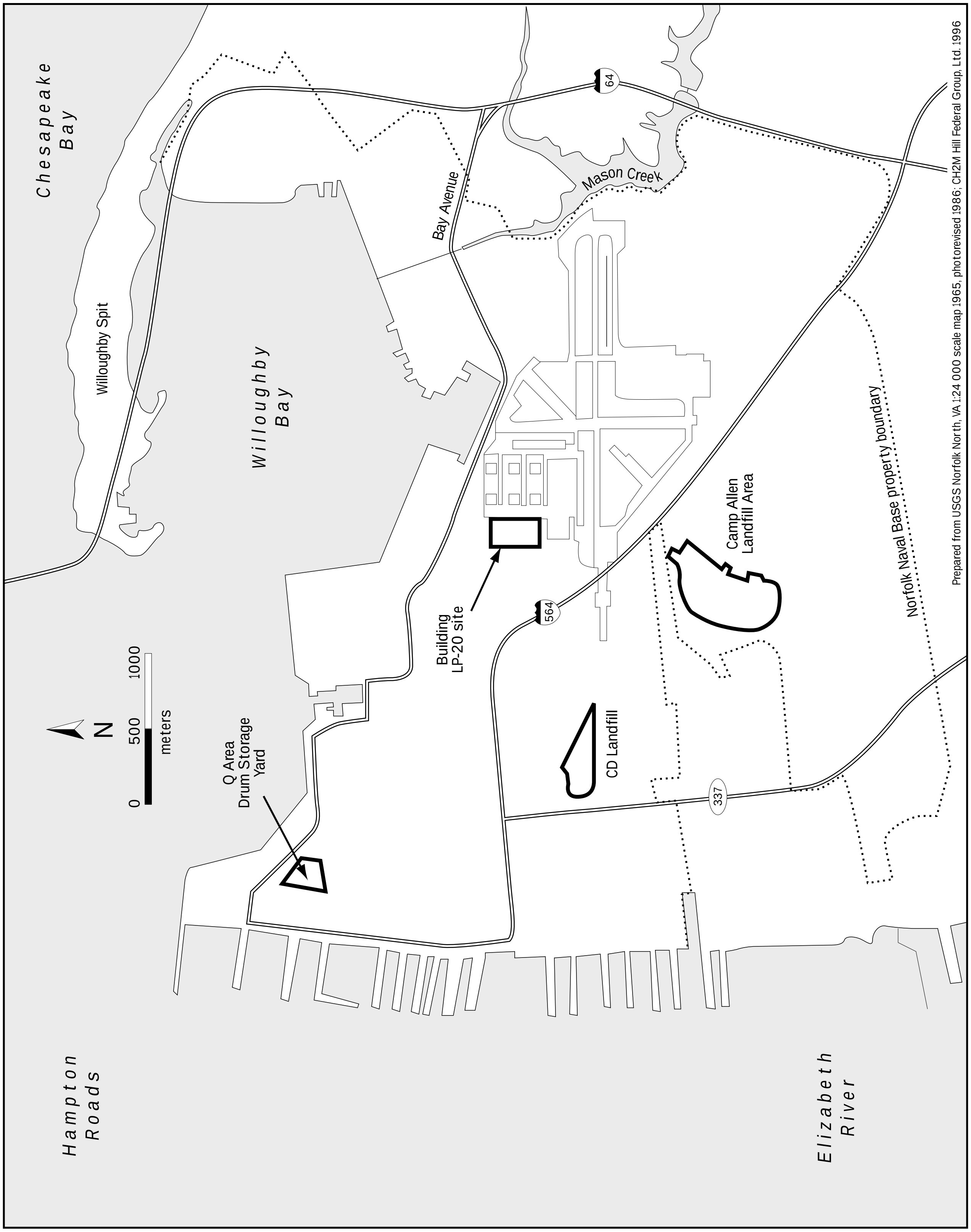

Figure 2. Detail of Norfolk Naval Base

Landfill, the Q Area Drum Storage Yard (QADSY), the CD Landfill, and the Building LP-20 site. Table 1 lists the dates of use, types of wastes disposed, and remediation activities for these sites. The limited information available for the remaining sites indicated that cleanup was completed on five sites, while ten areas were determined to require no cleanup action (CH2M HILL Federal Group, Ltd. 1996).

Surface water runoff and groundwater migration are the potential pathways for contaminant transport from site areas to NOAA resources and associated habitats. Norfolk Naval Base is located on a nearly level plain, with surface elevations ranging from sea level to about 5 m above sea level at the central portion of the facility. The principal surface drainage feature at the site is the network of drainage ditches rerouting and replacing the Bousch Creek system that once covered most of the base. The outfalls from this drainage system end in Mason Creek, the Elizabeth River, and Willoughby Bay. No diagrams of this drainage system were found in any of the reviewed reports, although Table 1 lists the specific surface water pathways that were identified for each source area.

Groundwater at the base is present at 2 to 2.5 m bgs in the unconfined Columbia aquifer, which consists of thin, discontinuous layers of heterogeneous sand and shell lenses. The underlying Yorktown aquifer is confined by beds of silt and clay, which may be breached or absent in localized areas of the site due to erosion by meandering streams and rivers. Area groundwater is tidally influenced. In the central and northern portions of the base, groundwater flows generally east and northeast. On the east side of the base, groundwater appears to flow west and northwest toward the main drainage culvert. In the southwestern quarter of the base, groundwater flows south and southeast, again toward surface drainage features (Baker Environmental, Inc. 1995a).

NOAA Trust Habitats and Species

Habitats of primary concern to NOAA are surface waters and associated bottom substrates of the lower Elizabeth River and Hampton Roads, an estuarine area where the Elizabeth, James, and Nansemond rivers meet Chesapeake Bay. Anadromous fish, estuarine fish, and invertebrates use the estuary and are the resources of concern to NOAA (Table 2). Estuarine waters of this area range from extensive shallow flats generally less than 3 m deep to trenches up to 30 m deep (USGS 1964, 1965). Salinities range from 15 to 20 ppt and sediments range from silts to sands (Majumdar et al. 1987).

The estuary provides nursery and adult habitat for many estuarine and marine fish. Estuarine residents include bay anchovy, oyster toadfish, sheepshead minnow, killifishes, silversides, pipefish, gobies and hogchoker. These species spend all life stages within the estuary; several are highly abundant. Species such as bluefish, mullet, pinfish, butterfish, and the sciaenids (croaker,

Table 1. Description of hazardous waste sites at Norfolk Naval Base.

Site Name	Dates	History of Use	Contaminants of Concern	Potential Migration Pathway
Camp Allen Landfill	early 1940s - 1974	Unlined landfill used to dispose of municipal, solid, and hazardous wastes. Soil removal completed and long-term groundwater pump and treatment being implemented. Most of area capped and revegetated to minimize surface erosion.	Chlorinated organic sovents, metals, pesticides, and an estimated 150 kg metals plating sludge, 230 kg parts cleaning sludge, and 1,500 kg paint stripping residue.	Surface water runoff is channelled into Willoughby Bay by drainage ditches surrounding the site. Groundwater flows north and northeast towards Willoughby Bay and Mason Creek. The Camp Allen Landfill is 1.5 km south of Willoughby Bay.
Q Area Drum Storage Yard	1950s - present	Storage of 55-gallon steel drums including an area for damaged and leaking drums.	Petroleum products (oil lubricants, hydraulic fluid), chlorinated organic solvents, paint thinners, pesticides, formaldehyde, and acids.	Surface runoff is directed into numerous open storm drains that lead directly to the Elizabeth River to the west and Willoughby Bay to the north. Groundwater discharge also flows to the Elizabeth River and Willoughby Bay. QADSY is about 350 m from both the Elizabeth River and Willoughby Bay.
CD Landfill	1974 - 1987	Unpermitted landfill from 1974 to 1979, used for disposal of ash residues, sandblasting grit, and spent rice hulls. Permitted landfill from 1979 to 1987 for disposal of demolition wastes and non-putrescible wastes. Closure plan submitted in 1988. Capped with thin layer of soil and vegetation.	Cadmium- and lead-contaminated sandblasting grit and rice hulls. Possibly, additional chemicals were disposed.	Two unlined drainage ditches surrounded by wetlands border the site to the north and south. They flow eastward into culverts beneath the Naval Air Station that convey surface water runoff to Willoughby Bay. Groundwater flow is northwest towards the Elizabeth River and Willoughby Bay. CD Landfill is about 1 km east of the Elizabeth River and 1.8 km south of Willoughby Bay.
Building LP-20 Site (Buildings LP-20, LP-22, LP-24, and U-132)	early 1940s - present	Aircraft paint shops, testing facilities, blasting booths, cleaning shop, repair shops, hazardous waste storage, and metal plating shops.	Heavy metals, acids, chlorinated solvents, VOCs, and petroleum products.	Storm sewers are used to drain the area to Willoughby Bay. Groundwater movement in this area is northeast towards Willoughby Bay, although the Bousch Creek culvert beneath the base may affect groundwater flow patterns. The Building LP-20 site is about 750 m southwest of Willoughby Bay.

Table 2. NOAA trust fish and invertebrate species that use the Elizabeth River, Hampton Roads and Chesapeake Bay.

Species		Habitat Use			Fisheries	
Common Name	Scientific Name	Spawning Ground	Nursery Ground	Adult Forage	Comm. Fishery	Recr. Fishery
ANADROMOUS/CATADROMOUS						
Alewife	*Alosa pseudoharengus*		♦			
American eel	*Anguilla rostrata*		♦		♦	
American shad	*Alosa sapidissima*		♦			
Atlantic sturgeon	*Acipenser oxyrhynchus*		♦	♦		
Blueback herring	*Alosa aestivalis*		♦			
Striped bass	*Morone saxatilis*		♦	♦	♦	
White perch	*Morone americana*		♦	♦		
MARINE/ESTUARINE FISH SPECIES						
Atlantic croaker	*Micropogonias undulatus*		♦	♦		♦
Atlantic herring	*Clupea harengus*		♦	♦		
Atlantic menhaden	*Brevoortia tyrannus*		♦	♦		
Bay anchovy	*Anchoa mitchilli*		♦	♦		
Black drum	*Pogonias cromis*		♦	♦		
Black sea bass	*Centropristis striata*		♦	♦		
Bluefish	*Pomatomus saltatrix*		♦	♦		♦
Butterfish	*Peprilus triacanthus*		♦	♦		
Cownose ray	*Rhinoptera bonasus*		♦	♦		
Gobies	*Gobiosama* spp.	♦	♦	♦		
Hogchoker	*Trinectes maculatus*	♦	♦	♦		
Killifish	*Fundulus* spp.	♦	♦	♦		
Mullets	*Mugil* spp.		♦			
Northern pipefish	*Syngnathus fuscus*	♦	♦	♦		
Northern searobin	*Prionotus carolinus*		♦			
Pinfish	*Lagodon rhomboides*		♦	♦		
Red drum	*Sciaenops ocellatus*		♦	♦		♦
Red hake	*Urophycis chuss*		♦			
Oyster toadfish	*Opsanus tau*	♦	♦	♦		
Scup	*Stenotomus chrysops*		♦			
Sheepshead minnow	*Cyprinodon variegatus*	♦	♦	♦		
Silversides	*Menidia* spp	♦	♦	♦		
Skates	*Raja* spp.		♦	♦		
Spot	*Leiostomus xanthurus*		♦	♦		♦
Spotted seatrout	*Cynoscion nebulosus*		♦	♦		♦
Summer flounder	*Paralichthys dentatus*		♦	♦		♦
Tautog	*Tautoga onitis*		♦	♦		
Weakfish	*Cynoscion regalis*		♦	♦		♦
Windowpane flounder	*Scophthalmus aquosus*		♦	♦		
INVERTEBRATE SPECIES						
Bay shrimp	Crangon septemspinosa	♦	♦	♦		
Blue crab	*Callinectes sapidus*	♦	♦	♦	♦	♦
Blue mussel	*Mytilus edulis*	♦	♦	♦		
Eastern oyster	*Crassostrea virginica*	♦	♦	♦		♦[1]
Grass shrimp	*Palaemonetes pugio*	♦	♦	♦		
Northern quahog	*Mercenaria* spp.	♦	♦	♦		♦[1]

[1]: Bivalve harvests in Hampton Roads are restricted in areas surrounding the Naval Station.

weakfish, seatrout, spot, drum) are coastal spawners; eggs and larval stages drift offshore and later juvenile stages migrate into the estuary. Because many of these species are long-lived, juveniles may spend several years in the estuary. Adults of several of the species also use the estuary seasonally. Bluefish, spot, and Atlantic croaker are particularly abundant in the area (Stone et al. 1994).

Several anadromous fish use the estuary as a migratory corridor, juvenile nursery, and adult habitat. Juvenile and adult white perch are abundant in the estuary. The adults spawn in freshwater upstream of the base, and both juveniles and adults reside in the estuary. Striped bass, particularly juvenile stages, are common in the estuary. Adults may spend time in the area as well, but many move seaward. American shad, blueback herring, and alewife spawn in the freshwater upstream of the base. Juveniles use the estuary as a nursery but usually migrate seaward as adults. Atlantic sturgeon are considered rare near the base and in Chesapeake Bay. The catadromous American eel is found throughout the Chesapeake basin, and juvenile life stages are present near the site (Stone et al. 1994).

Several invertebrates use the estuary, including blue crab, grass shrimp, eastern oyster, and northern quahog. Juvenile and adult blue crab are abundant; mating and larval stages are also seen in the estuary, although females usually migrate to coastal waters to brood and release eggs. Grass shrimp, oyster, and quahog spend all life stages in the estuary (Stone et al. 1994).

There are substantial commercial and recreational fisheries in the Hampton Roads portion of Chesapeake Bay. Popular recreational catches include bluefish, croaker, spot, weakfish, flounder, blue crab, oyster, and quahog (Majumdar et al. 1987). The total landings for 1996 for the Elizabeth River were over 100,000 kg. The bulk of the commercial harvest is for blue crab, but American eel and striped bass also support substantial commercial fisheries (O'Reilly 1997). Bivalves are harvested in other areas of Hampton Roads, but are restricted surrounding the base because of industrial runoff (Wright 1997).

Site-Related Contamination

Data collected during several site investigations indicate that soils, groundwater, surface water, and sediments at the Norfolk Naval Base are contaminated in varying degrees with trace elements, pesticides, and organic compounds, including PAHs, VOCs, and SVOCs. Separate investigations were conducted for each source area. The most recent data used to determine maximum contaminant concentrations for each area came from remedial investigations in 1990-1993 for the QADSY (Environmental Science & Engineering, Inc. 1994), in 1992-1993 for the Camp Allen Landfill (Baker Environmental, Inc. 1994), in 1993-1994 for the CD Landfill (Baker Environmental, Inc. 1995a), and 1994-1995 for the Building LP-20 site (Baker Environmental, Inc. 1995b). Table 3 summarizes maximum

Table 3. Maximum concentrations of contaminants in soils, groundwater, surface water, and sediments at Norfolk Naval Base.

	Soils (mg/kg)	Location	Mean U.S.[a] (mg/kg)	Ground-water (µg/L)	Location	Surface Water (µg/L)	Location	AWQC[b] (µg/L)	Sediment (mg/kg)	Location	ERL[c] (mg/kg)
Trace Elements											
Arsenic	270	QADSY	5.2	340	QADSY	64	CAL	36	590	CAL	8.2
Cadmium	89	CAL	0.06	96	QADSY	NA	–	1.1	180	CAL	1.2
Chromium	1,000	CDL	37	1,100	QADSY	300	CDL	11	3,000	CAL	81
Copper	3,100	CDL	17	380	CAL	450	CAL	12	500	CDL	34
Lead	3,200	CDL	16	1,000	CAL	800	CAL	3.2	1,000	CAL	46.7
Mercury	0.84	CDL	0.058	3	CAL	3.9	CAL	0.012	3	CAL	0.15
Nickel	520	CDL	13	430	CAL	250	CDL	8.3	340	CDL	20.9
Silver	180	CDL	0.05	12	LP20	12	CAL	0.12	110	CAL	1.0
Zinc	6,200	CDL	48	1,600	QADSY	2,600	CDL	86	700	CDL	150
Pesticides/PCBs											
Dieldrin	0.051	CDL	NA	0.04	CDL	0.035	CDL	0.002	0.12	CDL	NA
4,4'-DDE	0.035	CDL	NA	ND	–	ND	–	14[d]	0.18	CDL	0.0016[e]
4,4'-DDT	0.010	CDL	NA	0.02	CDL	ND	–	0.001	0.11	CDL	0.0016[e]
Total PCBs	3.4	CAL	NA	ND	–	ND	–	0.014	1.5	CAL	0.023
Other Organic Compounds											
Benzene	0.25	CAL	NA	860	LP20	12	CAL	700[d]	ND	–	NA
1,1-dichloroethene	0.42	CAL	NA	3,600	LP20	3	CAL	NA	ND	–	NA
1,2-dichloroethene	1.5	QADSY	NA	28,000	LP20	46	CAL	NA	ND	–	NA
Toluene	3,000	CAL	NA	4,400	LP20	ND	–	5,000[d]	ND	–	NA
Trichloroethene	3.1	CAL	NA	54,000	LP20	45	CAL	2,000[d]	0.013	CDL	NA
Vinyl chloride	ND	–	NA	15,000	LP20	22	CAL	NA	ND	–	NA
Acetone	5.4	LP20	NA	1,300	QADSY	ND	–	NA	0.27	CDL	NA
Dibenzofuran	1.7	CAL	NA	7	CAL	ND	–	NA	8.4	CDL	NA
Xylene (total)	340	CAL	NA	180	LP20	3	CAL	NA	0.002	CDL	NA
Total PAHs	55	LP20,CAL	NA	110	LP20, CAL, CDL	ND	–	NA	540	CDL	4.0

a: Shacklette and Boerngen (1984), except for cadmium and silver which represent average concentrations in the earth's crust from Lindsay (1979).
b: Quality Criteria for Water (EPA 1993). Lowest value was chosen from fresh and marine water criteria because stream is tidally influenced.
c: Effects range-low; the concentration representing the lowest 10 percentile value for the data in which effects were predicted in studies compiled by Long et al. (1995).
d: Lowest Observed Effect Level (EPA 1993).
e: ERL for total DDT.
ND: Not detected; detection limit not available.
NA: Screening guidelines not available; data not available.
CAL: Camp Allen Landfill.
CDL: CD Landfill.
LP20 Building LP-20 site.
QADSY: Q Area Drum Storage Yard.

concentrations of contaminants, as well as the source area where each contaminant was found in the greatest concentration, along with applicable screening guidelines.

Not all media were analyzed in all of the remedial investigations. No surface water samples were taken in the QADSY investigation, and no surface water or sediment samples were collected at the Building LP-20 site. All surface water and sediment data reported in Table 3 were collected from the Bousch Creek drainage system near the Camp Allen Landfill.

The highest concentrations of trace elements in soils were from the CD Landfill, except for arsenic and cadmium, which were found at the highest concentrations at the QADSY and Camp Allen Landfill, respectively. In groundwater, the highest concentrations were found at the QADSY, Camp Allen Landfill, and the Building LP-20 site. Maximum concentrations in surface water and sediments were detected at the Camp Allen Landfill and the CD Landfill. Maximum on-site concentrations of trace elements were greater than all screening guidelines for soils, surface water, and sediments. Groundwater concentrations were greater than ten times the AWQC for all reported inorganic substances except arsenic.

Maximum concentrations of pesticides in all media were found at the CD Landfill. Dieldrin concentrations exceeded AWQC guidelines by more than ten times in groundwater and surface water. DDT concentrations in groundwater were greater than ten times the AWQC, and concentrations of DDT and DDE in sediments exceeded the ERL guidelines. PCBs were found at elevated concentrations in soil and sediment samples taken from the Camp Allen Landfill area. Values for total PCBs represent the sum of Aroclors 1242, 1254, and 1260. The maximum concentration of total PCBs in sediment exceeded the ERL guideline; there is no screening guideline for total PCBs in soils.

A variety of other organic compounds were detected in all media. Total PAH results represent the sum of acenaphthene, anthracene, benz(a)anthracene, benzo(b) and / or (k)fluoranthene, chrysene, fluoranthene, fluorene, naphthalene, phenanthrene, and pyrene. The highest concentrations of PAHs in soils were found at the Building LP-20 site and the Camp Allen Landfill. Maximum concentrations of other organic compounds in soils were from the Camp Allen Landfill, the QADSY, and the Building LP-20 site. There are no screening guidelines for any of the organic compounds detected in soils. Elevated concentrations of organic compounds were detected in groundwater samples from the Building LP-20 site, the QADSY, and the Camp Allen Landfill. Few organic compounds were detected in surface waters; those detected were found at the Camp Allen Landfill. Existing LOEL concentrations for organic compounds other than pesticides and PCBs were not exceeded in surface water, but were exceeded in groundwater by more than ten times for one contaminant, trichloroethene. Total PAH concentrations exceeding ERL guidelines were found in sediments from the CD

Landfill source area. All other PAH compounds detected in sediments were also from the CD Landfill, although no screening guidelines exist for these constituents.

Summary

Elevated concentrations of trace elements, PAHs, chlorinated solvents, pesticides, and PCBs have been detected in soils, groundwater, surface water, and sediments to varying degrees at Norfolk Naval Base. Several of these contaminants were detected at concentrations that far exceed their screening guidelines. NOAA trust habitats bordering the site include the lower Elizabeth River and Hampton Roads, both of which support many anadromous fish, estuarine fish, and invertebrate species. The resources of concern use the waterways as migratory corridors, juvenile nurseries, and adult habitats.

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