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Section: 03.04
Site 20903-5640 (White Oak)
Doc. #: 0001 Vol. I

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Volume I of III

REMEDIAL INVESTIGATION REPORT

DAHLGREN DIVISION DETACHMENT, WHITE OAK SILVER SPRING, MARYLAND

Prepared for:

Naval Facilities Engineering Command
Chesapeake Division
Washington, D.C. 20374

Contract No. N62477-85-C-0060

October 1992

Malcolm Pirnie, Inc.
ENVIRONMENTAL ENGINEERS, SCIENTISTS & PLANNERS

Section: 03.04
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EXECUTIVE SUMMARY

INTRODUCTION

This report presents the results of Phase I and Phase II of the Remedial Investigation (RI) for seven sites at the Naval Surface Warfare Center (NSWCWODET), White Oak, Maryland for the Naval Facilities Engineering Command (NAVFAC), Chesapeake Division, Washington, D.C. under the Navy's Installation Restoration Program (IRP). The seven sites investigated during the RI included:

- Apple Orchard Landfill (Site 2)
- Pistol Range Landfill (Site 3)
- Chemical Burial Site (Site 4)
- Ordnance Burn Area (Site 7)
- Abandoned Chemical Disposal Pit (Site 8)
- Industrial Wastewater Disposal Area 300 (Site 9)
- Industrial Wastewater Disposal Area 100 (Site 11)

Although none of the seven sites investigated score high enough under the Navy's scoring system to qualify for the National Priority List (NPL), the Navy's policy is that all of the remedial investigation activities be performed in accordance with the U.S. Environmental Protection Agency (USEPA). We have no data to indicate that the facility has been scored under the HRS or NRSII Hazardous Ranking Systems. The USEPA guidelines for the RI as set forth in ***Guidance on Remedial Investigations and Feasibility Studies under CERCLA***, EPA Office of Solid Waste and Emergency Response (OSWER) Directive 9335.3-01, dated March 1988, require an investigation of the general nature, extent, fate, and transport of contamination as well as a baseline risk assessment at each site.

The RI report summarizes the data collected and the results of both Phase I and Phase II of the RI for each site. Appendices A through F provide documentation to support the RI Report. The risk assessment determinations for both human health and the environment have been included as Appendix G. The results and conclusions of the Risk Assessment for each site have been incorporated into the main text of the RI report.

BACKGROUND

The basis for this RI is contained in a November 1984 ***Initial Assessment Study (IAS) Report***, NEESA 13-050, which was submitted to the NAVFAC, Chesapeake Division, by the Naval Energy and Environmental Support Activity, Port Hueneme, California. This report completes Phase I of the IRP Program at the NSWCWODET. The study concluded that 7 of 14 sites investigated at the NSWCWODET posed a potential threat to human health or the environment sufficient to warrant further study under the IRP program.

In April 1987, a ***Verification Phase Report*** was submitted to NAVFAC, Chesapeake Division by Malcolm Pirnie. This study concluded that subsequent investigative efforts should be conducted at the NSWCWODET for all seven sites under the Navy IRP program. All seven sites were recommended for further investigation to characterize the extent of contamination, define the impact on the environment by the sites, if any, and to design appropriate remediation methods to clean up the affected sites.

Phase I of the RI was conducted by Malcolm Pirnie, Inc. from January 1989 until April 1990. Prior to initiating the field work required for implementing Phase I of the RI, a Work Plan and Quality Assurance Project Plan (QAPP) were developed which described in detail the procedures used to collect and evaluate the data necessary to define the nature and extent of the contamination at each site. The Work Plan and QAPP were submitted to the NAVFAC, Chesapeake Division, in August 1989. The results of Phase I was summarized in a draft RI Report submitted to NAVFAC, Chesapeake Division in April 1990.

Prior to initiating the field work required for implementing Phase II of the RI, a Work Plan and QAPP were developed which described in detail the procedures used to collect and evaluate the data necessary to allow for the completion of the Feasibility Study and was submitted to NAVFAC, Chesapeake Division, in January 1991. Phase II of the RI

began in August, 1990 and will be completed with the submittal of the ***Feasibility Study***, which is scheduled for early Fall, 1992.

PURPOSE OF REMEDIAL INVESTIGATION

The purpose of the RI was to collect specific information concerning chemical contamination necessary to evaluate the extent of contamination in various media, the transport mechanisms, and the risk to human health and the ecosystem. The various media of concern include the surface water, groundwater, air, stream sediment, and soil. Phase I of the RI for the seven sites at the NSWCWODET was conducted to define the nature and extent of contamination at the seven sites. Subsequent activities conducted on the Phase II of the RI were conducted and designed to develop sufficient data to support a Feasibility Study (FS).

SUMMARY OF REMEDIAL INVESTIGATION

The nature and extent of contamination, the contaminant fate and transport, the baseline risk assessment, and the remedial objectives for each of the seven sites investigated is summarized as follows:

Site 2 - Apple Orchard Landfill

Site 2 (Apple orchard Landfill) is an abandoned landfill located south of Perimeter Road. The Site 2 landfill was operated as open disposal area and landfill from 1948 until 1982. According to the IAS, waste disposed of at Site 2 included domestic refuse, oils containing poly-chlorinated bi-phenols (PCBs), solvents, paint residue, acids and miscellaneous compounds. Prior to 1970, approximately 500 gallons of PCB-contaminated oil were deposited at this site.

Metals and PCBs were identified in the surface soil, subsurface soil, and the stream sediments at Site 2. PCBs concentrations at detectable levels in the soils and sediments exceeded the Resource Conservation and Recovery Act (RCRA) Corrective Action level of 0.09 mg/L. PCBs in the surface soils may be transported as fugitive dust in the atmospheric system or eroded by sheetflow processes, and to some extent, migrate downward into the

soil profile. PCBs and metals in the stream sediments can migrate as a suspended load when the stream flow is sufficient to erode the stream bed.

Metals and Trichloroethene (TCE) were identified in the groundwater beneath Site 2 during both Phase I and Phase II. Migration of the contaminants in the groundwater beneath Site 2 is predominantly towards the east southeast, towards the center of the facility, although groundwater near the stream diverges from the predominant direction and flows toward the stream. The migration of the contaminants in the groundwater at Site 2 is considered low based on the flow velocity of the groundwater.

The risk assessment of contamination present at Site 2 indicates that the primary threat to human health and the environment is from PCB contaminants in the sediment and soil. The primary exposure route would be through ingestion and dermal contact to the soil and dermal contact of the sediment. The remedial objective is to remove or stabilize the source(s) of contaminants, to prevent further contaminant migration into the soil and stream sediments, and to reduce the health risk associated with the exposure to contaminated surface soils and stream sediment to acceptable levels under the USEPA Superfund remediation goal.

Site 3 - Pistol Range Landfill

A soil gas survey, conducted during Phase I, identified the presence of volatile organic constituents in the soil gas vapor. Metals (cadmium, chromium, copper, and lead) contamination was confirmed in the surficial soils along the face of the landfill during Phase II.

Metals (cadmium, chromium, and lead) and volatile organics (1,2-dichloroethene (DCE), TCE, chlorobenzene, and methylene chloride) contamination were identified in the groundwater beneath Site 3 during both Phase I and Phase II. The source for the groundwater contamination is the generation of leachate from the landfill. Migration of the leachate in the groundwater is to the south-southeast, toward the center of the facility, and is considered to be moderate in magnitude. The analytical results for the surface water and sediment and the benthic survey indicate that the landfill has not impacted the quality of the surface water system.

The risk assessment of contamination present at Site 3 indicates that the primary threat to human health and the environment is from exposure of TCE in the groundwater. The primary exposure route would be through ingestion of groundwater and soil. The

remedial objective is to limit migration of contaminants into the soil or groundwater beneath the landfill. In addition, the remedial objective is to limit further migration of the contaminant outside the landfill in the groundwater and soil.

Site 4 - Chemical Burial Site

Information from a GPR survey was used to delineate the boundaries of four burial pits and to identify the presence of objects within the pits. The soil gas survey, conducted during Phase I, identified the presence of volatile organic constituents in the soil gas vapor.

Metals (cadmium, chromium, lead, mercury, and zinc) and volatile organic compounds (TCE, 1,2-DCE, 1,1,2,2-tetrachloroethane, methylene chloride, benzene, and chloroform) contamination were identified in the groundwater beneath Site 4 during both Phase I and Phase II. The groundwater contamination emanates from multiple sources that converge to form one plume. The volatile organic compound plume of greatest concern is the TCE plume. Migration of the leachate in the groundwater is to the south toward the center of the facility.

The risk assessment of contamination present at Site 4 indicates that the primary threat to human health and the environment is from groundwater contaminated with vinyl chloride and TCE. The primary exposure route would be through ingestion of contaminated groundwater. The remedial objective is to remove the source(s) of contaminants, to prevent further contaminant migration into the soil and groundwater, and to reduce the health risk associated with the exposure to contaminated groundwater to acceptable levels under the USEPA Superfund remediation goal.

Site 7 - Ordnance Burn Area

Nitroaromatic compounds (HMX, RDX, and 2,4,6-TNT) were detected in the surface soils at Site 7 in the area of the swale and in areas outside the swale and burn area. The vertical soil contamination profile indicates that the nitroaromatic contaminants are migrating from the surface down into the soil profile.

Nitroaromatic compounds (RDX, 2,4,6-TNT, HMX, 1,3,5-TNB, 1,3-DNB, 2,6-DNT, and 4-DNT), volatile organic compounds (TCB, CIS-1,2-DCE, and 1,1,2,2-tetrachloroethane) and low levels of metals (chromium, copper, lead, and zinc) contamination were identified in the groundwater beneath Site 7 during both Phase I and Phase II. The volatile organic compound plume appears to be related to the migration of volatile organics from Site 4

and/or Site 9. Migration of the nitroaromatics in the groundwater beneath the burn area is to the south towards the center of the facility.

The risk assessment of contamination present at Site 7 indicates that the primary threat to human health and the environment is from the nitroaromatic and volatile organic contaminants in the soils and groundwater. The primary exposure route would be through ingestion of groundwater and soil. The remedial objective is to remove the source of nitroaromatic and volatile organic compounds within the soil to prevent further downward contaminant migration and prevent contaminants within the soil from reaching groundwater. In addition, the remedial objective is to limit further migration of the contaminants identified in the groundwater.

Site 8 - Abandoned Chemical Disposal Pit

Metals were identified in the surface soil at Site 8 during Phase I. Metals (cadmium, chloride, lead, and mercury), volatile organic compounds (1,1,2-trichloroethane (TCA) and chloroform) and semi-volatile organic compounds (Bis(2-ethylhexyl)phthalate) were identified in the groundwater beneath Site 8 during both Phase I and Phase II. Migration of the contaminants in the groundwater beneath Site 8 is predominantly towards the north. The migration of the contaminants in the groundwater at Site 8 is considered very low based on the flow velocity of the groundwater and the distribution of contaminants in the groundwater samples.

The risk assessment of contamination present at Site 8 indicates that the primary threat to human health and the environment is from TCA and Bis(2-ethylhexyl)phthalate in the groundwater. The primary exposure route would be through ingestion of the groundwater. The remedial objective is to remove the source(s) of contaminants, to prevent further contaminant migration into the soil and stream sediments, and to reduce the health risk associated with the exposure to contaminated surface soils and stream sediment to acceptable levels under the USEPA Superfund remediation goal.

Site 9 - Industrial Wastewater Disposal Area 300

At Site 9, the primary source of contamination are nitroaromatic compounds (HMX, RDX, 2,6-DNT, and nitrobenzene), TCE and low levels of dissolved metals. The direction of the volatile organic compound and nitroaromatic contaminants in the groundwater is to

the south-southeast towards the confluence of the perennial stream and the intermittent stream.

Soil gas surveys near Buildings 304, 344, and 345 detected no volatile organic compounds in the soils while soil gas surveys near Buildings 336, 328, 310, and 311 documented the presence of volatile organic compounds in the soils. This indicates that former leaching wells/fields at those locations were used to dispose of industrial laboratory wastewater that included various volatile organic compounds that have impacted shallow soil and possibly groundwater in the area. Based on the shallow groundwater conditions and the potential mobility and concentration of the contaminants detected in the groundwater, contaminant transport in the groundwater system has been moderate.

The risk assessment of contamination present at Site 9 indicates that the primary threat to human health and the environment is from the nitroaromatic and volatile organic contaminants in the groundwater. The primary exposure route would be through ingestion of groundwater and a secondary exposure route would be through transport of contaminants in the soil. The remedial objective is to remove any remaining source(s) of contaminants to prevent contaminant migration into soil or groundwater and to limit further migration of the contaminant plume in the groundwater.

Site 11 - Industrial Wastewater Disposal Area 100

Metals (cadmium, chromium, copper, and lead) and volatile organic compounds (acetone, benzene, chloroform, 1,2-DCA, 1,2-DCE, TCE, tetrachloroethene) contamination were identified in the groundwater beneath Site 11 during both Phase I and Phase II. The groundwater contamination appears to emanate from multiple sources associated with the former leaching wells. Migration of the leachate in the groundwater is to the south from the center of the facility toward the southern boundary.

The risk assessment of contamination present at Site 11 indicates that the primary threat to human health and the environment is from the volatile organic contaminants in the groundwater. The primary exposure route would be through ingestion of groundwater and a secondary exposure route would be through transport of contaminants in the soil. The remedial objective is to remove any remaining source(s) of contaminants to prevent contaminant migration into soil or groundwater and to limit further migration of the contaminant plume in the groundwater.

1.0 INTRODUCTION

1.1 PURPOSE OF REPORT

This report documents the first and second phases of the Remedial Investigation (RI) for seven sites currently under study at the Naval Surface Warfare Center (NSWCWODET) in White Oak, Maryland (Figure 1-1). The first phase of the RI was conducted to define the nature and extent of contamination at seven distinct NSWCWODET sites (Figure 1-2). Subsequent activities conducted under the second phase of the RI were conducted and designed to develop data sufficient to support a Feasibility Study (FS).

Although none of the seven sites investigated scored high enough under the Navy's scoring system to qualify for the National Priority List (NPL), the Navy's policy is that all of the remedial investigation activities be performed in accordance with the U.S. Environmental Protection Agency (USEPA). The USEPA guidelines followed during the RI are set forth in "Guidance on Remedial Investigations and Feasibility Studies under CERCLA", EPA Office of Solid Waste and Emergency Response (OSWER) Directive 9335.3-01, dated March, 1988.

The activities in the RI are geared towards collecting the information necessary to evaluate the type and magnitude of contamination as well as the transport mechanisms and impacts of contamination on various media, such as surface water, groundwater, air, stream sediment and soils. The specific objectives for Phases I and II of the RI were to:

- Define the extent and nature of groundwater and soil contamination at the seven sites studied at the facility.
- Determine if surface waters have been contaminated with organic/inorganic compounds emanating from the studied sites.
- Develop an understanding of groundwater flow directions, hydraulic gradients and aquifer characteristics.
- Develop a list of Applicable, Relevant and Appropriate Requirements (ARARs) for the site.
- Develop data sufficient to prepare a baseline risk assessment for the seven sites.

1.2 REPORT ORGANIZATION

The remainder of this report summarizes the results of data collected during both phases of the RI for each site. Section 1 provides an introduction and summary of the facility's background, previous investigations, site investigations conducted during the RI, the risk assessment and the analytical methodology utilized for the RI. Sections 2 through 8 address each individual site by providing a site introduction, and discussions on site and facility background information, facility and site history, previous investigations, and investigations completed under each phase of the RI. During the RI, investigations were conducted on site surface features, surface water and stream sediment, soil and vadose zone (soil area between the surface and groundwater), groundwater, and geological features. The RI investigations were accomplished through environmental sampling, monitoring well/piezometer installations, soil borings, ground penetrating radar surveys, soil gas surveys and ecological sampling. Each site section also includes a discussion of the site physical characteristics, nature and extent of contamination, contaminant fate and transport, and a summary of the risk assessment conclusions.

Section 9 discusses investigations conducted at background sites. Paint Branch Creek was used as a source for background samples for surface water, sediment, and ecological sampling. Two background wells (BGW16 and BGW40) were used for collection of background groundwater samples.

1.3 FACILITY BACKGROUND

1.3.1 Facility Description

NSWCWODET is a Navy owned and operated facility for naval surface warfare research, located approximately 5 miles north of Washington, D.C. off New Hampshire Avenue. The facility is located in both Prince George's and Montgomery Counties (Figure 1-1). The NSWCWODET consists of about 732 acres of land bordered to the north by a mixture of residential, park and industrial/commercial properties, to the east by residential properties, to the southeast by the Harry Diamond Laboratory and USNR training center, to the southwest by the Hillandale residential community, and to the west by New Hampshire Avenue. Water is supplied to the facility, surrounding residences and businesses by municipal water systems.

1.3.2 Facility History

In 1944, the Navy acquired 870 acres of land in White Oak, Maryland for the expansion of the Washington Navy Yard-based Naval Ordnance Laboratory (NOL). On November 9, 1945, the Bureau of Ordnance Chief, Admiral Hussey, assigned NOL its first mission to carry out research and development for naval ordnance including explosives, projectiles, mines, and related munitions and control systems. In June 1948, the command and administration functions of NOL were officially transferred from the Washington Navy Yard to the facility. The site expanded rapidly during the Korean War, but has developed at a slower pace since the 1950s.

On November 3, 1969, 137 acres of land were transferred from the NOL to the United States Army. A fenced boundary was installed around this area, which is now the location of the Harry Diamond Laboratories. In September 1974, the NOL was renamed the Naval Surface Weapons Center during the consolidation of NOL with the Naval Weapons Laboratory located in Dahlgren, Virginia. Recent reorganizations within the Navy have resulted in assignment of the facility as a division detachment to Dahlgren with Dahlgren as the division headquarters. It is currently called the Naval Surface Warfare Center, Dahlgren Division Detachment, White Oak (NSWCWODET) which better describes its activities and mission.

NSWCWODET has kept the same basic mission throughout its history serving as the Navy's principal Research, Development, Test and Evaluation Center (RDT&E) for surface warfare weapon systems, ordnance technology, and strategic systems support. Because of its function as an ordnance RDT&E center, the contaminants of concern at the facility are typically:

- Laboratory solvents, acids and bases;
- Residuals from explosives (nitroaromatics); and
- Solid wastes.

1.3.3 Regional Ecology

1.3.3.1 Biological Resources

Vegetation communities on the facility have formed as a result of a variety of land uses, soil conditions, and slope. Former land uses such as gravel mining, building construction, landfilling, and logging have influenced the successional stages and plant species composition of the site. This, in turn, has affected the animal communities on the facility. The physical environment of, and various land uses on, the facility are typical of the region. Thus, the vegetation communities and wildlife habitats on-site are representative of regional patterns.

The biological resources of the site are discussed in the following sections. A list of plant species, animals, and potential vertebrates observed during site visits from April through June 1991 is contained in Appendix A. Also included in Appendix A is a list of the of the expected freshwater fishes of Maryland.

The facility covers approximately 732 acres. Areas occupied by roads, buildings and landscaping comprise 96.8 acres. The remaining acreage consists of 270.6 acres of open field and scrub-shrub community, 32 acres of pine forest, and 332.6 acres of hardwood forest (NSWCWODET, 1985).

<u>Developed Areas</u>

In developed areas, lawns consist of Kentucky Bluegrass, Red and Tall Fescue, Bermuda Grass, Red Clover, Korean Lespedeza, Annual Ryegrass, Zoysia Grass and Crown Vetch. Weed species commonly found in these areas include White Clover, Yellow Wood Sorrel, Chickweed, Henbit, Ground Ivy, Wild Strawberry, Purslane, Spotted Spurge, Knotweed, Garlic, Mustard, Dandelion, Plantain, Crabgrass, Goosegrass, Foxtail, Knotweed, and Nut Sedge (NSWCWODET, 1985). Trees in developed areas consist of maples, oaks, elms, poplars, and dogwoods.

Amphibian species associated with developed areas include Chorus Frog and Fowler's Toad. Reptile species include Fence Lizard, Box Turtle, Black Racer and Black Rat Snake. Bird species include Mourning Dove, European Starling, House Sparrow, Barn Swallow, Chimney Swift, Purple Martin, American Robin, Catbird, Brown Thrasher, Northern Mocking Bird, and Song Sparrow. Typical mammal species include Opossum, Eastern Cottontail, Gray Squirrel, Red Fox, Raccoon, and Striped Skunk.

Old field communities are found in abandoned areas. Vegetation found in these areas is determined by the length of time since abandonment. Pioneer species include Crabgrass and Horseweed. Mid-successional species are dominated by Goldenrod, White Aster and Broomsedge. As succession continues pines will invade the area and if left undisturbed, the area will evolve into a pine, or pine-hardwood forested community.

Typical amphibian and reptile species inhabiting this community type include Fowlers and American Toads, Six-lined Racerunner Lizard, Black Racer, and Black Rat Snake. Bird species include Red-tailed Hawk, Bobwhite Quail, Mourning Dove, Eastern Bluebird, Yellow-breasted Chat, Eastern Meadowlark, Northern Cardinal, Rufous-sided Towhee, Savannah Sparrow, and Grasshopper Sparrow. Mammal species include Opossum, Short-tailed Shrew, Least Shrew, Common Mole, Eastern Cottontail, White-footed Mouse, Meadow Mouse, Meadow Vole, Long-tailed Weasel, Striped Skunk, and Red Fox.

Scrub-Shrub Community

The scrub-shrub community represents a successional stage between an old field and forest community and is very diverse because it supports vegetation representative of both communities. Saplings characteristic of this community type include Loblolly Pine, Virginia Pine, Sweetgum, Eastern Redcedar, and Black locust. Other characteristic species include Japanese Honeysuckle, Persimmon, brambles, Poison Ivy, Trumpet Creeper, sumac, Virginia Creeper, and grape. The understory includes asters, goldenrods, Wild Onion, Strawberry, and Blackberry.

Typical amphibian species of this community type include Northern Cricket Frog, Northern Spring Peeper, American and Fowlers Toad, and Upland Chorus Frog. Reptiles characteristic of this habitat type include Eastern Mud Turtle, Box Turtle, Eastern Painted Turtle, Six-lined Racerunner, Northern Water Snake, Northern Black Racer, Black Rat Snake, and Eastern Kingsnake. Birds of this habitat type include Bobwhite Quail, American Robin, European Starling, Yellow-rumped Warbler, Northern Cardinal, Dark-eyed Junco, Tree Sparrow, White-throated Sparrow, White-eyed Vireo, Eastern Bluebird, Indigo Bunting, and Common Goldfinch. Typical mammal species include Short-tailed Shrew, White-footed Mouse, Meadow Vole, Red Fox, Raccoon, Striped Skunk, and White-tailed Deer.

Pine Forest

Pine forest in the Atlantic Coastal Plain is successional and indicative of disturbed areas. Primary canopy species are Loblolly and Virginia Pine. Older pine stands have an understory of White and Red Oak, hickory, Blackgum, and Sweetgum. Shrub layer species include Japanese Honeysuckle, Trumpet Creeper, Poison Ivy, Virginia Creeper, Highbush Blueberry, Flowering Spurge, and Spotted Wintergreen.

Typical amphibians of the pine forest community include Eastern Spadefoot Toad, Pine-woods Frog, and Green Tree Frogs. Typical reptiles include Eastern Box Turtle, Fence Lizard, Six-lined Racerunner, Ground Skink, Five-lined Skink, Corn Snake, and Black Rat Snake. Raptor species associated with this habitat type include Red-tailed Hawk, Broad-winged Hawk, and Great-horned Owl. Other birds include Bobwhite Quail, Mourning Dove, Common Flicker, Hairy Woodpecker, Yellow-throated Warbler, Pine Warbler, Eastern Meadowlark, and Rufous-sided Towhee. Typical mammal species include Pine Mouse, Opossum, Eastern Cottontail, Gray Fox, Raccoon, and White-tailed Deer.

Mixed Deciduous Forests

The majority of the forested regions of NSWCWODET can be classified as mixed deciduous. The mixed deciduous forest consists of an abundance of broad-leaved trees, including oaks, poplars, hickory, and maples and evergreens including pines, hemlocks, and magnolias. Trees and shrub species, including oaks, poplars, hickory, and maples are generally diverse and support a variety of animals.

The composition of the mixed deciduous forest varies due to selective climatic, soil, topographic, and land use factors. The mixed deciduous understory is populated with dogwoods, Eastern Redbud, American Holly, Striped Maple, Hophornbeam, and members of the magnolia family. The shrub layer consists of Northern Spicebush, Witch Hazel, Pawpaw, Wild Hydrangea, Mountain Pepperbush, and sumac. The forest floor supports numerous flower species including lilies, Ladies Slipper, Bloodroot, Wood Poppy, Larkspur, Spring Beauty, Trillium and various violets and mints.

A variety of food and nesting sites are available to bird species ranging from hawks and owls to warblers and finches. Other birds utilizing this habitat type may include Red-tailed Hawk, Ruffed Grouse, Pileated Woodpecker, Great Crested Flycatcher, Bluejay, Carolina Chickadee, Tufted Titmouse, Hermit Thrush, Veery, Red-eyed Vireo, Scarlet

Tanager, and several warbler species. Mammalian species typical of this habitat type includes Gray Squirrel, Eastern Chipmunk, Raccoon, foxes, Bobcat, and White-tailed Deer.

Oak-Hickory Forest

In undisturbed areas, a climax forest community known as an oak-hickory forest results. The oak-hickory forest is relatively dry and the soil is often sandy. The trees are generally widely spaced, with a low undergrowth of shrubs and vines.

Plants in this forest type include Pitch Pine, Tulip Poplar, Sweetgum, Shagbark Hickory, and Mockernut Hickory. Northern Red, Blackjack, White and Bur Oak are found in the canopy layer. Shrub species include Eastern Redbud, Flowering Dogwood, Northern Spicebush, American Hazel, Rhododendron, and Mountain Laurel. Typical understory species include Birdfoot Violet, Goat's Rue, Climbing Bittersweet, Wild Geranium, Big Merrybells, Solomon's Zigzag, Catbrier, and Moccasin Flower.

Animal species associated with this habitat type include Opossum, Gray Squirrel, Eastern Chipmunk, Eastern Cottontail, Raccoon, Gray Fox, White-tailed Deer, Broad-winged Hawk, Ruffed Grouse, Wild Turkey, Whip-poor-will, Red-bellied Woodpecker, Common Flicker, Blue Jay, Red-eyed Vireo, Scarlet Tanager, Summer Tanager, and Rose-breasted Grosbeak.

White-Tailed Deer

The most conspicuous mammalian species on the facility is the White-tailed Deer. Few deer were sighted during mammalian surveys of individual sites and tracks, scats, and browse sign were very evident. The most recent population surveys conducted on site indicate a herd of approximately 70 deer (Thomas Wray, II, Ph.D., personal communication).

At present, there is no hunting allowed on the facility. As a result, the deer on site are diurnal, commonly seen foraging in the mid-morning and mid-afternoon in the vicinity of Dahlgren Road and Keuster Road. It was possible to approach several of the deer quite closely during our field investigations. The deer appeared to be smaller than average size, emaciated, and had generally poor quality pillages. Assuming that approximately 635.2 acres of usable deer habitat exists at the facility (scrub-shrub, old field, pine forest and hardwood forest), and a herd of approximately 70 individuals exists on the base, the ratio of cover (in

acres) to individuals is approximately 9 to 1. This is much higher than the optimum ratio of 64 acres per deer, indicating that the herd is overpopulated (Barrett, 1991).

Paint Branch Creek

Paint Branch Creek represents the most important surface water body on the facility. The creek is located within the Potomac River Basin, and the Washington Metropolitan Area Sub-Basin (Area 02-14-02). Paint Branch Creek and all tributaries above the Capital Beltway (I-495) are designated as Class III - Natural Trout Waters. This use designation includes waters which have the potential for growth and propagation of trout and are capable of supporting self-sustaining trout populations and their associated food organisms.

Stocking continued in the area irregularly until 1944. It is believed that a naturally reproducing Brown Trout population existed in the Montgomery County portion of the watershed as early as the 1930's. The presence of Brown Trout in Paint Branch Creek was documented by the Maryland DNR in 1973, from the extreme headwaters to the upper boundary of the NSWCWODET (C. Gougeon, 1985).

Fish surveys conducted during the period 1974-1978 documented a dramatic reduction in the number of trout inhabiting the mainstem. The reasons for this are not clear. It is thought that both human-induced and natural factors contributed to the decline (C. Gougeon, 1985).

Since 1978, the Brown Trout has shown some signs of recovery as a result of several consecutive years of excellent reproduction in the headwaters. In the late 1970's, special fishing regulations were introduced in order to offer some protection for the trout population without eliminating recreational fishing opportunities. As a result, the Paint Branch Creek watershed, above Fairland Road (approximately 2.5 miles north of the NSWCWODET), was designated as a "Special Native Trout Management Area" (effective January 1, 1980). These regulations allow fishermen to catch trout on single hooks or flies, and required all fish caught to be released. These regulations remain in effect at the present time.

Maryland DNR has conducted numerous surveys since becoming aware of the natural Brown Trout fishery in Paint Branch Creek in 1973. Sampling on the facility was completed by DNR in the summer of 1990, however, the number of fish collected was not-sufficient to accurately quantify the population. Sampling during this study in April 1991 again confirmed the presence of Brown Trout in the stream on the facility. The survey did show

that the stream supports a marginal trout population. The stream is characterized by sparse trout habitat and variable water levels. Juvenile trout and fry are limited in this portion of the stream due to fluctuating water flow and temperature, and possibly increased sedimentation. Adult trout are more tolerant of these changes and are found on the facility (Thomas Wray, II, Ph.D., personal communication; Charles Gougeon, personal communication).

1.3.4 Facility Soils

Soils of the NSWCWODET tend to be moderately acidic with a pH ranging from 4 to 6 (Soil Survey Report, U.S. Naval Ordnance Laboratory, White Oak, Maryland, 1920). This may be due to the presence of hydroxyal, humic, and fulvic acids derived from the decay of organic matter. With the exception of streambed soils, the area soils tend to be moderately to excessively well drained and moderately to severely eroded.

1.3.5 Regional Geology

The area surrounding the NSWCWODET straddles the Piedmont and the Coastal Plain Physiographic Provinces (Figure 1-3). The boundary between these two provinces, referred to as the Fall Line, is a zone in which the Coastal Plain units are thin to absent due to non-deposition or erosion. The Fall Line on NSWCWODET is approximately 2,000 feet west and parallel to the Prince George's and Montgomery County Line (Figure 1-3). Both provinces are divided into eastern and western subdivisions by geographic features; the Piedmont by Parrs Ridge and the Coastal Plain by the Chesapeake Bay. The NSWCWODET straddles the eastern Piedmont subdivision and the western Coastal Plain subdivision. The topography of both subdivisions is similar and can be characterized as rolling to hilly uplands with steeply eroded stream valleys.

The Coastal Plain province consists predominately of unconsolidated, interbedded sand, silt, gravel, and clay units inclined (dipping) to the east to southeast. The sedimentary units of the Coastal Plain form a wedge-like deposit which thins along its western margin of the deposit at the Fall Line and thickens eastward. Minor consolidated horizons associated with shelly layers may extend over very localized horizontal zones. Due to sea level fluctuations during deposition of the Coastal Plain deposits, several erosional surfaces (referred to as unconformities) were formed during low sea level stands and also during periods of sea level rise. Coastal Plain sediments range in age from the Cretaceous to the

Holocene. The sediments overlie the igneous and metamorphic rocks of the Piedmont Province.

The Piedmont Province consists of fractured and faulted igneous, sedimentary, and metamorphic rocks. The eastern subdivision, which the NSWCWODET straddles, consists of gneiss, slate, phyllite, schist, quartzite, marble, serpentinite, granitic and gabbroic rocks. Rock units of the eastern subdivision range in age from Precambrian to Ordovician. Piedmont rocks dip to the southeast at approximately 125 feet per mile (Johnston, 1964) and extend under the Coastal Plain sediments. The rocks of the Piedmont are covered by Coastal Plain sediments, thick residual soils or saprolite (weathered rock) except along major river or stream valleys where the overburden has been eroded. The upper surface of the Piedmont rocks can be highly fractured. The degree of fracturing influences the rate of weathering of these crystalline rocks; the rate of weathering is accelerated in highly fractured zones due to the greater surface area exposed to weathering processes and the larger volume of water seeping through the fractured zones.

The saprolite developed in place by weathering of the underlying rock and varies greatly in thickness ranging from none to where rock outcrops to more than 100 feet. Generally, the saprolite is thickest on hilltops and thinnest in stream valleys. In the NSWCWODET area, the saprolite is generally 20 to 50 feet thick with some areas exceeding 50 feet (Froelich, 1975). The lithology of the saprolite depends on the mineralogy of the parent rock. Some minerals weather more readily than others and new minerals are formed depending on the bedrock mineralogy. Studies on saprolite in the northern Virginia area, indicate that some general weathering patterns can be expected. Rocks abundant in feldspars and quartz (felsic - i.e., granite) weather to kaolinite-bearing (a type of clay) soils. Rock with abundant mafic minerals (ultramafics high in iron and magnesium - i.e., diabase) weather to montmorillonite-bearing (a type of clay) silty soils (Obermeier and Langer, 1986).

A generalized stratigraphic column and geologic unit description for the vicinity is provided in Table 1-1.

1.3.6 Facility Geology

The NSWCWODET occurs within the Beltsville geologic quadrangle which was mapped by Withington and Froelich in 1974. The geologic units mapped across the NSWCWODET facility at that time are supported by soil borings conducted during the Verification Phase and RI and are illustrated on the surficial geology map Figure 1-3. As

mentioned previously, geologic units of the Piedmont and Coastal Plain provinces underlie the NSWCWODET. The boundary between these two units crosses the NSWCWODET from southwest to northeast approximately 2,000 feet west and parallel to the Montgomery and Prince George's County line. On the NSWCWODET facility, Piedmont units are exposed at elevations below approximately 340 feet above mean sea level (MSL) and are overlain by Coastal Plain deposits at elevations above approximately 340 feet MSL.

The typical pattern of Coastal Plain deposits overlying Piedmont units described in Section 1.3.5 exists at the NSWCWODET. Several of the stratigraphic units of the general vicinity, however, were not been observed on the NSWCWODET, such as the Quaternary Alluvium, Terrace Deposits, Upland Terrace Deposits, and Diabase Dikes. The Piedmont is represented by the Wissahickon Formation and the Coastal Plain by the Potomac Group and Upland Gravel and Sand. In the Fall Line zone, Coastal Plain sediments are generally only a few tens of feet thick and in many places have been entirely eroded away. For example, along stream valleys in the eastern portion of the facility west of Site 3 and southern portion of Site 9. However in the far eastern portion of the facility in the vicinity of Site 4, geologic logs of background well BGW16 and well 9GW7 at Site 9, indicate that these sediments can be up to 70 feet thick. Logs for wells 4GW82 and 4GW80 indicate that the thickness of Coastal Plain sediments can vary widely over short horizontal distances. wells 4GW82 and 4GW80 are approximately 150 feet apart. Bedrock was encountered in well 4GW82 at a depth of 65 feet below ground surface (BGS) and was not encountered in well 4GW80 at the completion depth of 82 feet. In fact, in well 4GW80 the drilling log indicates evidence that the completion depth of the well was still in Coastal Plain sediments. Variation in unit thickness is related to variations in the depositional processes and erosional processes that occurred during past and present day conditions. The upper surface of the gneiss bedrock of the Wissahickon Formation is quite variable due to weathering and appears to be covered by a layer of saprolite ranging in thickness from 4 to 90 feet thick.

Site specific geological information was obtained during the field investigations of the Verification Phase and RI studies. This information was used along with local and regional geologic information to determine the subsurface geology of the NSWCWODET. The NSWCWODET is underlain by the following three geologic units, listed in order from uppermost to lowermost:

- The upland gravel and sand (tug);
- The Potomac Group - consists of a sand and gravel facies (Kps) and a clay facies (Kpc);
- The Wissahickon Formation - consists of two facies and their corresponding saprolite:
  - A pelitic schist facies (Wp) and saprolite (Wps)
  - A diamictite gneiss facies (Wd) and saprolite (Wds)

1.3.7 Regional Hydrogeology

Groundwater in the unconfined aquifer in the NSWCWODET area is derived from the infiltration of precipitation in the immediate area (Johnston, 1964). Water that is not lost to sheetflow, interflow, transpiration, or evaporation, infiltrates into the unconsolidated overburden due to the force of gravity. The soils in the unsaturated zone, the area between the ground surface and the water table, vary in moisture content. The amount of soil moisture increases with depth and the water table forms at the point where soils become completely saturated. Within the saturated zone, groundwater flows laterally, by gravity flow, toward lower groundwater elevations to points of discharge such as wells, springs, seeps, or surface water bodies. The aquifer underlying the facility in classified as a TYPE I aquifer, according to Maryland Standard (COMAR 26).

The use of the term "permeability" in this text refers to the effective permeability of a material which is the percent of open pores or voids in a material that are interconnected and will allow the transmission of a fluid (Fetter, 1988). The terms "high" and "low" permeability refer to the relative permeability between two materials. When high permeable material (i.e., sand and gravel) alternates with low permeable material (i.e., clay), groundwater flow is altered by the lower transmissivity of the low permeable material. If a low permeable unit is overlying a high permeable unit and both units are inclined, groundwater flows down dip (down the inclined surface) in response to gravity and is subject to pressure due to the confining nature (lower transmissivity) of the upper low permeable unit. Groundwater infiltration may be slowed or stopped by a low permeable layer underlying a permeable layer. Groundwater accumulating on a low permeable unit that is situated above the regional groundwater table is referred to as a perched water table.

Groundwater in Coastal Plain units occurs under both unconfined and confined conditions depending on the relationship of the permeable and low permeable units. Groundwater in the Coastal Plain sediments occurs within the permeable sand, gravel, and coarse-grained silt units (aquifers). The low permeable clay and fine-grained silt units restrict groundwater flow (aquitard) which may reduce or prevent local recharge to deeper aquifers. The uppermost aquifer in the Coastal Plain Province is referred to as the water table aquifer or surficial aquifer and is considered unconfined. Aquifers situated between two aquitards are considered confined.

Groundwater in the Piedmont Province occurs within the crystalline rocks and/or the overlying saprolite which is residual material developed by weathering crystalline rocks (Figure 1-4). Groundwater movement in crystalline rocks is controlled by the presence, interconnection, and the orientation of structural features such as joints (fractures), cleavage planes, and faults. Joints commonly occur in sets of three (a joint system) oriented perpendicularly to one another. Two sets tend to be almost vertically inclined and the third is almost horizontal to slightly inclined. Thus, joints and other structural features provide vertical paths for groundwater infiltration and horizontal paths for lateral groundwater flow. Although groundwater can move underground for miles in crystalline rocks, such as those in the NSWCWODET area, movement is restricted by the lack of laterally extensive well-integrated networks of large interconnected structural features such as joints, fractures or faults. Studies on the Maryland Piedmont indicate that groundwater circulation occurs in the upper 300 feet of a saprolite and/or bedrock section and that the individual water-bearing fractures probably do not extend laterally more than a few hundred feet (Nutter, 1977).

The water bearing capacity of saprolite depends on the structure and texture of the parent rock unit as well as the degree of weathering resulting in saprolite development. Saprolite, in many cases, retains the original texture and structure of the parent rock. Saprolite developed on a massive unfractured crystalline rock tends to form a low permeable layer whereas saprolite developed on a highly fractured crystalline rock would tend to be more permeable due to preservation of the fracture patterns of the parent-rock by the saprolite. Texture of the parent rock also effects the permeability of the saprolite. Fine textured parent rocks tend to form clayey saprolite that would have a low permeability while coarse textured parent rocks tend to develop granular saprolite that would have a higher permeability (Water Supply Division, 1987). Saprolite forms at the top of a bedrock unit

in responses to weathering and develops with depth over time. Therefore, the upper portion of a saprolite unit is older and has experienced weathering longer than saprolite of the same unit at greater depths. As weathering continues in the saprolite unit, the texture and structure of the parent material may be altered. Fractures and joints that at one time were preserved in the upper portion of a saprolite unit may fill with clay or precipitates which lowers the effective permeability of the saprolite while saprolite at greater depths may still preserve the texture and structure of the parent-rock and exhibit a high permeability. Clayey saprolite or the more weathered upper portion of a saprolite unit can act as an aquiclude which may prevent local recharge to the aquifer.

1.3.8 Facility Hydrogeology

The results of the previous investigations provided the general geologic framework of each site and an initial estimate of groundwater flow direction at each site. Phase II of the RI included installation of seventeen additional soil borings from 8.5 to 85 feet in depth, 15 additional groundwater monitoring wells and one piezometer at the seven sites across the facility. These wells and the existing monitoring well network were used to determine the groundwater level and the extent of contamination migration. Multiple-well aquifer tests (pumping tests) and single-well aquifer tests (slug tests) were designed and conducted to define some of the hydrologic parameters of the saturated sediments and saprolite.

Groundwater occurs in both unconfined and confined conditions under the facility. The sand and gravel units of the Coastal Plain Province and the upper most weathered zone of the saprolite of the Wissahickon Formation, comprise the unconfined or water table aquifer. The thickness of the saprolite varies with the degree of weathering. Where erosion has removed the overlying Cretaceous and Tertiary sediments, the saprolite is thicker due to greater exposure to weathering processes. Based on drill logs from the recent field investigation, the saprolite acts as an aquitard in places where it has a high clay content and unfractured texture. Therefore, the saprolite can limit the water flow between the overlying water table and the underlying fractured Wissahickon Formation (Wd) when there is a high clay content. Groundwater flow within the competent bedrock is limited to fractures and occurs under confined conditions at most sites.

Interconnection between the groundwater flow confined within the fractures of the bedrock and the water table aquifer appears limited based on analysis of soil borings during the RI field investigations. However, it is likely that where the structural fabric of the

fractures has been retained in the saprolite despite weathering, hydraulic connection occurs. At points of interconnection between the two aquifers, relative hydrostatic pressure determines the direction of groundwater movement. In topographically high areas, the hydrostatic pressure of the water table aquifer is generally higher than the confined aquifer and therefore, recharge into the fractures probably occurs. In topographically low areas where the confined groundwater is under high hydrostatic pressure, groundwater flow is probably out of the fractures and into the water table aquifer. At Site 4, a topographically high area, analysis of samples collected during installation of well 4GW82 indicated that the saprolite prevented downward infiltration of groundwater into the underlying Wissahickon Formation. Samples collected from 4GW82 from the Coastal Plain sediments below the water table were saturated while deeper samples from the saprolite were dry. At Site 3, a topographically low area, a water bearing fracture zone was intercepted approximately 68 feet below ground surface (BGS) during installation of well 3GW78D. Water rose to approximately 11 feet BGS after completion of the well. This is the approximate elevation of the nearby perennial stream flowing on fractured bedrock. Groundwater flow from fractured bedrock probably supports the stream in this area.

Within the sediments that comprise the water table aquifer, variability in grain size produce interbedded layers of high and low permeability. The low permeability units which consists predominately of silty clays, produce locally perched water table conditions. At Site 4 two separate silty clay layers within the Potomac Group inhibit the infiltration of groundwater. The perched water table appears to be intermittent and occurs during wet seasons or for a short period following heavy precipitation events based on water level data from wells 4GW10, 11 and 11A.

Groundwater circulation occurs within the upper portion of the unconsolidated material. At the large scale, groundwater moves from recharge zones in upland areas to discharge zones which support perennial stream flow such as Paint Branch Creek and its tributaries in lowland areas. Generalized groundwater flow directions for the facility are presented on Figure 1-4. Flow directions for each site are based on graphical analysis of water levels measured on August 19 and 20, 1991 and have been adjusted, as much as possible, to reflect site conditions such as topography or adjacent surficial features. In general, groundwater flow mimics the topographic surface, and flows from topographically high areas to topographically low areas. Groundwater flow is also influenced by the surface water drainage pattern of Paint Branch Creek and its unnamed tributaries which transect

the site. Table 1-8 presents water levels recorded at the facility during the Confirmation Study in 1986, the Phase I Remedial Investigation in 1990, and the just completed Phase II Remedial Investigation in 1991.

In addition to defining the direction of groundwater flow for the facility based on graphical analysis of water levels in wells at each site, the Phase II Remedial Investigation included tests to determine the physical parameters of the aquifer at Sites 4 and 11 using multiple-well, constant-rate pumping tests and at all sites under investigation using single-well slug tests.

A summary of the construction details and water table elevations for all groundwater monitoring wells and piezometers on the NSWCWODET is provided in Table 1-2. The well elevations listed in Table 1-2 for Phase I wells were established by Kamber Engineering and for Phase II wells by Maryland Photogrammetric, Inc., during a well survey and include both horizontal and vertical control. A listing of wells and piezometers installed during each phase is provided on Plate 1. A copy of the well survey reports is provided in Appendix D. The hydrogeologic summary for each site describes significant features that may impact the migration of contaminants associated with surface water and groundwater.

Hydrogeologic Framework

The hydrogeologic framework of an aquifer system is defined by the rate of water movement through the material (Hydraulic Conductivity (K)), the rate of water movement through the entire saturated water column of the aquifer (Transmissivity (T)), and the amount of water available from within the pore spaces between the sediment grains of the aquifer (Storativity (S)). For clarity in the report, all values of K are presented as centimeters per second (cm/sec), all values of T are presented as centimeters squared per second, and by convention S is unitless.

Determination of K permits estimation of rate of contaminant migration if contaminant characteristics are known. Calculation of T for the aquifer is an estimate of the rate of flow for the aquifer and when combined with S allows estimation of water flow volumes required for remediation design. Determination of the aquifer thickness for each site is based upon analysis of boring logs collected during the field investigation and from prior site characterization studies.

Grain size analysis was conducted on selected samples collected from soil borings during the previous field investigation to characterize the grain size distribution of sediments for the seven sites at the facility. Samples selected for grain size analysis were prepared using ASTM Method D-421-85 and analyzed using ASTM Method D-422-63 (Re-approved 1972). Grain size distribution curves were produced from the results of the analysis. The well number, the sample number, and the depth below ground surface for each of the samples analyzed and the grain size distribution charts are provided in Appendix E.

Initial estimates of hydraulic conductivities within the saturated sediments underlying each site were derived from grain size analysis of selected samples and published charts (Driscoll, 1986). An approximate estimate of hydraulic conductivity can be based on the grain size distribution analysis sediment particles from a particular strata or unit. A more precise estimate is derived based on comparison of the grain size distribution analysis with published curves in Driscoll (1986) which relate grain size distribution to various hydraulic conductivities for grain sizes greater than clay sized particles. These estimates were used in the constant-rate pumping test and slug test design. After the initial estimates of hydraulic conductivities were derived, the pumping wells were designed for construction at Sites 4 and 11. In addition, wells to be slug tested were selected for all sites under investigation. Sedimentologic characteristics determined during the grain size analysis provide an approximate measure of hydraulic conductivity.

Constant-Rate Pumping Test Design

Multiple-well tests to delineate the hydrological characteristics of the saturated sediments underlying Sites 4 and 11 were conducted. The facility straddles two physiographic provinces, the Piedmont and the Coastal Plain which have different geologic and therefore different hydrologic properties. Constant-rate pumping tests were conducted in order to determine the hydrologic characteristics sediments of each province. Each constant-rate pumping test for a 24-hour pumping cycle and 24-hour recovery period. Two constant-rate pumping tests at Site 4 were conducted to provide three dimensional aquifer characterization of the Tertiary and Cretaceous unconsolidated sediments of the Coastal Plain Province. Site 4 was selected for testing of Coastal Plain sediments since the thickest deposits of Coastal Plain sediments occurred on the site. One constant-rate pumping test was conducted at Site 11 to characterize groundwater flow within the saprolite zone of the Piedmont Province. Site 11 was selected because no to very thin Coastal Plain sediments

were present and there would be no interference from Coastal Plain sediments during testing of the saprolite.

Three of the 15 groundwater quality monitoring wells installed during Phase II of the RI were designed as pumping tests wells (4GW79, 4GW81d, and 11GW87) prior to commencing the field program. In order to reduce overall project costs placement of the constant-rate pumping test wells and associated observation wells were limited since each well was also required for groundwater monitoring. Previously installed groundwater monitoring wells were utilized as observation wells where possible to reduce overall project costs.

Each well scheduled for a constant-rate pumping test was designed to meet three criteria based on the minimum hydraulic conductivities estimated from the grain size distribution curves. The three criteria are as follows: the well screen and sand pack used during well construction would not limit or restrict the groundwater inflow from the aquifer; the aquifer thickness in the vicinity of the planned pumping well would be adequate to support a pumping well; and there would be observation wells within 75 to 100 feet of the planned pumping well location to facilitate monitoring of the groundwater level drawdown during the constant-rate pumping test.

Analysis of the initial groundwater characteristics determined from previous studies of the site and published data suggested that the water bearing unconsolidated sediments probably extended 95 to 120 feet below ground surface at Site 4, depending upon the degree of erosion. Geologic information suggested that the saprolite (wds) at Site 11 was between 50 and 70 feet thick. During pumping well design, grain size distribution curves (Appendix E) for selected samples from well 4GW50 were used to characterize the grain size distribution of the planned pumping well screened interval. Well 4GW50 was the closest well sampled to a depth approximating the planned screened zone for pumping wells 4GW81D and 4GW79. Analysis of the grain size distribution curves suggested an average K of between 0.047 and 0.071 cm/sec (1,000 and 1,500 gpd/ft^2) for Site 4. Grain size distribution curves for selected samples from Wells 11GW66, 11GW67, 11GW69, 11GW70D, and 11GW71 were used to characterize the grain size distribution of the pumping well screened interval for Site 11. These sediment samples were selected to provide a representative grain size distribution for the design of the Site 11 pumping well. Analysis of grain size distribution curves for wells 11GW66, 11GW67, 11GW69, 11GW70D, and

11GW71 (Appendix E) suggest an average hydraulic conductivity between 0.024 and 0.047 cm/sec (500 and 1000 gpd/ft^2) for the saprolite at Site 11.

Initial well design was based on a 6-inch inside diameter (I.D.) well with 30 feet of continuous wrapped screen (0.02 or 0.03 inch opening). Continuous wire wrapped screen was used rather than machine slotted screen (normally used for monitoring wells) to maximize screen open area. The screen open area was selected along with an appropriate sand pack having an appropriate grain size distribution to restrict inflow of formational material (sands) while maximizing groundwater inflow. The sand pack was designed to restrict 90 percent of the formational material while not limiting the passage of groundwater into the well. A Number 1 Morie Filter Graded Sand was used for sand pack for all pumping wells. As designed, the minimum specific yield of the two wells at Site 4 were estimated to be between 12 and 15 gallons per minute (260 gpd/sq.ft.) and between 7.5 and 9 gallons a minute for the well at Site 11. After installation, each well was developed using the air surging method to remove fines from within the well and the immediate vicinity of sand pack to insure that the flow of groundwater during pumping was representative of the characteristics of the aquifer.

An In-Situ Hermit Data Logger and pressure transducers were used to automatically record the water levels in the pumping well and in at least two observation wells during each constant-rate pumping test and recovery period. In the observation wells, a pressure transducer was inserted in the well at a predetermined depth below the water table. A pressure transducer was inserted in the pumping well at a predetermined depth below the top of the water table and above the top of the submersible pump. the transducers were connected to the data logger which recorded the change in water level on a logarithmic time scale. Water levels were also recorded manually in the pumping well and in several observations wells during each constant-rate pumping test and recovery period.

Water level data, pumping rates and the pumping test analysis for the constant-rate pumping tests conducted at Site 4 and Site 11 are provided on Appendix E. Both Time-Drawdown and Distance-Drawdown curves were generated from the water level data collected. Calculations and graphical methods used to derive relative T, K and S were from Driscoll, 1986.

At Site 4, well 4GW81D which penetrated Coastal Plain sediments to a depth of 84 feet below ground surface was pumped for a continuous 24-hour period on July 17 and 18, 1991 at a constant rate of 8 gpm. Throughout the pump test, water levels were monitored

at frequent intervals until 95 percent recovery was observed in the pumping well. During the pump test and recovery period, water levels were recorded in the pumping well (4GW81D), and in observation wells 4GW81S, 4GW80, 4GW50, and 4GW82.

Hydraulic conductivity, Transmissivity and Storativity were calculated from results measured during the pumping test at 4GW81D. Using wells 4GW81S, 4GW80 and 4GW50, drawdown at time (t = 100, 500, and 1,000 in minutes) at known distances from the pumping well, calculations were to derive values of T of 3520, 4310, and 3911 gpd/sq.ft., respectively. The calculated storativity values were 1.09×10^{-3}, 2.21×10^{-3}, and 5.21×10^{-3} (storativity is a unitless number). Values of T based on Time-Drawdown in specific observation wells (4GW81S and 4GW80) were calculated to be 3641 and 4911 gpd/sq.ft., respectively. These values are similar to those derived using the Distance-Drawdown curves. Storativity values were calculated to be 2.21×10^{-3} and 3.75×10^{-4}.

The second pump test at Site 4 was conducted on well 4GW79 which penetrated Coastal Plain sediments to a depth of 78 feet below ground surface. The well was pumped for a continuous 24-hour period on August 19 and 20, 1991 at a constant rate of 7 gpm. Water levels were monitored at frequent intervals until 95 percent recovery was observed in the pumping well. The well recovery period was approximately 4 hours. During the pump test and recovery period, water levels were recorded in the pumping well (4GW79) and in observation wells 4PZ89, 4GW50, and 4GW81S.

Hydraulic conductivity, Transmissivity and Storativity were calculated from results measured during the pumping test at 4GW79. Using wells 4PZ89, 4GW50 and 4GW81D, drawdown at time (t = 1,000 in minutes) at known distances from the pumping well, the calculated value of T was 7,700 gpd/sq.ft., respectively. The calculated storativity value was 2.98×10^{-3}. Values of T based on the Distance-Drawdown method approximate the estimates derived from the grain size distribution curves. The estimates of storativity are much lower than expected for an unconfined aquifer. Driscoll (1986) reports that the average estimated storativity value for unconfined aquifers ranges from 0.1 to 0.03 and that storativity ranges from 10^{-2} to 10^{-4} for confined aquifers.

A significant change was observed in the hydraulic characteristics of the aquifer between the two pumped wells at site 4. Values of T derived from distance-drawdown plots at a specific time ranged from 3,500 to 7,700 gpd/ft^2. This variation in hydraulic characteristics is attributed to the variable nature of the sediments underlying the site.

One pump test was conducted at Site 11 on well 11GW87. Prior to conducting the pump test, the initial groundwater characteristics determined estimated using previous studies of Site 11 and published data. This analysis suggested that the water bearing saprolite probably extended 25 to 70 feet below ground surface, depending upon the degree of weathering and erosion. Grain size distribution curves suggested a value of K of between 500 and 1,000 gpd/sq.ft.

During installation of well 11GW87, ground water was intercepted at approximately 30 feet below ground surface. The well was terminated at 56.5 feet below ground surface because drill cuttings indicated that competent rock had been reached. Sampling through 4¼-inch I.D. HSA was stopped at 30 feet below ground surface due to auger refusal. However, visual analysis of the sample in the split spoon sampler from that interval indicated moist and very dense saprolite. As a result, air rotary drilling was used to finish drilling the borehole to the top of competent bedrock. After removal of drilling equipment, water rose in the borehole to approximately 16 feet below ground surface. The well was set at 56.6 feet below ground surface and developed after installation by air surging techniques. A preliminary pump test was conducted using a pumping rate of 5 gpm, which was approximately 66 percent of the estimated yield based on the grain size distribution. The well was pumped dry in approximately 12 minutes, which indicates that recharge to the well from the aquifer was significantly lower than expected.

A pressure transducer inserted in the well and connected to an automatic data logger was used to record the rate of well recovery. Hydraulic conductivity values derived using the well recovery rate (Bouwer, 1988) suggests that K for the saprolote is approximately 4.62 x 10^{-5} cm/sec, which is several orders of magnitude lower then the value estimated based on the grain size distribution curves. However, this variation is not unexpected since the estimation procedure using grain size distribution curves (Driscoll, 1986) is known to be invalid for material with a grain size smaller than silt-size grains. Thus, the variation, probably can be attributed to the higher clay-size material within the saprolite. During drilling of well 11GW87, it was noted that soil sample within the same 18-inch split spoon sampler range widely from clay to sand-sized grains depending on the textural variation of the parent rock. Observations from the soil samples indicate that the gnessic portions of the Wissahickon weather to interbedded layers of sand and silty clay with sand forming from quartz grains and silty clay from feldspars with the gneiss. Since the parent rock of gneiss

has a banded texture predominately of quartz and feldspar, it is not unexpected that it would weather to bands or layers of sand (quartz) and clay (feldspar).

A summary of the results of the pumping test analysis is provided in Table 1-3. Observations recorded during the constant-rate pumping test and analysis for Sites 4 and 11 are provided in each site specific geology discussion, Sections 4.3.4 and 8.3.4, respectively. The values derived from the analysis of the constant-rate pumping test conducted at Site 4 were used to determine the velocity of groundwater flow through the unconsolidated sediments at Sites 7, 8, and 9. The values derived from the analysis of the constant-rate pumping test conducted at Site 11 were used to determine the velocity of the groundwater flow through the saprolite unit at Sites 2 and 3. A summary of the estimated groundwater velocity at each site is provided in Table 1-4.

Single-Well Aquifer Slug Tests

The single-well aquifer or "slug" tests were conducted at each site under investigation at the facility to determine estimates of the hydraulic conductivity of site sediments. Selected monitoring wells were used to conduct the tests. The testing procedure consisted of placing a pressure transducer connected a data logger to record the change in water level with respect to time as a known volume of water was removed or added to the well. The estimated hydraulic conductivity is based on the change in water level over time until the pretest water level (static water level) was achieved. This test method permits estimation of the saturated hydraulic conductivity (K) of aquifer materials directly around the tested well based on water level response to the test (Bouwer, 1988). Calculation of estimated hydraulic conductivity is based upon mathematical equations from Bouwer and Rice (1976) and Bouwer (1988). The 38 wells tested and the estimated hydraulic conductivities are summarized in Table 1-3.

1.3.9 Potential Routes of Migration

The investigation results of the site physical characteristics, the contaminant characteristics, the site source characteristics, and the extent of contamination for each site has been used to define the potential routes of contaminant migration and fate. A qualitative screening analysis has been conducted to provide an assessment of contaminant fate and transport for each site. The screening analysis was designed to identify each transport process affecting the migration and fate of various contaminants within and among

environmental media, to determine the direction of migration and to provide an approximate estimate of the rate of transport, and to identify areas to which contaminants have been transported.

The potential routes of contaminant migration and fate can be separated into five basic categories:

- Atmospheric system;
- Surface water system;
- Soil system;
- Groundwater system; and
- Biotic system (no transport involved).

The atmospheric fate will be addressed whenever the potential exists for gaseous or airborne particulate contaminants are released from the site based on the results of the fate assessment of the surface water, soils, and/or groundwater. The fate of atmospheric contaminants is based on the relative directional frequencies of wind over the site. The rate and extent of migration of atmospheric contamination is based on the relative speed and stability of the wind and, for particulates, the grain size. Contaminant migration associated with atmospheric releases include fugitive dust resulting from wind erosion and/or vehicular travel over contaminated soils, and volatilization releases from soil vapor, surface spills, and surface water. Settle-out and rain-out are important mechanisms of contaminant transfer from atmospheric media to both surface soils and surface water. Rates of contaminant transfer caused by these mechanisms are difficult to assess qualitatively; however, they increase with increasing soil adsorption coefficients, solubility, particle size and precipitation frequency. If areas identified as likely to receive significant contaminant concentrations include areas supporting edible biota, the bio-uptake of contaminants is also considered as a possible environmental fate pathway. Direct bio-uptake from the atmosphere is a potential fate mechanism for lipophilic contaminants. Bio-uptake from soils or water following transfer of contaminants to these media will also be considered.

The fate of contaminants released from the site to surface water was considered. The direction of contaminant movement is defined only for contaminants introduced to streams by the site. Important intermedia transfer mechanisms that were considered where significant surface water contamination was expected included transfers to groundwater

where hydrology in the area indicated significant surface water/groundwater exchange; transfers to biota where water contaminated with lipophilic substances support edible biotic species, transfers to the atmosphere where surface water was contaminated by volatile substances. Transfer to stream sediment was also considered in those cases where contaminants were in the form of suspended solids, or in a dissolved state or were hydrophobic substances that may be adsorbed by organic matter in the bed sediments. Transfer between the surface water and the stream sediments was considered to be a reversible process. Stream sediments often act as a temporary repository that can gradually release contaminants into the stream. Sorbed and particulate contaminants are frequently transported with stream sediment to migrate downstream.

The fate of contaminants in the soil medium was considered whenever soil contamination was identified by the RI or through transfer mechanisms from other contaminant media. The most significant contaminant movement in soils is a function of liquid movement through the soils. Liquid contaminants can infiltrate directly through soils under the influence of gravity. Infiltration of liquid contaminants can be enhanced following precipitation events due to infiltrating water. Precipitation, run-on, or human-applied water migrates by percolation through the soil. Soluble contaminants in the soil can be dissolved and leached by the percolating water and migrate downward through the soil column and can eventually reach the water table. The downward migration rate of soluble contaminants in the soil is a function of net water recharge rates, the solubility and density of the contaminants present, and the physical characteristics of the soil. Contaminants with high soil adsorption coefficients may bind to soils and become relatively immobile. Important intermedia transfer mechanisms affecting soil contaminants other than leaching include volatilization and suspension (fugitive dust) into the atmosphere, bio-uptake by plants and soil organisms, and sheetflow erosion into nearby surface water bodies.

The fate of contaminants in the groundwater medium was considered whenever groundwater contamination was identified through the RI or through the transfer mechanisms from other contaminated media. The direction and rate of contaminant migration in the groundwater was based on the hydrogeologic information obtained during the RI and chemical/physical properties of the contaminants. Contaminant migration associated with the groundwater includes both vertical and horizontal migration of contaminants in the saturated zone of the aquifer. Important mechanisms of contaminant

transfer from groundwater to other environmental media include contaminated water exchange between groundwater and surface water and bio-uptake.

The fate assessment for the biotic medium will be considered whenever the potential existed for biotic contamination based on the results of the fate assessment of the atmosphere, surface water, soils, and/or groundwater. The assessment addressed the biotic contact with the contaminated media and identified biota used directly by man and those that introduce the contaminants to species used by man through the food chain. Fate assessments associated with edible tissue concentration was beyond the limits of the data for the RI and, therefore, are not addressed.

1.4 PREVIOUS INVESTIGATIONS

1.4.1 Initial Assessment Study

In November 1984, an Initial Assessment Study (IAS) Report, NEESA 13-050, was submitted to the Department of the Navy. This report completed Phase I of the Navy Installation Restoration Program (IRP) at the NSWCWODET. The study concluded that seven of the 14 sites investigated at the NSWCWODET posed a potential threat to human health or the environment sufficient to warrant further study under the IRP. Figure 1-2 illustrates the specific location for each of the seven hazardous waste sites. The criteria used during the IAS to recommend inclusion in the Navy Confirmation Study were that:

- Sufficient evidence existed to indicate the presence of contamination; and
- The contamination posed a potential threat to human health or the environment.

1.4.2 Confirmation Study

Following completion of the IAS in 1984, the next investigation conducted at NSWCWODET was performed in two steps. The first step consisted of a Verification Study which focused on determination of the presence or absence of contamination at the seven sites recommended for further study by the IAS. The second step consisted of a Confirmation Study which focused on characterization of the contamination at each of the seven sites. Begun in the 1985, the investigation was concluded in 1987 with the completion of the Confirmation Study.

The Confirmation Study included determining whether specific toxic or hazardous substances had contaminated the environment at the seven sites within the facility. The purpose of this phase was to determine if soil and water contamination existed at the seven sites and to characterize the types of contamination at the sites. This was accomplished through various types of field investigation techniques including monitoring well/piezometer installation, soil gas surveys, geophysical surveys, and environmental sampling (groundwater, surface water, soil, and stream sediment). The results of the investigations indicated that contaminants were present in varying concentrations at all of the sites and further investigations were required to fully characterize the contamination at the seven sites.

A Confirmation Study Ranking System (CSRS) was used to systematically evaluate the relative severity of potential problems at the seven sites recommended for further investigation. The CSRS scores reflect the characteristics of the wastes, the potential migration pathways from the site, and possible contamination receptors on and off the sites. The scores of the sites listed in the IAS were used to develop a priority list for scheduling projects and were not used to decide which sites would require further investigation.

1.5 REMEDIAL INVESTIGATION

The RI was conducted in two phases. The first phase conducted from January, 1989 and concluded in April, 1990 was conducted to define the nature and extent of contamination for each of the seven sites under investigation. Investigations conducted included installation of groundwater monitoring wells, performance of soil gas and geophysical surveys, and sampling of groundwater, surface water and surface soils. The results of Phase I were summarized in a draft RI Report submitted to NAVFAC in April, 1990. The second phase of the RI was conducted to obtain data that would allow the completion of the Feasibility Study. The second phase of the RI began in August, 1990 and will be completed with the submittal of the Feasibility Study, scheduled for 1993.

The field investigation methods used during the performance of this RI were selected to meet the data needs established in the IRP Work Plan for this facility. The field investigation methods accomplished were used to investigate site physical characteristics, define the sources of contamination, and evaluate the nature and extent of contamination. Performance of the three above-mentioned methods is called site characterization. Areas investigated during the site characterization phase included the following:

- Surface features investigations;
- Contaminant sources investigations;
- Surface water and sediment investigations;
- Soil and vadose zone investigations; and
- Groundwater Investigations.

A summary of the sampling and investigation tasks performed for each media by site is summarized for both phase of the RI in Table 1-5.

1.6 TECHNICAL MEMORANDA

The following technical memoranda for the field work is a brief, technical summary of several activities completed during this phase of work. Full descriptions of the activities are provided on Appendix F . The following activities are discussed:

- Soil gas surveys;
- Geophysical surveys (ground penetrating radar);
- Monitoring well/piezometer procedures;
- Subsurface soil collection;
- Subsurface soil screening for volatile organics;
- Measurement of groundwater levels;
- Groundwater sampling;
- Surface soil and sediment sampling;
- Surface water sampling; and
- Ecological sampling.

1.6.1 Soil Gas Surveys

Soil gas surveys were performed at Sites 2, 3, 4, 9, and 11 to gain a better understanding of volatile organic plume extent and orientation to aid in the finalization of well placement. A grid was staked out in the area of concern for each site to be surveyed. Soil gas was screened near each staked point or node of the grid. At each node a solid probe was driven into the ground to the desired depth. The solid probe is a single piston slam bar, used to make a vertical, small diameter hole in the soil. After the hole is made, the probe is carefully withdrawn to prevent collapse of the walls of the hole. The soil gas probe is inserted in the hole. A HNu Photoionization Detector is connected to the probe. Subsurface organic compound concentrations are measured after the probe has been purged. The soil gas sampling procedures are described in more detail in a Standard Operating Procedure (SOP) in Appendix F.

1.6.2 Geophysical Surveys

A Ground Penetrating Radar (GPR) survey was performed at Site 4 to define the approximate location of the former waste disposal pits; four at Site 4 and one at Site 8. The GPR standard operating procedures are described in more detail in Appendix F. The expected GPR penetration at this site was about 8 to 15 feet and was limited by the depth of a silty clay lens identified during previous monitoring well installations. Lithologic samples were collected using a split spoon sampler and were used to characterize the subsurface geology at each site. A summary of the geologic sampling conducted is summarized in Table 1-6.1

1.6.3 Monitoring Well/Piezometer Procedures

The procedures that were utilized during the installation, abandonment, and testing of the monitoring wells and piezometers are provided below. Lithologic samples were collected using a split spoon sampler and were used to characterize the subsurface geology at each site. A summary of the geologic sampling conducted is summarized in Table 1-6. The development and sampling date for each well is summarized in Table 1-7.

1.6.3.1 Installation

The installation of 26 additional monitoring wells and eight piezometers during Phase I and 15 wells and one piezometer during Phase II were performed at the 7 NSWCWODET sites. The wells and piezometers were drilled as borings for geologic information and then completed as monitoring wells or piezometers. All borings were drilled using a 4 7/8-inch or 6-inch inside diameter continuous flight hollow stem auger during Phase I. During Phase II wells were installed using air rotary or dual wall air rotary as specified in the following discussion. Soil samples were collected using a 1.4-inch inside diameter split spoon sampler driven 18 to 24 inches using a 140-pound hammer falling 30 inches as described in ASTM D-1586. Blow counts were recorded for each 6-inch interval.

All 2-inch inside diameter monitoring wells and piezometers installed using hollow stem augers were constructed of 2-inch inside diameter, flush-threaded Schedule 40 PVC. The borings were advanced with either 4 7/8-inch or 6-inch inside diameter hollow steam augers to the appropriate depth. The well casing and screen was placed through the annulus of the augers, leaving approximately two feet of riser extending above the ground surface for stickup wells or the riser was cut off just below ground surface for flush mounted wells.

An appropriately graded coarse sand was placed inside the augers and around the well casing as the augers were removed. Sand was placed to a minimum of 2 feet above the top of the well screen. A minimum of 1 to 2 feet of bentonite was placed above the sand around the well riser to form a seal to prevent downward migration of contamination from the surface. A neat cement/bentonite grout was placed above the bentonite around the well riser to ground surface. A lockable protective cover and bollards were secured into a 2-foot by 2-foot cement pad around the stickup wells. A lockable cap was attached to the PVC riser and a manhole cover was secured into a 2-foot by 2-foot cement pad. Monitoring well construction diagrams for all wells except monitoring well 3GW78D are presented on Figures 1-5, 1-6 and 1-7.

Monitoring Wells 3GW78D, 4GW79, 4GW81D, and 11GW87, and piezometer 4PZ89 were installed using air rotary drilling techniques. Monitoring wells 4GW79, 4GW81D and piezometer 4PZ89 were installed using dual wall air rotary drilling. The dual wall air rotary system includes an outer (8-inch inside diameter) casing with a drill bit attached to an inner drill rod. The drill bit locks below the outer casing during operation, and cuts an 9-inch outside diameter hole. When the drill bit is not operating, it retracts to 7 and 3/4-inch and can be removed without removing the outer casing. The well is constructed through the

annulus of the outer casing in a manner similar to that of well installation through hollow stem augers. This drilling method allowed installation of large diameter wells (6-inch inside diameter) to depths of 84 feet in the unconsolidated sand and gravel unit at Site 4.

Monitoring well 11GW78 was installed using air rotary drilling through the saprolite. Formational material at Site 11 allowed simple air rotary drilling to top of rock using a 10-inch air rotary drill bit. After achieving the appropriate depth, the drill rod and bit were removed and the well was constructed through the open borehole using techniques equivalent to the hollow stem auger techniques.

Monitoring Well 3GW78D was installed using air rotary drilling techniques through unconsolidated overburden and crystalline rock at Site 3. Initial drilling used a 10-inch outside diameter drill bit to drill through the 23 feet of unconsolidated overburden and at least 9 feet into the crystalline rock. The drill bit and rod were removed from the boring and a 6-inch inside diameter carbon steel casing was installed to depth through the open borehole with a 1 1/2-foot stickup. The steel casing was then grouted in place and the grout was allowed to set for 24 hours in accordance with the manufacturer's recommendation. After the grout had set, a 5 7/8-inch outside diameter air hammer drill bit was advanced inside the steel casing to the final depth (72 feet BGS). Monitoring Well 3GW78D was completed as an open-rock well due to the nonfriable condition of the bedrock. A locking security casing and bollards were set into a concrete pad. The monitoring well construction diagram for monitoring well 3GW78D are presented on Figure 1-7. Cuttings from the augering of borings were placed in 55-gallon drums, transported to the hazardous waste storage area and were retained until lab analysis was completed. The cuttings were then disposed of by the facility.

1.6.3.2 Well and Boring Abandonment

Well casings were removed from each well abandoned and a neat bentonite seal was pumped into the annulus of the boring or well until full. The grout was allowed to settle overnight before filling the remaining depth of the boring or well with bentonite cement grout. Wells abandoned during Phase II of the RI include wells 11GW70S, 11GW20 and 11GW21.

1.6.3.3 Subsurface Soil Testing

Subsurface samples for laboratory analysis were collected by split spoon at three well locations at Site 4. A sample was collected above and below the water table at each well. Depths of samples collected are provided on the individual well log (Appendix E).

1.6.3.4 Screening Subsurface Soils for Volatile Organics

During installation of monitoring wells and piezometers, the subsurface soil samples collected using split spoon samples were screened upon opening the split spoon with an HNu for the presence of detectable volatile organic compounds. At the shallow monitoring well locations where split spoon sampling was not performed, soil cuttings were screened as they were removed from the ground.

1.6.3.5 Measurement of Groundwater Levels

Water level measurements were collected for each well prior to sample collection. Measurements were made to the nearest one-hundredth of a foot. This data was used to evaluate the direction of water movement in conjunction with the existing data and assess the effects of seasonal changes. These measurements are summarized on Table 1-8.

1.6.3.6 Groundwater Sampling

During Phase I of the RI, groundwater samples were collected from the Verification Phase wells and the newly constructed wells. During Phase II, samples were collected from Verification Phase, RI Phase I and RI Phase II wells (Plate 1). These wells were sampled following the procedures outlined in Appendix F.

Prior to sampling, each well was purged until three to five casing volumes were evacuated in accordance with the procedures set forth in Standard Operating Procedure Number 8 in Appendix F or until the well was purged dry. The water was discharged back onto the ground at the well location.

Once purged, groundwater was sampled using teflon bailers for the newly constructed wells which have been decontaminated and dedicated PVC bailers for the Verification Phase wells. Samples were collected following procedures outlined in Appendix F. The order of filling sample containers was based on the volatility of the particular compounds of concern. Volatile organic compounds were collected first, followed by semi-volatile compounds and so on until all parameters required were collected. Sampling of individual monitoring wells

also followed a preferential order. The wells with known contamination as determined by the Verification Phase results were sampled last to minimize cross contamination. If data was not available on groundwater quality, then the deeper wells were sampled first, followed by wells screened closer to the surface. Samples were then transferred from the bailer to the laboratory sample containers. Those designated for metals analysis were filtered in the field.

Field measurements of pH, specific conductivity, and temperature were made at each well during and after purging. Both the pH and specific conductivity meters were calibrated for water temperature before they were used.

1.6.4 Surface Soil and Sediment Sampling

Surface Soil and/or sediment samples were collected at Sites 2, 3, 7, 8, 9, 11, and Paint Branch Creek during Phase I. During Phase II, surface soil and/or sediment samples were collected at Sites 2, 3, 9, 11 and Paint Branch Creek. Subsurface soils were collected at Site 7 from depths of 5, 10 and 15 feet. The specific locations of the surficial soil and sediment samples are discussed in each site specific discussion. The surface soil and sediment sampling methodologies are discussed in the standard operating procedures in Appendix F.

1.6.5 Surface Water Sampling

Surface water samples were collected at Sites 2, 3, 9, 11, and Paint Branch Creek. The specific locations of the surface water samples are discussed in Section 4. The surface water sampling methodology is described in Appendix B.

1.6.6 Ecological Sampling

Ecological Sampling consisted of surveys of terrestrial vegetation and mammal species at all seven sites, benthic surveys at five sites (2, 3, 9, 11, and Paint Branch Creek), and fish surveys at four sites (2, 9, 11, and Paint Branch Creek). These surveys were conducted in accordance with the procedures detailed in Standard Operating Procedure Number 58 provided in Appendix F. Fish samples for bioassay analysis were collected from four sites (2, 9, 11, and Paint Branch Creek).

1.7 RISK ASSESSMENT

The risk assessment presents assessments of potential human and environmental health risks associated with contaminants detected at seven sites NSWCWODET. The risk assessment is a component of the Remedial Investigation (RI) study and is included as Appendix G of the RI report. A brief summary of the results of the risk assessment evaluation for each site is provided in appropriate site specific discussion in the RI report.

The objectives of the assessment were to:

- Provide an analysis of baseline risks, currently and in the future, in the absence of any major action to control or mitigate site contamination; and
- To assist in determining the need for and extent of remediation.

The risk assessment provides a basis for comparing a variety of remedial alternatives, and determining which will be the most protective of human and environmental health. A brief description of the human health evaluation and ecological risk assessment is provided in the following subsections.

1.7.1 Human Health Evaluation

The human health evaluation presents an assessment of potential human health risks associated with exposure to contaminants detected at or migrating from each of the seven RI sites. The baseline risk assessment follows guidance provided in the U.S. Environmental Protection Agency's (USEPA) ***Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A),*** (USEPA, 1989a) and ***Risk Assessment Guidance for Superfund, Volume I: Human Health. Supplemental Guidance. "Standard Default Exposure Factors", Interim Final*** (USEPA, 1991a) which are companion documents to USEPA's RI/FS guidance document, ***Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA*** (USEPA, 1988a)

1.7.1.1 Objectives

The goal of the human health evaluation process is to provide a framework for developing the risk information necessary to assist decision-making at the seven NSWCWODET sites. This human health evaluation will be conducted on the seven sites

previously discussed in this RI Report. A site-by-site risk assessment was conducted that included the components of hazard identification, exposure assessment, toxicity assessment and risk characterization.

Preliminary screening was performed to reduce the level of effort for the human health evaluation at some of the sites. Specific objectives of the process were to:

- Provide an analysis of baseline risks (human health) and help determine the need for remedial action at the seven sites.
- Provide a basis for determining levels of chemicals that can remain at each of the sites and still be adequately protective of public and NSWCWODET personnel health.
- Provide a basis for comparing potential health impacts of various remedial alternatives at the sites.
- Provide a consistent process for evaluating and documenting public health threats at the sites.

1.7.1.2 Human Health Evaluation Components

The human health evaluation phase of the baseline risk assessment process is site-specific. Therefore it may vary in both detail and the extent to which qualitative and quantitative analyses are used, depending on the complexity and particular circumstances of the site, as well as the availability of ARARs and other criteria, advisories and guidance. There are four components to the baseline risk assessment process: (1) hazard identification; (2) exposure assessment; (3) toxicity assessment; and (4) risk characterization. Each step is described briefly as follows:

- **Hazard Identification** involves gathering and analyzing the site data relevant to the human health evaluation and identifying the chemicals of potential concern at each site that are the focus of the risk assessment process. The selection of such chemicals is based on a number of parameters, including the frequency of detection and concentration in each environmental medium, environmental fate and transport characteristics, intrinsic toxicity and the likelihood of human exposure via significant exposure routes.

- Exposure Assessments are conducted to estimate the magnitude of actual and/or potential human exposures, the frequency and duration of these exposures, and the pathways by which humans are exposed. In the exposure assessment, reasonable maximum estimates of exposure are developed for both current and future land-use assumptions. Conducting an exposure assessment involves analyzing contaminant releases, identifying exposed populations, identifying all potential pathways of exposure, estimating exposure point concentrations for specific pathways and estimating contaminant intakes for specific pathways. The results of this assessment are pathway-specific intakes for current and future exposures to individual substances.

- Toxicity Assessments consider the types of adverse health effects associated with chemical exposures, the relationship between magnitude of exposure and adverse effects and related uncertainties such as the weight of evidence of a particular chemical's carcinogenicity in humans. Qualitative and quantitative toxicity data for each chemical of potential concern are summarized, and appropriate guidance levels with which to characterize risks are identified.

- Risk Characterization summarizes and combines outputs of the exposure and toxicity assessments to characterize baseline risk, both in quantitative expressions and qualitative statements. The likelihood and magnitude of adverse health risks are estimated in this step, in the form of non-cancer hazard quotients and cancer risks.

1.7.2 Ecological Risk Assessment

The ecological risk assessment presents an assessment of potential environmental risks associated with contaminants detected at the seven RI sites at NSWCWODET. The ecological risk assessment follows guidance contained in the USEPA ***Risk Assessment Guidance for Superfund, Volume II, Environmental Evaluation Manual*** (USEPA, 1989b) which is a companion document to USEPA's RI/FS guidance document, ***Guideline for Conducting Remedial Investigations and Feasibility Studies under CERCLA*** (USEPA, 1988a).

1.7.2.1 Objectives

Contamination of groundwater and soils, as well as sediments, may have an impact on terrestrial and aquatic organisms on or in the vicinity of NSWCWODET through uptake of compounds during feeding and nesting activities and through direct contact with the contaminated media. The objective of the ecological risk assessment is to determine the potential threat posed by the NSWCWODET RI sites to wildlife utilizing the sites or vicinities of the sites.

1.7.2.2 Ecological Risk Assessment Components

Evaluating ecological risk involves integrating information on possible chemical exposures with published toxicity data for the pollutants of concern. Various steps are involved in conducting such an assessment, and include the following components:

- Determining existing ecological conditions;
- Selecting the chemicals of potential concern;
- Determining available pathways of exposure;
- Determining existing or potential receptors to exposure; and
- Characterizing the exposure and ecological risk.

1.8 ANALYTICAL METHODOLOGY

1.8.1 Parameter Summary

In each site specific section a summary is provided of the environmental sampling performed at each site investigated as well as the two background wells and Paint Branch Creek. Analysis included groundwater sampling at all seven sites and surficial soil, subsurface soil, stream sediment, and surface water sampling at selected sites. During Phase I, samples were collected during one sample event from mid-September through late October 1989. All analytical services were performed by Versar, Inc. of Springfield, Virginia except for several TOX and TOC samples which were subcontracted by Versar, Inc. to Analytical Technologies, Inc. (ATI) for analysis. During Phase II, samples were collected during one sample event from early April through late June, 1991. All analytical services were performed by Hittman-Ebasco Associates, Inc. of Columbia, Maryland except for the bioassay analysis. Bioassay analysis was performed by Wadsworth/Alert Laboratories Inc. of North Canton, Ohio. Table 1-9 lists the parameters analyzed for and their respective analytical methodology and detection limit for water and soil samples for Phase I and Table 1-10 provides the same information for Phase II. The results of the analytical work for all samples is summarized in each site specific discussion.

1.8.2 Water Quality Standards and Soil/Sediment Guidelines

In order to qualitatively and to quantitatively (risk assessment) address the contamination levels of groundwater, surface water, soils and sediments at NSWCWODET, the analytical results from the sampling events were compared to a set of standards or guidelines. Generally, there are standards established for metals and volatile organics in ground and surface water as promulgated by the Environmental Protection Agency (EPA) and State agencies. USEPA has proposed soil corrective action levels under RCRA. In some cases, there are no established guidelines for soils and sediment with which to compare the analytical data.

Compounds will be reported as being at levels of concern when their concentration exceeds an established standard, action level, or other set guideline. However, this does not necessarily indicate a known hazard but only suggests that the levels are above some standard or background concentration.

1.8.2.1 Ground/Surface Water Criteria

Criteria used for comparison of ground and surface water is listed in Table 1-11. Criteria for groundwater include USEPA maximum contaminant levels (MCLs), Maryland Groundwater Standards and proposed RCRA Corrective Action levels. Criteria for surface water includes USEPA ambient water quality criteria, Maryland Surface Water quality criteria and proposed RCRA corrective action levels. Other criteria are also listed in Table 1-11.

1.8.2.2 Soils and Sediment Guidelines

Criteria has not been established for soils and stream sediment for which to compare the analytical data, and therefore, samples that are deemed as "background" (in areas relatively free of contamination) will be used as guidelines in determining levels of concern for soils and sediment. Table 1-13 lists those compounds for which a guideline has been set based upon background levels. Also, the detection limit has been initially established as the levels of concern for compounds such as nitroaromatics, volatile organics, semi-volatiles, PCBs, and mercury until further data is available to make a more quantitative assessment of the hazards.

2.0 SITE 2 - APPLE ORCHARD LANDFILL DISCUSSION

2.1 SITE BACKGROUND

2.1.1 Site Description and History

The Apple Orchard Landfill is an abandoned landfill approximately 0.8 acres in size and is located south of Perimeter Road approximately one-half mile south of the northwest facility boundary. The landfill is situated on a small hill approximately 340 feet mean sea level (MSL) in elevation. A small unnamed stream located adjacent to the site flows to the west and south of the landfill. The Apple Orchard Landfill was operated as an open disposal area and landfill from 1948 until 1982. The landfill is a single unit that is composed of several disposal areas. In addition to domestic refuse, wastes reportedly disposed of consisted of oils containing polychlorinated biphenyls (PCBs), solvents, paint residue, acids and miscellaneous compounds. The IAS reported an estimated 500 gallons of PCB-contaminated oils were deposited at this site prior to 1970.

2.1.2 Previous Investigations

Three groundwater wells, ten sediment and four surface water sampling locations were sampled during the Verification Phase. The analytical data suggested that the landfill was contributing leachate to the shallow groundwater, which in turn, was discharging these compounds to the adjacent stream. No significant impacts were noticeable in the shallow groundwater across the stream from the landfill. Based on these results, it appears that the stream is a discharge boundary for the shallow groundwater. TOC and TOX levels were elevated in the groundwater in areas down gradient of the landfill while only low levels of PCBs, metals and VOCs were detected in the stream sediment samples.

Data gaps identified after analysis of the Verification Phase data included:

- Metal concentrations in the groundwater beneath the landfill;
- Metal concentrations being discharged from the landfill to the shallow groundwater; and
- Extent of contaminated sediments downstream of the landfill.

Verification Phase recommendations included:

- Installation of one additional monitoring well;
- Resampling the soil, stream sediment, and surface water sampling locations at the site; and
- Sampling the new and existing groundwater monitoring wells.

Recommendations that were made subsequent to the Verification Phase Final Report included:

- Perform a soil gas survey to better evaluate potential volatile organic contamination of the groundwater;
- Sample two surface soil sample locations located within the confines of the landfill; and
- Relocate some of the surface water and sediment sampling locations further downstream from the landfill.

2.2 REMEDIAL INVESTIGATIONS

2.2.1 Surface Feature Investigations

The purpose of surface feature investigations was to identify possible contaminant migration and to locate potentially affected receptors. Surface feature investigations included location of surface disposal areas, property lines, drainage ditches, streams, leachate seeps (if any), vegetation, topography of the landfill, and the presence of landfilled wastes evident at the face of the filled area.

2.2.2 Surface Water and Sediment Investigations

During both Phase I and Phase II of the RI, samples were collected from the surface water (six samples) and sediment (ten samples) of the small stream that passes to the south of the landfill at the locations shown on Figure 2-1. The stream's surface water and sediment were sampled at numerous locations from where the stream enters the facility (northwest corner of the landfill), downgradient along the stream, and from where the stream exits the facility approximately 600 feet east of the landfill. Numerous parameters

were analyzed in the water and sediment. Section 1.8.1 discusses the parameter analysis performed for the individual sites for all media (i.e., groundwater, surface water, etc.). The purpose of the sampling was to document the chemical quality of the surface water and stream sediment at Site 2. Tables 2-1 and 2-2 provide summaries of field sampling for Phase I and Phase II, respectively.

2.2.3 Soil and Vadose Zone Investigations

During Phase I, soil and vadose zone investigations for Site 2 included the collection of two surficial soil samples to determine the chemical concentrations in the soil and the performance of a soil gas survey of the shallow soil to document volatile organic concentrations and potential movement through the vadose zone. Figure 2-2 illustrates the sampling grid and the results of the soil gas survey.

During Phase II, surficial soil sampling was conducted using a 14-point sampling grid (Samples 2SL3 through 2SL16) established at Site 2. Also within the sampling grid, soil samples were collected at three additional locations (Sample 2SB1 through 2SB3) at depths of 1-foot and 3-foot at each location. Nine additional surficial Soil Samples (2SL17 through 2SL25) were collected from areas beyond the landfill boundary. Three additional Soil Borings (2SB4 through 2SB6) were located beyond the landfill boundary were sampled at depths of 1 foot, 3 feet, and 5 feet. Figure 2-3 illustrates the locations of the surficial soil samples.

The purpose of these investigations was to measure the release of gaseous volatile organic contamination through the soil, to predict contaminant movement through the vadose zone, and to quantify the chemical contamination in the surface soils for Risk Assessment purposes. Summaries for field sampling are presented in Tables 2-1 and 2-2 for Phase I and Phase II, respectively.

2.2.4 Groundwater Investigations

During Phase I of the RI, groundwater Monitoring Well 2GW45 was installed southeast of Site 2. Four groundwater Monitoring Wells (2GW30, 2GW31, 2GW32, and 2GW45) were sampled. During Phase II of the RI, groundwater Monitoring Well 2GW76 was installed north of the site. All five groundwater Monitoring Wells (2GW30, 2GW31, 2GW32, 2GW45, and 2GW76) were sampled. Figure 2-1 illustrates the location of the monitoring wells. A summary of the installation, development, and sampling times for these

wells are included in Table 1-2. Construction details for each well are provided on the borehole logs for Wells 2GW45 and 2GW76 presented in Appendix B. Tables 2-1 and 2-2 provide summaries of field sampling for Phase I and Phase II, respectively.

2.2.5 Geological Investigations

During both Phase I and Phase II one borehole was drilled at Site 2 and each were converted to a groundwater monitoring well (Wells 2GW45 and 2GW76, respectively). Split spoon samples were collected during drilling to characterize the subsurface lithology at the intervals indicated on Table 1-6, Geological Investigations Summary. Descriptions of the individual split spoon samples obtained are given in Appendix B on the borehole log for 2GW45 and 2GW76. Soil samples were collected using the standard procedures presented in Section 1.6 and Appendix F of this report. A summary of field sampling events are presented in Tables 2-1 and 2-2 for Phase I and Phase II, respectively.

2.2.6 Ecological Investigations

During Phase II of the RI, ecological investigations were conducted in order to assess the current ecological conditions on-site. Included in the investigations were terrestrial vegetation, mammal, fish, and benthic invertebrate surveys.

The vegetation survey consisted of a quantitative analysis of species types located on site. In this study, field identification was supplemented with office confirmation of the major vegetative species. Relative abundance of the species was established and vegetation community relationships were delineated on the project site map.

A general mammalian survey was performed and benthic invertebrate sampling was conducted using a kick screen method at three locations along the stream which transect Site 2 (upstream, mid-stream, and downstream). The fish survey was completed using a Smith-Root electrofisher at upstream, mid-stream and downstream points along the length of the stream on site. Specific sampling materials and methods are used are presented in Section 1.6 and outlined in Appendix F.

2.3 PHYSICAL CHARACTERISTICS OF THE SITE

2.3.1 Surface Features

An unnamed stream runs from west to east at the southern base of the hill and landfill at an approximate elevation of 395 feet MSL at its origin to an approximate elevation of 250 feet MSL where it cross the facility boundary. An apartment complex is located immediately north of the site but outside of the NSWCWODET property boundary. The NSWCWODET land immediately surrounding the site is cleared and covered by grass or woods. An industrialized portion of the NSWCWODET is located approximately 500 feet southwest of the site.

2.3.2 Surface Water Hydrology

An unnamed stream flows from west to east at the base of the hill and landfill and continues towards the east for approximately 1,000 feet before exiting the facility. Approximately 500 feet north of the facility boundary, the stream joins Paint Branch Creek which then flows back onto the facility approximately 5,000 feet east of Site 2. Water in the stream originates from four sources: stormwater sheetflow from land surfaces including the landfill, stormwater discharges from a drainage swale adjacent to the western side of the landfill which extends off the facility and north of the site, discharges from a facility NPDES permitted discharge from an industrialized area southwest of the site, and groundwater recharge. Based on observations during field investigations, the stream flow upstream of the NPDES discharge point is extremely low and almost stagnant and is almost nonexistent during dry seasons. Downstream of the NPDES discharge point, the stream flow is moderate and exists throughout the year. The NPDES discharge originates from a stormwater drainage swale along Perimeter Road and may contain runoff from an apartment complex immediately north of the facility boundary.

The stream at Site 2 has a sandy substrate with pebbles up to one inch in diameter. This substrate has a very high mica content, no boulders and very few cobbles. The algal content in the stream was extremely low at the time of the field survey. Water in the stream averaged 2 feet wide and approximately 3 to 6 inches in depth.

2.3.3 Soils

The soils at Site 2 beyond the areas disturbed by landfilling activities belong to the Manor series. According to the soil survey for NSWCWODET, the Manor series soils are a residual soil which have formed on weathered Piedmont schists. They are well drained to somewhat excessively drained. The soils have a moderate to very high available moisture capacity and are very micaceous. The soil pH ranges from 4.5 to 5.5. A typical profile of the Manor series in a wooded area consists of approximately of a 1-inch "O" horizon consisting very dark gray decaying organic debris which overlies a 7-inch "A" horizon consisting of brown silty loam. The "B" horizon extends from approximately 7 to 18 inches BLS and consists of a brown silty loam grading to a brown silty clay loam with depth. The "C" horizon extends from approximately 18 inches BLS to bedrock and consists of a reddish-brown silty clay loam containing considerable fragments of bedrock. (Soil Survey Report, U.S. Naval Ordnance Laboratory, White Oak, Maryland, 1970.)

2.3.4 Geology

The Apple Orchard Landfill is underlain by two geologic units. The uppermost unit is the Upland Sand and Gravel and ranges in thickness from 4 to 10 feet. A maximum thickness of 10 feet was observed during drilling of Well 2GW45. The Upland Sand and Gravel unit at this site consists of a brownish-grey silt to a silty sand with a trace of gravel. As indicated on the surficial geology map for NSWCWODET (Figure 1-6), the Potomac Formation does not occur in the western portion of the NSWCWODET. This was confirmed by data obtained during the drilling program. The Upland Sand and Gravel lies unconformably on saprolitic (weathered) Precambrian gneiss of the Wissahickon Formation. During the Verification Phase Study, it was noted that the saprolite unit varies in thickness from approximately 2 feet at Well 2GW30 to approximately 35 feet at 2GW76. The host gneiss (Wd) beneath the saprolite unit was cored at Well 2GW30. The core barrel intercepted several heavily weathered fracture zones, indicating groundwater movement within these fracture zones.

2.3.5 Hydrogeology

The Verification Phase Study indicated that shallow groundwater flow at Site 2 is influenced by an unnamed intermittent tributary of Paint Branch Creek. Groundwater is present in the saprolite, the bedrock, and to a minor extent in the Upland Sand and Gravel

unit. Depth to the water table aquifer measured in August 1991 ranged from 6.40 feet from top of PVC well casing (TPVC) at Well 2GW30 to 19.39 feet TPVC at Well 2GW76. Water table aquifer elevations during August 1991 ranged from 321.07 feet MSL at Well 2GW76 to 291.92 from Well 2GW45. The average saturated thickness of the water table aquifer based on the 1991 measurements was 20 feet (6.09 m).

Graphical analysis of water level data collected from wells which have screened intervals in the Upland Sand and Gravel and/or saprolite during August 1991 support the initial groundwater flow directions determined during the Verification Phase. Groundwater flow underlying the site is toward the east-southeast in the direction of the intermittent stream. The graphical analysis indicated that the groundwater gradient ranged from approximately 3 to 5 percent with a geometric mean of 4 percent. Groundwater underlying the site discharges into the intermittent stream.

Two rising head slug tests were conducted on the unconfined aquifer using Wells 2GW32 and 2GW45. The estimated K calculated indicates groundwater flow ranges for 1.2 x 10^{-3} cm/sec (3.6 gpd/ft^2) to 2.6 x 10^{-2} cm/sec (72.3 gpd/ft^2). One falling head slug test was conducted using Well 2GW32. The K as determined by the analysis of the falling head test was 4.0 x 10^{-4} cm/sec (1.14 gpd/ft^2). The geometric mean of K for Site 2 was 2.4 x 10^{-2} cm/sec (48.9 gpd/ft^2).

Groundwater flow velocities at Site 2 are based on the pumping test analysis conducted for Well 11GW87 at Site 11 during Phase II of the RI. Pumping test data from Site 11 is used because the pumping test evaluated the same hydrogeologic unit as that present at Site 2. Also, velocities estimated based on pumping tests are more representative of an aquifer than velocities estimated from slug test data. The pumping test results for Well 11GW87 indicate that the K for the saprolite unit is approximately 4.62 X 10^{-5} cm/sec (0.97 gpd/ft^2). As discussed in Section 1.3.8, the transmissivity of the water table aquifer at Site 2 is approximately 0.028 cm^2/sec (19.4 gpd/ft). The velocity of the groundwater flow is estimated to be 7.00 X 10^{-6} cm/sec (0.15 gpd/ft^2) with an effective porosity of 26 percent.

2.3.6 Ecology

The top of the landfill is covered with typical old field vegetation. Old field species consist of grasses, Virginia Creeper, goldenrod, Northern Spicebush, Common Blackberry, Horse Nettle, and Poison Ivy. This area has approximately 60 percent coverage and is

dominated by grasses that include species of clover, goldenrod, and plantain. A vegetation inventory of the site is included in Appendix A.

Similar species are located on the slope of the landfill. This area is dominated by clover, Virginia Creeper, goldenrod, and Blackberry. Young Black Locust, Big-toothed Aspen, and Princess Tree are found at the margins of the landfill. In areas of lower elevation adjacent to the stream, mixed deciduous forest and old areas predominate. These areas are 90 percent vegetated.

Forested areas immediately adjacent to the slope of the landfill are primarily hardwood forest consisting of Tulip Poplar, American Beech, White Oak, Sourgum, and Flowering Dogwood with some Virginia Pine. These areas contain a heavy understory layer consisting of Common Blackberry, Dewberry, Catbrier, Grape, and Poison Ivy.

Areas immediately adjacent to the stream are less densely vegetated. Two White Oak trees adjacent to the stream are infected with fungal galls. Fern and blueberry are the predominate herbaceous layer species.

On sloping areas, south of the landfill, and in the vicinity of groundwater Monitoring Wells 2GW32, 2GW30, and 2GW45; shrub species consist primarily of Northern Spicebush, Flowering Dogwood, Catbrier, Poison Ivy, and Highbush Blueberry. Tree species include Tulip Poplar, White Oak, Sourgum, and Black Cherry. Total coverage in forested regions was 75 percent at the time of the survey.

Evidence of mammalian use of the site was noted, including species such as Eastern Cottontail, Eastern Chipmunk, Woodchuck, and White-tailed Deer.

The upstream portion of the stream south of Site 2 averaged 4 feet wide and 1-inch deep, and flowed at approximately 1 cu. ft./second (cfs), at the time of the field investigation. The substrate of this system consisted of a bedrock bottom with some sand and a few 10- to 12-inch diameter boulders. Algal mats grow in this stream and an oil sheen was noted on the surface of the water, possibly resulting from storm sewer runoff. It was not known if the sheen was from petroleum or naturally occurring sources.

The mid-stream portion of the stream adjacent to Site 2 has a substrate very high in organic matter. The stream is approximately 10 feet wide and 1-foot deep with an abundance of leaf litter present. Much of the flow in the stream is from stormwater runoff especially the portion downstream of the NPDES discharge point. The substrate is sandy and contain pebbles up to 1 inch in diameter.

The downstream portion of the stream at Site 2 is 2 feet wide and 1-inch deep. The substrate in this area has a high organic content. The water has a green tint and a visible oil sheen on the surface.

The results of benthic and fishery sampling are summarized here and the details are provided in Appendix A. The upstream portion of the stream contained very few benthic macroinvertebrates. The total sample consisted of six Annelids including one Tubificid worm, one Copepoda, and one Chironomid midge. There were no specimens in the duplicate upstream sample. The mid-stream sample contained two Annelids and two Tubificid worms. The mid-stream duplicate contained one Annelid, two oligochaete worms, one Diplopoda, and one crane fly (Tipula). The downstream sample for Site 2 consisted of two Annelids and seven oligochaete worms, one Brychius, 16 Tipulidae, and one caddisfly larva (Cheumatopsyche sp.). Thirty-seven oligochaete worms, one chironomid midge larva, one dance fly larva (Phylodronia sp.), two Tipula sp., and one Cheumatopsyche sp. were collected in the Site 2 downstream sample.

Aquatic worms, particularly those of the genera Tubifex and Limnodrilus, have been strongly suggested to be excellent indicators of pollution. It has long been known that members of the family Tubificidae are present in large numbers of polluted areas. Oligochaetes, often known as sludge worms or sewage worms, are good indicators of poor water quality (Goodnight, 1983; Goodnight and Whitley, 1961).

Goodnight and Whitley (1961) suggested a method utilizing the easily recognized oligochaetes as an indication of the degree of pollution in streams. In their study of Elliott Ditch near Lafayette, Indiana, they found oligochaetes at all stations sampled. The stations at which the samples were taken varied from one having a high degree of organic enrichment to one which was relatively free of enrichment. In their collections of macroinvertebrates, they determined that in the station having the highest degree of organic enrichment, tubificids constituted 97 percent of the macroinvertebrate bottom fauna; at the cleanest station they represented only 13 percent. Their general conclusion was that whenever the population of these oligochaetes constituted more than 80 percent of the total population of macroinvertebrates a high degree of either organic enrichment or industrial pollution was indicated. A percentage between 60 and 80 percent indicated doubtful conditions; below 60 percent indicated good conditions. (Goodnight, 1973).

Site 2 contained 33 percent oligochaete worms at the upstream station. The Site 2 mid-stream and mid-stream duplicate population consisted of 50 and 60 percent

oligochaetes, respectively. Approximately 33 and 88 percent of the downstream and downstream duplicate samples were oligochaete worms. These calculations indicate that the water quality was decreasing as the observer traveled downstream.

Another important indicator of stream water quality is the percentage of Ephemeroptera, Plecoptera, and Trichoptera in the general macroinvertebrate population. These mayflies, stoneflies, and caddisflies are generally intolerant of pollution and require clean, aerated water to survive. Other benthic organisms such as oligochaetes and Chironomus sp. midges are very tolerant of pollution.

The Hilsenhoff Biotic Index (HBI) was used to assign pollution tolerance values to the macroinvertebrates sampled at the facility. The HBI proposed by Hilsenhoff (1977) has been modified for use with the index values given in Appendix A. Results are comparable between stations in the same and nearby stream if similar habitats are sampled using similar methods and sampling effort. The following formula was used:

$$HBI = \sum \frac{n_i \, a_i}{N}$$

Where "n_i" is the number of individuals in the "i^{th}" taxa, "a_i" is the index value of that taxa, and "N" is the total number of individuals in the sample. Biotic index values below 1.75 indicate excellent water quality, 1.76 to 2.50 indicate good water quality, 2.51 to 3.75 indicate fair water quality, and 3.76 to 4.00 indicate poor water quality, and over 4.00 indicate serious water quality problems (EPA, 1990).

HBI values for Site 2 station were 3.80, 2.55, and 3.08 for upstream, mid-stream, and downstream locations. This indicates poor water quality at the upper end and fair water quality in the mid-stream and downstream locations.

Black-nosed dace were the only fish found in Stream 2. It is not known whether the limiting factor in the stream is water quality or lack of adequate cover. The extremely shallow water depth, and lack of riffle-run complexes or pools could limit the available cover for fish populations.

The combination of a visible oil sheen on the surface of the water, a high amount of organic material in the substrate, a predominance of oligochaete worms in the benthic population, and a lack of fish in the stream indicate that the water quality is poor in this

stream. There is not enough data to indicate a cause and effect relationship between the Site 2 landfill and reduced water quality in the stream. The factors mentioned above could be caused by a combination of concentrated stormwater runoff from the upgradient parking lots and building, and street flow/groundwater flow from the landfill.

2.4 NATURE AND EXTENT OF CONTAMINATION

2.4.1 Soil and Vadose Zone

A soil gas survey of the vadose zone was conducted in the area surrounding the face of the landfill during Phase I. A Hnu Photoionization Detector (PID) was used to identify the presence of volatile organic compounds in the soil vapor. The PID is capable of detecting the cumulative concentration of volatile organic vapors that have an ionization potential less than 11.2 electric volts (eV). The PID is not capable of identifying the individual volatile organic species nor can it detect volatile organic species with an ionization potential greater than 11.2 eV, such as methane.

A grid containing 18 sample points was established to measure the volatile organic vapor level in the vadose zone. Figure 2-2 shows the location of the sampling points. A background level of 0 parts per million (ppm) was established prior to the survey. Volatile organic vapor was detected at four Sampling Points (2, 4, 17, and 18) and the highest concentration measured was 3 ppm at Sample Point 4. Sample Points 2 and 4 are located to the west of the landfill near Building 111. Building 111 is a maintenance facility for the Public Works Department, Roads and Grounds Shop. Sample Points 17 and 18 are located to the east of the landfill.

Two surface Soil Samples (2SL1 and 2SL2) were collected at Site 2 during Phase I of the RI and twenty three surface Soil Samples (2SL3 through 2SL25) were collected at Site 2 during Phase II of the RI to document contamination on the surface of the landfill for Risk Assessment determinations. The surface soil samples were collected at the surface of the landfill in areas easily accessible to man during Phase I. During Phase II, a sampling grid was established based on the Phase I data to further delineate the extent and the degree of contamination. The locations for each sampling point are illustrated on Figure 2-3. The analytical data obtained from the sampling revealed compound concentrations above background concentrations for soils as established in Section 1.8.2, Water Quality Standards and Soil Sediment Guidelines. Tables 2-3 (1989) and 2-4 (1991) summarize the

analytical data for the surficial soil samples from Site 2. All detectable levels of compounds have been reported. The parameters detected at concentrations above background (Table 1-13) are shaded on Tables 2-3 and 2-4. The shaded values are within the range reported for natural U.S. soils (Table 1-12).

The total metals present are largely confined to chromium, copper, lead, and zinc. The highest concentrations detected for cadmium was 1.9 mg/Kg from Soil Sample 2SL14; for chromium was 45 mg/Kg from Soil Sample 2SL9; for copper was 52 mg/Kg from Soil Sample 2SL14; and for lead and for zinc was 101 mg/Kg and 164 mg/Kg from Soil Sample 2SL3, respectively.

Concentrations of PCBs detected in soil samples collected during Phase I and Phase II of the RI were at levels greater than the established background concentrations. The highest concentration of PCBs detected was 8,700 μg/Kg for Soil Sample 2SL2 collected during Phase I. The values above the background levels for samples collected during Phase II ranged from 24 μg/Kg in Sample 2SL4 to 2500 μg/Kg in Sample 2SL3. RCRA Corrective Action level for PCBs in soil is 90 μg/Kg.

No volatile organic compounds were detected in soil samples collected from Site 2 during Phase I of the RI. The volatile organic compounds present during Phase II are largely confined to acetone and methylene chloride. The highest concentration of acetone detected was 720 μg/Kg and was found in Sample 2SL10. The highest concentration of methylene chloride was found in Sample 2SL24 and was 190 μg/Kg. The occurance of acetone and methylene chloride suggest that the detection of these compounds are as a result of laboratory contamination instead of, or in addition to, contamination at the site. The RCRA corrective action levels for Acetone and Methylene Chloride are 8,000 mg/Kg and 90 mg/Kg, therefore, these compounds are not at levels of concern. The analytical results for acetone and methylene chloride in soil samples collected during Phase II were rejected based on suspected laboratory contamination as determined during the data evaluation.

A wide variety of semi-volatile organic compounds were detected in soil samples collected from both Phase I and Phase II of the RI. The highest concentration of semi-volatile compounds reported among both data sets in the soil were detected in Soil Sample 2SL13 (Table 2-4). Other high concentrations of semi-volatile compounds among both data sets were detected in Soil Samples 2SL17 and 2SL23. The concentrations reported for each semi-volatile parameter in Soil Sample 2SL23 and for benzoic acid in Soil

Samples 2SL10, 2SL16, and 2SL25 have been estimated because the analytical results did not meet internal standard criteria for the analysis. The analytical results for benzoic acid in Soil Samples 2SL7, 2SL17, and 2SL18 were rejected due to errors in laboratory equipment calibration based on the data evaluation.

A total of 15 soil samples were collected at Site 2 from six shallow Soil Borings (2SB1A, 2SB1B, 2SB2A, 2SB2B, 2SB3A, 2SB3B, 2SB4A, 2SB4B, 2SB4C, 2SB5A, 2SB5B, 2SB5C, 2SB6A, 2SB6B, and 2SB6C) during Phase II of the RI. Three Soil Borings (2SB1, 2SB2, and 2SB3) were located within the boundary of the landfill and surface soil sampling grid. Soil samples were collected at intervals of 1-foot (indicated by "A" suffix in sample number) and 5 feet (indicated by "B" suffix in sample number) from each of these soil borings to be used to determine the vertical extent of contamination at the landfill. Three additional Soil Borings (2SB4, 2SB5, and 2SB6) were located outside the landfill and surface soil sampling grid. Soil samples were collected at intervals of 1-foot ("A" suffix), 3 feet ("B" suffix), and 5 feet ("C" suffix) from each of these soil borings to further delineate the vertical extent of soil contamination.

The parameters shaded on Table 2-5 (1991) were found at levels higher than the background concentrations for soils as established in Section 1.8.2, Water Quality Standards and Soil Sediment Guidelines. Of the total metals analyzed, metal contamination in the soil samples collected from the soil borings are largely confined to copper, lead, and zinc. The highest concentrations detected for cadmium, chromium, copper, lead, and zinc were from Sample 2SB2B (3 feet below land surface (BLS)) and were 8.1 mg/Kg, 42 mg/Kg, 1530 mg/Kg, 533 mg/Kg, and 1440 mg/Kg, respectively.

The volatile organic compounds present in the subsurface soil are largely confined to acetone and methylene chloride. The highest concentration of acetone detected in the soil boring samples was 170 μg/Kg for Sample 2SB6A at a depth of 1-foot below land surface. The highest concentration of methylene chloride detected in the soil boring samples was 90 μg/Kg from Sample 2SB4C collected from a depth of 5 feet below land surface. A wide variety of semi-volatile organic compounds were detected in soil boring samples collected during Phase II of the RI. The highest concentration of semi-volatile compounds reported in the soil were detected in Sample 2SB4A. These concentrations have been reported as estimated values in Table 2-5. PCB detected in the subsurface soil is at levels greater than the RCRA Corrective Action level. Vertical distribution of the PCBs appears random. PCB was present in soil samples collected from Soil Borings 2SB2, 2SB3, and 2SB4.

The soil gas survey of the vadose zone indicated that volatile organic vapor was present in the soils at low levels in areas to the east and west of the landfill.

The surface soil samples collected from the top of the landfill during Phase II confirmed the analytical results of Phase I of the RI. The analytical results from Phase I and Phase II surface soil sampling indicate that a potential may exist for health hazards associated with possible inhalation of and/or ingestion of dust containing PCBs, metals, volatile organic compounds and semi-volatile organic compounds. The analytical results from the soil boring samples indicate that the contaminants are unstratified within the soil profile. The vertical distribution of PCBs and metals within the soil to a depth of 5 feet appears to be randomly distributed with the highest values occurring in the northwestern and the southern portion of the landfill surface. The horizontal distribution of the volatile organic compounds is more uniform across the site. The horizontal distribution of the semi-volatile compounds appears to be somewhat random with the highest soil concentrations close to the periphery of the landfill and lower concentrations toward the center of the landfill

2.4.2 Groundwater

Groundwater samples were collected to document groundwater quality at Site 2. Four groundwater Monitoring Wells (2GW30, 2GW31, 2GW32, and 2GW45) were sampled during Phase I of the RI. Groundwater Monitoring Wells 2GW30, 2GW31, and 2GW32 were installed during the Verification Phase. Groundwater Monitoring Well 2GW45 was installed during Phase I of the RI. One additional Monitoring Well (2GW76) was installed north of the landfill during Phase II of the RI. All five groundwater monitoring wells were sampled during Phase II of the RI. The location for each groundwater monitoring well at Site 2 is illustrated on Figure 2-1. Table 2-6 (1989) and Table 2-7 (1991) summarize the groundwater analytical data for the site. The analytical results for groundwater indicate the presence of metals, volatile organic compounds at concentrations above the criteria established for groundwater in Section 1.8.2 Water Quality Standards and Soil/Sediment Guidelines. The parameters with values greater than the established criteria have been highlighted on Tables 2-6 and 2-7.

Of concerns were the detected concentration of total cadmium and total lead detected in the groundwater samples at 74 μg/L and 377 μg/L, respectively, collected from Monitoring Well 2GW31 during Phase II of the RI. The values for total metals as reported

on Table 2-7 reflects the concentration of metals suspended in the groundwater on particulates and metals dissolved in the groundwater. The values reported on Table 2-8 for filtered metals reflects the concentration of metals dissolved in the groundwater only and are below the levels detected at Well 2GW31. The highest concentration of total chromium and total lead detected in the groundwater was 147 μg/L and 235 μg/L, respectively, from groundwater sample collected from Monitoring Well 2GW76 during Phase II. The highest concentration of trichloroethene (TCE) detected was 240 μg/L in groundwater collected from Monitoring Well 2GW32 during Phase I. During Phase II, TCE at Monitoring Well 2GW32 was detected at 1450 μg/L. Mercury was detected in only one well during Phase I of the RI. The total mercury concentration for groundwater from Monitoring Well 2GW32 was 62.7 μg/L.

The contaminants of greatest concern in the groundwater at Site 2 are cadmium, mercury, and TCE. The cadmium concentration in the groundwater has decreased slightly at Monitoring Well 2GW32, but has increased downgradient at Monitoring Well 2GW31 over the past 6 years. Cadmium levels in groundwater samples from other monitoring wells have not varied significantly. Mercury concentrations in the groundwater during Phase I is of concern but the full extent of mercury contamination cannot be addressed at this time due loss of mercury data as a result of laboratory errors encountered during Phase II.

Based on water elevations for site wells, groundwater flow in the area of the landfill near the unnamed stream is to the east-southeast towards Monitoring Well 2GW31. The presence of metals in the groundwater from Monitoring Well 2GW31 suggests that leachate in the shallow aquifer system is generated by the landfill and is transported toward the unnamed stream. The presence of metals in the groundwater from Monitoring Well 2GW76, installed during Phase II, suggests that groundwater flow and leachate migration in this area of the landfill is to the northwest. The presence of metals in all of the wells at Site 2 suggests leachate migration may be radial from the landfill. Graphical analysis of the groundwater levels reported during Phase II indicates that the predominant groundwater flow direction at Site 2 is to the east-southeast. However, localized groundwater flow near the unnamed stream is diverted from the predominant flow direction toward the stream. This diversion of groundwater also supports the hypothesis of radial migration of the metals leachate.

A decrease in the concentration of TCE in the groundwater at Monitoring Well 2GW32 has been observed from Phase I to Phase II. TCE was not detected at 2GW32 in 1985 which suggests that the TCE contamination detected during Phase I followed by a decrease in TCE during Phase II may be the result of a limited event such as a drum leaking or it may be due to weather conditions (intense rain) experienced at the site prior to sampling during Phase I. Groundwater during Phase I was collected during the Fall which is historically the wet season for the White Oak area of Maryland. Groundwater during Phase II was collected during the Spring which historically follows a dry season for the White Oak area of Maryland. The increased infiltration of rainwater water during the Fall of 1989 (Phase I) through the uncapped landfill may have induced an increased production of TCE leachate resulting in higher concentrations of TCE in the groundwater.

The TDS concentration of 37,700 mg/L reported for Phase I analysis of a groundwater sample from Monitoring Well 2GW32 is significantly higher than the secondary Maximum Contaminant Level (MCL) of 500 mg/L in drinking water. However, because the secondary MCL is for aesthetic reasons only, there is no health risk associated with the TDS levels.

2.4.3 Surface Water and Sediments

Six surface water locations were sampled during Phase I and Phase II of the RI to document surface water quality and to determine if leachate from the landfill has affected the stream quality. Figure 2-1 illustrates the location of the surface water sampling locations. Table 2-8 (1989) and Table 2-9 (1991) summarize the surface water analytical data for Site 2. The analytical data obtained from sampling during Phase I indicates that total dissolved solid (TDS) concentrations are above the MCL water quality standards for each sampling location. The analytical results for Phase II indicate that the concentration of TCE for surface water sample 2SW3 was detected at the MCL of 5 μg/L.

Sediment samples were collected at ten locations (Sample Points 2SD1 through 2SD10) along the stream during Phase I and at ten locations (Sample Points 2SD1, 2SD2, 2SD3 through 2SD7, and 2SD9 through 2SD12) during Phase II to document contaminant concentrations in the sediment. Figure 2-1 shows the location of the sediment sampling locations. Concentrations above background levels (Table 1-13) have been shaded on Tables 2-3 and 2-10. The shaded values are within the range of concentrations in natural U.S. soils (Table 1-12).

Metals, PCBs, and some volatile organic compounds were detected in the sediments at concentrations greater than the established background criteria during both Phase I and Phase II of the RI. Review of the analytical results indicate a decrease in metals concentration in the sediments from Phase I to Phase II at Sample Points 2SD1, 2SD2, 2SD3, 2SD5, 2SD7, and 2SD11 except for copper levels in Sample 2SD11 and lead levels in Sample 2SD2, 2SD3, and 2SD7. The analytical results indicate an increase in metals concentration in the sediments from Phase I to Phase II at Sample Points 2SD4, 2SD9, 2SD10, and 2SD12 except for copper levels in Sample 2SD9; chromium levels in Samples 2SD4, 2SD10, and 2SD12; and zinc levels in Samples 2SD4 and 2SD10.

The analytical results for Phase II sampling reflect the most current conditions at Site 2. The highest concentrations of cadmium, copper, lead, and zinc detected in the sediment samples from Phase II were 3.8 mg/Kg, 52 mg/Kg, 119 mg/Kg, and 183 mg/Kg, respectively, and were from Sample 2SD10. The highest concentration of chromium detected in the sediment during Phase II was 43 mg/Kg in sample 2SD9. PCB concentrations in the sediment ranged from 340 μg/Kg in Sediment Sample 2SD9 to 56,000 μg/Kg in Sediment Sample 2SD10 during Phase II. The range of concentrations for acetone detected in the sediment samples is 5 μg/Kg for Sample 2SD5 to 52 μg/Kg for Sample 2SD6 during Phase II. The concentration of methylene chloride detected in the sediment samples ranged from 2 μg/Kg in Sample 2SD11 to 170 μg/Kg in Sample 2SD5 during Phase II.

The analytical results from Phase I and Phase II indicate that the concentration of PCBs in the sediments increased greatly at each sampling point. For example, during Phase I the PCB concentration in Sample 2SD10 was 140 μg/Kg and during Phase II Sample Point 2SD10 was 56,000 μg/Kg. The analytical results from Phase I to Phase II indicated that the concentration of acetone and methylene chloride in the sediments increased slightly.

The analytical results for acetone and methylene chloride in Sediment Sample 2SD4 collected during Phase II were rejected based on suspected laboratory contamination as determined during the data evaluation.

The levels of TDS in the surface water collected during Phase I were consistent throughout the entire length of the stream sampled. The levels of TDS are only slightly above the secondary MCL (aesthetic reasons only) and are not significant.

The contaminant of greatest concern is PCB in the sediments. The PCB levels from samples collected during Phase II greatly exceed the established background criteria for the facility. The PCB concentrations in the sediments have not varied significantly since 1986

except in sediment sample Location 2SD10. There has been a large increase in PCB concentration in the sediment at 2SD10. Sediment Sample 2SD10 was collected from the upstream portion of the unnamed stream within the facility's boundaries. Sediment Sample 2SD10 is located near Soil Boring 2SB4 and surface soil location 2SL3. The highest concentration of PCB detected in the sediment was from Sample 2SD10 which coincides with high concentrations of PCB detected in soil from Boring 2SB4 and surface Soil Sample 2SD3. The PCB levels detected in the sediments indicate a progressive decrease in concentration down stream from sediment Sample Location 2SD10. The source of the PCB contamination in the sediments may be due to surface runoff or from the western portion of the landfill. The presence of the highest concentration of PCB detected in the sediment at Site 2 in the most upstream sampling location also suggests possible contribution of PCBs from off site sources.

The levels of metals, in most cases are within the range of the background guidelines in either the surface water or the sediments. The metal levels detected in the sediment indicate a decrease in concentration downstream from Sediment Sample 2SD10. Volatile organic concentration in the surface water and sediment are only slightly elevated above detection limit. Storm water runoff from an industrial area directly upstream from the facility may contribute some or all of the contamination found in the stream sediments and surface waters.

2.5 CONTAMINANT FATE AND TRANSPORT

2.5.1 Potential Routes of Migration

The contaminants of greatest concern at Site 2 include PCBs in surface soils and stream sediments; TCE and cadmium contamination in the groundwater. The potential routes of migration at Site 2 include the transport of contaminants through four routes:

- Soil system;
- Groundwater system;
- Surface water system; and
- Air system.

2.5.2 Contaminant Migration

As discussed in Appendix A of the Risk Assessment, PCBs are expected to remain sorbed onto soil particles with little natural biodegradation, volatilization, or isomorphic substitution. The surface soils contaminated with PCBs are subject to transport by surface water flow and to a much lesser extent as airborne particles. During precipitation events, sheet flow can erode the PCB-contaminated soil particles. At Site 2, PCB contaminated soil can be transported, with time, downslope towards the unnamed creek adjacent to the landfill. The process of transporting contaminated soil by sheet flow erosion is in general an effective transport process in unvegetated areas but the efficiency is reduced by increased vegetation. The rate of migration of contaminated soils is directly dependent on the duration of sheet flow, the slope of the land surface, the amount of vegetation and surface debris, and the size of the contaminated particle. Site 2 has been used as a staging area for materials which have been moved by heavy equipment. Soil agitation from machinery during dry periods in un-vegetated areas can cause contaminated soil particles to become airborne. The distance that a particle can travel in the air is, in part, directly related to the size of the particle and the force of the air currents that the particle is suspended. In general, very small particles will travel a farther distance than larger particles given the same air conditions. The direction of migration for airborne particles is dependent the direction of wind currents.

PCB contaminated sediments are subject to transport as a suspended load in the surface water during periods of high flow. During periods of high flow, sediments can be eroded or scoured from the stream bed and transported further downstream. This migration pathway is supported by the analytical results for stream sediment samples from Phase I and Phase II of the RI. PCB-contaminated sediments have migrated from the stream adjacent to the landfill downstream to at least the point where the stream crosses the facility boundary. The rate of transport is directly related to the flow of the unnamed stream and the size of the contaminated particle. The extent of further migration of the PCB contaminated sediment away from the facility is not known at this time. The PCBs are expected to remain sorbed onto the sediment with little natural biodegradation, and therefore, potential uptake by aquatic organisms in the unnamed stream could be significant.

Groundwater contaminated with TCE, cadmium, and mercury at 2GW32 appear to have migrated to some extent. Based on the Phase I and Phase II results, the TCE plume appears to extend from the southern toe or edge of the landfill to the unnamed stream. As

discussed in Section 1.3.9, Facility Hydrogeology, the velocity of groundwater flow in the saprolite unit at Site 2 has been estimated as 7.00 X 10^{-6} cm/sec. The velocity of the TCE plume in the groundwater is approximately the same as the groundwater flow velocity. Therefore, transport of TCE in the groundwater system has been low.

The migration of cadmium in the groundwater is limited by the species of cadmium detected. The ionic species have an affinity to sorb to soil particles by cation exchange processes and therefore have limited mobility. Insoluble species may be present in the soil water but will not migrate appreciably. Soluble species are subject to groundwater transport by advection but transformations in route help to retard the advance of the cadmium. The rate of transport of cadmium in the groundwater is expected to be much lower than that of the TCE at Site 2. The migration of mercury in groundwater would be similar to that of cadmium.

2.6 RISK ASSESSMENT SUMMARY

2.6.1 Human Health Evaluation

The human health evaluation addresses the consequences of "reasonable maximum exposure" to site contaminants. The USEPA recommends use of this approach, which yields the maximum exposure that is reasonably expected to occur at a site. For example, the concentrations selected for the evaluation are either the 95th percent upper confidence limit (UCL) on the mean or the maximum concentration detected. Frequent exposure to contaminants is considered, even though exposure may be infrequent. The approach is consistent with that recommended by the USEPA.

A summary of the risk estimates in relation to USEPA's Superfund remediation criteria is presented in Table 2-11. The risk assessment determinations are included as Appendix G. The non-cancer and cancer risks associated with exposure to contaminants at Site 2 are summarized in the following sections. It is important to note that, for the purpose of this risk assessment, the terms "hazard quotient and "USEPA Superfund Remediation Goal" are important concepts.

- **Hazard Quotient**: The ratio of the estimate of the CDI to the health-protective criterion (CDI/RfD) is called the hazard quotient (USEPA, 1989a). The hazard quotient assumes that there is a level of exposure (i.e., the RfD) below which it is unlikely for even sensitive subpopulations to experience adverse

health effects. If the hazard quotient exceeds 1.0, there may be concern for potential non-cancer effects. The greater the hazard quotient above 1.0, the greater the level of concern.

- **Superfund Remediation Goal**: For known or suspected carcinogens, the remediation goal is defined as concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6} using information on the relationship between dose and response. The 10^{-6} risk level shall be used as the point of departure for determining remediation goals for alternatives when ARARs are not available or are not sufficiently protective because of the presence of multiple contaminants at a site or multiple pathways of exposure. For the purpose of this report, values "within" the remediation goal will be recommended for remediation.

2.6.1.1 Non-Cancer Risks

As stated in Section 2.1.4.1 of the Human Health Evaluation (Appendix G), an oral RfD for PCBs has not been established, and therefore, a quantitative evaluation for non-cancer risks was not performed.

2.6.1.2 Cancer Risks

For NSWCWODET workers, the estimated cancer risks for ingestion of and dermal contact with soil and dermal contact with sediment are within the USEPA Superfund remediation goal. PCB is the only contaminant of concern in the soil and sediment.

The total cancer risk for off-site adults who potentially have dermal contact with contaminated sediment is about 2 in 100 million which is less than the USEPA Superfund remediation goal. The total cancer risk for adolescents who potentially have dermal contact with contaminated sediment is about 2 in 10 million which is also less than the USEPA Superfund remediation goal.

Thus, based on the human health evaluation (which evaluates current and future human health risks in the absence of remedial action), consideration of the need for remediation of surface soils and sediment (on-site adjacent to the landfill) at Site 2 is warranted.

2.6.2 Ecological Risk Assessment

In determining the potential risk of inorganic analytes and PCBs in the media at Site 2 to wildlife, the toxicity and availability of the parameters for many compounds are dependent on many factors including water chemistry, soil chemistry, chemical species, and the presence of the other compounds within the media.

Concentrations of cadmium in food sources for the indicator species selected for this risk assessment were slightly above the acceptable levels. Therefore, a low to moderate risk to wildlife in general is expected from the presence of cadmium in contaminated media at the Site 2.

Copper levels in American Eel caught downstream of Site 2 were twice as high as the calculated acceptable level. Copper levels in dace species were below the calculated acceptable level. The risk from exposure to copper in the contaminated media at the site is expected to be low.

Concentrations of Arochlor 1260 (a PCB) in food sources were significantly higher than the acceptable levels in the Belted Kingfisher. This, combined with the consistently high levels found in all media at the site, and the high frequency of detection, would suggest a high risk to wildlife from exposure to PCBs in the contaminated media at the Site 2.

2.7 SUMMARY AND CONCLUSIONS

2.7.1 Summary

Site 2 (Apple orchard Landfill) is an abandoned landfill located south of Perimeter Road. The Site 2 landfill was operated as open disposal area and landfill from 1948 until 1982. According to the IAS, waste disposed of at Site 2 included domestic refuse, oils containing PCBs, solvents, paint residue, acids and miscellaneous compounds. approximately Prior to 1970, approximately 500 gallons of PCB-contaminated oil were deposited at this site.

The RI at Site 2 included a hydrogeologic investigation, and contaminant characterization and risk assessment. The hydrogeologic investigation included lithologic descriptions of the subsurface, monitoring well elevation and location survey, groundwater level measurements and three aquifer slug test. The lithology beneath Site 2 consists of the Upland Sand and Gravel unit which lies unconformably on the gneiss saprolite of the Wissahickon Formation. Depth to the water table ranges from approximately 6 to 20 feet

below grade. Predominant groundwater flow at the site is to the east southeast. The groundwater gradient ranged from 3.0 to 5.0 percent with a geometric mean of 4.0 percent. The geometric mean of K based on the analysis of the slug test data was 2.4 x 10^{-3} cm/sec (48.9 gpd/ft^2).

The contaminant characterization included the collection and analysis of samples from the surface water, sediments, soil, groundwater, and biota to be used for determining the risk to human health and the environment. Groundwater Monitoring Well 2GW45 was installed during Phase I and Monitoring Well 2GW76 was installed during Phase II. Six surface water samples, 10 sediment samples, 2 surface soil samples, and 4 groundwater samples were collected for analysis during Phase I. A soil gas survey was performed during Phase I to determine the concentration of the volatile organic compounds in the shallow soil. Six surface water samples, 10 sediment samples, 14 surface soil samples, 6 soil samples from 3 soil borings, and 5 groundwater samples were collected during Phase II.

The ecological investigation during Phase II consisted of terrestrial vegetation, mammal, fish, and benthic surveys. The top of the landfill at Site 2 are covered primarily with disturbed herbaceous old field vegetation. The slopes and toes of the landfill are covered with mixed deciduous forest and old field areas. Two White Oak trees adjacent to the stream are infected with fungal galls. The mammalian species found at the site are those commonly associated with a forested and old field ecosystem.

The substrate of the upstream portion of the stream is bedrock with sand and boulders. Algae mats grow in the stream and impede the flow. An oily sheen from an unknown sources or sources was noted on the surface of the water. The substrate of the mid-stream portion of the stream consists of a pebbly sand and covered with thick organic matter (mostly leaf litter). Much of the flow in the stream is from storm water runoff. The substrate of the downstream portion of the stream is also high in organic matter.

Based on the population percent of oligocheates (segmented worms) in the stream sediments, the water quality of the stream decreases in the downstream direction. The HBI values for the stream indicate poor water quality at the upstream location and fair water quality in the mid-stream and downstream locations.

The risk assessment determinations are included as Appendix G in this text. PCBs are the only contaminant of concern in the sediment and the soil. A quantitative evaluation of the non-carcinogenic health effects was not performed because an oral RfD for PCBs has not been established. The total cancer risk to the NSWCWODET workers who may

potentially be exposed to PCB contaminated soil and sediment is within the USEPA Superfund remediation goal. The total cancer risk to the residential population who may potentially be exposed to PCB contaminated sediment is less than the USEPA Superfund remediation goal. Therefore, based on the human health evaluation, consideration of the need for remediation of surface soils and stream sediment at Site 2 is warranted.

According to the ecological risk assessment, there is a low to moderate risk to wildlife expected from exposure to cadmium in the contaminated media. The risk to wildlife from exposure to copper in the contaminated media is expected to be low. There is an expected high risk to wildlife from exposure to PCBs in the contaminated media.

2.7.1.1 Nature and Extent of Contamination

The results of the soil gas survey indicated the presence of volatile organic compounds in the soil vapor at concentrations less than 3 ppm to the west of the landfill near Building 111 (Sampling Points 4 and 2) and to the east of the landfill near Perimeter Road (Sampling Points 17 and 18). Metals (mostly chromium, copper, lead, and zinc), PCBs, volatile organic compounds, and semi-volatile organic compounds were detected in the surface soils at Site 2 (Tables 2-3 and 2-4). PCBs concentrations at detectable levels in the surface soils exceeded the RCRA Corrective Action level of 0.009 mg/Kg during Phase I and Phase II. No volatile organic compounds were detected in the surface soil during Phase I. During Phase II, the volatile organics detected were largely confined to acetone and methylene chloride which are common laboratory contaminants. A wide variety of semi-volatile compounds were detected in the surface soil samples from Phase I and Phase II. The majority of the compounds were species of anthracene, fluoranthene, naphthlyene, phthalate, and pyrene.

Subsurface soil samples were collected only during Phase II. Metals, PCBs, and volatile organic compounds were detected in the subsurface soil at Site 2 (Table 2-5). The metals present in the subsurface soil at levels above background were mostly copper, lead, and zinc. PCBs concentrations at detectable levels in the surface soils exceeded the RCRA Corrective Action level of 0.009 mg/Kg. The volatile organic compounds were largely confined to acetone and methylene chloride which are both common laboratory contaminants.

The vertical distribution of PCB and metals within the soil to a depth of 5 feet appears to be randomly distributed with the highest values occurring to the northwestern and southern portion of the landfill. The horizontal distribution of the metals, PCBs, and semi-volatiles organic compounds appears to be randomly distributed across the site. The horizontal distribution of the volatile organic compounds appears to be more uniform across the site.

The contaminants of greatest concern ion the groundwater at Site 2 are cadmium, mercury, and TCE (Tables 2-6 and 2-7). The cadmium concentration in the groundwater has not varied significantly from the Phase I and Phase II except for a slight decrease in concentration at Monitoring Well 2GW32 and an increase in concentration at Monitoring Well 2GW31. The presence of elevated levels of metals in all of the wells at Site 2 suggests leachate migration maybe radial from the landfill.

The TCE concentrations in the groundwater from samples collected from Monitoring Well 2GW32 increased from the Verification Phase to Phase I and a decreased in concentration from Phase I to Phase II. Variations observed in TCE concentrations may be the result of a limited event such as the migration of TCE slug generated by a drum leaking or an increase in leachate generation due to weather conditions prior to sampling (i.e., intense rain).

The PCBS are the contaminants of greatest concern in the stream sediments. PCBs concentrations at detectable levels in the stream sediments exceeded the RCRA Corrective Action level of 0.009 mg/Kg during both Phase I and Phase II. The PCB levels detected in the sediments indicate a progressive decrease in concentration in the downstream direction. The location of the highest PCB level detected in the sediment was from the most upstream sampling location which suggests possible contribution of PCB contaminants from off-site sources.

The levels of metals (chromium, copper, lead, and zinc) in the sediment and surface water are within the range of background conditions for the NSWCWODET facility. The metals levels detected in the sediments indicate a decrease in concentration in the downstream direction. Volatile organic compound concentration (TCE) in the surface water and sediment are only slightly elevated above the detection limit. Storm water runoff from an industrial area directly upstream from the facility may contribute all or some of the contamination found in the stream and sediment.

2.7.1.2 Fate and Transport

At Site 2, the primary contamination of concern are the PCBs in surface soils and stream sediments; and TCE and cadmium in the groundwater. The major potential routes of migration include the transport of contaminants through the soil system, groundwater system, surface water system and air system. At Site 2, PCB contaminated surface soil can be transported sheetflow erosion and deposited into the stream. Soil agitation by heavy machinery can generate PCB contaminated fugitive dust which can be transported by wind currents. The PCB contaminated sediments will migrate downstream when stream flow is large enough to erode or scour the stream bed. The rate of sediment migration was not determined because sediment size and the flow conditions of the stream were not determined.

Transport of TCE and dissolved metals in the groundwater is predominantly to the east-southeast groundwater flow near the stream, the flow diverges from the predominant flow direction and towards the stream. Based on the groundwater condition, and the potential mobility and concentration of the contaminants detected in the groundwater, transport of the TCE and dissolved metals in the groundwater system has been low. Based on the analytical results of the surface water samples, TCE and dissolved metals contaminated groundwater entering the stream is apparently diluted by the flow of the stream.

2.7.2 Conclusions

The hydrogeologic investigation from Phase I and Phase II provided the information necessary to determine the direction of groundwater flow, the groundwater gradient, and the hydraulic conductivity and transmissivity of the unconfined aquifer.

The biota identified at the landfill during the ecological investigation consisted primarily of disturbed old field areas and mixed deciduous forest with commonly associated mammalian species. Two White Oak plant had fungal growth. The combination of a visible oil sheen on the surface of the water, a high amount of organic material in the substrate, a predominance of oligocheate worms in the benthic population, and a lack of fish in the stream indicate that the water quality is poor in the stream at Site 2.

Metals and PCBs were identified in the surface soil, subsurface soil, and the stream sediments at Site 2. PCBs concentrations at detectable levels in the soils and sediments exceeded the RCRA Corrective Action level of 0.009 mg/Kg. PCBs in the surface soils may

be transported as fugitive dust in the atmospheric system or eroded by sheetflow processes, and to some extent, migrate downward into the soil profile. PCBs and metals in the stream sediments can migrate as a suspended load when the stream conditions are severe enough to erode the stream bed.

Metals and TCE were identified in the groundwater beneath Site 2 during both Phase I and Phase II. Migration of the contaminants in the groundwater beneath Site 2 is predominantly towards the east southeast although groundwater near the stream diverges from the predominant direction and flows toward the stream. The migration of the contaminants in the groundwater at Site 2 is considered low based on the flow velocity of the groundwater.

The risk assessment identified a potential concern for total cancer risk for off-site populations who may be exposed to the groundwater from Site 2. A quantitative evaluation of the non-carcinogenic health effects was not performed because an oral RfD for PCBs has not been established. Based on the human health evaluation, consideration of the need for remediation of groundwater at Site 2 is warranted.

According to the ecological risk assessment, there is a low to moderate risk to wildlife expected from exposure to metals contamination in media. There is an expected high risk to wildlife from exposure to PCBs in the contaminated media.

2.7.2.1 Data Limitations

The analytical results for mercury in the groundwater were rejected due to laboratory quality control problems discovered during our data evaluation. The extent and potential migration of mercury contamination in the groundwater, therefore, is evaluated using Phase I data only.

Several physical properties of Site 2 that were required to model the contaminant fate and transport were not quantified, including soil moisture profile, soil carbon content, soil cation exchange capacity (CEC), infiltration capacity, and the vertical hydraulic conductivity. Contaminant transport modeling in the atmospheric system requires the determination of the prevailing and seasonal wind direction and speed. For fugitive dust migration analysis, the particle size of the contaminated soil is required. Modeling of contaminant transport in the surface water system requires several parameters which include stream-morphology parameters (i.e., channel width and depth), high and low stream flow velocities, sediment particle size analysis, groundwater/surface water interface flow properties.

2.7.2.2 Preliminary Remedial Action Objectives

The risk assessment of contamination present at Site 2 indicates that the primary threat to human health and the environment is to on-site workers from PCB contaminants in the sediment and soil. The primary exposure route would be through ingestion and dermal contact to the soil and dermal contact of the sediment. The remedial objective is to remove any remaining source(s) of contaminants, to prevent further contaminant migration into the soil and stream sediments, and to reduce the health risk associated with the exposure to contaminated surface soils and stream sediment to acceptable levels under the USEPA Superfund remediation goal.

3.0 SITE 3 - PISTOL RANGE LANDFILL

3.1 SITE BACKGROUND

3.1.1 Site Description

The Pistol Range Landfill is located directly north of Dahlgren Road approximately one-third mile south of the northeast facility boundary. A small unnamed stream located adjacent to the western edge of the site flows southward past Site 3. The Pistol Range Landfill was operated as a landfill from the late 1940s until the mid-1970s. Fill materials were pushed into a gully adjacent to the site that was formed by a small perennial tributary which flows into Paint Branch Creek. The landfill is about 0.9 acres in size. Wastes disposed at this site as reported by the IAS study included solid wastes, solvents, oils possibly containing PCBs, sodium nitrate, and miscellaneous metallic objects. The primary wastes of concern are about 8,000 gallons of solvents and oils reportedly disposed of at the site over a period of 30 years.

3.1.2 Previous Investigation

Three groundwater monitoring wells, three surface water, and six stream sediment sampling locations were sampled during the Verification Phase. The analytical data suggests that leachate from the landfill was migrating to the shallow groundwater. However, unlike Site 2, sediment and surface water sample results do not indicate conclusively that leachate is discharging to the stream. Slight volatile organic compound contamination of the shallow groundwater was indicated. PCBs were not detected in any of the samples while metals concentrations were detected at slightly elevated levels in groundwater samples. Low levels of TOX and TOC were present but were not significantly elevated in the groundwater and surface water. Some contaminants were detected in wells located across the stream from the landfill, however, it is believed that the majority of the landfill leachate is being discharged to the stream.

Data gaps identified after the analysis of the Verification Phase Final data included:

- Unknown if contamination migrates under the roadway to the south of the landfill, in the direction of the surface water flow; and
- Incomplete information on the groundwater flow directions and gradients.

Verification Phase recommendations included:

- Installation of one additional monitoring well;
- Selection of two surface soil, and one new surface water sampling location;
- Sampling of the new and existing groundwater monitoring wells; and
- Resampling of the surface water sampling locations.

Recommendations that were made subsequent to the Verification Phase Final Report included:

- Perform a soil gas survey to better evaluate the contamination of groundwater by volatile organic compounds; and
- Replace the two stream sediment sample locations with two shallow soil samples obtained from the highly erodible portion of the landfill adjacent to the stream.

3.2 RI INVESTIGATIONS

3.2.1 Surface Features Investigations

The purpose of surface feature investigations was to identify possible contaminant migration and the location of potentially affected receptors. Surface feature investigations included location of surface disposal areas, property lines, streams, leachate springs, vegetation, topography of the landfill, and the presence of landfilled wastes emanating from the face of the fill.

3.2.2 Surface Water and Sediment Investigations

Surface water and stream sediment were sampled at four locations during Phase I from the unnamed stream that passes to the west of the landfill and flows north to south. The surface water and stream sediment sampling locations extended from the point where the stream enters the facility (northwest corner of the landfill) and along the stream downgradient to the point where the stream exits the facility. The purpose of the sampling

was to document the chemical quality of the surface water and stream sediment for selected constituents at Site 3.

Surface water was not sampled during Phase II. Sediment samples were collected at the same approximate four locations during Phase II.

A summary of the investigative tasks for Phase I and Phase II are listed on Table 1-5. The sample locations during Phase I and Phase II are illustrated on Figure 3-1. A summary of the environmental sampling conducted during both Phase I and Phase II is presented on Table 3-1 and 3-2. Surface water and sediment samples were collected using the standard procedures presented in Appendix F. In addition, two Monitoring Wells (3GW47 and 3GW78S) were slug tested to determine an estimate of the hydraulic conductivity of the water table aquifer at the site.

3.2.3 Soil and Vadose Zone Investigations

During Phase I, soil and vadose zone investigations for Site 3 included the collection of two surficial soil samples and a soil gas survey of the shallow soil adjacent to the landfill. A soil gas survey sampling grid was established to the west and south of the landfill. The purpose of these investigations was to measure the release of gaseous volatile organic contamination through the soil, potentially predict contaminant movement through the vadose zone, and measure the chemical contamination in the surface soils for Risk Assessment purposes. During Phase II, two additional surface soil samples were collected A soil gas survey was not conducted during Phase II.

A summary of the investigative tasks for Phase I and Phase II are listed on Table 1-5. The sample locations during Phase I and Phase II are illustrated on Figure 3-1. A summary of the environmental sampling conducted during both Phase I and Phase II is presented on Tables 3-1 and 3-2. Soil samples were collected using the standard procedures presented in this report in Appendix F.

3.2.4 Groundwater Investigations

During Phase I, one groundwater Monitoring Well (3GW47) was installed south of Site 3. Groundwater samples were collected from four Monitoring Wells (3GW17, 3GW18, 3GW19, and 3GW47). During Phase II, three additional Monitoring Wells (3GW77, 3GW78S, and 3GW78D) were installed and groundwater samples were collected from seven

Monitoring Wells (3GW17, 3GW18, 3GW19, 3GW47, 3GW77, 3GW78S, and 3GW78D) at the site.

A summary of the investigative tasks for Phase I and Phase II are listed on Table 1-5. The well locations are illustrated on Figure 3-1. Construction details for the wells installed during Phase I and Phase II are listed on the borehole logs for 3GW47, 3GW77, 3GW78S and 3GW78D and are presented in Appendix B. Tables 1-6 and 1-7 summarize the installation, development, and sampling dates for each well. A summary of the environmental samples collected during both Phase I and Phase II is provided on Tables 3-1 and 3-2. Groundwater samples were collected using the standard operating procedures provided in Appendix F.

3.2.5 Geological Investigations

During Phase I, one borehole was drilled at Site 3 and converted to a groundwater Monitoring Well (3GW47). During Phase II, three boreholes were drilled and converted to groundwater Monitoring Wells (3GW77, 3GW78S, and 3GW78D). Soil samples were collected with a split spoon sampler during drilling to characterize the subsurface lithology at the intervals indicated on Table 1-6. Descriptions of the individual split spoon samples obtained are given in Appendix B on the borehole log for Borings 3GW47, 3GW77, 3GW78S, and 3GW78D. Soil samples were collected using the standard operating procedures presented in Appendix F.

3.2.6 Ecological Investigations

Included in the Site 3 investigations were terrestrial vegetation, mammal, fish and benthic invertebrate surveys. The vegetation survey consisted of a qualitative analysis of species types located on site. In this study, field identification was supplemented with office confirmation of the major vegetative species. Relative abundance of the species was established and vegetation community relationships were delineated on the project site map. A general mammalian survey was performed and benthic invertebrate sampling was conducted using a kick screen method at two locations along the stream (upstream and downstream) adjacent to Site 3. The fish survey was completed using a Smith-Root electrofisher at upstream and downstream points along the length of the stream on site. Fish specimens were collected for bioassay and sent to the laboratory to be analyzed for

metals, PCBs and PAHs. Specific sampling materials and standard operating procedures are included in Appendix F.

3.3 PHYSICAL CHARACTERISTICS

3.3.1 Surface Features

The Pistol Range Landfill is located within the valley of a perennial tributary of Paint Branch Creek. The landfill covers approximately 0.9 acres of land west of the stream. The site has been cleared but the area immediately surrounding it is covered by woodlands. No industrial complexes are located adjacent to the site. A large sand and gravel quarry operation is located approximately 500 feet north of the NSWCWODET and Site 3.

3.3.2 Surface Hydrology

The perennial stream adjacent to Site 3 flows due south through the NSWCWODET and joins Paint Branch Creek slightly south of the NSWCWODET property boundary approximately 2,000 feet south of Site 3. The stream enters the NSWCWODET facility along the northern boundary approximately 2,000 feet east of Paint Branch Creek. The stream flows through the University of Maryland Plant Research Farm and bisects a large sand and gravel quarry north of the NSWCWODET. Prior to entering the NSWCWODET, water in the stream originates from three sources: sheetflow, groundwater discharge, and storm water discharges. If the quarry relies on dewatering activities to lower the water table to permit quarry operations, the water from the well point network may be discharged into the perennial stream.

This stream has a width ranging from 4 to 8 feet and a depth of 4 to 6 inches. The substrate is iron-colored and little planktonic or algae life was noted. The substrate size was an average of three inches in diameter, or cobble size.

3.3.3 Soils

The soils covering Site 3 belong to the Wehadkee series. These are poorly drained soils developed on floodplains of the Piedmont. The soils are strongly mottled and have a high water table during most of the year. The SCS reports the soil pH ranges from 4.5 to 5.5 (Soil Survey Report, US Naval Ordnance Laboratory, White Oak, Maryland, 1970).

3.3.4 Geology

Two geologic units are present at the Pistol Range Landfill. The sand facies (Kps) of the Potomac Group occurs at the surface and continues to a depth of approximately 6 to 8 feet below ground surface. It consists of a brown to light-brown silty sand with quartz pebbles and cobbles. Underlying the Potomac Group is the saprolite member (Wds) and the fractured gneiss (Wd) of the Wissahickon Formation. The saprolite thickness ranged from 4 to 7 feet across Site 3.

Four of the seven wells at this site penetrated the underlying gneiss unit. Rock cores were collected from Wells 3GW17, 3GW18, and 3GW19 in the fractured gneiss during the Verification Study. This unit contains slight to moderate fracturing based on the rock cores collected. Several of the fractures were mud filled which indicates that some groundwater seeps along the fracture zones. Air rotary drilling of Well 3GW78D intercepted a water bearing fracture zone approximately 65 feet below the ground surface.

3.3.5 Hydrogeology

Groundwater flow at Site 3 is similar to the situation described at Site 2. Graphical analysis of the water levels measured during Phase II from Wells 4GW82, 3GW77, and 3GW47 indicate that groundwater flow direction is to the west towards the unnamed tributary and from Wells 3GW17, 3GW19 and 3GW78S is to the south approximately in the general direction of surface water flow of the unnamed tributary to Paint Branch Creek. Graphical analyses indicate that the groundwater gradient ranges from 1.8 to 5 percent with a geometric mean of 3.5 percent. Figure 3-1 illustrates the estimated groundwater flow direction for Site 3.

Two slug tests were conducted on the unconfined aquifer using Monitoring Wells 3GW47 and 3GW78S (Table 1-3). Analysis of the slug test data resulted in an estimated hydraulic conductivity (K) for each well. The geometric mean of the K values for each well was then calculated to determine the average K for Site 3. Since a slug test determines an estimated K over a limited area of influence around each well tested, the groundwater flow velocities for Site 3 are based on the multi-well pump test analyses conducted on similar stratigraphic units at Site 11, adjacent to Site 3. This data should be more representative of regional conditions.

The estimated velocity of the groundwater flow beneath the site is 6.2×10^{-6} cm/sec.

The depth to the water table in August, 1991, ranged from 8.39 feet below TPVC at Well 3GW19 to 10.57 feet below TPVC at Well 3GW78s. Water table elevations during August, 1991, ranged from 201.86 feet MSL at Well 3GW77 to 214.18 feet MSL at Well 3GW17. Based on the 1991 water level data, the approximate saturated thickness of the water table aquifer within the saprolite unit was 20 feet.

The potentiometric surface of the groundwater confined in the fractured bedrock underlying the site is the approximate elevation of the nearby perennial stream flowing on the saprolite, fractured bedrock and alluvial sediments. Water from the fracture intercepted at 65 feet below ground surface in Well 3GW78D rose to approximately 11 feet below ground surface. Groundwater flow from fractured bedrock probably supports the stream since the thin veneer of overlying unconsolidated Coastal Plain sediments and regolith probably would not be sufficient to supply adequate groundwater to the stream, particularly during periods of low precipitation.

3.3.6 Ecology

Vegetated areas on Site 3 consist of mowed grass, old field areas, and forested regions. Immediately adjacent to the road on site is a mowed field with greater than 80 percent coverage, and dominated by species of graminoid grasses, plantain, and clover. Areas of old field are dominated by clover, goldenrod, honeysuckle, Blackberry, Pigweed, Wild Onion, Horse Nettle, thistle, Box Elder Maple, Halberd-leaved Tearthumb, Common Yarrow, and Dewberry.

Successional forested areas on-site are dominated by Tulip Poplar, Red Maple, Box Elder Maple, Black Oak, Scarlet Oak, Northern Catalpa, and Flowering Dogwood. Many of the Red Maple trees on-site appear to be infected with a leaf fungus.

The upstream portion of the Site 3 stream has an average width of 4 to 5 feet with a depth ranging from 4 to 6 inches. The substrate is iron-colored cobble of a 3-inch average diameter. Planktonic life in this stream is minimal.

The midstream section of the Site 3 stream has a width ranging from 6 to 7 feet, and water depth and substrate type similar to upstream locations. Iron content in the water is very high and little or no algae or plankton is present.

The downstream portion of the stream has a width of 6 to 8 feet, and iron-stained substrate consisting of cobbles averaging 3 inches in diameter. Very little plankton life is present in this stretch of the stream.

The upstream portion of the stream contained very few benthic organisms. The total sample consisted of one annelid worm, one Astacidae (a crustacean), and one caddisfly (Cheumatopsyche sp.). The duplicate upstream sample contained two annelid worms and seven midges (Cricotopus sp.). The mid-stream station had 14 Annelids, one fishfly (Corydalus sp.), two caddisflys, one Cheumatopsyche sp., and one Hydropsyche sp. The mid-stream duplicate sample had five annelid worms, one unidentified member of the Class Insecta, and one Hydropsyche sp. larva. The lower station contained one annelid worm and one Hydropsyche sp. The 3C Duplicate sampling location yielded seven annelid worms and five caddisflys.

Sampling results for the Site 3 stream included 33 and 22 percent annelid worms for Sites 3A and 3A Duplicate, respectively. There were 78 and 71 percent annelid worms for Sites 3B and 3B Duplicate, and 50 and 58 percent Annelids for Sites 3C and 3C Duplicate, respectively. The calculations indicate that there are higher quantities of organic pollution in the mid-stream portion of the stream. However, the results of the Hilsenhoff Biotic Index (HBI) calculations do not corroborate this conclusion.

The HBI values for the Site 3 stations were 2.53, 2.84, and 2.77 for upstream, middle, and downstream stretches. These indicate fair water quality throughout the sampling area.

The Site 3 stream supports fish species which include the American Eel, Black-nosed Dace, Creek Chub, Cutlips Minnows, Northern Hogsucker, Pearly Dace, Rosyside Dace, and Fathead Minnow. There exists ample cover for both herbivorous and carnivorous fish in the stream. The presence of several species in this stretch indicate a moderately healthy stream. The existence of shallow pools and several riffle-run complexes help support individuals measuring up to 6 inches in length. Crayfish, salamander larvae, and Leopard Frogs were also found to inhabit the stream.

3.4 NATURE AND EXTENT OF CONTAMINATION

3.4.1 Soils and Vadose Zone

Four surficial Soil Samples, 3SL1 through 3SL4, were collected to document surficial soil contamination for Risk Assessment determinations. Samples 3SL1 and 3SL2 were collected in 1989 on the face of the landfill slope at points halfway between the stream and the apex of the landfill. Sample 3SL3 was collected in 1991 at the base of the slope, just above the stream and sample 3SL4 was collected in 1991 at the apex of the landfill, just

northwest of the intersection of Perimeter and Dahlgren Roads. The location of the sample points is shown on Figure 3-1. Summaries of the analytical data for surficial soil samples collected during Phase I and II are presented on Table 3-3 and Table 3-4, respectively.

Levels of metals (including mercury) and semi-volatiles were detected above background levels during Phase I. The surficial soil results for samples 3SL1 and 3SL2, collected during Phase I, revealed levels of metals (Cadmium, Chromium, Copper, Lead, Mercury, and Zinc) in the soils above background levels established for the facility (Table 1-13). Analytical results for sample 3SL1 indicated that levels of cadmium, copper, lead and mercury exceeded the levels noted for naturally occurring soils (Table 1-12). Analytical results for 3SL2 indicated levels of cadmium and mercury in soils that exceeded those levels noted for naturally occurring soils. In addition, levels of cadmium in sample 3SL1 exceeded the RCRA Corrective Action levels. Levels of semi-volatile organic compounds were above detection limits and slightly above the typical background ranges reported for soils in urban areas (Table 1-12) in both samples collected during Phase I.

Levels of metals (cadmium, chromium, copper, and lead) were detected at significantly lower levels during Phase II sampling. Semi-volatile organic compounds were not detected in the samples collected during Phase II.

Contamination is present in the surficial soil on the face of the landfill. However, soil contamination appears limited based on sampling results. The lower metals concentrations and the absence of semi-volatiles reported in the 1991 samples may be related to the location of sampling points and not to a decrease through time in overall contamination at the site. A Risk Assessment of Site 3 was performed based upon the levels of metals and semi-volatiles in the soil and is included in Appendix G.

In 1989, a soil gas survey to monitor the vadose zone was conducted at Site 3 with an HNu Photoionization Detector. A grid containing 21 sampling points was established to the west of the landfill and extending to the south (downgradient) of the landfill to measure the volatile organic concentrations in the shallow soil. Figure 3-2 shows the location of the sampling grid and the results of the survey. Of the 21 points sampled, only those south of Dahlgren Road revealed detectable quantities of volatile organic compounds. These readings ranged from 0.60 to 15.0 ppm for the downgradient soil gas points. A background level of 0 ppm was established at the site prior to survey.

The soil gas survey showed the highest levels of volatile organic compounds south of Dahlgren Road. The most contaminated points being on the landfill side of the stream may indicate either movement of volatile organic compounds from the landfill directly to the south or that another source for the volatile organic compounds is present. Based upon groundwater flow directions and assuming that flow through the vadose zone to the groundwater table follows a similar pattern, the movement of contamination is apparently towards the stream. The pattern of shallow soil contamination of volatile organic compounds and groundwater contamination at Site 3 may indicate a separate source.

3.4.2 Groundwater

Four existing Monitoring Wells 3GW17, 3GW18, 3GW19, and 3GW47 and three newly installed Monitoring Wells 3GW77, 3GW78S, and 3GW78D were sampled to determine groundwater quality at Site 3 in 1991. Figure 3-1 shows the locations of the seven monitoring wells. The analytical data obtained from sampling revealed compound concentrations above accepted drinking water MCLs as established in Section 1.8.2, Water Quality Standards and Soil Sediment Guidelines. Tables 3-6 and 3-7 summarize the analytical data for the groundwater samples collected from Site 3. The parameters detected above background and MCLs are shaded.

The analytical data gathered in 1989 for the Wells (3GW17, 3GW18, and 3GW19) is very similar to the data obtained in 1985. Well 3GW17 was the least contaminated well with Well 3GW19 being the most contaminated. Although Well 3GW17 is downgradient from the landfill, it is located towards the northwest boundary of the landfill and would only receive a small portion of the total possible leachate generated from the landfill which may have little or no affect on groundwater quality in the well. The presence of contamination in Wells 3GW17, 3GW18, 3GW19 suggest that leachate in the groundwater may migrate in groundwater to the west of the perennial stream. The highest concentration of metals was detected in a groundwater sample from Well 3GW47. However, these levels were for non-filtered samples. Filtered samples analyzed for metals did not detect levels of metal compounds which exceeded any drinking water MCL except for lead in Well 3GW47. No volatiles were detected in Well 3GW47 during Phase I. Well 3GW47 is located downgradient from Wells 3GW18 and 3GW19 and on the eastern (landfill) side of the stream (See Figure 3-1). Volatile organic contamination remained virtually unchanged between 1985 and 1989.

The analytical data gathered in 1991 for the four existing wells and the three newly installed monitoring wells is similar to that reported in 1989. Well 3GW19 remains the most contaminated. The newly installed Well 3GW77, located on the same side of the stream as the landfill and downgradient was reported to contain TCE. However, no volatiles were detected in Well 3GW47, located between the landfill and Well 3GW77. This suggests a possible alternate source of volatile organic contamination downgradient of Site 3. Well 3GW78D is a bedrock well which intercepts a water bearing fracture approximately 65 feet below grade. No contaminants of concern were reported in the sample analyzed from Well 3GW78D except methylene chloride, a contaminant not previously detected in samples from this site. Methylene chloride was found in laboratory QA/QC samples and is, therefore, considered a laboratory contaminant and is not a constituent of concern in this instance.

A comparison of volatile organic compound data is as follows:

		Results (μg/L)		
Well Location	**Parameter**	**1985***	**1989**	**1991**
3GW18	1,2-Dichloroethene	14/ND	8	ND
	TCE	15/ND	7	ND
3GW19	1,2-Dichloroethene	ND/45	38	120
	TCE	ND/16	7	11
	Chlorobenzene	ND/13	16	27
3GW77	TCE	-----	-----	6
3GW78D	Methylene Chloride	-----	-----	7

Note: ND - None Detected
* Sampling Round A / Sampling Round B

Based upon the above data, it can be concluded that the landfill is leaching volatiles into the shallow groundwater. It appears that the plume extends from some distance horizontally across a hydrogeologic boundary at the stream and is also migrating downgradient but the extent remains unknown at this time. In addition, it is possible that a second source, located at some point downgradient of the landfill is contributing to the contamination identified to date.

3.4.3 Surface Water and Sediments

Four surface water locations were sampled in the stream west of the landfill in 1989. Figure 3-1 shows the four sampling locations. No contaminants were detected with levels above the drinking water MCLs and no surface water samples were collected in 1991 based on the 1989 results. Table 3-7 summarizes the analytical data for the surface water results for Site 3.

Four sediment samples were collected along the stream west of the landfill during Phase I and Phase II. The analytical data obtained from sampling revealed compound concentrations above background sediment levels as established in Section 1.8.2, Water Quality Standards and Soil Sediment Guidelines. Tables 3-3 and 3-4 summarize the analytical data for the sediment samples collected from Site 3. The parameters detected above background are shaded on Tables 3-3 and 3-4. Elevated levels of contaminants, including chromium, copper, lead, methylene chloride, acetone, carbon disulfide, and TCE were noted.

Surface water data does not confirm that the landfill is leaching contaminants into the stream. Stream sediment analytical data indicates, as the surface water data does, that there is little impact to the stream by the landfill. The levels of chromium and mercury during Phase I and chromium, copper, and lead during Phase II are at similar concentrations at the sediment sampling point where the stream enters the facility as they are at sediment sampling points adjacent to and downstream from the landfill. Again, the levels are only slightly higher than the background guidelines being used, and therefore, are not a concern.

A comparison of data is as follows:

		Results (mg/kg)	
Sample Location	Parameters	1989	1991
3SD1	Chromium	33.9	8.3
	Mercury	0.19	R
3SD2	Chromium	12.0	3.5
	Mercury	0.18	R
3SD3	Chromium	6.3	8.7
	Mercury	0.24	R
3SD6	Chromium	16.8	7.4
	Mercury	0.17	R

R - Analytical Result Rejected
E - Compound Present, Concentration Estimated

3.5 CONTAMINANT FATE AND TRANSPORT

3.5.1. Potential Routes of Migration

The contaminants of greatest concern at Site 3 are volatile organic compounds (i.e., TCE, chlorobenzene, and 1,2-dichloroethene) and metals (lead) in the groundwater system, and low levels of metals (cadmium, chromium, mercury, and copper) in the surface soils. The major potential routes of migration at the Site 3 include the transport of contaminants through the:

- Soil system; and
- Groundwater system.

Although there were no target compounds detected in the surface water and stream sediments during the Phase I and Phase II of the RI, transport of contaminants through the surface water/sediment system and the atmospheric system will still be addressed as the result of possible contaminant transfer from the groundwater system and the soil system. There was no groundwater contamination detected in the bedrock.

3.5.2 Contaminant Migration

At Site 3, the primary source of contamination is leachate generation from the Pistol Range Landfill. However, low levels of contamination were identified in the surface soils. Due to the shallow water table (7 to 8 feet below land surface for the seven wells), transport of contaminants vertically through the soil is limited and is not a significant pathway for potential exposure. There is the potential for soil contamination at the surface to be transferred to the atmosphere as fugitive dust but the low levels of contamination do not merit further analysis of this transport pathway.

TCE, 1,2-dichloroethene, and chlorobenzene were identified in groundwater Monitoring Wells 3GW18 and 3GW19. These wells are located to the west of the landfill and also on the opposite side of the stream adjacent to the landfill. Significant levels of metals were detected in the non-filtered groundwater at Site 3 on both sides of the stream. However, significant levels of dissolved lead were detected in Well 3GW47 only during Phase I analysis of filtered samples. The highest concentrations, however, of dissolved

metals were detected on the landfill side of the stream and down gradient from the landfill (3GW47). The presence of volatile organic compounds and metals in the groundwater west of the stream indicates that there may be contaminant migration in groundwater beneath the stream. There is the potential for contaminated groundwater to be transferred to the stream.

As discussed in Section 1.3.8 Hydrogeology, the velocity of groundwater flow in the saprolite unit at Site 3 has been estimated as 6.2×10^{-6} cm/sec. If the estimated velocity of a TCE, DCE, and chlorobenzene plume in the groundwater approximates the groundwater velocity, and because of the existence of shallow groundwater conditions at this site and the high mobility rate of these compounds, the migration of low levels of volatile organic compounds from the landfill at Site 3 in the groundwater has extended to approximately 500 feet from the landfill. Using data collected, the migration rate is calculated to be 0.02 feet per day. The contamination would be expected to move an additional 700 feet in 100 years at this rate. The migration of the dissolved metals plume in the groundwater is expected to be retarded by chemical reaction of the metals during transport and, therefore, the estimated migration rate of the dissolved metals plume in the groundwater would be slower than the volatile organic compound plume. The dissolved metals plume appears to be larger than the volatile organic plume and is therefore probably older.

The volatile organic compound plume and the dissolved metals plume is expected to migrate towards the south-southwest of the landfill along the stream valley and south towards the center of the facility. Contaminated groundwater entering the stream, at present, is at concentrations low enough to be diluted by the stream flow to undetected levels.

3.6 RISK ASSESSMENT

3.6.1 Human Health Evaluation

A summary of the risk estimates in relation to USEPA's Superfund remediation criteria is presented in Table 3-8. The non-cancer and cancer risks associated with exposure to contaminants at Site 3 may be summarized as follows.

3.6.1.1 Non-cancer Risks

Adverse non-carcinogenic health effects in the residential population (adults and children) from exposure to the chemicals of potential concern in the groundwater are unlikely. The total hazard indices for the pathways for both adults and children are less than the criterion of 1.0.

3.6.1.2 Cancer Risks

The total cancer risk for adults and children who, if groundwater were used in the vicinity of the landfill at a future date for residential use, potentially may ingest, have dermal contact with or inhale airborne chemicals from contaminated groundwater is within the USEPA Superfund remediation goal. Ingestion of groundwater constitutes the pathway of greatest concern for residential adults and children with TCE being the chemical of potential concern as the main contributor to the risk.

Thus, based on the cancer risk evaluation and potential future use as a residential area, consideration of the need for remediation of groundwater at Site 3 is warranted.

3.6.2 Ecological Risk Assessment

In determining the potential risk of inorganic analytes and polychlorinted biphenyls in the media at the Pistol Range Landfill to wildlife, it should be noted that for many compounds, the toxicity and availability of the parameters are dependent on many factors including water chemistry, soil chemistry, the form in which the particular compound is in at the site, and the presence of other compounds within the media.

Concentrations of copper in food sources for the indicator species selected for this risk assessment were slightly below the acceptable levels calculated. The risk from exposure to copper in the contaminated media at the site is expected to be very low.

Concentrations of mercury in food sources were significantly higher than the acceptable levels for the Belted Kingfisher. This, combined with the presence of mercury in the sediment at Site 3, would suggest a high risk to wildlife from exposure to mercury in the contaminated media at the Pistol Range Landfill.

Concentrations of Aroclor 1254 and Aroclor 1260 in food sources for the indicator species selected were well above the acceptable levels calculated. However, samples were not collected for PCB analysis from any of the media sampled at Site 3. The origin of the

Aroclor 1254 and Aroclor 1260 in the biota at the site is not known. Therefore, the risk that Site 3 poses to the biota in the area is not known.

3.7 SUMMARY AND CONCLUSIONS

3.7.1 Summary

Site 3 (Pistol Range Landfill) was operated as a landfill from the 1940s until the mid-1970s. Waste disposed of at this site included solid wastes, approximately 8,000 gallons of solvents and oils, sodium nitrate, and miscellaneous objects. The oils possibly contained PCBs.

The RI at Site 3 included a hydrogeologic investigation, and contaminant characterization and risk assessment. The hydrogeologic investigation included lithologic descriptions of the subsurface, monitoring well elevation and location survey, groundwater level measurements, and two aquifer slug test. The lithology beneath Site 3 consists of a sand facies of the Potomac Group overlying the gneiss saprolite of the Wissahickon Formation. Groundwater flow at the site is to the south-southwest towards the stream and Dahlgren Road at a rate of about 6½ feet per year (see Figure 3-1).

The contaminant characterization included the collection and analysis of samples from the surface water and sediment, soil, groundwater, and biota to be used for determining the risk to human health and the environment. Four surface water samples, four sediment samples, two surface soil samples, and three groundwater samples were collected during Phase I. A soil gas survey was conducted during Phase I to delineate areas with soils contaminated with volatile organic compounds. Two surface soil samples and seven groundwater samples were collected during Phase II. Surface water and sediments were not sampled during Phase II.

The ecological investigation during Phase II consisted of investigations of the terrestrial vegetation, fish, and benthic invertebrate. Results from the benthic survey, based on percent annelid worm calculations, indicated that there are higher quantities of organic pollution in the mid-stream portion of the stream at Site 3. The Hilsenhoff Biotic Index (HBI) values for the same stream indicated fair water quality throughout the sampling area. Fish specimens were collected for bioassay and toxicological analyses to be used for risk assessment determinations.

The risk assessment determinations are included as Appendix G in this report. Adverse non-carcinogenic health effects in the residential population from exposure to chemicals of potential concern in the groundwater are unlikely. The total cancer risk to a future, on-site residential population who may potentially ingest, have dermal contact or inhale airborne chemicals (namely TCE) from contaminated groundwater is within the USEPA Superfund remediation goal. Therefore, based on this cancer risk evaluation, consideration of the need for remediation of groundwater at Site 3 is warranted.

The ecological risk assessment identified mercury and PCBs (Aroclor 1260 and Aroclor 1254) in food sources for the indicator species selected that were well above the acceptable levels calculated. This suggest the potential for a high risk to wildlife from exposure to mercury in the contaminated media. Samples were not collected for PCB analysis from any of the media sampled at Site 3, therefore, the risk to wildlife from exposure to Aroclor 1254 and Aroclor 1260 in the media is unknown at this time.

3.7.1.1 Nature and Extent of Contamination

The soil gas survey indicated the presence of volatile organic compounds in the soils. The areas with the highest soil gas contamination were located along the landfill side of the stream and in an area to the south of Dahlgren Road. The analytical results from the soil samples confirmed the presence of metals contamination (cadmium, chromium, copper, and lead) in the surficial soil along the face of the landfill. Semi-volatile organic compounds were identified in the surficial soil during Phase I but were not identified during Phase II. However, the soil contamination appears to be limited based on the RI sampling results.

The analytical results from the groundwater sampling confirmed the presence of volatile organic compounds and metals in the groundwater beneath Site 3 as a result of leachate migration from the landfill. In addition, the analytical results indicated a possible second source of volatile organic compounds in the groundwater at some point downgradient from the landfill. The volatile organic compounds identified in the groundwater at levels above the MCLs included 1,2-dichloroethene, TCA, chlorobenzene, and methylene chloride during Phase II. The metals in unfiltered samples identified in the groundwater at levels above background or MCLs were cadmium, chromium, and lead during Phase II. No levels above background or MCLs were detected in filtered samples analyzed for metals.

The surface water and stream sediment analytical data indicated that there has been little impact to the quality of the stream by the landfill. Although, low levels of metals were

identified in the stream sediments adjacent to the landfill, low levels of metals were also identified in the sediments where the stream enters the facility.

3.7.1.2 Fate and Transport

At Site 3, the primary source of contamination is dissolved metals and volatile organic compound leachate generation from the Pistol Range Landfill. The major potential routes of migration include the transport of contaminants through the soil and groundwater system. Based on the shallow groundwater conditions and the potential mobility and concentration of the contaminants detected in the groundwater, transport of the landfill leachate in the groundwater system has been moderate. The metals plume appears to be larger than the volatile organic plume and is therefore probably older. The direction of the leachate migration in the groundwater is to the south-southwest of the landfill.

Based on the analytical results from the surface water and stream sediment samples, any migration of leachate into the stream system has been diluted to levels below the detection limit of the analysis.

3.7.2 Conclusions

The hydrogeologic investigation from Phase I and Phase II provided the information necessary to determine the direction of groundwater flow, the groundwater gradient, and the hydraulic conductivity of the unconfined aquifer.

A soil gas survey, conducted during Phase I, identified the presence of volatile organic constituents in the soil gas vapor. Metals contamination was confirmed in the surficial soils along the face of the landfill during Phase II.

Metals and volatile organics contamination were identified in the groundwater beneath Site 3 during both Phase I and Phase II. The source for the groundwater contamination is the generation of leachate from the landfill. Migration of the leachate in the groundwater is to the south-southwest and is considered to be moderate in magnitude.

The analytical results for the surface water and sediment and the benthic survey indicate that the landfill has not impacted the quality of the surface water system.

The risk assessment identified TCE contaminated groundwater as a potential concern for total cancer risk for adults and children who may be exposed to the groundwater from Site 3. Based on the cancer risk evaluation, remediation of the groundwater at Site 3 should

be considered. The ecological risk assessment identified mercury and PCBs at concentrations above acceptable levels to the wildlife at Site 3.

3.7.2.1 Data Limitations

Due to the rejection of all of the analytical results for mercury in the groundwater, the stream sediments, and the surficial soil, based on the data evaluation during Phase II of the RI, the extent and potential migration of mercury contamination in the groundwater and surface water system could not be concluded. Also, the risk of exposure to wildlife could not be adequately addressed.

The ecological risk assessment identified PCBs in the food sources for the indicator species selected. The samples collected from the groundwater, soil, surface water, and sediment at Site 3 were not analyzed for PCBs, therefore, the risk to wildlife from exposure to Aroclor 1254 and Aroclor 1260 in the media of Site 3 is unknown at this time. Several physical properties of Site 3 were required to model the fate and transport of the contaminants including the soil moisture profile, soil carbon content, the cation exchange capacity of the soil (CEC), infiltration capacity of the soil and the vertical hydraulic conductivity of the soil. To properly determine the migration potential of contaminants in the atmospheric system, the prevailing wind direction, wind velocity, and particle size distribution of the surface soils would need further study.

3.7.2.2 Preliminary Remedial Action Objectives

The risk assessment of contamination present at Site 3 indicates that the primary threat to human health and the environment is from the volatile organic contaminants and metals in the groundwater. The primary exposure route would be through ingestion of groundwater and soil. The remedial objective is to remove the source of contamination or limit migration of contaminants by covering the landfill with an impermeable cover. The liner would prevent contaminated leachate generated by percolation of rainwater downward through the site and mixing with contaminants within the landfill, from migrating into the soil or groundwater. In addition, the remedial objective is to limit further migration of the contaminant outside the landfill in the groundwater and soil.

4.0 SITE 4 - CHEMICAL BURIAL SITE

4.1 SITE DESCRIPTION

4.1.1 Site Description and History

The Chemical Burial Site is located south of Perimeter Road and is about 400 yards northeast of Site 3. The Chemical Burial Site was reportedly used from the mid-1950s until the early 1970s for chemical disposal in four discrete locations within the site and is about 1.1 acres in size. Wastes reportedly disposed at this site included acids, explosive compounds, kerosene, chlorinated solvents and numerous unidentified laboratory compounds with a total volume of chemical substances buried in the four areas estimated at about 600 cubic feet.

4.1.2 Previous Investigations

Six groundwater Monitoring Wells were sampled during the Verification Phase. The analytical data indicated that the burial site was leaching organic compounds, as suggested by total organic carbon and total organic halides (TOC and TOX) data, to the shallow groundwater. The wells located nearest to the burial site display relatively greater TOC and TOX levels than those located down gradient and furthest from the site. This situation may support the concept of a perched water table. Low levels of volatile organic compounds, oils and greases, and metals were also present at the site.

Data gaps identified after the analysis of the Verification Phase data included:

- Possible influence of the gravel pit on the groundwater flow direction and gradients.
- Impact of a perched water table on the transport of site contaminants.

The Verification Phase recommendations included:

- Installation of minimum of four additional monitoring wells with two of them being clustered wells.
- Sampling of all of the new and existing Monitoring Wells.

Recommendations that were made subsequent to the Verification Phase Final Report included:

- Collection of soil samples from three of the borings during well installation with the soil samples collected from above and below the groundwater table by the split spoon sampling method.
- Perform a shallow soil gas survey.
- Perform a geophysical survey using Ground Penetrating Radar (GPR).

The soil gas survey was added to better evaluate volatile organic contamination of groundwater, and GPR was added to better define the location and extent of the disposal areas.

4.2 RI INVESTIGATIONS

4.2.1 Surface Feature Investigations

Surface feature investigations included location of surface disposal areas, property lines, drainage ditches, streams, vegetation, and topography of the burial site. The purpose of surface feature investigations was to identify possible contaminant migration and the location of potentially affected receptors.

4.2.2 Contaminant Source Investigations

At Site 4, the contaminant source investigation included the completion of a Ground Penetrating Radar (GPR) survey during Phase II. The GPR survey was performed to identify the four distinct burial areas defined in the IAS report and to document the location of buried metallic objects such as containers or drums, if found. Figure 4-1 illustrates the results of the GPR survey.

4.2.3 Soil and Vadose Zone Investigations

During Phase I, soil and vadose zone investigations for Site 4 included the collection of soil samples and a soil gas survey. A total of six soil samples were collected from Borings 4SB2, 4SB2, and 4SB3 (two from each) that were completed during the installation of monitoring wells. The purpose of the soil sampling was to measure the concentration of

contaminants in the soil. The purpose of the soil gas survey of the shallow soil was to document volatile organic compound concentrations in the soil and to determine the potential movement of these compounds through the upper soil and vadose zone. A sampling grid was established to provide control of the sampling density during the soil gas survey. The sampling grid and soil gas results are presented on Figure 4-2.

During Phase II, the soil investigation included the collection of two Surface Soil Samples (4SL1 and 4SL2) to measure the concentration of contaminants in the surface soil. No soil gas survey was conducted during Phase II

A summary of the investigative tasks for Phase I and Phase II are listed on Table 1-5. The soil sample locations during Phase I and Phase II are illustrated on Figure 4-3. A summary of the environmental sampling conducted during Phase I and Phase II are presented on Tables 4-1 and 4-2, respectively. Soil samples were collected using the standard procedures presented in this report in Appendix F.

4.2.4 Groundwater Investigations

During Phase I, six groundwater Monitoring Wells (4GW48, 4GW49D, 4GW49S, 4GW50, 4GW51D and 4GW52) were installed at Site 4. Two wells were installed as a well cluster, one deep (4GW49D) and one shallow (4GW49S). Groundwater from 12 Monitoring Wells (4GW10, 4GW11A, 4GW11, 4GW12, 4GW13, 4GW15, 4GW48, 4GW49D, 4GW49S, 4GW50, 4GW51D and 4GW52) was sampled during Phase I.

During Phase II, an additional six groundwater Monitoring Wells were installed (4GW79, 4GW80, 4GW81S, 4GW81D, 4GW82, and 4PZ79). Two wells were installed as a well cluster, one deep (4GW81D) and one shallow (4GW81S). Wells 4GW79 and 4GW82D were constructed to be used as constant rate pumping test wells. Groundwater from 17 Monitoring Wells (4GW10, 4GW11A, 4GW11, 4GW12, 4GW13, 4GW14, 4GW15, 4GW48, 4GW49D, 4GW49S, 4GW50, 4GW51D, 4GW52, 4GW80, 4GW81S, 4GW81D, 4GW82, and 4PZ79) was sampled during Phase II. Aquifer slug tests were conducted at 7 Monitoring Wells (4GW10, 4GW12, 4GW13, 4GW48, 4GW50, 4GW52, and 4GW80). Constant rate pumping test were conducted at 2 Monitoring Wells (4GW79 and 4GW81D).

A summary of the investigative tasks for Phase I and Phase II are listed on Table 1-5. A summary of the installation, development, and sampling times for these wells is presented in Table 1-2. Construction details for the wells are listed on the borehole logs for each well presented in Appendix B. A summary of the environmental sampling conducted during

Phase I and Phase II are presented on Table 4-1 (1989) and 4-2 (1991), respectively. The well locations during Phase I and Phase II are illustrated on Figure 4-3. A summary of the slug test analyses and pumping test analyses are presented on Table 1-3 and are detailed in Appendix E. Groundwater samples were collected using the standard procedures presented in Appendix F.

4.2.5 Geological Investigations

Six boreholes were drilled at Site 4 and converted to groundwater Monitoring Wells (4GW48, 4GW49D, 4GW49S, 4GW50, 4GW51D and 4GW52) during Phase I of the RI. During Phase II, six additional boreholes were drilled and converted to groundwater Monitoring Wells (4GW79, 4GW80, 4GW81S, 4GW81D, 4GW82, and 4PZ89). Soil samples were collected in split spoon samplers during drilling at Boreholes 4GW80, 4GW81S, 4GW82, and 4PZ89 to characterize the subsurface lithology at the intervals indicated on Table 1-2. Descriptions of the soil from the individual split spoon samples obtained are given in Appendix B on the borehole logs for each borehole. Soil samples were collected using the standard procedures presented in Appendix F of this report.

4.2.6 Ecological Investigation

Included in the Site 4 investigations were terrestrial vegetation and mammal surveys. The vegetation survey consisted of a qualitative analysis of species located on site. In this study, field identification was supplemented with office confirmation of the major vegetative species at each location. Relative abundance of the species was established and vegetation community relationships were delineated on the project site map. A general mammalian survey was performed, as well. Specific sampling materials and methods are included in Appendix F.

4.3 PHYSICAL CHARACTERISTICS OF THE SITE

4.3.1 Surface Features

The Chemical Burial Site occupies approximately 1.1 acres on a small upland area in the northeastern quadrant of the NSWCWODET facility. This site is approximately 600 feet due west of Site 3 and has similar surface features. The same industrial and institutional

use areas north of Site 3 are also north of Site 4. The site is cleared and the immediate area surrounding the site is lightly forested or covered by grass.

4.3.2 Surface Water Hydrology

Runoff resulting from precipitation onto the Chemical Burial Site would drain into drainage ditches along Perimeter, Simms, and Dahlgren Roads which border the perimeter of the site. These drainage ditches discharge into an unnamed tributary to the Paint Branch Creek adjacent to Site 3 approximately 600 feet west of Site 4. No perennial stream exists in the vicinity of the Chemical Burial Site. The closest surface water body is the aforementioned Paint Branch Creek tributary.

4.3.3 Soils

The soils at this site belong to the Croom Series. These soils are excessively drained gravelly soils that are strongly acidic (pH 4.5 to 5.0) and comprised of strongly compact, firm and massive gravelly layers.

4.3.4 Geology

Three geologic units underlie the Chemical Burial Site. The Upland Sand and Gravel unit forms the uppermost unit and occurs at the surface and is underlain by the Potomac Group. Due to the similarity in lithology and sedimentary features, it was difficult to determine the contact between the two units. The unconsolidated sediments range in thickness from 45 to 65 feet. The thicker deposits occur in topographically higher areas. Within the unconsolidated sediments, a thin (1.0 to 1.75 feet), tan to buff clayey silt to silty clay member (Kpc) of the Potomac Group was observed at the site, and was also observed during the Verification Phase Study at Well BGW16. This unit appears to be laterally continuous to the east. The silty clay seam dips (is inclined) to the south, and in at least one location grades into very thin (0.1 to 0.4 feet) silty seams. Underlying the unconsolidated sediments is the saprolite member (Wds) of the Wissahickon Formation. None of the boreholes encountered the host weathered gneiss during Phase I of the RI. Weathered gneiss was, however, encountered at 65 feet below grade during the drilling of Soil Boring 4GW82 in the southern portion of the site. The thickness of the saprolite at Soil Boring 4GW82 was 21 feet. Soil Boring 4GW80, approximately 150 feet to the east of Soil Boring 4GW82, was drilled to a depth of 82 feet without encountering bedrock or saprolite.

This suggests that the surface of the bedrock and the saprolite unit dips steeply to the east in this area.

4.3.5 Hydrogeology

Groundwater at this site occurs under unconfined conditions in the unconsolidated sediment-regolith unit and the very uppermost portion of the saprolite. The saprolite in this area is an aquitard which restricts groundwater movement from the water table aquifer downward into the underlying competent bedrock, based on the observations from Boring 4GW82. Boring 4GW82 completed during Phase II extended down to bedrock (Wissahickson Formation (Wd)). The saprolite was encountered at 44 feet. Samples at deeper depths within the saprolite exhibited no water bearing fractures and very little to no water was in the saprolite matrix. Depth to the water table from the top of monitoring wells in August, 1991, ranged from 28.14 feet at Well 4GW11 to 58.10 feet at Well 4GW81S. Water table elevations during August, 1991 ranged from 244.36 feet mean sea level (MSL) at Well 4GW81s to 251.01 feet MSL at Well 4GW11. The average saturated thickness of the water table aquifer based on the 1991 measurements at Well 4GW82 was 21 feet.

Graphical analysis of the water level data collected during 1991 from wells which have screened intervals in the unconsolidated sediment support the initial groundwater flow direction determined during the Verification Phase. Groundwater Flow is toward the south southeast. A groundwater divide exist along the western portion of the site where groundwater flow is to the west toward the unnamed stream at Site 3. Although graphical determination of groundwater flow direction indicates the flow is predominantly to the south southeast, groundwater flow at the base of the aquifer may be diverted channeled in a different direction due to changes in surface elevations of the top of bedrock and saprolite as observed in Soil Borings 4GW82 and 4GW80. Graphical analysis indicated that the groundwater gradient ranged from approximately 0.8 to 2.2 percent with a geometric mean of 1.4 percent.

The extent of silty clay to clayey silt layers, identified during the Verification Phase and the Phase I of the RI was confirmed during the Phase II drilling program. A 0.5 to 1-foot thick silty clay to clayey silt layer approximately 20 to 25 feet below ground surface appears to influence the downward percolation of groundwater beneath the site. Sediments overlying this layer were either moist to wet or saturated while sediments directly under this layer were dry. The low permeable silty clay to clayey silt seams appear to reduce the

downward percolation of groundwater forming a perched groundwater zone above the seams. These silty clay to clayey silt seams can stratify vertical groundwater movement and influence horizontal groundwater flow and contaminate migration. Also, during the Verification Phase, a saturated sand at approximately 4 feet below ground surface was encountered perched above a clay seam in Boring 4GW11A. The clay seam appears to be limited to the northern area beneath the site. However, the degree of effect of the perched zones on groundwater movement and contaminate migration cannot be quantified at this time.

Rising head aquifer slug tests were conducted at seven monitoring wells (4GW10, 4GW12, 4GW13, 4GW48, 4GW50, 4GW52, and 4GW80) during Phase II. Calculations and graphical methods were used to estimate K based on methods from Bower and Rice (1989). Recovery curves were generated based on the measured water levels at a time after the test began. The geometric mean for K for the unconfined aquifer at Site 4 based on the slug test is 9.4×10^{-4} cm/sec (18.4 gpd/ft^2). Slug test calculations and graphs can be found in Appendix E.

Two constant rate pumping tests were conducted at Site 4 during Phase II of the RI. The design for the Pumping Wells 4GW81D and 4GW79 was based on the analysis of the initial groundwater characteristics determined from published data and previous studies of the site. Published data suggested that the water bearing unconsolidated sediments probably extended 95 to 120 feet below ground surface, depending upon the degree of erosion (Froelich, 1975). Grain size distribution curves suggested an average K of between 1,000 and 1,500 gpd/ft^2. As designed, the minimum pumping rates of the wells were estimated to be between 12 and 15 gallons per minute with a hydraulic conductivity of approximately 260 gpd/ft^2.

Well 4GW81D drilled to 84 feet below ground surface was pumped during a 24-hour period on 17 and 18 July, 1991, at a constant rate of 8 gpm. During the pumping test and recovery period, water levels were recorded in the Pumping Well 4GW81D, and in Observation Wells 4GW81S, 4GW80, 4GW50, and 4GW82. During recovery, water levels were monitored until 95 percent recovery was observed in the pumping well. No water level changes were observed in Well 4GW82, indicating the zone of influence of the cone of depression created during pumping did not affect that well. Well 4GW82 is approximately 250 feet to the west of Pumping Well 4GW81D.

Well 4GW79, drilled to 78 feet below ground surface was pumped during a 24-hour period on 19 and 20 August at a constant rate of 7 gpm. During the pumping test and recovery period, water levels were recorded in the Pumping Well 4GW79 and Observation Wells 4PZ89, 4GW50, and 4GW81S. During the recovery period, water levels were monitored until 95 percent recovery was observed in the pumping well, approximately 4 hours.

Water level and pumping information recorded for both pump tests are presented in Appendix E. Calculations and graphical methods used to derive relative T and S were from Driscoll, (1986). Distance-Drawdown curves were generated based on drawdown measured in each observation well at the same time since pumping began.

T and S were calculated from results measured during the pumping test at Well 4GW81D. Drawdown measurements for wells at known distances from the Pumping Well (4GW81S, 4GW80 and 4GW50) at times equal to 100, 500, and 1,000 minutes were used to calculate values of T at 5.06×10^{-2}, 6.19×10^{-2}, and 5.62×10^{-2} cm^2/sec (3520, 4310, and 3911 gpd/ft.), respectively. Storativity values were calculated at 1.09×10^{-3}, 2.21×10^{-3}, and 5.21×10^{-3}. Values of T based on Time-Drawdown in Observation Wells 4GW81S and 4GW80 were calculated to be 5.23×10^{-2} and 1.43×10^{-2} cm^2/sec (3,641 and 4,911 gpd/ft.) respectively, similar to those derived using the Distance-Drawdown curves. Storativity values were calculated to be 2.21×10^{-3} and 3.75×10^{-4}.

T and S were calculated from results measured during the pumping test at 4GW79. Drawdown measurements for wells at known distances from the Pumping Well (4PZ89, 4GW50 and 4GW81D) at time equal to 1,000 minutes were used to calculate the values of T to be 1.11×10^{-1} cm^2/sec (7,700 gpd/ft.). Storativity value was calculated at 2.98×10^{-3}.

Values of T based on the Distance-Drawdown method approximate the estimates derived from the grains size distribution curves, however, the estimates of S are much lower than expected for an unconfined aquifer. Driscoll (1986) estimated that storativity values between 0.1 and .03 are normal for unconfined aquifers and that storativity ranges in the 10^{-2} to 10^{-4} ranges were normal for confined aquifers.

A significant change was observed in the hydraulic characteristics of the aquifer between the two pumped wells at Site 4. Values of T derived from distance-drawdown plots at specific time ranged between 5.06×10^{-2} and 1.11×10^{-2} cm^2/sec (3,500 and 7,700 gpd/ft.). This variation is attributed to the variable nature of the sediments underlying the site.

4.3.6 Ecology

Site 4 consists primarily of disturbed and mature deciduous forest. The disturbed areas on-site are located adjacent to roads, leaf composting areas, and in areas used previously for trash burning. These areas consist of predominately herbaceous and shrub species such as grasses, Soft Rush, Dewberry, Indian Hemp, Multiflora Rose, blackberries, Goldenrods, daisies, and cattails in ditches and depressions on-site. A portion of this site was used for gravel excavation. Approximately 15 feet of sand and gravel has been removed in this location resulting in a steep embankment which is inhabited by Mud-dauber Wasps. The lower portion of this excavated area contains typical old field vegetation. Tree and shrub species found in these areas include Black Locust, Virginia Pine, Big-toothed Aspen, Red Maple, sapling Tulip Poplar, Blackberry, Staghorn Sumac, Milkweed, Dogbane, Black Cherry, Crab Apple, and members of the Compositae family.

Mature deciduous forested portions are characterized by species such as Southern Red Oak, Scarlet Oak, Blackjack Oak, Black Oak, Red Maple, Tulip Poplar, Mockernut Hickory, Mountain Laurel, Sourgum, and Tulip Poplar. Black Locust, Eastern Sycamore, and Big-toothed Aspen are found along the margin of the forest. The sapling layer in this area is dominated by Virginia Pine, Flowering Dogwood, and Mountain Laurel. The shrub layer is dominated by Mountain Laurel, Highbush Blueberry, and oak saplings.

Evidence of site usage by mammalian species such as Eastern Cottontail, Woodchuck, Grey Squirrel, and White-tailed Deer was found on-site. Bird species noted on-site include Northern Cardinal, Rufous-sided Towhee, Common Flicker, American Robin, Common Crow, Carolina Chickadee, and Indigo Bunting.

4.4 NATURE AND EXTENT OF CONTAMINATION

4.4.1 Sources

A Ground Penetrating Radar (GPR) survey was performed at Site 4 during Phase I of the RI to locate four suspected burial areas and any potential contamination sources such as waste chemical drums or containers. STS Consultants, Ltd., of Chantilly, Virginia performed the geophysical survey. The GPR survey indicated that four burial areas appear to be present. Figure 4-1 shows the location of four burial pits. The GPR survey indicates that all four fill areas appear to contain objects which could represent chemical containers or rocks. However, Burial Pit 4 produced radar images that had a shape and size that

suggest potential chemical drums or containers. Appendix C contains the entire GPR Survey Report prepared by STS Consultants, Ltd. The GPR survey provided information for determining more precisely the placement of additional Monitoring Wells, soil borings, and surficial soil sampling points that were needed for Phase II activities.

4.4.2 Soils and Vadose Zone

Six soil samples were collected at Site 4 to document contamination in the subsurface during Phase I. Samples were collected in standard split spoons during installation of three groundwater Monitoring Wells (4GW48, 4WG51S, and 4GW52). There were no compounds detected above background levels in the subsurface soils at this site. Table 4-3 summarizes all analytical data on subsurface soil sampling at Site 4 during Phase I.

Two surface soil samples were collected from Site 4 to document contamination at the surface of the site during Phase II. The location for each surface soil sample Site 4 is illustrated on Figure 4-3. Table 4-4 (1991) summarizes the surface soil sample data for the site collected during Phase II. The analytical results from the samples indicate the presence of compound concentrations above acceptable background levels for soils as established in Section 1.8.2. The list of parameters with values greater than the acceptable background concentrations (Table 1-13) from the Phase I and Phase II analytical results are shaded on Tables 4-3 (1989) and 4-4 (1991), respectively. The shaded values are within the range of concentrations of natural U.S. soils (Table 1-12).

The analytical results for copper from surface Soil Sample 4SL1 are above acceptable background concentrations but was below the detection limit for the analysis. Estimated values reported in Table 4-4 include volatile organic compounds in Sample 4SL1 and 4SL2 and the semi-volatile organic compound pyrene in the Sample 4SL1. These estimated values are based on the results of unsatisfactory laboratory calibration as determined during the data evaluation. The volatile organic compound detected at the highest concentration in the surface soil was methylene chloride reported as estimated 350 ug/kg in sample 4SL2. The only semi-volatile organic compound detected in the surface soil was pyrene at an estimated concentration of 340 ug/kg from sample 4SL1. Methylene chloride and acetone are common laboratory contaminants.

Vadose zone monitoring was accomplished through the performance of a soil gas survey of the shallow soil during Phase I. A grid containing 26 sampling points was established to investigate volatile organic levels in the soil pores at Site 4. Figure 4-2

illustrates the sampling grid and the results of the soil gas survey. Readings of 0 to 40 ppm were measured throughout the site. A background level of 0 ppm was established for volatile organic vapor at this site.

Subsurface soil contamination was insignificant for the compounds analyzed. There appears to be significant volatile organic contamination in the vadose zone at Site 4, but the actual levels in the subsurface soils is unclear at this time since volatile organic vapor screen was not performed.

The analytical results from the surface soil samples indicate that elevated concentrations of volatile organic and semi-volatile organic compounds are present within the surface soil at Site 4. The low concentrations of metals detected in the surface soil are not considered significant. The extent of the contamination in the surface soil cannot be delineated with the data available.

The greatest levels of volatile organic compounds in the soil gas appear to be in the area near Burial Pit 2. Soil gas levels above background were detected to the northwest toward the perimeter fence and to the southwest mirroring the actual groundwater flow direction. The highest readings were measured near Burial Pit 2 suggesting that one of the sources of the volatile organic compounds is from that pit.

4.4.3 Groundwater

Groundwater samples were collected to document groundwater quality at Site 4. Twelve groundwater Monitoring Wells (4GW10, 4GW11, 4GW11A, 4GW12, 4GW13, 4GW15, 4GW48, 4GW49S, 4GW49D, 4GW50, 4GW51S, 4GW52) were sampled during Phase I of the RI. Seventeen groundwater monitoring wells were sampled during Phase II of the RI. Groundwater Monitoring Wells 4GW10, 4GW11, 4GW11A, 4GW12, 4GW13, 4GW15 were installed prior to Phase I activities; groundwater Monitoring Wells 4GW48, 4GW49S, 4GW49D, 4GW50, 4GW51S, 4GW52 were installed during Phase I; and groundwater Monitoring Wells 4PZ79, 4GW80, 4GW1D, 4GW81S, 4GW82 were installed during Phase II. The location for each groundwater monitoring well at Site 4 is illustrated on Figure 4-3. Table 4-5 (1989) and 4-6 (1991) summarizes all groundwater analytical data for the site. The analytical results from the samples indicate the presence of compound concentrations above acceptable drinking water MCL concentrations for groundwater as established in Section 1.8.2. The list of parameters with values greater than the drinking water MCLs are shaded in Tables 4-5 and 4-6.

TDS levels were slightly elevated in groundwater samples collected from Monitoring Wells 4GW15 and 4GW48 during Phase I but were not considered significant. Four Wells (4GW13/15/48/52) have significant levels of TCE detected in them, ranging from 160 to 1,000 μg/L. The TCE concentrations have increased from 58 and 38 μg/L to 160 μg/L in 4GW13 and from 26 and 54 μg/L to 170 μg/L in 4GW15 from 1985 to 1989 (Phase I). From 1989 to 1990 (Phase II) the TCE concentrations in groundwater have decreased from 160 μg/L to 90 μg/L in Monitoring Well 4GW13, from 170 μg/L to 24 μg/L in Monitoring Well 4GW15, and from 1000 μg/L to 650 μg/L in Monitoring Well 4GW50. The TCE concentrations have increased from 590 μg/L to 860 μg/L in 4GW48 and from 170 μg/L to 650 μg/L in 4GW50 from 1989 to 1991. The highest concentration of cadmium, copper, lead, and zinc detected in the groundwater during Phase II were from Monitoring Well 4GW11A and were 25 μg/L, 1150 μg/L, 96 μg/L, 5310 μg/L, respectively. Monitoring Well 4GW11A is a very shallow designed to be used for monitoring the water quality of a perched water zone that was identified in the northern portion of the site. The analytical results from mercury concentrations in groundwater sampled during Phase II were rejected based on 0 percent matrix spike recoveries for both the total mercury and filtered mercury analyses as determined during the data evaluation. The analytical results for methylene chloride and/or acetone for Monitoring Wells 4GW10, 4GW11, 4GW11A, 4GW12, 4GW13, 4GW15, 4GW50, and 4GW51 and the analytical results for semi-volatile organic compounds for Monitoring Wells 4GW11, 4GW11A, 4GW12, 4GW15, 4GW49S, 4GW51, 4PZ79, 4GW80, 4GW81D, 4GW81S, and 4GW82 were rejected based on the data evaluation.

Vinyl chloride was detected at a low concentration of 11 μg/L in groundwater sample collected from Monitoring Well 4GW13. Even at low levels, the presence of vinyl chloride in the groundwater is of great concern as a potential risk to human health. Although vinyl chloride was not detected during Phase I, it was detected in the groundwater during both sampling events of the Verification Phase of the RI at levels of 19 μg/L and 8 μg/L in samples from Monitoring Well 4GW13.

Volatile organic contamination has been identified at Site 4. Significant quantities of volatile organic compounds (especially TCE) are leaching from the burial areas to the groundwater and appear to be migrating towards the south. The source of TCE in the groundwater at Site 4 appears to be from multiple locations within the pits. The TCE multiple source plume extends from Pit 1 and 2 down to Monitoring Well 4GW81. The TCE contamination is present in both the Coastal Plain sediments and in the upper portion

of the Piedmont saprolite unit The actual extent of the TCE plume may be influenced by the surface topography of the bedrock and saprolite unit. As observed in Soil Borings 4GW80 and 4GW82, the bedrock surface dips steeply to the east which may divert and channelize contaminated groundwater in the lower portion of the aquifer in a direction other than the south southeast trend identified by graphical analysis of water level data.

The increase followed by a decrease in TCE concentration in the groundwater at Monitoring Wells 4GW13 and 4GW15 suggests an increase in the leaching of organic compounds to the groundwater from a source upgradient to the wells followed by a decrease in leaching. The decrease in leaching indicates that the source of the TCE contributing contamination to these wells is becoming depleted and that the TCE plume is dispersing and/or advecting. The nearest upgradient TCE source for Monitoring Well 4GW13 would be within Burial Pit 3. Burial Pit 2 is nearest upgradient TCE source area identified for Monitoring Well 4GW15 but is offset laterally to the groundwater flow to the well. This suggest that there may be another TCE source not identified which is more directly upgradient to Monitoring Well 4GW15. Identification of an alternate source area is not considered a priority since the concentration of TCE is decreasing in the groundwater at this well.

The decrease in TCE concentration in the groundwater at Monitoring Well 4GW50 suggests a decrease in TCE leachate generation upgradient from that well. An upgradient TCE source for Monitoring Well 4GW50 could be within Burial Pit 2 or 4. An increase in the TCE concentration in the groundwater at Monitoring Well 4GW48 indicates an active source area leaching TCE into the groundwater. This source area is probably located upgradient from Well 4GW48 in either Burial Pit 1 or Burial Pit 2.

The presence of vinyl chloride, 1,2-dichloroethane and/or 1,2-dichloroethene indicate the degradation and transformation of the TCE in the groundwater at Monitoring Wells 4GW13 and 4GW50.

The low level ethylbenzene and xylenes in the groundwater at Monitoring Well 4GW82 are probably related to a small isolated source. Both ethylbenzene and xylenes are common constituents of industrial solvents as well as additives to petroleum hydrocarbons.

4.5 CONTAMINANT FATE AND TRANSPORT

4.5.1 Potential Routes of Migration

The contaminants of greatest concern at Site 4 are volatile organic compound TCE, and low levels of cadmium, chromium and lead in the groundwater system, and the semivolatile organic compound pyrene in the surface soils. The major potential routes of migration at the Site 3 include the transport of contaminants through:

- Soil system.
- Groundwater system.

Although, there were no significant compounds detected in the surface soil during the Phase I and Phase II of the RI, transport of contaminants through the atmospheric system will still be addressed as the result of possible contaminant transfer from the groundwater system and the soil system. The saprolite unit in this area is an aquitard based upon the observation during the drilling at Boring 4GW82, therefore, groundwater contamination in the bedrock as a result of migration of leachate generated from Site 4 is not expected.

4.5.2 Contaminant Migration

At Site 4, the primary source of contamination is leachate generation from the Chemical Burial Site. Four burial pits were identified by GPR survey during Phase I of the RI (Figure 4-1). TCE was identified in several wells during Phase I and Phase II. Of the four pits it appears that leachate containing TCE may be released, to some degree, from Pits 1, 2, and 3. Although it appears that there are multiple sources at varying leachate strengths, the multiple sources are relatively close to each other and the plumes from each source converge to eventually form one larger TCE plume. The multiple sources are believed to be the result of leaking containers within each pit. The contaminants leaking from the containers will percolate down through the landfill towards the water table. Rainwater percolating through the landfill will increase the rate of downward migration of these contaminants. There is the potential for soil contamination within the landfill to be transferred to the atmosphere as a vapor through soil gas migration. The results of the soil gas survey indicated only low levels of volatile organic compounds in the surface soils and

does not merit further analysis of this transport pathway. There is also the potential for surface soil contamination to be transferred to the biota by rihizo uptake. There are blackberry bushes growing overtop of the landfill which may be consumed by man, and facility personnel have been observed picking blackberries during the growing season. The low levels of surface contaminants detected indicate that this contaminant fate may not be significant but the Risk Assessment will further determine this.

As discussed in Section 1.3.8, Hydrogeology, the velocity of groundwater flow in the unconsolidated sediment unit at Site 4 has been estimated as 2.29×10^{-4} to 3.25×10^{-4} cm/sec. The estimated velocity of a TCE plume in the groundwater is expected to approximate the groundwater velocity. Based upon the estimated velocity of the groundwater at this site and the high mobility rate of these compounds, there has been moderate migration of low levels of volatile organic compounds from the landfill at Site 4 in the groundwater, extending approximately 1,500 feet downgradient of the landfill. Using the data collected, the contamination is expected to move at a rate of 0.92 ft/day. The migration of the dissolved metals plume in the groundwater is expected to be attenuated by chemical reactions with soil during transporting and therefore, the estimated velocity of the dissolved metals plume in the groundwater is expected to be slower than the volatile organic compound plume migration velocity. As stated earlier, there is a clay lens present that appears to be impacting the groundwater flow and potentially the volatile organic contamination in the groundwater due to various volatile organic compounds' soil sorption characteristics. In fact, the TCE plume and the dissolved metals plume has migrated south of the landfill toward the center of the facility only 1,500 feet. Given the age of the suspected contamination and the expected rate of travel, the plume is moving at a much slower rate than expected.

Elevated levels of pyrene and low levels of carbon disulfide, 1,1,1-TCA, m- and p-xylenes and copper were identified in one surface soil sample during Phase II. Only two surface soil samples were collected during Phase II, therefore, the extent and degree of surface soil contamination could not be determined. The potential migration pathways for these contaminants in the surface soil include transfer to the groundwater by downward percolation of the contaminants with infiltrating rainwater and the transfer of the contaminants into the atmosphere as fugitive dust or, in the case of the volatile organic compounds, as a vapor.

4.6 RISK ASSESSMENT

4.6.1 Human Health Evaluation

A summary of the risk estimates in relation to USEPA's Superfund remediation criteria is presented in Table 4-7 The non-cancer and cancer risks associated with exposure to contaminated groundwater at Site 4 may be summarized as follows. The risk assessment determinations are included in Appendix G.

4.6.1.1 Non-cancer Risks

Adverse non-carcinogen health effects in the residential population (adults and children) from exposure to groundwater are unlikely. The total hazard indices for the pathways for adults and children are less than the criterion of 1.0.

4.6.1.2 Cancer Risks

The total cancer risk for adult and child residents who potentially may be exposed to contaminated groundwater from Site 4 from future, on-site residential uses exceeds the USEPA Superfund remediation goal. For adults and children, ingestion of contaminated water constitutes the greatest concern. Vinyl chloride and TCE are the main contributors to the cancer risk.

Thus, based on the cancer risk evaluation, consideration of the need for remediation of groundwater at Site 4 is warranted.

4.6.2 Ecological Risk Assessment

TCE is not known to bioaccumulate in animals. In addition, TCE was found in relatively low concentrations. This would suggest a low risk to wildlife from exposure to TCE in the contaminated media at the Chemical Burial Site.

This risk assessment is based upon actual sampling of surface soil. Contaminants were found in various surface soil samples. Actual levels of contaminants in vegetation and wildlife inhabiting the site and its vicinity were not determined. Some uncertainty is present in the assessment of actual risks to various species of concern. Adverse impacts due to the contaminants found, therefore, have not been quantified. Additional investigative activities would be needed to quantitatively determine impacts.

4.7 SUMMARY AND CONCLUSIONS

4.7.1 Summary

Site 4 (Chemical Burial Site) was operated as a burial area from mid-1950s until the early-1970s for chemical disposal in four discrete locations within the site. Waste disposed of at this site were reported to include acids, explosive compounds, kerosene, chlorinated solvents, and numerous unidentified laboratory compounds.

The RI at Site 4 included a hydrogeologic investigation, contaminant characterization and risk assessment. The hydrogeologic investigation included lithologic descriptions of the subsurface, monitoring well elevation and location survey, groundwater level measurements, seven aquifer slugtests (wells 4GW10, 4GW12, 4GW13, 4GW48, 4GW50, 4GW52, and 4GW80) and two constant rate pumping tests (wells 4GW81D and 4GW79). The lithology beneath Site 4 consists of the Upland Sand and Gravel unit overlying a sand facies of the potomac group which is underlain by the gneiss saprolite of the Wissahickon Formation. Groundwater flow at the site is to the south southeast. A groundwater divide exist along the western portion of the site at which point, groundwater flow is to the west towards the unnamed stream at Site 3. The groundwater gradient ranged from 0.8 to 2.2 percent with a geometric mean of 1.4 percent. The average hydraulic conductivity based on the analysis of the slugtest data was 9.4×10^{-4} cm/sec (19.2 gpd/ft^2). Based on the distance drawdown analyses of the constant rate pumping test data, the transmissivities values of the aquifer ranged between 5.06×10^{-2} to 1.11×10^{-1} cm^2/sec (3,500 to 7,700 gpd/ft). The variation in transmissivity is attributed to the variable nature of the sediments underlying the site. Table 1-3 list the results of the aquifer slugtest and constant rate pumping test analysis.

The contaminant characterization included the collection and analysis of samples from the soil, groundwater, and biota to be used for determining the risk to human health and the environment. Ground penetrating radar (GPR) survey was conducted to delineate the four distinct burial areas and to locate buried containers. Six groundwater monitoring wells were installed during Phase I. Six soil samples from three soil borings and twelve groundwater samples were collected for analysis during Phase I. A soil gas survey was conducted also during Phase I to delineate areas with soils contaminated with volatile organic compounds. An additional six groundwater monitoring wells were installed during Phase II. Two surface soil samples and seventeen groundwater samples were collected during Phase II.

The ecological investigation during Phase II consisted of terrestrial vegetation and mammal surveys. Site 4 consists primarily of disturbed and mature deciduous forest. The disturbed areas consist predominately of herbaceous and shrub species. The mature deciduous forest portions are characterized by various species of oak, maple, hickory, laurel, poplar and gum. The mammalian species found at the site are those commonly associated with a forested ecosystem.

The risk assessment determinations are included as Appendix G in this text. Adverse non-carcinogenic health effects in the residential population from exposure to the groundwater are unlikely. The total cancer risk to a future, on-site residential population who may potentially be exposed to contaminated groundwater (namely vinyl chloride and TCE) exceeds the USEPA Superfund remediation goal. Therefore, based on the cancer risk evaluation, consideration of the need for remediation of groundwater at Site 4 is warranted.

The ecological risk assessment is based on the analytical results of the surface soil samples. Actual levels of contaminants in the vegetation and wildlife were not determined. Adverse impacts to the ecosystem due to the contaminants identified have not been quantified.

4.7.1.1 Nature and Extent of Contamination

The GPR survey confirmed the presence of four burial pits and suggested the possibility of waste chemical drums, containers, and or/rock within the pits. Figure 4-1 illustrates the location of each pit.

The soil gas survey indicated the presence of volatile organic compounds in the soils. Readings of 0 to 40 ppm were measured throughout the site. Figure 4-2 illustrates the sampling grid and the results of the soil gas survey. Subsurface soil contamination was insignificant for the compounds analyzed during Phase I. The analytical results from the surficial soil samples indicate that elevated concentrations of volatile organic and semi-volatile organic compounds were present within the surface soils at Site 4 during Phase II. The volatile organic compounds detected at levels above background, from highest to lowest, were methylene chloride, acetone, TCE, carbon disulfide, 1,1,1-trichloroethane, and m- and p-xylene. The only semi-volatile organic compound identified above background was pyrene during Phase II. The Phase II analytical results also indicated that copper was slightly elevated above the background levels in one surface soil sample.

The analytical results from the groundwater sampling confirmed the presence of volatile organic compounds and dissolved metals in the groundwater beneath Site 4 as a result of leachate migration from the burial pits. The volatile organic compounds identified in the groundwater at levels above the MCLs, from highest to lowest, included TCE, 1,2-dichloroethene, 1,1,2,2-tetrachloroethane, methylene chloride, benzene, and chloroform during Phase I and TCE, acetone, methylene chloride, 1,2-dichloroethene, vinyl chloride, 1,1,2,2-tetrachloroethane, and chloroform during Phase II. The metals identified in the groundwater at levels above background or MCLs were cadmium, chromium, lead and mercury during Phase I and cadmium, lead and zinc during Phase II. The largest volatile organic compound plume is comprised of TCE. One TCE plume appears to originate from Pits 1 and 2, and a second TCE plume appears to originate from Pit No. 3. The source of a third TCE plume associated with the observed contaminant levels in groundwater at Monitoring Well 4GW15 was not identified but is not considered significant since TCE levels have decreased in the groundwater from 1989 to 1991 at monitoring well 4GW15. The TCE from the three possible sources converge beneath Site 4 to form one plume.

4.7.1.2 Fate and Transport

At Site 4, the primary contamination are volatile organic compounds (namely TCE) and low levels of metals. The major potential routes of migration include the transport of contaminants through the soil and groundwater systems. Based on the shallow groundwater conditions and the potential mobility and concentration of the contaminants detected in the groundwater, transport of the leachate in the groundwater system has been moderate. The direction of the leachate migration in the groundwater is to the south of the burial pits towards the center of the facility.

4.7.2 Conclusions

The hydrogeologic investigation from Phase I and Phase II provided the information necessary to determine the direction of groundwater flow, the groundwater gradient, and the hydraulic conductivity and transmissivity of the unconfined aquifer.

Information from the GPR survey was used to delineate the boundaries of the four burial pits and to identify the presence of objects within the pits. The soil gas survey, conducted during Phase I, identified the presence of volatile organic constituents in the soil

gas vapor. The analytical results from the surficial soil samples indicated the presence of semi-volatile and volatile organic compounds in surficial soils during Phase II.

Metals and volatile organic compounds contamination were identified in the groundwater beneath Site 4 during both Phase I and Phase II. The groundwater contamination emanates from multiple sources associated that converge to form one plume. The volatile organic compound plume of greatest concern is the TCE plume. Migration of the leachate in the groundwater is to the south toward the center of the facility

The risk assessment identified TCE and vinyl chloride contaminated groundwater as a potential concern for total cancer risk for future, on-site adults and children who may be exposed to the groundwater from Site 4. Based on the cancer risk evaluation, remediation of the groundwater at Site 4 should be considered. The risk to the ecosystem was not quantified.

4.7.2.1 Data Limitations

The volatile organic compound and semi-volatile organic compound analytical results for the surface soil samples collected during Phase II were reported as estimated values based on the data evaluation. These estimated values are believed to represent the conditions at Site 4 but are not accurate values for the groundwater samples that were analyzed. This limits the discussion of comparing changes in contaminant concentration in the groundwater from Phase I to Phase II.

The analytical results for mercury in the groundwater were rejected based on the data evaluation during Phase II of the RI. The extent and potential migration of mercury contamination in the groundwater, therefore, could not be adequately discussed.

Actual levels of contamination in the vegetation and the wildlife inhabiting the site and vicinity were not determined, therefore, the assessment of actual risk to various species could not be quantified.

Several physical properties of Site 4 that were required to confidently model the contaminated fate and transport of the contaminants identified were not quantified, including soil moisture profile, soil carbon content, the cation exchange capacity of the soil (CEC), infiltration capacity of the soil and the vertical hydraulic conductive of the soil.

4.7.2.2 Preliminary Remedial Action Objectives

The risk assessment of contamination present at Site 4 indicates that the primary threat to human health and the environment is from on-site groundwater contaminated with vinyl chloride and TCE. The primary exposure route would be through ingestion of contaminated groundwater. The remedial objective is to remove any remaining source(s) of contaminants, to prevent further contaminant migration into the soil and groundwater, and to reduce the health risk associated with the exposure to contaminated groundwater to acceptable levels under the USEPA Superfund remediation goal.

5.0 SITE 7 - ORDNANCE BURN AREA

5.1 SITE BACKGROUND

5.1.1 Site Description and History

The Ordnance Burn Area (Site 7) is located north of Dahlgren Road about 300 yards southeast of the Chemical Burial Site (Site 4). The Ordnance Burn Area was reportedly used for disposal by thermal destruction of waste ordnance compounds from 1948 until 1968. The site consists of a swale about 250 feet long and 20 feet wide. Wastes disposed at this site included various types of explosives, primarily nitroaromatics and nitroaliphatics. About 33,000 pounds of explosives were reportedly destroyed by burning at this site over a period of 20 years.

5.1.2 Previous Investigations

One groundwater monitoring well and 54 soil boring locations were sampled during the Verification Phase. The analytical data demonstrated nitroaromatic contamination of both soils and, potentially, the shallow groundwater. Soil contamination was considered significant within the drainage swale.

Data gaps identified after analysis of the Verification Phase data included:

- Groundwater flow directions and gradients;
- Extent of groundwater contamination; and
- Extent of surface soil contamination perpendicular to the drainage swale.

Verification Phase recommendations included:

- Installation of two additional monitoring wells;
- Sampling of the new and existing monitoring wells; and
- Selection of 27 new soil boring locations.

Recommendations that were made subsequent to the Verification Phase Final Report included the installation of a piezometer.

5.2 RI INVESTIGATIONS

5.2.1 Surface Feature Investigations

Surface feature investigations included location of surface burn areas, property lines, drainage ditches, streams, vegetation, and topography of the burn area. The purpose of surface feature investigations was to identify possible contaminant migration and the location of potentially affected receptors.

5.2.2 Soil and Vadose Zone Investigations

During Phase I, soil and vadose zone investigations for Site 7 included the collection of 59 soil samples taken from 27 Borings (7SB1 through 7SB28) made to a depth of 5 feet with a hand auger to determine the nitroaromatic concentrations in the soil. The purpose of these investigations was to measure the chemical contamination in the soils in the burn area swale which is oriented toward the Site 9 in a southwesterly direction and also to determine any contamination outside of the swale to determine horizontal movement.

During Phase II, two Soil Borings (7SB28, 7SB29) were drilled with samples collected at 5, 10, and 15 feet BLS to estimate the vertical extent of nitroaromatic contamination in the shallow soil within the swale and just outside of the swale.

A summary of the investigative tasks for Phase I and Phase II are listed on Table 1-2. Figure 5-1 illustrates soil sampling locations for Phase I and Phase II. A summary of the environmental sampling conducted during Phase I and Phase II are presented on Tables 5-1 and 5-2, respectively. Soil samples were collected during the standard procedures presented in this report in Appendix F.

5.2.3 Groundwater Investigations

During Phase I, two groundwater Monitoring Wells (7GW41 and 7GW43) and one Piezometer (7PZ42) were installed at Site 7. Groundwater samples were collected from Monitoring Wells 7GW9, 7GW41, and 7GW43. During Phase II, the three existing wells were resampled. Two aquifer slug test were performed at Monitoring Wells 7GW41 and 7GW43 to determine the K value of the aquifer media adjacent to the well.

A summary of the investigative tasks for Phase I and Phase II are listed on Table 1-5. The locations for each well are illustrated on Figure 5-2. A summary of the installation, development, and sampling times for these wells is presented in Table 1-2. A summary of the aquifer slug test results is presented on Table 1-3. Construction details for the wells are listed on the borehole logs for each well presented in Appendix B. A summary of the environmental sampling conducted during Phase I and Phase II are presented on Tables 5-1 and 5-2, respectively. Groundwater samples were collected during the standard procedures presented in this report in Appendix F.

5.2.4 Geological Investigations

Three boreholes were drilled During Phase I at Site 7 and converted to two groundwater Monitoring Wells (7GW41 and 7GW43) and one Piezometer (7PZ42). During Phase II, two Soil Borings (7SB28 and 7SB29) were drilled to a depth of 15 feet. Split spoon samples were collected during drilling to characterize the subsurface lithology at the intervals indicated on Table 1-5. Descriptions of the individual split spoon samples obtained are given in Appendix B on the borehole logs for each borehole. Soil samples were collected using the standard procedures presented in Appendix F of this report. In addition, slug tests were performed on two Monitoring Wells (7GW41 and 7GW43) to calculate the hydraulic conductivity of the water table aquifer at the site.

5.2.5 Ecological Investigations

An ecological investigation was not conducted during Phase I. During Phase II, terrestrial vegetation and mammal surveys were performed for Site 7. The vegetation survey consisted of a quantitative analysis of species located on site. Field identification was supplemented with office confirmation of the major vegetative species at each location. Relative abundance of the species was established and vegetation community relationships were delineated on the project site map. One and 10 meter quadrants were used to sample herbaceous and forested regions on site. A general mammalian survey was also performed. Materials and methods for the Site 7 ecological field investigations are included in Appendix B.

5.3 PHYSICAL CHARACTERISTICS OF THE SITE

5.3.1 Surface Features

The Ordnance Burn Area is located within a swale in the northeastern quadrant of the NSWCWODET approximately 800 feet southeast of Site 4. The swale is approximately 20 feet wide and 250 feet in length. A storage compound for hazardous wastes is located immediately south of the swale. The compound contains two buildings used to store hazardous wastes. The remainder of the area surrounding the swale is either cleared or covered by woodland or grass.

5.3.2 Surface Water Hydrology

Stormwater runoff from the surrounding area enters the swale in which Site 7 is located and flows to the southwest toward Site 9. No perennial streams are located near Site 7.

5.3.3 Soils

The soils at this site belong to the Beltsville series. They are moderately deep and moderately well drained soils. A dense, compact layer, called a fragipan exists in the subsoil. Though not cemented, it's relatively impermeable to plant roots and water. During the wet season there is a temporary water table perched on top of the fragipan. The Soil Conservation Service reports that the fragipan is approximately 31 to 48 inches below the surface. These soils are strongly acidic (pH 4.0 to 5.0).

5.3.4 Geology

Three geologic units underlie the Ordnance Burn Area. The Upland Sand and Gravel unit forms the uppermost unit and is underlain by the Potomac Group. Due to the similarity in lithology and sedimentary features, it was difficult to determine the contact between the two units. The unconsolidated sediments beneath the site range in thickness from 58 to 68 feet. The thicker deposits occur in topographically higher areas. Within the unconsolidated sediments, a thin (1.0 to 2.0 feet thick), pale white to beige clayey silt to silty clay member (Kpc) of the Potomac Group was observed at the site at a depth ranging from 40 to 45 feet below land surface at Monitoring Wells 7GW41 and 7PZ42, and was also observed during the Verification Phase Study at Well BGW16. This unit may correlate to

the silty clay silt unit observed beneath Site 4, approximately 800 feet to the north. Underlying the unconsolidated sediments is the saprolite member (Wds) of the Wissahickson Formation. None of the boreholes encountered the host weathered gneiss during Phase I of the RI, therefore, the thickness of the saprolite unit in this area is undetermined.

5.3.5 Hydrogeology

The groundwater information obtained during the Verification Phase Study could not be used to determine the groundwater flow direction at Site 7 through graphical analysis because there was only one well installed at the site. Two additional wells and one piezometer were installed during the field program for Phase I of the current study. No additional wells were installed during Phase II. Depth to the water table in August, 1991, ranged from 34.46 feet TPVC at Well 7GW8 to 50.93 feet TPVC at Well 7GW41. Water table elevations during August, 1991 ranged from 241.76 feet MSL at Well 7GW41 to 246.97 feet MSL at Well 7GW8.

Although the wells are screened in different geologic units (see Table 1-2), they are screened in the same water bearing unit which allows for a general analysis of the flow direction based on elevations. Graphical analysis of the water level data collected during 1991 support the initial groundwater flow direction determined during the Verification Phase. Groundwater Flow is toward the south-south east. Graphical analysis indicated that the groundwater gradient ranged from approximately 0.3 to 2.2 percent with a geometric mean of 1.0 percent.

A 1- to 2-foot thick silty clay to clayey silt layer approximately 40 to 45 feet below ground surface near the top of the water table may influence the downward percolation of groundwater beneath the site. The low permeability of the clayey silt layer may reduce the downward percolation of groundwater forming a perched groundwater zone above the layer at times when the static water table is below the silty clay layer and precipitation is sufficient enough for infiltrating groundwater to collect above the silty clay layer. This silty clay layer can stratify vertical groundwater movement and influence horizontal groundwater flow and contaminant migration. However, the degree of effect of the silty clay layer on groundwater movement and contaminant migration cannot be quantified at this time.

Two aquifer slug tests were performed at Monitoring Wells 7GW42 and 7GW43. Analysis of the slug test data for each well resulted in an estimated hydraulic conductivity

(K) for that well. The geometric mean of the K values for each well was then calculated to determine the average K for Site 7. The estimated hydraulic conductivity for Site 7 slug tests indicates that groundwater flow averages 1.67×10^{-3} cm/sec (34.6 gpd/ft^2).

Groundwater flow velocities at Site 7 are based on the pumping test analyses conducted at Monitoring Wells 4GW79 and 4GW81D during Phase II. The estimated groundwater velocity of the shallow aquifer under Site 7 ranges from 2.05×10^{-4} to 4.06×10^{-4} cm/sec with an assumed effective porosity of 40 to 41 percent. Based on the results of the two pump test analyses, the estimated hydraulic conductivity of the water table aquifer beneath Site 7 ranges between 6.78×10^{-3} and 1.3×10^{-2} cm/sec (140 and 270 gpd/ft^2), which, when compared to the hydraulic conductivities calculated from the slug tests, are fairly consistent, considering the geology in the area. Pump test analyses results for Site 7 are presented on Table 1-4.

5.3.6 Ecology

Site 7 consists of a mature forest, shrub area and a disturbed herbaceous old field area. The mature forested area is dominated by Red Maple, Southern Red Oak, Scarlet Oak, Black Cherry, Willow Oak, Grape Vine, Tulip Poplar, and Flowering Dogwood. The shrub area consists primarily of Poison Ivy, Common Blackberry, Virginia Creeper, Catbrier, and sapling Southern Red Oak, Tulip Poplar, Red Maple, and Black Cherry. A vegetation inventory of Site 7 is included in Appendix A.

Old field areas on the site consist of herbaceous vegetation with some small shrubs. Species typical of these areas include goldenrod, Common Blackberry, grass species, Virginia Creeper, sapling Red Oak, sapling Red Maple, Poison Ivy, Dogbane, Horse Nettle, Common Dandelion, and honeysuckle. The coverage of the areas sampled ranged from 60 to 90 percent. Formic ants inhabit the herbaceous areas on-site. These ants have constructed nests which average 1-foot in height and 3 feet in diameter. The areas surrounding these ant hills were very sparsely vegetated at the time of the site visit.

Red Maple plants in the vicinity of this site appear to be infected with a fungal growth. Also, Virginia Creeper and Common Blackberry found on-site were noted to have deformities of leaf structure. The source of these deformities is unknown.

A broad-head arrow was found on Site 7 indicating that the area was utilized for deer hunting. Eastern Chipmunk and Gray Squirrel also inhabit this site. Bird species noted

include Wood Thrush, Rufous-sided Towhee, Broad-winged Hawk, Tufted Titmouse, Northern Cardinal, and American Robin.

5.4 NATURE AND EXTENT OF CONTAMINATION

5.4.1 Soils

Nitroaromatic contamination of the soils at Site 7 was investigated by sampling subsurface soil at 27 Soil Boring Locations (7SL01 through 7SL27) during Phase I of the RI and at 2 Soil Boring Locations (7SB28 and 7SB29) during Phase II. Figure 5-1 shows the locations of all soil borings. Samples were collected in the drainage swale as well as outside of the swale to aid in the estimation of the vertical and horizontal movement of the nitroaromatics through the shallow soil. Tables 5-3 and 5-4 summarizes all soils analytical data for Site 7. The analytical results from the samples indicate the presence of compound concentrations above acceptable background levels for soils as established in Section 1.8.2 of this report. The list of parameters with values greater than the acceptable background concentrations from Phase I and Phase II analytical results are shaded on Tables 5-3 and 5-4.

Nitroaromatic contamination of the soils was detected in all samples collected from the swale during Phase I (7SL11, 7SL12, 7SL13, 7SL19, 7SL20, 7SL21, 7SL22, and 7SL23) and Phase II (7SB28) except for the three locations adjacent to Perimeter Road (7SL24, 7SL26, and 7SL27) which is at the farthest point along the swale from the actual ordnance burn area. Contamination was also present in several samples collected outside of the swale (7SL03, 7SL06, 7SL15, 7SL16, 7SL17, and 7SL18). HMX levels in samples collected from the swale during Phase I and Phase II ranged in concentration from 160,000 μg/kg in Sample 7SL19A to 0.40 μg/kg in Sample 7SB28B. HMX levels in samples collected outside the swale during Phase I and Phase II ranged in concentration from 51,000 μg/kg in Sample 7SL16A to 250 μg/kg in Sample 7SL23C.

RDX was detected in soil samples collected during both Phase I and Phase II. RDX levels in samples collected from the swale during Phase I and Phase II ranged in concentration from 1,000 μg/kg in Sample 7SL13A to 260 μg/kg in Sample 7SL20B. HMX levels in samples collected outside the swale during Phase I and Phase II ranged in concentration from 8,300 μg/kg in Sample 7SL03A to 220 μg/kg in Sample 7SL17A.

2,4,6-TNT was detected in soil samples collected during Phase I but not during Phase II. 2,4,6-TNT levels in samples collected from the swale during Phase I ranged in concentration from 600 μg/kg in Sample 7SL21A to 210 μg/kg in Sample 7SL13A. 2,4,6-TNT levels in samples collected outside the swale during Phase I ranged in concentration from 34,000 μg/kg in Sample 7SL18B to 120 μg/kg in Sample 7SL16A.

Nitroaromatic contamination is present in and along the swale as described in the Verification Phase Report and further confirmed during the Phase I and Phase II of the RI. HMX contamination has been confirmed at a maximum depth of 15 feet below land surface during Phase II while during the Verification Phase in 1985 the nitroaromatics were not detected below a depth of 5 feet. This suggests that HMX contamination has migrated deeper in the soil. Overall, the analytical results for HMX indicated that HMX levels were highest near the land surface and decreased in concentration rapidly with depth. There has been an increase in HMX levels within the swale in the downgradient direction. This suggests horizontal movement of the contaminant within the swale.

The analytical results for RDX in the soil show concentration increasing with depth for RDX detected in samples collected from within the swale and concentrations decreasing with depth for RDX detected in samples collected from outside the swale. This suggests a differential downward vertical migration of RDX within the soils at Site 7.

The analytical results for 2,4,6-TNT in the soil show an increase in concentration with depth relationship for 2,4,6-TNT detected from samples both outside and within the swale.

The nitroaromatic contamination within the soils extends from the burn area along the soil surface into the swale near Sample Locations 7SL03 and 7SL06 and extends within the swale towards the west near perimeter road. Some of the contamination extends outside the berm of the swale in the vicinity of Sample Locations 7SL15, 7SL16, 7SL17, and 7SL18. The contamination outside the berm in this area may have been deposited as a result of out-of-bank flow during periods of high rainfall.

5.4.2 Groundwater

Groundwater samples were collected to document groundwater quality and to determine the movement of nitroaromatics through the groundwater at Site 7. Three groundwater Monitoring Wells (7GW8, 7GW41, and 7GW43) were sampled during Phase I and Phase II of the RI. Groundwater Monitoring Well 7GW8 was installed during the Verification Phase and groundwater Monitoring Wells 7GW41 and 7GW43 were installed

during Phase I. Also one piezometer (7PZ42) was installed for use in groundwater flow direction determinations. The location for each well at Site 7 is illustrated on Figure 5-2. Tables 5-5 (1989) and 5-6 (1991) summarizes groundwater analytical data for the site. The analytical results from the samples indicate the presence of constituents at concentrations above background concentrations or drinking water MCLs for groundwater as established in Section 1.8.2. The list of parameters with values greater than the MCLs or the background concentrations are shaded on Tables 5-5 and 5-6.

Metals were present in the groundwater at Site 7 during Phase I. The metals, however, were detected at concentrations below the MCLs. During Phase II no metals were detected at levels above the MCLs in the groundwater samples. The analytical results for mercury analysis for Phase II were rejected based on the data evaluation. In general, the values for the total metals analytical results are higher than the results for filtered metals which suggests that metals are present as particulates in the groundwater sample. The metals in particulates are less mobile than metals dissolved in the groundwater.

The groundwater samples were not analyzed for volatile organic constituents during Phase I. Low levels of volatile organic compounds were detected in the groundwater at Site 7 during Phase II. Cis-1,2-Dichloroethene, TCE, and 1,1,2,2-Tetrachloroethane were detected in Monitoring Well 7GW41 at concentrations of 6 μg/L, 33 μg/L, and 6 μg/L, respectively. Acetone was reported at an estimated concentration of 17 μg/L in Monitoring Well 7GW43. The acetone concentration for groundwater from Monitoring Well 7GW43 was estimated because the value exceeded the calibration curve as determined during data evaluation.

Nitroaromatics were detected in groundwater samples from Site 7. There was an increase in HMX and RDX concentrations from Phase I to Phase II in groundwater samples collected from Monitoring Well 7GW8. HMX levels increased from 190 μg/L and 700 μg/L to 470 μg/L and 2,300 μg/L, respectively. No nitroaromatics were detected in Monitoring Wells 7GW41 and 7GW43 downgradient from the burn area during Phase I and only 1,3,5-TNB was detected in Well 7GW41 at 1.1 μg/L during Phase II.

The contaminants of greatest concern at this site are the nitroaromatic compounds. Nitroaromatic contamination in 7GW8 has varied in concentration from the Verification Phase until Phase II of the RI. Levels of nitroaromatics in the groundwater were lower

during Phase I than either the Verification Phase(1985) or Phase II (1991). The following chart shows the variations:

Well Location	Compound	Results (μg/L) 1985*	1989	1991
7GW8	TNT	1650/1596	N	1900
	HMX	300/210	190	470
	RDX	1384/2096	700	2300
	2,4-DNT	146/336	ND	3.1
	2,6-DNT	256/ND	ND	3.2
	1,3,5-TNB	20/ND	ND	31.1
	1,3-DNB	-	-	10.3

Note: * Sampling Events A and B
ND = None Detected
- Not used

The reason for the variation in nitroaromatic contamination in the groundwater at 7GW8 may be due to a release of nitroaromatics to the ground near Monitoring Well 7GW8 during the time between Phase I and Phase II of the RI. No nitroaromatic contamination was detected in the downgradient wells, this suggests that the extent of the nitroaromatic contamination in the groundwater is localized in the vicinity of Monitoring Well 7GW8.

The presence of low levels of volatile organic constituents in the groundwater at Monitoring Well 7GW41 is not consistent with the characteristics of potential releases associated with Site 7. The presence of the volatile organic compounds may be the result of a localized release of solvents along Dahlgren Road. It is possible that the volatile organic compounds may be the result of plume migration from Site 4, possibly along man-made conduits. The volatile organic compounds identified in the groundwater at Site 7 are similar to those identified in the plume associated with Site 4.

5.5 CONTAMINANT FATE AND TRANSPORT

5.5.1 Potential Routes of Migration

The contaminants of concern at the Ordnance Burn Area are nitroaromatic compounds to include HMX, RDX, and 2,4,6-TNT in the soil and HMX and RDX in the groundwater. The major potential routes of migration at the Site 7 include the transport of contaminants through:

- Soil system; and
- Groundwater system.

Because there were significant nitroaromatic compounds detected in the surface soil during the Phase II, transport of contaminants through the atmospheric system, surface water system, and biotic system will be addressed as the result of possible contaminant transfer from the soil system.

5.5.2 Contaminant Migration

There has been some downward vertical migration of nitroaromatics in the shallow unsaturated soil at the Ordnance Burn Area. Nitroaromatics have been detected outside of the burn area swale which suggests atmospheric transport of nitroaromatics from the burning of the ordnance. However, the residual ash from ordnance burning may have been placed in these locations to allow for further burning within the swale. Sheet flow after heavy rains may carry nitroaromatic contaminated soil and residual ash into the swale, and some horizontal migration may have occurred in the shallow soil to contribute nitroaromatics outside the burn area. Downward vertical migration of nitroaromatic contaminants has occurred beneath the site, and within the burn area. Some of the nitroaromatic contaminants have transferred from the soil system into the groundwater system approximately 32 feet below land surface (Well 7GW8). The extent of vertical migration in the unsaturated soil outside the burn area was less than 10 feet below land surface at Soil Borings 7SB28 and 7SB29 except for HMX which was detected in the 15-foot soil sample from Soil Boring 7SB28.

There is the potential for soil contamination to be transferred to the atmosphere as fugitive dust. There is also the potential for surface soil contamination to be transferred to the biota, but since there is no vegetation consumed by man directly or indirectly at Site 7, further discussion regarding this pathway is unwarranted.

As discussed in Section 5.3.5, Hydrogeology, the velocity of groundwater flow in the unconsolidated sediment unit at Site 7 has been estimated to range from 2.05×10^{-4} to 4×10^{-4} cm/sec. The estimated velocity of nitroaromatics in the groundwater is expected to be retarded at this site due to the low solubility of the nitroaromatic compounds and the affinity for nitroaromatic compounds to sorb onto soil particles. Nitroaromatic

contamination is present in Monitoring Well 7GW8 which is located within the burn area swale. However, no nitroaromatic contamination was detected in Wells 7GW41 and 7GW43 which are located approximately 500 feet hydraulically downgradient from the burn area, except for only a very low concentration of tetryl in Well 7GW41 (13.30 μg/L). Based upon the detected concentrations and the low mobility rate of these compounds, it is concluded that there has been limited migration of nitroaromatics from the burn area at Site 7 in the groundwater. The metals plume in the groundwater is expected to be attenuated by chemical reactors in the sand, the estimated velocity of the metals plume in the groundwater would be greater than the nitroaromatic plume. As stated earlier, there is a clay lense present that may be impacting the groundwater flow and potentially the movement of nitroaromatic and metals contamination in the groundwater due to soil sorption characteristics of clays and groundwater flow stratification. The contamination migration route is towards the south of the burn area towards Site 9. The calculated velocity for the groundwater is approximately 1 ft/day, however, field observations indicate that the contamination is moving at a much slower rate, and has moved only 400 feet. Considering that burning of ordnance compounds took place some 20 to 30 years ago, the rate of contaminant migration has been significantly reduced.

5.6 RISK ASSESSMENT

5.6.1 Human Health Evaluation

A summary of the risk estimates in relation to USEPA's Superfund remediation criteria is presented in Table 5-7. The non-cancer and cancer risks associated with exposure to contaminated surface soils and groundwater at Site 7 may be summarized as follows.

5.6.1.1 Non-cancer Risks

Adverse non-carcinogenic health effects for NSWCWODET workers from exposure to surface soils are unlikely. The total hazard indices for the pathways are less than the criterion of 1.0.

The potential for adverse non-carcinogenic health effects for a future on-site residential population (adults and children) exists from exposure to groundwater from Site 7 and is based on groundwater ~~form~~ from Site 7 used for potable water. The total hazard indices would be much greater than the criterion of 1.0.

Thus, based on non-cancer, consideration of the need for remediation of groundwater at Site 7 is warranted.

5.6.1.2 Cancer Risks

The total cancer risk for NSWCWODET workers who potentially may be exposed to surface soils at Site 7 is within the Superfund remediation goal.

The total cancer risk for future on-site residents who potentially may be exposed to groundwater from Site 7 exceeds the Superfund remediation goal. For adults and children, ingestion of groundwater constitutes the greatest concern.

Thus, based on cancer risk estimates and potential future uses as a residential area, consideration of the need for remediation of surface soils at Site 7 is warranted.

5.6.2 Ecological Risk Assessment

Several nitroaromatic compounds were detected in groundwater and surface soil samples for Site 7, including 2,4-DNT, 2,6-DNT, HMX, RDX, 1,3,5-TNB, and 2,4,6-TNT. DNT and TNT compounds are known to have low bioaccumulation potential and therefore, pose a low risk to wildlife at Site 7. The risk that nitroaromatic compounds including 1,3,5-TNB, RDX, and HMX pose to wildlife at Site 7 is unknown.

5.7 SUMMARY AND CONCLUSIONS

5.7.1 Summary

Site 7 (Ordnance Burn Area) was reportedly used for disposal by thermal destruction of waste ordnance from 1948 until 1968. Approximately 33,000 pounds of explosives, primarily nitroaromatics and nitroaliphatics, were reportedly destroyed by burning at this site.

The RI at Site 7 included a hydrogeologic investigation, and a contaminant characterization and risk assessment. The hydrogeologic investigation included lithologic descriptions of the subsurface, monitoring well elevation and location survey, groundwater level measurements, two aquifer slug test at Well 7GW41 and 7GW43. The lithology beneath Site 7 consists of the Upland Sand and Gravel unit overlying the Potomac group which in turn is underlain by the gneiss saprolite of the Wissahickon Formation. Depth to the water table ranges from 34 to 51 feet TPVC. Groundwater flow at the site is to the south southeast. A 1- to 2-foot thick silty clay to clayey silt layer approximately 40 to 45 feet BLS may stratify vertical and horizontal groundwater flow. The groundwater gradient ranged from 0.3 to 2.2 percent with a geometric mean of 1.0 percent. The estimated groundwater velocity ranges from 2.05 to 4.06 x 10^{-4} cm/sec (4.35 to 8.62 gpd/ft^2).

The contaminant characterization included the collection and analysis of samples from the soil, groundwater, and biota to be used for determining the risk to human health and the environment. Two groundwater monitoring wells and one piezometer were installed during Phase I. Fifty-nine soil samples from 27 soil borings and 3 groundwater samples were collected for analysis during Phase I. No additional groundwater monitoring wells were installed during Phase II. Six soil samples from 2 soil borings and 3 groundwater samples were collected during Phase II.

The ecological investigation during Phase II consisted of terrestrial vegetation and mammal surveys. Site 7 consists primarily of a mature deciduous forest and disturbed herbaceous old field area. The mature deciduous forest portions are characterized by various species of oak, maple, cherry, and dogwood. The Red Maple plants appeared to be infected with a fungal growth. The old field area is characterized by herbaceous vegetation and small shrub species. The Virginia Creeper and the Common Blackberry were noted to have leaf structure deformities. The causes for the deformities is unknown. The mammalian species found at the site are those commonly associated with a forested and old field ecosystem.

The risk assessment determinations are included as Appendix G in this text. Adverse non-carcinogenic health effects for the NSWCWODET workers from exposure to surface soil are unlikely. Adverse non-carcinogenic health effects for the NSWCWODET workers from exposure to the groundwater is within the USEPA Superfund remediation goal. The total cancer risk for a future, on-site residential population who may be exposed to nitroaromatic contaminated groundwater is within the USEPA Superfund remediation goal.

The total cancer risk for a future, on-site residential population who may potentially be exposed to nitroaromatic contaminated groundwater exceeds the USEPA Superfund remediation goal. Therefore, based on the non-cancer and cancer risk evaluation, consideration of the need for remediation of groundwater at Site 7 is warranted.

According to the ecological risk assessment, the nitroaromatics (2,4-DNT, 2,6-DNT, HMX, RDX, 1,3,5-TNB, and 2,4,6-TNT) detected in the soils and groundwater are known to have low bioaccumulation potential and therefore, pose a low risk to wildlife at Site 7. The actual risk to wildlife is unknown.

5.7.1.1 Nature and Extent of Contamination

Nitroaromatic contamination is present along and in the swale as described in the Verification Study report and further confirmed during Phase I and Phase II of the RI. The nitroaromatic compounds detected in the soil at Site 7 were HMX, RDX, and 2,4,6-TNT. A review of the analytical data (Tables 5-3 and 5-4) indicates a downward vertical migration of nitroaromatic contaminants within the soils in the swale and in the area outside the swale.

The analytical results from the groundwater sampling confirmed the presence of nitroaromatic constituents in the groundwater beneath Site 5 as a result of downward migration of contaminants from the burn area. The nitroaromatic compounds identified in the groundwater at levels above the background and MCLs, from highest to lowest concentration, included RDX, 2,4,6-TNT, HMX, 1,3,5-TNB, 1,3-DNB, 2,6-DNT, and 4-DNT. Metals were detected at levels slightly above the MCLs in the groundwater a Site 7 during Phase I. During Phase II, however, the total metals analytical results were below the MCLs. The metals identified in the groundwater during Phase II were chromium, copper, lead, and zinc. Several volatile organic compounds were detected at low concentrations in the groundwater from samples collected from Monitoring Well 7GW8 during Phase II of the RI. The volatile organic compounds identified in the groundwater at levels above the background and MCLs included HMX, RDX, 2,4-DNT, 2,6-DNT, 1,3,5-TNB, 2,4,6-TNT, 1,3-DNB, TCE, cis-1,2-dichloroethene, and 1,1,2,2-tetrachloroethane. The presence of the volatile organic compounds in the groundwater at Monitoring Well 7GW8 is not consistent with the characteristics of potential releases associated with Site 7. It is likely that these volatile organic compounds are associated with contamination from Site 4 or Site 9.

5.7.1.2 Fate and Transport

At Site 7, the primary contamination of concern are the nitroaromatic compounds (HMX, RDX, and 2,4,6-TNT in the soil and HMX and RDX in the groundwater. The major potential routes of migration include the transport of contaminants through the soil and groundwater systems. The analytical results for the soils and groundwater indicate that nitroaromatic compounds have migrated vertically downward through the soil at some point and into the groundwater beneath the burn area. Based on the groundwater condition, and the potential mobility and concentration of the contaminants detected in the groundwater, transport of the nitroaromatics in the groundwater system has been low. The direction of the migration in the groundwater is to the south of the burn area.

5.7.2 Conclusions

The hydrogeologic investigation from Phase I and Phase II provided the information necessary to determine the direction of groundwater flow, the groundwater gradient, and the hydraulic conductivity and transmissivity of the unconfined aquifer.

The biota identified during the ecological investigation at Site 7 consisted primarily of mature deciduous forest and disturbed old field areas with commonly associated mammalian species. Several plant species had fungal growth and leaf structure deformities. The cause for the leaf deformities is unknown.

Nitroaromatic compounds and low levels of metals were detected in the surface soils at Site 7 in the area of the swale and in areas outside the swale and burn area. The vertical soil contamination profile indicates that the nitroaromatic contaminants are migrating from the surface down into the soil profile.

Nitroaromatic compounds, volatile organic compounds and low levels of metals contamination were identified in the groundwater beneath Site 7 during both Phase I and Phase II. The volatile organic compound plume appears to be related to the migration of volatile organics from Site 4 and/or Site 9. Migration of the nitroaromatics in the groundwater beneath the burn area has extended some 400 feet south towards the center of the facility

The risk assessment identified a potential concern for adverse non-cancer and total cancer risk for adults and children who may be exposed to the groundwater from Site 7 if the future land use is residential. Based on the risk evaluation and future land use concerns, remediation of the groundwater at Site 7 should be considered.

Based on the ecological risk assessment, nitroaromatics have a low bioaccumulation potential and therefore, pose a low risk to wildlife at Site 7. The actual risk to wildlife was not quantified.

5.7.2.1 Data Limitations

The analytical results for mercury in the groundwater were rejected based on the data evaluation during Phase II of the RI. The extent and potential migration of mercury contamination in the groundwater, therefore, could not be adequately discussed.

Several physical properties of the soils at Site 7 are required to model the contaminant fate and transport including a soil moisture profile, soil carbon content, soil cation exchange capacity (CEC), infiltration capacity, and the vertical hydraulic conductivity. In addition, contaminant transport modeling in the atmospheric system requires the compilation of prevailing and seasonal wind direction and speed data. For fugitive dust migration analysis, the particle size of the contaminated soil is required. Modeling of contaminant transport in the surface water system requires several parameters which include stream morphology parameters (i.e. channel width and depth), high and low stream flow velocities, sediment particle size analysis, groundwater/surface water interface flow properties.

5.7.2.2 Preliminary Remedial Action Objectives

The risk assessment of contamination present at Site 7 indicates that the primary threat to human health and the environment is from the nitroaromatic and volatile organic contaminants in the soils and groundwater. The primary exposure route would be through ingestion of groundwater and soil. The remedial objective is to remove remaining source of nitroaromatic and volatile organic compounds within the soil to prevent further downward contaminant migration and prevent contaminants within the soil from reaching groundwater. In addition, the remedial objective is to limit further migration of the contaminants identified in the groundwater.

6.0 SITE 8 - ABANDONED CHEMICAL DISPOSAL PIT

6.1 SITE BACKGROUND

6.1.1 Site Description and History

The Abandoned Chemical Disposal Pit is located along the southern facility boundary at the end of Perimeter Road. The Abandoned Chemical Disposal Pit was used from 1951 until 1971 for disposal of miscellaneous waste chemicals from laboratories at the facility. The site was described as a pit about 10-feet by 10-feet by 12-feet. Wastes disposed at this site included acids, mercury, solvents and numerous unidentified waste chemicals. The primary wastes of concern are solvents and mercury. It is estimated by the IAS study that about 180 pounds of mercury were disposed of at this location.

6.1.2 Previous Investigations

Four groundwater monitoring wells were installed and sampled during the Verification Phase to determine the existence of groundwater contamination and identify groundwater flow direction. The analytical data from these wells suggested that no mercury contamination of the groundwater existed as a result of past disposal practices. Some metal and VOC contamination was detected in the groundwater in all of the wells but significant elevated levels were detected in only one well. Results for TOC, TOX, and oils and greases were relatively low. A geophysical survey was conducted in an attempt to locate the former underground disposal area. While the results did not provide a definitive location of the disposal area, interpretation of the results indicated a probable location for the disposal site.

Data gaps identified after analysis of the Verification Phase data included:

- Inadequate data base for interpretation of VOC trends; and
- Inadequate data base for the determination of the levels of mobile dissolved metals.

Verification Phase recommendations included:

- The installation of an additional monitoring well; and
- The sampling of the new and existing monitoring wells.

Recommendations that were made subsequent to the Verification Phase Final Report included:

- Changing the monitoring well to a piezometer; and
- Adding the collection of two surface soil samples.

6.2 RI INVESTIGATIONS

6.2.1 Surface Feature Investigations

Surface feature investigations included location of surface disposal areas, property lines, drainage ditches, streams, vegetation, and topography of the abandoned disposal pit. The purpose of surface feature investigations was to identify possible contaminant migration and the location of potentially affected receptors.

6.2.2 Surface Water and Sediment Investigations

During Phase I, no streams or surface water bodies were identified within the immediate vicinity of Site 8, and therefore, no surface water or stream sediment sampling was conducted at the site. For the same reason, no investigations were performed for this media during Phase II.

6.2.3 Soil and Vadose Zone Investigations

During Phase I, two surficial soil samples were collected to determine the chemical concentrations in the surficial soil and performance of a Ground Penetrating Radar (GPR) geophysical survey to better define the location of the abandoned disposal pit defined in the IAS report and to document the location of buried metallic objects such as containers or drums. The purpose of these investigations was to measure the chemical concentration in the soil, to determine the potential presence of buried drums underlying the site and to

assist in prediction of contaminant movement through the vadose zone for Risk Assessment purposes. A summary of the environmental sampling conducted during Phase I for soil contamination is shown on Table 6-1.

No soil or vadose zone investigations were conducted during Phase II of the RI.

6.2.4 Groundwater Investigations

During Phase I, one additional Monitoring Well (8GW53) was installed at Site 8. A summary of the well installation is presented on Table 1-6, and a summary of well development and sampling is presented in Table 1-7. Construction details for the well are listed on the borehole log for 8GW53 presented in Appendix B. Monitoring Wells 8GW33, 8GW34, 8GW35 and 8GW36, installed during the Verification Phase, and the newly installed 8GW53 were sampled during Phase I. A summary of the environmental sampling for groundwater contamination for Phase I is presented on Table 6-1.

During Phase II of the RI all five monitoring wells at the site were sampled. A summary of the Phase II environmental sampling for groundwater contamination is presented on Table 6-2. In addition, determination of the hydraulic characteristics of the water table aquifer, including grain size analysis, interpretation of single- and multiple-well tests, and flow direction and gradient were conducted during Phase II including estimates of hydraulic conductivity and transmissivity to assist in prediction of contamination movement through the vadose zone, and to measure chemical contamination in the surface soils for Risk Assessment Purposes.

6.2.5 Geological Investigations

During Phase I, one borehole was drilled at Site 8 and converted to a Monitoring Well (8GW53). Split spoon samples were collected during drilling to characterize the subsurface lithology at the intervals indicated on Table 1-6. Descriptions of the individual split spoon samples obtained are given in Appendix B on the borehole log for 8GW53. Soil samples were collected using the standard procedures presented in Appendix F of this report.

No additional geologic investigations were conducted at Site 8 during Phase II.

6.2.6 Ecological Investigations

No ecological investigations were conducted at the site during Phase I.

During Phase II of the RI, ecological investigations were conducted in order to assess the current ecological conditions on site. Included in the investigations were terrestrial vegetation and mammal surveys.

The vegetation survey consisted of a qualitative analysis of species located on site. In this study, field identification was supplemented with office confirmation of the major vegetative species. Relative abundance of the species was established and vegetation community relationships were delineated on the project site map. A general mammalian survey was also performed. Species were identified by signs such as tracks, scats, and evidence of forging. Materials and methods for the Site 8 ecological field investigations are included in Appendix A.

6.3 PHYSICAL CHARACTERISTICS OF THE SITE

6.3.1 Surface Features

The Abandoned Chemical Disposal Pit is located on an upland area approximately 290 feet in elevation along the south central boundary of the facility approximately 900 feet west of Paint Branch Creek. The pit covers an area 30-feet by 30-feet with a reported approximate depth of 12 feet. No surface water bodies exist in the immediate vicinity of the site.

6.3.2 Surface Water Hydrology

Stormwater runoff from this site most likely would drain into Paint Branch Creek approximately 900 feet west of the site or to an unnamed tributary of Paint Branch Creek approximately 400 feet south of the site, if there are no other stormwater control devices in place. There are no perennial streams which drain the Abandoned Chemical Disposal Pit site.

6.3.3 Soils

The soils covering this site belong to the Croom series. Soils of the same series also cover Site 4 and the soils at Site 8 would have the same characteristics as those described

under Section 4.3.2 for Site 4. Analysis of borehole data for this site indicates that the soil zone at this site is approximately 12 to 24 inches thick.

6.3.4 Geology

Two geologic units are present below Site 8. The upper unit is the Upland Sand and Gravel which ranges in thickness from 0 to 10 feet. This is underlain by the saprolite member (Wds) of the Wissahickon Formation which was encountered approximately 5 to 10 feet below ground surface. The fractured gneiss bedrock was encountered at 31 feet below ground surface during drilling of borehole 8GW53. Based on borehole data from 8GW53 and 8GW34 the Wds ranges from 20 to 39 feet thick.

6.3.5 Hydrogeology

The groundwater flow direction was determined from graphical analysis of water levels in Monitoring Wells (8GW33, 8GW34, 8GW35, 8GW36, and 8GW53) during both Phase I and Phase II of the RI. Groundwater is present in the saprolite unit of the Wissahickon Formation. Depth to the water table aquifer measured in August 1991, ranged from 30.89 feet below TPVC at Well 8GW36 to 38.22 feet TPVC at Well 8GW33. Water table aquifer elevations during August 1991, ranged from 250.06 feet MSL at Well 8GW53 to 246.74 feet MSL at Well 8GW34. The average saturated thickness of the water table aquifer based on the 1991 measurements was 20 feet (6.09 m).

Graphical analysis of water level data collected from wells in August 1991, during Phase II of the RI indicates that the flow direction is predominately to the north. However, due to the topographically high location of the site, there may be some radial flow of groundwater from the site. Due to a lack of water level data south of the site beyond the property boundary, it is not possible to make any conclusions regarding radial flow from the site. Groundwater underlying the site discharges north of Site 8 into an unnamed, intermittent tributary of the Paint Branch Creek which receives storm water runoff from Site 11, flows adjacent to the northern boundary of Site 8 and then west to the Paint Branch Creek. The graphical analysis of water level data indicates that the water table gradient ranges from 2 to 4 percent with a geometric mean of 3 percent.

Rising head aquifer slug tests were conducted at Monitoring Well 8GW35 at Site 8 during Phase II. Calculations and graphical methods used to derive K are from Bower and Rice (1989). Recovery curves were generated based on the measured rising water levels

throughout the test. The estimated K for the unconfined aquifer at Site 8 based on the slug test is 2.28 x 10^{-3} cm/sec. Slug test calculations and graphs can be found in Appendix E.

Groundwater flow velocities at Site 8 are based on the pumping test analyses for Well 11GW87 at Site 11 during Phase II of the RI. This data should be more representative of regional conditions and the hydrologic units are similar. The pumping test results for 11GW87 indicate that the hydraulic conductivity (K) for the saprolite unit is approximately 4.62 x 10^{-5} cm/sec. Transmissivity (T) of the water table aquifer underlying Site 8 is approximately 0.028 cm^2/sec. The velocity of the groundwater flow is estimated to be 4.78 X 10^{-6} cm/sec with an assumed effective porosity of 26 percent.

6.3.6 Ecology

Site 8 consists primarily of a mature deciduous forested region with 12- to 15-inch DBH trees. Trees characterizing this region include Tulip Poplar, American Beech, White oak, Black Oak, and Black Cherry. Species in the shrub and sapling layers include American Holly, Maple-leaf Viburnum, Tulip Poplar, Black Oak, Sourwood, and Flowering Dogwood. Typical groundcover in the forested region includes Deer-Tongue Grass, Virginia Creeper, Highbush Blueberry, Arrowood, and Christmas Fern. In areas immediately adjacent to the road, and within the traffic circle at the east boundary of the site were grasses, plantains, clover, and Virginia Creeper.

Species noted during the on-site investigation were Grey Squirrels, and domestic cat. A melanistic grey squirrel was noted on site. Bird species observed on site include Ovenbird and Rufous-sided Towhee.

6.4 NATURE AND EXTENT OF CONTAMINATION

6.4.1 Sources

A Ground Penetrating Radar (GPR) survey was performed at Site 8 during Phase I of the RI to locate the suspected burial site and any potential contamination sources such as waste chemical drums or containers. The survey lines are shown on Figure 6-1. STS Consultants, Ltd. of Chantilly, Virginia performed the geophysical survey. The GPR survey indicated that one burial area was present at the site. The approximate location of the burial pit boundaries is shown on Figure 6-1. Appendix C contains the entire GPR Survey Report prepared by STS Consultants, Ltd.

GPR results confirmed the existence and general location of the burial pit at Site 8. The abandoned pit extends underneath the existing perimeter road. No potential sources such as waste chemical drums were identified during analysis of the survey results.

6.4.2 Soils

Two surface Soil Samples (8SL1/8SL2) were collected during Phase I to document surface contamination at Site 8 for Risk Assessment determinations. Figure 6-2 shows the sampling locations. Table 6-3 summarizes the surficial soil analytical data for the surficial soil samples. Parameters with higher concentrations than facility-specific background levels are listed as follows:

	Sample Location	Parameter
Phase I	8SL1	Chromium, lead
	8SL2	Chromium, Copper, Lead, Zinc

The surface soil results for metals are slightly higher than the background levels from samples collected during Phase I but are within the range of concentration for natural U.S. soils. Surface Sample 8SL2 was collected directly above the disposal pit and surface sample 8SL1 was collected outside the pit boundary to the southwest. As expected the values for surface sample 8SL2 are slightly higher than surface sample 8SL1.

6.4.3 Groundwater

Five groundwater Monitoring Wells (8GW33 through 8GW36 and 8GW53) were sampled to document groundwater quality at Site 8 during both Phase I and Phase II of the RI. Groundwater Monitoring Wells 8GW33 through 8GW36 were installed during the Verification Phase. Groundwater Monitoring Well 8GW53 was installed during Phase I. Figure 6-2 shows the locations of the five monitoring wells. Table 6-4 summarizes the groundwater analytical data for Site 8 collected during Phase I and Table 6-5 summarizes groundwater analytical data collected during Phase II. Parameters with higher concentrations than background levels are listed as follows:

	Well Location	Parameter
Phase I	8GW33	Chromium, Lead, Mercury, Bis(2-ethylhexyl)phthalate
	8GW34	Chromium, Lead
	8GW35	Chromium, Lead, bis(2-Ethylhexyl)Phthalate
	8GW36	Chromium, Lead, 1,1,2-TCA, Bis(2-ethylhexyl)phthalate
	8GW53	Chromium, Lead, Bis(2-ethylhexyl)phthalate
Phase II	8GW33	Lead, Chloride
	8GW34	Chloride
	8GW35	Chloroform
	8GW53	Cadmium

Metals were detected in the groundwater collected at Site 8. The metal concentrations in the groundwater decreased in concentration from Phase I to Phase II. Chromium levels detected in the groundwater during Phase I were approximately three times higher than the appropriate drinking water MCL for chromium. Chromium levels in the groundwater during Phase II were below MCL and established background levels. Mercury was present in groundwater Samples 8GW33 and 8GW34 during Phase I. The level detected in sample 8GW34 was below the MCL and established background levels but was above the detection limit of the analysis. The analytical results for mercury levels in the groundwater during Phase II were rejected. Cadmium was detected in 8GW36 during Phase II analysis at the detection limit (5 μg/L). However, Cadmium was not detected in 8GW36 in Phase I, or in any other well on site during the either Phase I or Phase II, suggesting a possibly active, low level source within the abandoned disposal pit.

Low levels of 1,1,2-TCA were present in groundwater Sample 8GW36 during both Phase I (7 μg/L) and Phase II (4 μg/L). The level of 7 μg/L detected during Phase I was only slightly higher than the 5 μg/L detection limit and MCL for the compound. The level of 1,1,2-TCA detected during Phase II (4 μg/L) was slightly lower than the 5 μg/L detection limit and MCL for the compound. Low levels of Bis(2-ethylhexyl)phthalate were present in the groundwater during Phase I but the analytical results for Bis(2-ethylhexyl)phthalate during Phase II were rejected. Chloroform and methylene chloride were present at low levels in the groundwater during Phase II. The analytical results for acetone levels in

groundwater Samples 8GW33 and 8GW34 during Phase II were rejected due to laboratory contamination. The semi-volatile analytical results for the groundwater samples collected during Phase II were rejected.

The decrease in concentration of metals in the groundwater from Phase I to Phase II suggest a reduction in metals leachate generation from the abandoned disposal pit. Mercury was not detected during the Verification Phase in groundwater Samples 8GW33 and 8GW34 during the two sampling events performed. The presence of low levels of mercury in the groundwater Samples 8GW33 and 8GW34 during Phase I of the RI suggest possible leachate generation of mercury from the Abandoned Disposal Pit. The rejection of the mercury analytical results during Phase II limits further confirmation of the extent of mercury contamination in the groundwater at Site 8.

Volatile organic compounds were detected at low levels in the groundwater at Site 8. 1,1,2-TCA, not detected during the Verification Phase, was identified in the sample of groundwater from 8GW36 during the both Phase I and Phase II. The initial presence of 1,1,2-TCA during Phase I suggested an active source for volatile organic compounds from the abandoned disposal pit. However, the lower level of 1,1,2-TCA in the groundwater during Phase II suggest that the source for 1,1,2-TCA leachate was limited and the contribution to the groundwater has been minor.

The low levels of both volatile and semi-volatile organic compounds and metals suggest that the extent of contamination is localized near the abandoned disposal pit area. The presence of metals and/or volatile organic compounds in groundwater Samples 8GW33, 8GW34, 8GW35 and 8GW36, and the presence of semi-volatile organic compounds in 8GW33, 8GW35, 8GW36 and 8GW53 indicate radial migration of contamination from the abandoned pit. The highest concentrations of contaminants detected in groundwater were metals from Sample 8GW33 which suggests that the predominant direction of plume migration has been towards the north, which is confirmed by graphical analysis of water levels presented in Section 6.3.5.

6.5 CONTAMINANT FATE AND TRANSPORT

6.5.1 Potential Routes of Migration

The potential route of contaminant migration at Site 8 is through transport of contaminants through the groundwater system. There are no streams present for transport of potential surface water and sediment contamination.

6.5.2 Contamination Migration

As listed in Appendix A of the Risk Assessment, the only contaminants of concern in the groundwater at Site 8 are 1,1,2-TCA and Bis(2-ethylhexyl)phthalate. 1,1,2-TCA was detected in 8GW36 during both Phase I and Phase II sampling events. Since the 1,1,2-TCA is present in low concentrations, it is expected to move with the groundwater. In saturated, deep soils, conditions similar to those identified in 8GW36, a much higher fraction of 1,1,2-TCA is expected to be in the soil water phase and transported with flowing groundwater. The persistence of 1,1,2-TCA in the soil/groundwater system is not well documented. In most cases, it should be assumed that 1,1,2-TCA will persist for months to years (or more). Biodegradation in the soil/groundwater system should be assumed to be of minimum importance.

The presence of Bis(2-ethylhexyl)phthalate was identified in groundwater samples from 8GW33, 8GW35, 8GW36 and 8GW53 at concentrations between 7 and 19 μg/L during Phase I of the RI. Analytical results for Bis(2-ethylhexyl)phthalate were rejected during Phase II of the RI. Based on physical characteristics, Bis(2-ethylhexyl)phthalate biodegrades under aerobic conditions and adsorbs to soil. Bis(2-ethylhexyl)phthalate was not identified in surficial soil samples collected during Phase I of the RI (Table 6-3). Because of the low vapor pressure and Henry's Law constant for the compound, evaporation is slow, and migration is expected to be limited. Also, the calculated velocity for groundwater is approximately 1 ft/day, however, filled observations indicate that contamination is moving at a much slower rate and has moved less than 100 feet. Considering that waste disposal at the site was ended in the early 1970's, contaminant migration has been significantly reduced.

6.6 RISK ASSESSMENT

6.6.1 Human Health Evaluation

A summary of the risk estimates in relation to USEPA's Superfund remediation criteria is presented in Table 6-6. The non-cancer and cancer risks associated with exposure to groundwater at Site 8 may be summarized as follows.

6.6.1.1 Non-cancer Risks

Adverse non-carcinogenic health effects in the residential population (adults and children) from exposure to groundwater are unlikely. The total hazard indices for the pathways for adults and children are less than the criterion of 1.0.

6.6.1.2 Cancer Risks

The total cancer risk for adults and children if groundwater were used in the vicinity of the site by residents who potentially may be exposed to contaminated groundwater from Site 8 exceeds the USEPA Superfund remediation goal. For adults and children, ingestion of groundwater constitutes the greatest concern.

Thus, based on cancer risk estimates, consideration of the need for remediation of groundwater at Site 8 is warranted.

6.7 SUMMARY AND CONCLUSIONS

6.7.1 Summary

Site 8 (Abandoned Chemical Disposal Pit) was operated from 1951 until 1971 and is located along the southern facility boundary at the end of Perimeter Road. According to the IAS, waste disposed of at Site 8 included acids, mercury, solvents and numerous unidentified chemicals. Approximately 180 pounds of mercury was disposed of at this site.

The RI at Site 8 included a hydrogeologic investigation, and contaminant characterization and risk assessment. The hydrogeologic investigation included lithologic descriptions of the subsurface, monitoring well elevation and location survey, groundwater level measurements and three aquifer slug test. The lithology beneath Site 8 consists of the Upland Sand and Gravel unit which lies on the saprolite member of the Wissahickon Formation. Depth to the water table ranges from approximately 30.89 to 38.22 feet TPVC.

Predominant groundwater flow at the site is to the north. The groundwater gradient ranged from 2.0 to 4.0 percent with a geometric mean of 3.0 percent. The geometric mean of K based on the analysis of the slug test data was 2.28×10^{-3} cm/sec.

The contaminant characterization included the collection and analysis of samples collected from the soil, groundwater, and biota to be used for determining the risk to human health and the environment. Groundwater Monitoring Well 8GW53 was installed during Phase I. Two surface soil samples and five groundwater samples were collected for analysis during Phase I. A GPR geophysical survey was performed during Phase I to locate the suspected burial site and any potential sources of contamination such as waste chemical drums or containers. GPR results confirmed the existence and general location of the burial pit but was unable to confirm the presence of buried waste chemical containers. No additional monitoring wells were installed and no soil samples were collected during Phase II. Five groundwater samples were collected during Phase II.

The ecological investigation during Phase II consisted of terrestrial vegetation and mammal surveys. Site 8 consists primarily of a mature deciduous forested region which contains various species of poplar, beech, oak, and cherry. The mammalian species found at the site are those commonly associated with a mature forested ecosystem.

The risk assessment determinations are included as Appendix G in this text. Ingestion of contaminated groundwater is of concern. Adverse non-carcinogenic health effects in the residential population from exposure to the groundwater is unlikely. The total cancer risk for off-site residents who may potentially be exposed to contaminated groundwater from Site 8 exceeds the USEPA Superfund remediation goal. Therefore, based on the human health evaluation, consideration of the need for remediation of surface soils and stream sediment at Site 8 is warranted.

6.7.1.1 Nature and Extent of Contamination

The results of the GPR survey confirmed the existence and general location of the disposal pit at Site 8. No potential point sources within the suspected pit area were identified. Metals (mostly chromium, copper, lead, and zinc) were detected in the surface soils at Site 8 (Tables 6-3 and 6-4). No volatile organic compounds were detected at concentration s above background in the surface soil during Phase I.

Groundwater contaminants detected at levels greater than the MCLs for drinking water at Site 8 are four metals (cadmium, chloride, lead, and mercury), two volatile organic compounds (1,1,2-TCA and chloroform), and one semi-volatile organic compound (Bis(2-ethylhexyl)phthalate).

The low levels of metals, volatile organic and semi-volatile organic compounds detected in the groundwater samples suggest that the extent of contamination is localized near the abandoned disposal pit area and the migration has been less than 100 feet since ending use of the pit in the early 1970's. The horizontal distribution of the contaminants in the groundwater suggests radial flow of contaminants with a predominant direction towards the north.

6.7.1.2 Fate and Transport

According to the Risk Assessment for Site 8, the primary contaminants of concern are 1,1,2-TCA and Bis(2-ethylhexyl)phthalate in the groundwater. The major potential routes of migration include the transport of contaminants through the groundwater system.

Transport of the organic contaminants in the groundwater is northward towards the center of the facility, although some radial flow from east to west has occurred based on the analytical data. Based on the groundwater conditions, and the potential mobility and concentration of the contaminants detected in the groundwater, migration of the organic compounds in the groundwater system has been limited.

6.7.2 Conclusions

The hydrogeologic investigation from Phase I and Phase II provided the information necessary to determine the direction of groundwater flow, the groundwater gradient, and the hydraulic conductivity of the unconfined aquifer. The biota identified at the landfill during the ecological investigation consisted primarily of mature forest areas with commonly associated mammalian species.

Metals were identified in the surface soil at Site 8 during Phase I. Metals, volatile organic compounds and semi volatile organic compounds were identified in the groundwater beneath Site 8 during both Phase I and Phase II. Migration of the contaminants in the groundwater beneath Site 8 is predominantly towards the north. The migration of the contaminants in the groundwater at Site 8 is considered very low based on the flow velocity of the groundwater and the distribution of contaminants in the groundwater samples.

The risk assessment identified a potential concern for total cancer risk for off-site populations who may be exposed to the groundwater from Site 8. Based on the human health evaluation, consideration of the need for remediation of groundwater at Site 8 is warranted.

6.7.2.1 Data Limitations

The analytical results for mercury in the groundwater were rejected based on the data during Phase II of the RI, therefore, the extent and migration of mercury contamination in the groundwater, therefore, could not be confirmed. However, mercury was detected only in an unfiltered sample from well 86W33 which indicates that mercury is adsorbed onto soil particulates in the groundwater and is not dissolved in groundwater.

Several physical properties of Site 8 that were required to confidently model the contaminant fate and transport were not quantified including a soil moisture profile, soil carbon content, soil cation exchange capacity (CEC), infiltration capacity, and the vertical hydraulic conductivity.

6.7.2.2 Preliminary Remedial Action Objectives

The risk assessment of contamination present at Site 8 indicates that the primary risk to human health and the environment, if groundwater were used in the vicinity of the site, is from 1,1,2 TCA and Bis(2-ethylhexyl)phthalate. The primary exposure route would be through ingestion of the groundwater. The remedial objective is to remove any remaining source(s) of contaminants, to prevent further contaminant migration into the soil and stream sediments, and to reduce the health risk associated with the exposure to contaminated surface soils and stream sediment to acceptable levels under the USEPA Superfund remediation goal.

7.0 SITE 9 - INDUSTRIAL WASTEWATER DISPOSAL AREA 300

7.1 SITE BACKGROUND

7.1.1 Site Description and History

The Industrial Wastewater Disposal Area 300 is located south of Dahlgren Road along the Montgomery/Prince George County line and extends southward to the facility boundary. A perennial tributary of Paint Branch Creek is located west and south of the site and an intermittent tributary of the creek is located to the east. The Industrial Wastewater Disposal Area 300 was used from the early 1950s until the mid-1970s. Several leaching wells and above ground discharges to the soil were used in this area for disposal of liquid wastes containing explosive compounds. Wastewater disposed at this site contained TNT, RDX, and several other explosive related compounds. It is estimated in the IAS study that at least 7,200 pounds of these wastewaters were disposed at this site over a period of approximately 25 years. It is also reported in the IAS that solvents were disposed in the same manner as the explosive compounds.

7.1.2 Previous Investigations

Seven groundwater monitoring wells and 15 stream sediment locations were sampled during the Verification Phase. Generally, TOC and TOX values were detected at low concentrations throughout the site. Volatile organic contaminants were detected in all of the monitoring wells at the site. Metal values were low at all sampling locations. Nitroaromatic contamination was present at one sediment sampling location, which was believed to have resulted from transport of contamination from Site 7 through run-off or wind. Nitroaromatics were also detected at Well 9GW1 during the first sampling event.

Data gaps identified after analysis of the Verification Phase data included:

- Extent of groundwater contamination at the site; and
- A thorough understanding of groundwater flow directions and gradients.

The Verification Phase recommendations included:

- Installation of two additional monitoring wells near Monitoring Well 9GW1 with the highest levels of VOC contamination;
- Resample the surface water; and
- Sample the new and existing groundwater monitoring wells.

Recommendations that were made subsequent to the Verification Phase Final Report included:

- Installation of six additional monitoring wells with at least two of them being clustered;
- Installation of three piezometers to better define groundwater flow directions;
- Sample two surface soil locations; and
- Perform a soil gas survey of the area near Monitoring Well 9GW1.

7.2 RI INVESTIGATIONS

7.2.1 Surface Feature Investigations

The purpose of surface feature investigations was to identify possible contaminant migration and the location of potentially affected receptors. Surface feature investigations included location of surface disposal areas, property lines, drainage ditches, streams, vegetation, and topography of the entire site.

7.2.2 Surface Water and Sediment Investigations

The purpose of the sampling was to document the chemical quality of the surface water and stream sediment at Site 9. During Phase I and Phase II, surface water and stream sediment investigations included the collection of three samples from the surface water and ten sediment samples from the small stream east of the site and from the stream west of the site. The stream west of Site 9 enters the facility at the northern boundary west of Site 3. Surface water and sediment were sampled at numerous locations within the stream at points where the streams entered the site along the downgradient stream intervals,

and where both streams exit the facility. Numerous parameters were analyzed for the water and sediment.

A summary of the investigative tasks for Phase I and Phase II are listed on Table 1-5. The sample locations during Phase I and Phase II are illustrated on Figure 7-1. A summary of the environmental sampling conducted during both Phase I and Phase II is presented on Tables 7-1 and 7-2. Surface water and sediment samples were collected using the standard procedures presented in Appendix F.

7.2.3 Soil and Vadose Zone Investigations

The purpose of these investigations was to measure the release of gaseous volatile organic contamination through the soil; potentially predict contaminant movement through the vadose zone, and measure the chemical contamination in the surface soils for Risk Assessment purposes. During Phase I, soil and vadose zone investigations for Site 9 included the collection of two surficial Soil Samples (9SL1 and 9SL2) and six soil gas surveys of the shallow soil near former leaching well fields. Sampling grids were established at six locations of former leaching wells/fields (Building 304, Buildings 344 and 345, Building 336, Building 328, Building 310, and Building 311). Figures 7-2, 7-3 and 7-4 illustrate sampling grids and present the results of the soil gas survey. No soil gas survey or surface soil sampling occurred during Phase II.

7.2.4 Groundwater Investigations

During Phase I, three Piezometers (9PZ44, 9PZ55, and 9PZ56) and six groundwater Monitoring Wells (9GW57S, 9GW57D, 9GW58, 9GW59, 9GW74 and 9GW75) were installed at Site 9 at the locations indicated on Figure 7-1. Two wells were installed as a cluster, one shallow (9GW57S) and one deep (9GW57D). During Phase I, groundwater samples were collected from 13 Monitoring Wells (9GW1, 9GW2, 9GW3, 9GW4, 9GW5, 9GW6, 9GW7, 9GW57S, 9GW57D, 9GW58, 9GW59, 9GW74, and 9GW75).

During Phase II, one additional groundwater Monitoring Well (9GW83) was installed. Groundwater samples were collected from 13 Monitoring Wells (9GW1, 9GW2, 9GW3, 9GW4, 9GW5, 9GW6, 9GW7, 9GW57S, 9GW57D, 9GW59, 9GW74, 9GW75, and 9GW83). Monitoring Well 9GW58 was damaged prior to Phase II and could not be sampled.

A summary of the investigative tasks for Phase I and Phase II are listed on Table 1-5. The well locations are illustrated on Figure 7-1. Construction details for the wells installed during Phase I and Phase II are listed on the borehole logs for 9GW57S, 9GW57D, 9GW58, 9GW59, 9GW74, 9GW75, and 9GW83 and are presented in Appendix B. Table 1-2 summarizes the installation, development, and sampling dates for each well. A summary of the environmental sampling conducted during both Phase I and Phase II is listed on Tables 7-1 and 7-2. Groundwater samples were collected using the standard procedures presented in this report in Appendix F. In addition, during Phase II nine Monitoring Wells (9GW1, (GW2, 9GW7, 9GW57D, 9GW575, 9GW58, 9GW59, 9GW74, and 9GW75) and one Piezometer (9PZ55) were slug tested to determine the estimated hydraulic conductivity of the site.

7.2.5 Geological Investigations

During Phase I, nine boreholes were drilled at Site 9 and converted to three piezometers (9PZ44, 9PZ55, 9PZ56) and six groundwater Monitoring Wells (9GW57S, 9GW57D, 9GW58, 9GW59, 9GW74 and 9GW75). During Phase II, one borehole was drilled and converted to a groundwater Monitoring Well (9GW83). Soil samples were collected in split spoon samplers during drilling to characterize the subsurface lithology at the intervals indicated on Table 1-2. Descriptions of the soil samples collected in the split spoon samplers are given in Appendix B on the borehole log for each piezometer or well. Soil samples were collected using the standard procedures presented in Appendix F of this report.

7.2.6 Ecological Investigations

Included in the investigation were terrestrial vegetation, mammal, fish and benthic invertebrate surveys. The vegetation survey consisted of a qualitative analysis of species types located on site. In this study, field identification was supplemented with office confirmation of the major vegetative species. Relative abundance of the species was established and vegetation community relationships were delineated on the project site map.

A general mammalian survey was performed and benthic invertebrate sampling was conducted using a kick screen at three locations along the stream which transect Site 9 (upstream, midstream, and downstream). The fish survey was completed using a Smith-

Root electrofisher at upstream and downstream points along the length of the stream. Fish specimens were collected for bioassay and transported to the laboratory for analysis.

Appendix A contains the specific materials and methods used in completing the ecological field investigations for Site 9.

7.3 PHYSICAL CHARACTERISTICS

7.3.1 Surface Features

The Industrial Wastewater Disposal Area 300 is situated on an upland interfluve between a perennial stream west of the site and an intermittent stream east of the site. Both the perennial and intermittent streams flow south where they join Paint Branch Creek. The site is characterized by moderate topographic relief with elevations ranging from 290 feet in the north central portion of the site to 190 feet along the perennial stream to the west and 160 feet along the perennial stream at the southern boundaries of the site. Several buildings used for research are located with the boundaries of the site.

7.3.2 Surface Water Hydrology

Storm water from Site 9 drains towards the east into an intermittent stream and towards the west into a perennial stream. The latter stream is the same surface water body sampled adjacent to Site 3.

The permanent stream west of Site 9 contains an iron-stained substrate consisting of pebbles and cobbles averaging 4 inches in diameter. The majority of the stream averages 3 feet wide and 4 inches deep; there are several pools in the stretch of the stream which are 3 to 5 feet wide and 2 to 3 feet deep. Very little algae was noted in the stream.

The intermittent stream east of Site 9 contains little iron coloration in its substrate. The water in the creek was somewhat cooler than that in the other surface water bodies on the facility. The substrate contained numerous cobbles and small boulders, averaging 6 inches in diameter. Stream width averaged 1 to 2 feet.

7.3.3 Soils

The soils at this site belong to the Croom Series (Soil Survey Report U.S. Naval Ordnance Laboratory White Oak, Maryland, 1970). These soils are excessively drained gravelly soils that are strongly acidic (pH 4.5 to 5.0). The soils are comprised of strongly compact, firm and massive gravelly layers.

7.3.4 Geology

Three geologic units underlie Site 9. The uppermost geologic unit is the Upland Sand and Gravel which is underlain by the Potomac Group. The saprolite member (Wds) and fractured gneiss (Wd) of the Wissahickon Formation underlie the unconsolidated sediments. Portions of the uppermost geologic units have been eroded due to the proximity of the site to perennial and intermittent tributaries of Paint Branch Creek. The northern part of the site is topographically higher than the southern part and has experienced less erosion.

A total of five wells and one piezometer were installed in the northern portion of Site 9 during the Verification Phase and RI Studies (9GW4, 9GW5, 9GW6, 9GW7, 9GW58, 9GW75, and 9PZ44). Based on borehole data from these wells and piezometers, the northern portion of the site is underlain by approximately 40 to 65 feet of unconsolidated sediments. Within the unconsolidated sediments, several silty clay seams were observed during drilling of Wells 9GW6, 9GW58, and 9PZ44. These do not appear to be correlative with the silty clay layer described for Sites 4 and 7. These silty clay layers appear to be more local in nature and do not appear to be laterally continuous. The saprolite member (Wds) of the Wissahickon Formation was encountered at 40 feet below ground surface in 9PZ44 and was approximately 25 feet thick. Below the saprolite/weathered gneiss, a highly weathered grey-green chlorite schist was encountered at approximately 65 feet below ground surface. The chlorite schist is a local, more highly metamorphosed member of the Wissahickon Formation.

A total of eight wells and one piezometer have been installed in the southern portion of Site 9 during the Verification Phase and RI Studies (9GW1, 9GW2, 9GW3, 9GW57S, 9GW57D, 9GW59, 9GW74, 9GW83, and 9PZ56). Based on borehole data from these wells, the Upland Sand and Gravel unit has been completely eroded and some of the upper portion of the Potomac Group has been eroded. The southern portion of Site 9 is covered by a thin veneer of interbedded red-grey sands approximately 5 to 15 feet thick. This is underlain by the saprolite member (Wds) of the Wissahickon Formation. The saprolite was

encountered at approximately 18 feet below ground surface during drilling of Well 9GW59 and at 5 feet below ground surface in piezometer 9PZ56. This variation in thickness is a result of more erosion of the unconsolidated sediments along stream valleys in the southern part of Site 9.

7.3.5 Hydrogeology

The Verification Phase Study suggested that groundwater flows to the south-southwest in the northern part of Site 9 towards a perennial stream and is only slightly influenced by an intermittent stream. In the southern portion of Site 9, the Verification Phase Study suggested that groundwater flow is affected by the intermittent stream and flows to the southeast. Graphical analysis of water level data collected from wells which have screened intervals in the Upland Sand and Gravel and/or saprolite during August, 1991 suggests local groundwater flow beneath the site is toward the south-southeast in the direction of the intermittent stream. The graphical analysis indicates there is a groundwater gradient with a geometric mean of 3 percent. During periods of high water table elevations, the groundwater in this area discharges into the intermittent stream.

The physical characteristics of the water table aquifer changes across the site from the north to south. In the northern portion of the site, the water table aquifer occurs in the Upland Sand and Gravel unit and to a minor extent in the underlying saprolite. In the southern portion of the site, the water table aquifer occurs in the saprolite unit. Depth to the water table aquifer measured in August, 1991, ranged from 9.86 feet TPVC at Well 9GW83 to 55.15 feet TPVC at Well 9GW5. Water table aquifer elevations during August 1991 ranged from 152.54 feet at Well 9GW83 to 242.32 feet at Well 9GW7. The estimated average saturated thickness of the water table aquifer based on the 1991 measurements was 18 feet in the northern portion of the site in the Upland Sand and Gravel unit and 5 feet in the southern portion of the site feet in the saprolite unit.

Analysis of the slug test data resulted in an estimated hydraulic conductivity (K) for each well. The geometric mean of the K values for each well was then calculated to determine the average K for Site 9. The estimated hydraulic conductivity for Site 9 slug tests indicates that groundwater flow averages 6.8×10^{-4} cm/sec.

Groundwater flow velocities at Site 9 are based on the pumping test analyses conducted during Phase II of the RI at Wells 4GW81D and 4GW79 for the northern portion of the site and at Well 11GW87 for the southern portion. The estimated transmissivity

of the water table aquifer beneath the northern portion of the site ranges from 1.22×10^{-1} to 2.34×10^{-1} cm^2/sec. The estimated groundwater velocity beneath the northern portion ranges from 4.71×10^{-4} to 9.33×10^{-4} cm/sec or 1.3 ft/day. The pumping test results for Well 11GW87 indicate the hydraulic conductivity (K) for the saprolite unit is approximately 4.63 $\times 10^{-5}$ cm/sec. The transmissivity of the water table aquifer beneath the southern portion of the site is approximately 7.0×10^{-5} cm^2/sec. The groundwater velocity in the southern portion is estimated at 8.01×10^{-6} cm/sec or 0.02 ft/day.

7.3.6 Ecology

Site 9 consists primarily of wooded areas adjacent to maintained lawns. The deciduous forested regions adjacent to the lawns consisted of Southern Red Oak, White Oak, Tulip Poplar, Eastern Sycamore, Red Maple, Black Cherry, American Holly, Willow Oak, Sour Gum, Highbush Blueberry, Common Dandelion and honeysuckle. Areas adjacent to the wooded areas consist of goldenrod, Wild Onion, members of the Family Compositae, American Beech, Black Locust, and young oaks.

Mammalian species noted include White-tailed Deer, Woodchuck, Eastern Cottontail, Eastern Chipmunk, and domestic cats. Bird species observed on-site include American Crow, Northern Mockingbird, Mourning Dove, European Starling, and Eastern Wood Peewee.

The benthic sampling at Site 3/9L (Table 8, Appendix A), in the permanent stream west of Site 9, contained three annelid worms, three oligochaete worms, one crayfish larva (Astacidae), three Chironomid midges, and one stonefly (Amphinemoura sp.). The sample from 3/9L Duplicate had five oligochaete worms, and one Chironomid midge (Cricotopus sp.).

Benthic sampling in the intermittent stream east of Site 9 at Site 9M (Table 8, Appendix A) yielded a wide variety of organisms. Seven annelid worms, including one oligochaete worm, five members of the Class Diplopoda, three springtails (Podura sp.), two biting midges (Bessia sp.), 196 Chironomid midges (195 Chironous sp.; 1 Pseudosmitta sp.), 26 black flies (Simulium sp.), seven crane flies (Family tipulidae), one fishfly larva (Chauliodes sp.), 253 stoneflies (Amphinemoura sp.), 50 caddisflies (13 Cheumatopsyche sp.; four Hydropsyche sp.; and 33 Dolophilus sp.), and two unidentified members of the Phylum Nematoda were collected. Site 9M Duplicate yielded four annelid worms, five members of the Class Diplopoda, three marshloving beetles (Lutrochus sp.), one springtail larva (Podura

sp.), 131 Chironomid midges (48 Chironomus sp.; 83 Cricotopus sp.), 79 black flies (Simulium sp.), four craneflies (Family Tipulidae), 517 stoneflies (Amplinemoura sp.), and 26 caddisflies (one Cheumatopsyche sp.; two Hydropsyche sp.; and 23 Dolophilus sp.).

Sampling results from the permanent stream west of Site 9 included 55 and 83 percent annelid worms for Sites 3/9L and 3/9L Duplicate, respectively. These calculations indicate fair to poor water quality in this portion of the stream. There were 1.3 and 0.5 percent annelid worms for the sample and duplicate sample from the intermittent stream east of Site 9 (Site 9M and Site 9M Duplicate), indicating excellent water quality in this surface water body.

The HBI values for Site 3/9L and Site 3/9L Duplicate were 3.11 and 3.58, respectively, indicating fair water quality in this permanent stream. HBI values for Sites 9M and 9M Duplicate were 1.95 and 1.37, respectively, indicating excellent water quality in this intermittent stream.

Site 3/9L has fair stream water quality, as indicated by the relative absence of mayflies, stoneflies, and caddisflies and relative abundance of annelid and oligochaete worms. This water quality is most likely not a limiting factor on fish populations. Forty-two Black-nosed Dace, 3 Flathead Minnows, and one Northern Hogsucker measuring 12 inches in length were found in this stretch of the stream. Five additional fish species including American Eel, Creek Chub, Catlips Minnow, Pearly Dace, and Rosyside Dace were collected from Sites 3A, 3B, and 3C, approximately 2,500 feet upstream from Site 3/9L. These species are expected to be found at Site 3/9L. It is suspected that the presence of water throughout the year and the existence of large pools and undercut banks, provides cover for many fish species in this stretch of the stream.

There were no fish collected from the stream at Site 9M. This absence of fish in the Stream is not necessarily an indication of poor water quality in this water body. Low-flow conditions in this stream during portions of the year is probably the most important limiting factor for fish populations.

7.4 NATURE AND EXTENT OF CONTAMINATION

7.4.1 Soils and Vadose Zone

Two surficial Soil Samples (9SL1/9SL2) were collected during Phase I to document surface contamination for Risk Assessment determinations at Site 9. Figure 7-1 shows the locations of the two samples collected. Table 7-3 summarizes the surficial soil analytical data for Phase I. Levels of contaminants above background levels are shaded.

Vadose zone monitoring was performed at six locations at Site 9 during Phase I. A soil gas survey was accomplished using an HNu Photoionization Detector to monitor the volatile organic compounds in the shallow soil. Soil gas surveys were performed at the following areas:

- Adjacent to Building 304;
- Adjacent to Buildings 344 and 345;
- Adjacent to Building 336;
- Adjacent to Building 328;
- Adjacent to Building 310; and
- Adjacent to Building 311.

Soil gas surveys were performed in these areas because former leaching wells or fields were utilized for the disposal of industrial wastewater including compounds such as solvents and other laboratory chemicals. Results of these surveys are summarized below:

Building 304: No volatile organic compounds were detected adjacent to Building 304 in the vicinity of the former leaching well. Figure 7-2 includes the sampling grid and survey results for this location.

Buildings 344 and 345: No volatile organic compounds were detected adjacent to Buildings 344 and 345 in the vicinity of the former leaching wells. Figure 7-2 includes the sampling grid and survey results for this location.

Building 336: Detectable levels of volatile organic compounds ranging from 1.2 to 4.8 ppm were measured at this soil gas survey location. Figure 7-3 includes the sampling grid and results of the survey. The leaching well is located near Sampling Point No. 13 where

the highest value was recorded. All detectable levels on the sampling grid are located downgradient from the leaching well toward the small stream to the east of Building 336.

Building 328: A sampling grid of 12 points was established adjacent to Building 328 to measure the volatile organic levels in the shallow soil. Three of these points had detectable levels of organic compounds in the shallow soil with the highest reading being 5.0 ppm at the approximate location of the former leaching well. Figure 7-4 shows the sampling grid and results of the soil gas survey.

Building 310: A 17 point sampling grid was established adjacent to Building 310 in the general vicinity of a former leaching field. Levels ranged from 0 to 0.80 ppm throughout the grid. The former leaching field may account for the low levels of volatile organic compounds measured in the shallow soil gas at this area. Figure 7-4 shows the sampling grid and results of the soil gas survey.

Building 311: A 12 point sampling grid was established at this location to measure the volatile organic concentrations in the shallow soil gas. Volatile organic levels ranged from 0 to 5.5 ppm at this area. The highest levels were measured at the row of points adjacent to the stream that flows to the east of Building 311. The location of the sampling grid and results of the soil gas survey at this location is shown in Figure 7-4.

The surficial soil results for samples 9SL1 and 9SL2, collected during Phase I, revealed levels of metals (Copper, Lead, and Zinc, and Zinc, respectively) in the soils above background levels established for the facility. While levels of metals in the soils were above those established as background (Table 1-13), no metals exceed the levels noted for naturally occurring soils (Table 1-12). In addition, no concentration of metals in soils exceeded RCRA Corrective Action levels. Levels of semi-volatile organic compounds fluoranthene and pyrene were above detection limits and slightly above the typical background ranges reported for soils in urban areas (Table 1-12) in sample 9SL1. No volatile organic compounds were reported above detection limits in the sample from 9SL2. No soils were sampled during Phase II.

Vadose zone monitoring through the performance of soil gas surveys was accomplished at the six locations described in the above section. Soil gas surveys at Buildings 304, 344, and 345 detected no volatile organic compounds in the shallow soil. The soil gas surveys performed at Buildings 336, 328, 310, and 311 document the presence of volatile organic compounds in the shallow soil. This indicates that the former leaching wells/fields at these locations which were once utilized for disposal of industrial or

laboratory wastewater that included various solvents or other laboratory wastes have impacted the shallow soil and potentially the groundwater.

7.4.2 Groundwater

Groundwater samples were collected to document groundwater quality at Site 9. Groundwater from 13 Monitoring Wells (9GW1 through 9GW7, 9GW57S, 9GW57D, 9GW58, 9GW59, 9GW74, 9GW75) was analyzed during Phase I of the RI. Groundwater from 12 existing monitoring wells and from one additional Monitoring Well (9GW83) was sampled during Phase II of the RI. Monitoring Well 9GW58 was damaged prior to Phase II and could not be sampled. Monitoring Wells 9GW1 through 9GW7 were installed during the Verification Phase. Monitoring Wells 9GW57S, 9GW57D, 9GW58, 9GW59, 9GW74, and 9GW75 were installed during Phase I and Monitoring Well 9GW83 was installed during Phase II. The location for each groundwater Monitoring Well at Site 9 is illustrated on Figure 7-1. Groundwater analytical data for Phases I and II, respectively, are summarized on Table 7-5 and 7-6. The analytical results from the samples indicate the presence of compound concentrations above acceptable drinking water MCLs and/or background levels for groundwater as established in Section 1.8.2. The list of parameters with values greater than the drinking water MCLs or established backgrounds are shaded in Tables 7-5 and 7-6.

The metals detected in the groundwater at Site 9 included lead. Lead levels above MCLs ranged in concentration from 130 μg/L from Monitoring Well 9GW57S to 32.4 μg/L from Monitoring Well 9GW3. Mercury and chromium levels slightly exceeded the MCLs in groundwater from Monitoring Wells 9GW5 and 9GW57S, respectively. There were no metals detected in the groundwater during Phase II with levels greater than the MCLs. The analytical results for mercury in the groundwater during Phase II were rejected. The nitroaromatics detected in the groundwater at Site 9 were largely confined to HMX and RDX. HMX and RDX levels in the groundwater from Phase II ranged in concentration from 10.60 μg/L and 214 μg/L to 1.6 μg/L and 12.10 μg/L, respectively. The highest concentration of HMX and RDX detected in the groundwater during Phase II was from Monitoring Well 9GW1. Nitrobenzene was detected in the groundwater from Monitoring Well 9GW4 at 3.3 μg/L. The analytical results for 1.3.5-TNB for groundwater samples 9GW2, through 9GW7, 9GW59, 9GW74, and 9GW83 collected during Phase I were rejected.

The volatile organic compounds were detected in the groundwater at Site 9 during both Phase I and Phase II were largely confined to trichloroethene (TCE). The highest level of TCE during Phase I and Phase II was from a sample collected from 9GW57D at concentrations of 100 μg/L and 160 μg/L, respectively. The analytical results for methylene chloride and/or acetone for groundwater samples 9GW2, through 9GW7, 9GW57S, 9GW57D, 9GW59, 9GW74, and 9GW75 collected during Phase II were rejected and are considered to be laboratory contaminants.

TOC and TOX levels during Phase I were only slightly elevated as compared to background levels, and therefore, are rather insignificant.

The contaminants of greatest concern at Site 9 are the nitroaromatic compounds and TCE. The extent of contamination can be grouped into four separate plumes as summarized in the table below. The estimated extent of contamination is shown on Figure 7-2 of Appendix G. A comparison of nitroaromatic and TCE data from the Verification Phase in 1985, Phase I in 1989, and Phase II in 1991 is summarized below:

Plume	Well Location	Contaminant	Results (μg/L) 1985	1989	1991
1	9GW5	TCE	ND/6	ND	14
	9GW6	TCE	6/7	ND	7
	9GW58	2,6-DNT	-	24	-
2	9GW4	RDX	ND	ND	12.5
		Nitrobenzene	-	-	3.30
3	9GW2	TCE	ND/18	17	16
	9GW3	HMX	ND/ND	14	ND
		TCE	ND/55	29	5
4	9GW1	HMX	ND	ND	10.6
		RDX	97/ND	150	214
		TCE	225/200	67	49
	9GW57D	HMX	-	ND	1.60
		RDX	-	ND	12.30
		TCE	-	31	160
	9GW57S	HMX	-	25	2.00
		RDX	-	ND	12.3
		TCE	-	100	160
	9GW83	HMX	-	-	3.10

Note: ND - Not Detected

The nitroaromatic and TCE contamination in the groundwater was identified in four distinct areas at Site 9. The largest area was a nitroaromatic and TCE plume located to the south of the Ordnance Wastewater Treatment Facility (Building 318). This plume extends to the southern boundary of Site 9 in the vicinity of Monitoring Well 9GW83. This plume is shown as Plume 4 on Figure 7-2 in Appendix G. The second largest area was a TCE plume located to the south of Building 304 and extended towards the south to approximately Building 336. The TCE plume could be derived from a multiple source area consisting of leaching wells associated with Buildings 304, 344, and 345. This plume is shown as Plume 1 on Figure 7-2 in Appendix G. The other two areas were much smaller and more localized. The first of these areas was a nitroaromatic and TCE plume located to south of Building 311 in the vicinity of Monitoring Well 9GW2. The source area for contamination was the acid leaching field located adjacent to the Building 311. The second part of this localized plume was a nitroaromatic and TCE plume located adjacent to the north side of Building 310. This contamination could be related to the leaching well located to the south of Building 328. This plume is shown as Plume 3 on Figure 7-2 in Appendix G. The second localized area was a nitroaromatic plume located to the south of Building 336 near Monitoring Well 9GW4. The source of the plume could be a leaching well associated with Building 336. This plume is shown as Plume 2 on Figure 7-2 in Appendix G.

Nitroaromatic contamination has not significantly changed since 1985. As stated above, the contamination is grouped into four separate plumes. The following paragraphs summarizes the changes observed in contamination based on the evaluation of the groundwater data.

Samples from the wells monitoring Plume 1 (9GW5, 9GW6 and 9GW58) show approximately the same concentration levels of contaminants from 1985 to 1991. This indicates very reduced to no migration of contaminants.

Well monitoring Plume 2 includes Monitoring Well 9GW4. Since 1985, there has been an increase in concentration levels of RDX and nitrobenzene. This indicates that these compounds are leaking from the soils into the groundwater.

Wells monitoring Plume 3 include Monitoring Wells 9GW2 and 9GW3. This plume consists of two very localized areas of contamination. For Monitoring Well 9GW2, contaminant levels of TCE have remained the same. For Monitoring Well 3 levels of HMX and TCE have decreased since 1985. In 1991, the level of HMX was non-detectable and TCE was detected at 5 μg/L. This indicates that the contaminant plume is diffusing and that the source may have been eliminated.

Wells monitoring Plume 4 (9GW1, 9GW57D, 9GW57S and 9GW83) show the most significant changes in concentration since 1985. The concentration of TCE in Monitoring Well 9GW1 has decreased; but has increased at Wells 9GW57D and 9GW57S. This indicates a migration of TCE from Well 9GW1 to Wells 9GW57D and 9GW57S. The most significant change in TCE levels was noted for Well 9GW57D which detected 31 μg/L in 1989 and 160 μg/L in 1991. This indicates that TCE contamination is moving deeper within the aquifer and toward Well 9GW83. However, no TCE was detected in 9GW83 in 1991.

The levels of HMX and RDX have increased slightly since 1985. Levels of HMX and RDX were detected in Well 9GW57D in 1991 but not in 1985. The levels of HMX and RDX in Well 9GW57S changed with a decrease in HMX but an increase in RDX. This indicates that these compounds are moved from Well 9GW1 to Wells 9GW57S, 9GW57D and 9GW83. The increase in concentration of HMX and RDX in Well 9GW57D indicates migration of these compounds to deeper portions of the compound.

7.4.3 Surface Water and Sediments

Three surface water Locations (9SW1, 9SW2, 9SW3) were sampled during Phase I and Phase II of the RI to document surface water quality in the two streams that flow through Site 9. Figure 7-1 shows the locations of the surface water sampling points. No contaminants above background levels or drinking water MCLs were detected in the surface water during Phase I. Only acetone and methylene chloride were detected at levels on above the background levels or drinking water MCLs in the surface water during Phase II. The surface water analytical data for Phases I and II is summarized on Tables 7-7 and 7-8, respectively.

No significant contamination is present in the surface water at this time in the two streams that flow through Site 9. The levels of metals detected in the sediment during both Phase I and Phase II were only slightly higher than the background levels established from the results at Paint Branch Creek. Because the levels were only slightly higher than the background levels, they are considered relatively insignificant. Methylene chloride and acetone were detected at elevated levels during Phase II with low levels of carbon disulfide, 2-butanone, and 1,1,1-trichloroethane which suggest the contribution of solvents to the stream sediments as a possible result of the activities at Site 9. The nitroaromatic compounds detected in Sediment Sample 9SD11 are probably related to the activities at Site 7, the Ordnance Burn Area, located approximately 300 feet to the northeast.

Ten stream Sediment Samples (9SD2, 9SD3, 9DS7, 9SD9, 9SD10, 9SD11, 9SD13, 9SD16, 9SD17, 9SD18) were collected at Site 9 during Phase I and Phase II to document contamination in the stream sediment at the two streams that flow through this site. Figure 7-1 shows the locations of the stream sediment samples. The stream sediment analytical data for Phases I and II, respectively, is summarized on Tables 7-3 and 7-4. Parameters with levels above background levels are shaded.

Analytical results of stream sediment samples from sampling events during both Phase I and Phase II indicates that levels of metals, including cadmium, chromium, copper, lead, and zinc were elevated above background levels established for the facility as presented on Table 1-13. Mercury was not detected in sediment samples during Phase I. Analytical results for mercury samples were rejected during Phase II. While levels of metals were above those established as background, none exceeded those of naturally occurring soils as shown in Table 1-12. In addition, no levels of metals exceeded RCRA Corrective Action levels.

Sediments samples were not analyzed for volatile organic compounds during Phase I of the RI. Volatile organic compounds were detected in the stream sediments samples collected during Phase II. The volatile organic compounds present are largely confined to methylene chloride and acetone although low levels of carbon disulfide, 2-butanone, and 1,1,1-trichloroethane were also detected in several samples. Values reported for methylene chloride in sediment sample 9SD10 and methylene chloride and acetone in sediment samples 9SD11 and 9SD13 were rejected and are considered to be lab contaminants. Values reported for the volatile organic compounds in sediment sample 9SD2, for 2-butanone in sediment samples 9SD3 and 9SD11, and for acetone in sediment samples 9SD16, 9SD17, and 9SD18 were estimated based on the results of the data evaluation.

Nitroaromatic analysis was not conducted on samples collected during Phase I. Nitroaromatic compounds were identified in sediment sample 9SD11 during Phase II.

7.4.4 Aquatic Biota

During fish collection for bioassay in Stream 3/9, approximately 2,700 feet of the stream was electrofished. The sample area extended from the southern property line up to a point approximately 800 feet south of Dahlgren Road. A total of three American Eel were taken in the lower 500 feet of the stream and prepared for laboratory analysis. Scores of Black-nosed Dace were collected for analysis over the entire 2,700 feet. Only one

250-gram sample was collected due to the fact that the dace population was insufficient for duplicate sampling.

Results of the bioassay for Site 3/9 are given in Table 14 (Appendix A). The data show that copper, mercury, and poly-chlorinated biphenyl (PCB) levels are above detection limits for fish in the lower stretch of Stream 3/9.

Copper levels for the Black-nosed Dace sample and for the two American Eel samples measures 1.54, 0.87 and 0.66 parts per million (ppm), respectively. Mercury concentrations for one of the eel samples measured 0.37 ppm. PCB Arochlor 1254 measures 4 ppm in the dace sample and 12 ppm in one eel sample. PCB Arochlor 1260 was at 2 ppm for the second eel sample.

Table 15 (Appendix A) contains a compilation of legal limits for hazardous metals and PCB's in fish and fishery products, measured in parts per million. The table shows that fish in the stream down gradient from Site 3/9 contain Arochlor 1254 levels in exceedence of the United States legal limit for total PCBs. American Eel samples in the stream contained Arochlor 1260 levels at the United States legal limit of 2.0 ppm.

It is not known whether the elevated levels of contaminants are due to sources on the White Oak site. The source of the elevated PCB levels, which are in some cases six times the legal limit for fish in the United States are unknown. The copper levels could be attributable to background levels of copper in the environment. The source of the elevated mercury levels in the eel is not known. A more rigorous bioassay would need to be performed in order to verify a cause and effect relationship between site contaminants and elevated pollutants in fish body burdens.

7.5 CONTAMINANT FATE AND TRANSPORT

7.5.1 Potential Routes of Migration

The contaminants of concern at Site 9 include nitroaromatic compounds (HMX, RDX, and 2,6-DNT) and volatile organics (TCE and tetrachloroethene). The major potential routes of migration at the Site 9 include the transport of contaminants through:

- Groundwater system; and
- Surface water/sediment.

Contamination is insignificant in the surface water and sediment of the two streams that flow through Site 9, and therefore, the streams are not considered significant potential routes of contamination. Although, there were no significant compounds detected in the surface soil during Phase II of the RI, transport of contaminants through the unsaturated soil will still be addressed as the result of contaminant transfer from the leaching wells into the soil system and into the groundwater system.

7.5.2 Contaminant Migration

There appears to be significant migration of volatile organics and nitroaromatics in the groundwater at Site 9. Volatile organic and nitroaromatic contamination in groundwater has not significantly changed since the sampling events of 1985; however, significant levels of these compounds have been detected in cluster wells located hydraulically downgradient from Site 9 and other existing monitoring wells. The significant changes in contamination at the site were observed for Plume 4 at the southern end of the site. Migration is occurring in a southeast direction toward the small stream that flows south of the site. It is expected that this migration will occur at the rate of 0.02 ft/day based on estimated groundwater velocity derived from a pumping test of a similar unit at Site 11. Based on field observations, it appears that contamination is migrating at a more rapid rate than expected for Plume 4. It is not fully understood at this time why migration is occurring at this rate. Additional information is required regarding the hydraulic conductivity of the sediments in the area at the leading edge of the plume and the chemical behavior of the contaminants of concern.

The contamination in this area is reportedly the result of the disposal of wastewater containing laboratory solvents and base neutral acids via three shallow (4 feet deep) chemical leaching wells. The laboratory chemicals introduced into the leaching wells percolate down through the unsaturated soil and into the groundwater. Rainwater percolating through the unsaturated soils in the vicinity increases the rate of downward migration of these contaminants. Although there are multiple contaminant sources with varying contaminant concentrations, the multiple sources are relatively close to each other and the plumes from each source converge to eventually form one larger plume.

As discussed in Section 7.3.5 Hydrogeology, the velocity of groundwater flow in the unconsolidated sediment unit at Site 9 has been estimated as 4.71×10^{-4} to 9.33×10^{-9} cm/sec. The estimated velocity of a TCE plume in the groundwater would approximate the groundwater velocity. Based upon the estimated velocity of the groundwater at this site and

the high mobility rate of these compounds, it can be concluded that there has been moderate migration of low level volatile organic compounds from the landfill at Site 9 in the groundwater. The migration of the nitroaromatic plume in the groundwater would be retarded due to the low solubility, attenuation, and transformation. Therefore, the estimated velocity of the nitroaromatic contaminants in the groundwater would be much lower than the volatile organic compound plume transport velocity. The fate of the TCE plume and the nitroaromatic contamination is to migrate to the south-southeast of Site 9 towards the confluence of the perennial stream and the intermittent stream.

There is the potential for groundwater contamination to be transferred from the groundwater into the surface water of the intermittent stream and/or the perennial stream. No contaminants were detected above background in the samples collected from the surface water during Phase II, and, therefore, this pathway merits no further discussion at this time. There is the potential for groundwater and soil contamination associated with the leaching wells to be transferred to the atmosphere through soil gas migration. The results of the soil gas survey indicated only low levels of volatile organic compounds in the surface soils, therefore, further analysis of this transport pathway is unnecessary. There is also the potential for unsaturated soil contamination to be transferred to the biota by rihizoan uptake, but here again, the results of the soil gas survey indicate that the potential for biota uptake is insignificant.

7.6 RISK ASSESSMENT

7.6.1 Human Health Evaluation

A summary of the risk estimates in relation to USEPA's Superfund remediation criteria is presented in Table 7-9. The non-cancer and cancer risks associated with exposure to ground water from Site 9 may be summarized as follows.

7.6.1.1 Non-cancer Risks

The potential for adverse non-carcinogenic health effects in the off-site residential population (adults and children) exists from exposure to groundwater from Site 9. The total hazard indices for the pathways for adults and children are greater than the criterion of 1.0. Ingestion or dermal contact with groundwater is not considered a realistic pathway since potable water supplies are provided by public utilities.

7.6.1.2 Cancer Risks

The total cancer risk for off-site adult and child residents who potentially may be exposed to contaminated groundwater from Site 9 exceeds the USEPA remediation goal. Ingestion of contaminated groundwater constitutes the greatest concern.

Thus, based on the non-cancer and cancer risk estimates, consideration of the need for remediation of groundwater at Site 9 is warranted.

7.6.2 Ecological Risk Assessment

In determining the potential risk to wildlife of contaminants in the media at Industrial Wastewater Disposal Area 300, it should be noted that for many compounds, the toxicity and availability of the parameters are dependant on many factors including water chemistry, soil chemistry, the form of the particular compound is in at the site, and the presence of other compounds within the media.

Concentrations of copper in food sources of the indicator species selected for this risk assessment were slightly below the acceptable levels calculated in Section 7.2.5 above. However, this compound was not detected in any of the media sampled at Site 9. Therefore, the risk from exposure to copper in the stream is unknown.

Concentrations of mercury and Aroclor 1260 in food sources were significantly higher than the acceptable levels for the Belted Kingfisher. These compounds were not detected in any of the media sampled at Site 9. Therefore the risk from exposure to mercury and Aroclor 1260 is unknown.

Concentrations of Aroclor 1254 in food sources for the indicator species selected were well above the acceptable levels calculated. However, this compound was not detected in any of the media sampled at Site 9. Therefore the risk from exposure to mercury and Aroclor 1254 is unknown.

7.7 SUMMARY AND CONCLUSIONS

7.7.1 Summary

Site 9 (Industrial Waste Disposal Area 300) was used from the early 1950s until the mid-1970s for chemical disposal in several leaching wells and above ground discharge areas. According to the IAS, approximately 7,200 pounds of liquid wastewater containing explosive compounds and solvents were disposed of at this site.

The RI at Site 9 included a hydrogeologic investigation, and contaminant characterization and risk assessment. The hydrogeologic investigation included lithologic descriptions of the subsurface, monitoring well elevation and location survey, groundwater level measurements, and ten aquifer slug tests were conducted on Monitoring Wells 9GW1, 9GW2, 9GW7, 9GW55, 9GW57S, 9GW57D, 9GW58, 9GW59, 9GW74, and 9GW75 for calculation of hydraulic conductivity. The lithology beneath the northern portion of the site consists of the Upland Sand and Gravel unit overlying the Potomac group which is underlain by the gneiss saprolite of the Wissahickon Formation. The lithology beneath the southern portion of the site consists of thin veneer of the Potomac group underlain by the saprolite of the Wissahickon Formation. Groundwater flow at the site is to the south-southeast toward the facility boundary. The average hydraulic conductivity based on the analysis of the slug test data was 6.9×10^{-4} cm/sec. Table 1-3 list the results of the aquifer slug test and constant rate pumping test analyses.

The contaminant characterization included the collection and analysis of samples from the soil, groundwater, and biota to be used for determining the risk to human health and the environment. Three piezometers (9PZ44, 9PZ55, and 9PZ56) and 6 groundwater Monitoring Wells (9GW57S, 9GW57D, 9GW58, 9GW59, 9GW74, and 9GW75) were installed during Phase I. A total of six soil gas surveys were conducted during Phase I to delineate areas with soils contaminated with volatile organic compounds (Building 304, Buildings 344 and 345, Building 336, Building 328, Building 310 and Building 311). Two surface soil samples and 13 groundwater samples were collected for analysis during Phase I. One additional groundwater Monitoring Well (9GW83) was installed during Phase II. Monitoring well 9GW58 was damaged prior to Phase II and could not be sampled. Thirteen groundwater samples were collected during Phase II.

The ecological investigation during Phase II consisted of terrestrial vegetation and mammal surveys. Site 9 consists primarily of deciduous forested areas adjacent to cultivated lawns. The deciduous forest portions are characterized by various species of sycamore, oak, cherry, poplar, gum, and holly. The mammalian species found at the site are those commonly associated with a forested ecosystem and domestic cats.

Results from the benthic survey, based on percent annelid worm calculations and the relative absence of mayflies, stoneflies and caddisflies, indicated that poor water quality in the stream to the west of Site 9. The percent annelid worm calculations indicated excellent water quality in the intermittent stream to the east of Site 9. The HBI values for the intermittent stream also indicated excellent water quality.

The risk assessment determinations are included as Appendix G in this text. Potential adverse non-carcinogenic health effects exist in the residential population from exposure to the groundwater. The total cancer risk the residential population who may potentially be exposed to contaminated groundwater exceeds the USEPA Superfund remediation goal. Therefore, based on the cancer risk evaluation, consideration of the need for remediation of groundwater at Site 9 is warranted.

The ecological risk assessment identified mercury and PCBs (Arochlor 1254 and Aroclor 1260) in food sources for the indicator species selected were well above the acceptable levels calculated. Samples were not collected for PCB analysis from any of the media sampled at Site 9, therefore, the risk to wildlife from exposure to mercury, Aroclor 1254 and Aroclor 1260 in the media is unknown at this time.

7.7.1.1 Nature and Extent of Contamination

The soil gas surveys indicated the presence of volatile organic compounds at low concentrations in the soils near Buildings 336, Building 328, Building 310, Building 311. No volatile organic compounds were detected in the soil gas vapor adjacent to Building 304 and Buildings 344 and 345. The analytical results for the surficial soil revealed elevated levels of metals and semi-volatiles above the background concentrations.

The contaminants of greatest concern in the groundwater are the nitroaromatic compounds and TCE. The nitroaromatics present consist of HMX, RDX, 2,6-DNT and nitrobenzene. Nitroaromatic and TCE contamination in the groundwater was identified in four distinct areas at Site 9. The largest area is a plume located to the south of the Ordnance Waste Water Treatment facility (Building 318) (Plume 4). This plume extends to the southern boundary of Site 9. The second largest area is a TCE plume located to the south of Building 304 (Plume 1) and extending south to approximately Building 336. The other two areas are much smaller nitroaromatic and TCE plumes which are located near Building 311 and Building 310 (Plume 3) and Building 336 (Plume 2). The concentration of the nitroaromatic and TCE in the groundwater has not significantly changed since 1985 except for Plume 4.

No significant contamination was detected in the surface water at Site 9. The levels of metals detected in the sediment during both Phase I and Phase II were only slightly higher than the background levels. Low levels of carbon disulfide, 2-butanone, and 1,1,1-trichloroethane were detected in the sediment which suggest the contribution of solvents to the stream sediments as a possible result of the activities at Site 9. The nitroaromatics

compounds detected in the sediment at Sample 9SD11 are also probably related to the activities at Site 9.

The bioassay conducted on fish collected from the surface water at Site 9 showed that copper, mercury, and PCBs were present in the fish collected from the lower stretch of the stream. It is not known whether the elevated levels of contaminants are due to sources on the NSWCWODET or from outside the facility.

7.7.1.2 Fate and Transport

At Site 9, the primary source of contamination are nitroaromatic compounds (HMX, RDX, and 2,6-DNT) and volatile organic compounds (namely TCE) and low levels of dissolved metals. The major potential routes of migration include the transport of contaminants through the soil and groundwater systems. Based on the shallow groundwater conditions and the potential mobility and concentration of the contaminants detected in the groundwater, transport of the leachate in the groundwater system has been moderate. The direction of the volatile organic compound and nitroaromatic contaminants in the groundwater is to the south-southeast towards the confluence of the perennial stream and the intermittent stream.

7.7.2 Conclusions

The hydrogeologic investigation from Phase I and Phase II provided the information necessary to determine the direction of groundwater flow, the groundwater gradient, and the hydraulic conductivity and transmissivity of the unconfined aquifer. Based on the shallow groundwater conditions and the potential mobility and concentration of the contaminants detected in the groundwater, transport of the leachate in the groundwater system has been moderate.

At Site 9, the primary source of contamination are nitroaromatic compounds and volatile organic compounds and low levels of dissolved metals. The direction of the volatile organic compound and nitroaromatic contaminants in the groundwater is to the south-southeast towards the confluence of the perennial stream and the intermittent stream.

Soil gas surveys near Buildings 304, 344, and 345 detected no volatile organic compounds in the soils while soil gas surveys near Buildings 336, 328, 310, and 311 documented the presence of volatile organic compounds in the soils. This indicates that former leaching wells/fields at those locations were used to dispose of industrial laboratory

wastewater that included various volatile organic compounds that have impacted shallow soil and possible groundwater in the area.

Based on the cancer risk evaluation, remediation of the groundwater at Site 9 should be considered.

7.7.2.1 Data Limitations

The analytical results for mercury in the groundwater were rejected. The extent and potential migration of mercury contamination in the groundwater, therefore, could not be confirmed.

Identification of the source of copper, mercury, and PCBs were present in the fish collected from the lower stretch of the stream. It is not known whether the elevated levels of contaminants are due to sources on the NSWCWODET or from outside the facility.

7.7.2.2 Preliminary Remedial Action Objectives

The risk assessment of contamination present at Site 9 indicates that the primary threat to human health and the environment is from the nitroaromatic and volatile organic contaminants in the groundwater. The primary exposure route would be through ingestion of groundwater and a secondary exposure route would be through transport of contaminants in the soil. The remedial objective is to remove any source(s) of contaminants to prevent contaminant migration into soil or groundwater and to limit further migration of the contaminant plume in the groundwater.

8.0 SITE 11 - INDUSTRIAL WASTEWATER DISPOSAL AREA 100

8.1 SITE BACKGROUND

8.1.1 Site Description and History

The Industrial Wastewater Disposal Area 100 is located near the western facility boundary adjacent to the main entrance. Ten former leaching wells used for wastewater disposal from the laboratories were located within the Industrial Wastewater Disposal Area 100. The leaching wells are scattered over an area of approximately 16 acres. Wastes disposed in the wells reportedly include dissolved metals, acids, chlorinated and non-chlorinated solvents, alcohols, lead, and organic explosive compounds. The primary wastes of concern are solvents and solutions containing metals such as silver, chromium, and lead. It is estimated that about 20,000 gallons of liquid wastes were disposed of in these wells.

8.1.2 Previous Investigations

Eight groundwater monitoring wells were sampled during the Verification Phase. TOC, TOX, and VOC data indicated groundwater contamination in all the wells at the site with greatest levels in those wells adjacent to the chemical waste disposal leaching wells. Metals were also detected at significantly elevated levels throughout the site. Very low levels of oils and greases were detected in three of the wells. No nitroaromatics were detected in any of the wells.

Data gaps identified after analysis of the Verification Phase data included:

- Extent of groundwater contamination at the site; and
- A thorough understanding of groundwater flow directions and gradients.

The Verification Phase recommendations included:

- The installation of two additional monitoring wells in the area where the VOC contamination was the greatest; and
- The sampling of the new and existing monitoring wells.

Recommendations made subsequent to the Verification Phase Final Report included:

- Installation of eight additional monitoring wells with at least two of them being clustered wells;
- Installation of four piezometers to better define groundwater flow directions; and
- Collection of two surficial soil, two surface water, and three stream sediment samples.

8.2 RI INVESTIGATIONS

8.2.1 Surface Feature Investigations

Surface feature investigations included location of surface disposal areas, property lines, drainage ditches, streams, vegetation, and topography of the entire site. The purpose of surface feature investigations was to identify possible contaminant migration and the location of potentially affected receptors.

8.2.2 Surface Water and Sediment Investigations

The purpose of the sampling during the Remedial Investigation was to document the chemical quality of the surface water and stream sediment at Site 11. Surface water and stream sediment investigations were accomplished by the collection of samples from the surface water and stream sediment of the small stream that passes to the west of the site and flows north to south through the golf course.

During Phase I, surface water and sediment were sampled at locations where the stream enters the site (northwest corner on the golf course), downgradient along the stream, and where the stream exits the facility at the southwestern part of Site 11. A summary of field environmental sampling parameters for Phase I of the RI is presented on Table 8-1.

During Phase II, samples were collected from the same sampling points in order to assess contamination trends within the surface water and stream sediments over time. The summary of the Phase II environmental sampling parameters is presented on Table 8-2.

8.2.3 Soil and Vadose Zone Investigations

During Phase I, soil and vadose zone investigations for Site 11 included the collection of two surficial soil samples to determine the chemical concentrations in the soil and the performance of three separate soil gas surveys of the shallow soil at several abandoned leaching well/field locations in order to document volatile organic concentrations and potential movement through the upper soil and vadose zone. Sampling grids were established at three locations where former leaching wells were used to dispose of industrial wastewater.

The purpose of these investigations was to measure the release of gaseous volatile organic contamination through the soil, potentially predict contaminant movement through the vadose zone, and measure the chemical contamination in the surface soils for Risk Assessment purposes.

During Phase II, no additional soil or vadose zone investigations were conducted at Site 11.

8.2.4 Groundwater Investigations

During Phase I, four Piezometers (11PZ62, 11PZ63, 11PZ64, 11PZ65) and nine groundwater Monitoring Wells (11GW66, 11GW67, 11GW68, 11GW69, 11GW70D, 11GW70S, 11GW71, 11GW72 and 11GW73) were installed at Site 11. The locations of these wells and piezometers are presented on Figure 8-1. During Phase II, five additional groundwater Wells (11GW84, 11GW85, 11GW86, 11GW87, and 11GW88) were installed at Site 11 at the locations indicated on Figure 8-1.

A summary of the well installation for both Phase I and Phase II field work at Site 11 is presented on Table 1-6, and a summary of well development and sampling dates for wells installed during the RI is presented in Table 1-7. Construction details for the wells and/or piezometers are listed on the borehole log for each Well and/or piezometer which are presented in Appendix B.

During Phase II, analysis of a pumping test and 13 slug tests, in conjunction with grain size analysis of split-spoon samples collected during Phase I, were used to define the hydrological characteristics of the water table aquifer at the site. In addition, graphical analysis of water level information collected during Phase II was conducted to determine depth to groundwater, groundwater flow direction, and gradient.

8.2.5 Geological Investigations

During Phase I, 13 boreholes were drilled and converted to the four piezometers and nine groundwater monitoring wells as detailed in the previous section. Split spoon samples were collected during drilling to characterize the subsurface lithology at the intervals indicated on Table 1-6. Descriptions of the individual split spoon samples obtained are given in Appendix B on the borehole log for each piezometer or well. In addition, selected split spoon samples collected during Phase I were analyzed for grain size in order to define general characteristics of the sediments and to assist in determination of the hydrological characteristics of the shallow aquifer underlying the site. The results of the grain size analysis is presented in Appendix E. Soil samples were collected using the standard procedures presented in Appendix F of this report.

During Phase II, five additional boreholes were drilled and converted into monitoring wells.

8.2.6 Ecological Investigations

During Phase II of the RI, ecological investigations were conducted in order to assess the current ecological conditions on site. Included in the investigations were terrestrial vegetation, mammal, fish and benthic invertebrate surveys.

The vegetation survey consisted of a quantitative analysis of species types located on site. In this study, field identification was supplemented with office confirmation of the major vegetative species. Relative abundance of the species was established and vegetation community relationships were delineated on the project site map.

A general mammalian survey was performed and benthic invertebrate sampling was conducted using a kick screen method at three locations along the stream which transects the site (upstream, mid-stream, and downstream). The fish survey was completed using a Smith-Root electrofisher at upstream, mid-stream and downstream points along the length of the stream on site.

Specific sampling materials and methods are used are presented in Section 1.6 and outlined in Appendix A.

8.3 PHYSICAL CHARACTERISTICS OF THE SITE

8.3.1 Surface Features

The Industrial Wastewater Disposal Area 100 is located in the extreme northwestern quadrant of the NSWCWODET facility on an upland area which ranges in elevation from 390 to 300 feet MSL. Several administration and office buildings as well as research buildings are located within the site boundaries. Several paved surfaces and roadways within the site boundaries increase the stormwater runoff from the site.

8.3.2 Surface Water Hydrology

An intermittent stream is located west of Site 11. The stream flows south through the NSWCWODET facility, empties into a pond in the southwestern portion of the site, flows out of the pond and off the facility. After leaving the facility, the stream flows southeast through the Hillandale housing development, and then flows back onto the facility, eventually entering Paint Branch Creek, 2,700 feet south of Dahlgren Road. Much of the water in the upper reaches of the stream originates as stormwater flow. A culvert, which collects runoff from a commercial area immediately north of the facility, runs under Michelson Road and empties into the stream immediately south of the road.

The upper section of the stream is intermittent in nature with a sand and silt substrate. The stream was approximately 1 foot wide and 1 to 2 inches deep at the time of sampling. The middle section of the stream has a maximum width of 8 feet and a depth ranging from 1 to 2 inches at the time of sampling. At the time of the field investigation, the substrate consisted primarily of small gravel resting on bedrock. A high iron content was noted in the stream substrate and algae mats were common in the middle portions of the stream. The lower section of the stream had a maximum width of 6 to 8 feet and a depth of 6 to 12 inches and contained more permanent flows. The substrate consisted of sand and gravel deposits along small intermittent riffle and deep pool areas.

8.3.3 Soils

The soils at this site belong to the Manor Series and the Croom series. The Manor series soils were described previously under Subsection 2.3.3 in the discussion of Site 2, and the Croom series soils were described previously under subsection 6.3.3 in the discussion of Site 8. Soil development is controlled by the parent material at the site. Where the

saprolite of the Wissahickon Formation was exposed at the surface, Manor Series soils have developed. Where the Upland Sand and Gravel unit overlies the Wissahickon Formation, Croom Series soils have developed. The soil zone at this site is approximately 12 to 28 inches thick.

8.3.4 Geology

A total of 28 soil borings have been installed within the boundaries of Site 11, 18 soil borings during Phase I and Phase II of the RI. The surficial geology map for the NSWCWODET facility (Figure 1-3) and borehole logs recorded during Phase I and Phase II from across Site 11 indicate that two geologic units are present below Site 11. The uppermost unit is a thin veneer of the Upland Sand and Gravel. The Upland Sand and Gravel ranged from 0 to 20 feet thick, with the thickest measurements on the southeast and east flanks of the site (15 to 20 feet). The Upland Sand and Gravel is thinnest in the north-central part of the site (0 to 9 feet). This may be due to non-deposition, excavation during construction of the facility buildings or erosion of the topographically high area or any combination of these factors. In the east and southeast area of the site where the Upland Sand and Gravel was thickest, the unit consists of brown silt and red-brown fine sand which grades into medium sand with traces of fine gravel near the base of the unit. In these same areas clayey silt seams (less than 1-foot) interbedded with fine gravel were encountered near the base of the unit.

The Wissahickon Formation underlies the Upland Sand and Gravel and was encountered in all boreholes. The saprolite member (Wds) ranged from 5 to 55 feet thick. Deep borings penetrated the weathered schist member (Wps) of the Wissahickon. This unit consists of a gray-green fine sand and silt with garnets. Texturally the two weathered units are quite similar and were differentiated on the basis of mineralogical and color changes. It was noted that less than one mile west of the site, bedrock changes from gneiss to peletic schist (Froelich, 1975). It is possible that the bedrock underlying Site 11 alternates from gneiss to schist which would yield the different weathered saprolites noted during soil boring installation.

8.3.5 Hydrogeology

The Verification Phase Study concluded that groundwater flow at Site 11 is influenced by topography. Groundwater is present in the saprolite, the bedrock, and to a minor extent

in the Upland Sand and Gravel unit. Depth to the water table aquifer measured in August, 1991 ranged from 5.23 feet TPVC at Piezometer 11PZ62 to 32.63 feet at 11GW86. Water table elevations during August ranged from 357.65 feet MSL at Piezometer 11PZ63 to 318.51 feet MSL at Well 11GW29. The average saturated thickness of the water table aquifer based on 1991 measurements was 31 feet (10.3 m).

Graphical analysis of water level data collected during Phase I and Phase II at Site 11 support flow directions determined during the Verification Phase. Site 11 is located on a topographically high area and is close to unnamed, intermittent tributaries of Paint Branch Creek. Considering the topography, it is probable that groundwater discharges to these nearby streams. Based on the water level readings, a shallow groundwater divide transects Site 11 from northwest to southeast approximately diagonally through the Main Administration Building. Southwest of the building, groundwater would flow to the southwest toward a small intermittent stream, which eventually becomes a tributary to Paint Branch Creek. Northeast of the building, groundwater would flow toward an intermittent stream. This is the same stream that flows across Site 2. Graphical analysis of water levels for Site 11 indicated that the gradient ranged from 0.1 to 10 percent with a geometric mean of 2 percent.

Sedimentologic characteristics determined during the grain size analysis provide an approximate measure of hydraulic conductivity. The grain size distribution curves generated from selected soil boring samples across Site 11 suggests an average hydraulic conductivity of 2.4 to 4.8 x 10^{-2} cm/sec for the saprolite. Analysis of the soil boring data and groundwater characteristics determined from previous studies of the site and published data suggested that the saprolite (Wds) was between 50 and 70 feet thick.

During installation of Well 11GW87, sampling through the 4 1/4-inch I.D. HSA had terminated at 30 feet due to auger refusal. However, visual analysis of the sample in the split spoon sampler from that interval indicated moist and very dense saprolite. As a result, air rotary drilling was used to finish the hole to top of rock. The well was terminated at 56.5 feet below ground surface as drill cuttings indicated that competent rock had been reached. Groundwater was intercepted at approximately 30 feet below ground surface rose to approximately 16 feet below ground surface after well completion. The well was set at 56.5 feet below grade and the well was developed using air surging.

A preliminary pump test was conducted using a pumping rate of 5 GPM, which was approximately 66 percent of the estimated yield based on the grain size distribution. As

designed, the minimum specific yield of 11GW87 well at site 11 was estimated to be between 7.5 and 9 gallons a minute based on analysis of the grain size distribution curves as prescribed by Driscoll (1986). The well was pumped dry in approximately 12 minutes, indicating that recharge to the well from the aquifer was significantly lower than expected. Hydraulic conductivity values derived using the rate of recharge to the well (Bouwer, 1988) suggest that the actual K for the well is approximately 4.62 X 10^{-5} cm/sec (0.98 gpd/ft^2), several orders of magnitude lower that estimated from the grain size distribution curves.

The extremely low recharge rate into Well 11GW87 suggests that groundwater within the saprolite is confined to flow along fracture zones which are remnant features from the parent material. Weathering along the fracture zones and at the surface produces clay particles, which in combination with the remnant rock texture may influence groundwater flow to along the fractures. Groundwater flow within the Wissahickon Formation has been reported to be controlled by fractures which provide both vertical and horizontal migration paths. The low flow rates measured in 11GW87 are probably derived from measurement of recharge over the limited area of the water bearing fracture as it is intersected by the screened interval of the well.

In addition to the pump test of Well 11GW87, several wells were slug tested. Thirteen wells were slug tested to determine hydraulic conductivities of the shallow aquifer at Site 11 during Phase II. Analysis of the slug test data for each well resulted in an estimated hydraulic conductivity (K) for that well. The geometric mean of the K values for each well was then calculated to determine the average K for Site 11. The estimated hydraulic conductivity for Site 11 slug tests indicates that groundwater flow averages 1.96 x 10^{-3} cm/sec (40.6 gpd/ft^2). Since slug tests measure K over a limited area around each well tested, groundwater flow velocities for Site 11 are based on the pump test analysis at Site 11. The pumping test results for Well 11GW87 indicate that the hydraulic conductivity (K) for the saprolite unit is approximately 4.62 X 10^{-5} cm/sec (0.98 gpd/ft^2). Transmissivity (T) for the water table aquifer is 0.042 cm^2/sec (227.2 gpd/ft^2). The velocity of the groundwater flow is estimated to be 3.82 X 10^{-6} cm/sec with an effective porosity of 26 percent.

Three monitoring wells, two installed during the Verification Phase (11GW20 and 11GW21) and one installed during Phase I (11GW70S), were abandoned. The location of these abandoned wells is presented on Figure 8-1.

8.3.6 Ecology

Site 11 consists largely of cultivated lawns. The majority of this site is developed and maintained in park conditions vegetated with grass species and trees such as oaks, Tulip Poplar, and Red Maple. Adjacent to these cultivated areas are portions of mixed deciduous forest. These mixed deciduous forested areas consist of Southern Red Oak, White Oak, Tulip Poplar, Black Cherry, and Red Maple with an understory layer of Honeysuckle, Virginia Creeper, Common Blackberry, Poison Ivy, Bristly Dewberry, Smilax, goldenrod, and Sassafras.

Woodchucks, squirrels, and White-tailed Deer utilized the site for foraging. Bird species noted include Broad-winged Hawk, Mallard, and European Starling. A Northern Water Snake was also noted adjacent to the stream on-site.

Three portions of the stream at Site 11 were sampled for benthic macroinvertebrates. Benthic sampling in the upstream portion of Sample Site 11 (Table 8, Appendix A) contained nine annelid worms, and one clam larva (Order Pelecypoda). Site llA Duplicate had five annelid worms.

Benthic sampling in the middle portion of the Stream Sample Site 11B, (Table 8, Appendix A) contained more diversity than Stream 11A. Stream 11B yielded four chironomid midges (Cricotopus sp.), one damselfly (Calopteryx sp.), and three stoneflies (Hydropsyche sp.). There was one Diplopoda, one predaceous diving beetle (Palpomyia sp.), three Chironomid midges (Cricotopus sp.), one pond bug (Microvelia sp.), one wasp (Order Hymenoptera), one Narrow-winged Damselfly (Argia sp.), and four caddisflies (one Chematopsyche sp.); and three Hydropsyche sp.) collected from Stream 11B Duplicate.

Benthic sampling in the southern portion of the stream, Sample Site 11, (Table 8, Appendix A) contained one member of the Order Araneae, one Coleopteran, one Chironomid midge (Chicotopus sp.), one Narrow-winged Damselfly (Ishnura sp.), 27 caddisflies (15 Cheumatopsyche sp.; 12 Hydropsyche sp.), one Pelecypod, and one Planarian. Stream 11C Duplicate yielded three Hydropsychid caddisflies larvae and one snail larva (Class Hastropoda).

Sampling results from Sites 11A and 11A Duplicate included 90 and 100 percent annelid worms, respectively. This indicates relatively poor water quality in the upstream portion of the stream. There were no annelid or oligochaete worms found in the middle and downstream portions of the stream, indicating relatively good water quality existing in these areas.

The HBI values for the three portions of the stream that transects Site 11 corroborate the general improvement of water quality as the observer travels downstream. HBI values for Site 11A, 11B, and 11C were calculated as 3.0, 1.9, and 2.6, respectively. Values for 11A Duplicate, 11B Duplicate, and 11C Duplicate were 3.0, 2.5, and 2.3, respectively. These indicate that there is better water quality in the middle and lower sections of the stream than in the upper portion. The stream morphology and substrate changes considerably from the upper to the lower reaches in the stream which may also influence the benthic macroinvertebrate community.

Fish were found below the outfall of the pond in the lower portion of the stream at Site 11. One 20-inch American Eel, 14, 2-inch Black-nosed Dace, and four 5-inch Common Goldfish were collected between the pond and the southern boundary of the facility. There were no fish found in the middle and upstream portions of Stream 11. It is likely that water depth and stream size are limiting factors to fish in the middle and upper reaches of this surface water body. Poor water quality in the upper segment of the stream may limit fish survival, as well.

8.4 NATURE AND EXTENT OF CONTAMINATION

8.4.1 Soils and Vadose Zone

Two surficial Soil Samples (11SL1/11SL2) were collected at Site 11 during Phase I of the RI to document contamination in the surface soil for the Risk Assessment determination. The location of these two surface samples is shown on Figure 8-1. The soil samples were used in establishing the background guidelines for metals for the entire facility based upon their low levels detected during the analysis of the samples. No levels of concern of any contaminants were detected for these two surficial soil samples. A summary of the analytical data for the Soil samples collected during Phase I is presented on Table 8-3. No surface Soil samples were collected during Phase II.

During Phase I, vadose zone monitoring was accomplished through the performance of soil gas surveys at three areas at Site 11. The surveys were performed on the softball field behind Building 30, behind Buildings 2 and 5, and behind Buildings 3 and 5 to document volatile organic contamination in the shallow soil. Results of the soil gas surveys are described below:

- Softball Field (Behind Building 30): A 36-point sampling grid was established on the softball field to measure the potential volatile organic contamination in the soil gas resulting from the disposal of industrial wastewater into two leaching wells located on the softball field. The location of the sampling grid and the results of the soil gas survey are shown on Figure 8-2. Only two of the sampling points had detectable levels of volatile organic compounds. The measurements were 0.8 and 1.5 ppm at the two points.

- Buildings 3 and 5: A 20 point sampling grid was established adjacent to Building 5 and behind Building 3 to measure the volatile organic concentrations in the shallow soil. The location of the sampling grid and the results of the soil gas survey are shown on Figure 8-3. Only one reading of 450 ppm was detected at this location to measure the possible impact of the three former leaching wells upon the shallow soil. This reading may have been an anomaly because we could not detect any other volatile organic when we tried to confirm this high level.

- Buildings 2 and 5: A 30 point sampling grid was established at this location to measure the volatile organic in the shallow soil to document the potential impact of the two former leaching wells at this location on the shallow soil and potentially the groundwater. The locations of the sampling points and the results of the soil gas survey are shown on Figure 8-3. No volatile organic compounds were detected at any of the 30 sampling points.

No levels of contamination of concern were detected in the two surficial soil samples and no significant levels of volatile organic compounds were detected in the shallow soil gas at any of the three locations where soil gas surveys were performed. This, however, does not mean that the former leaching wells did not have any impact on the environment.

As a result of the findings during Phase I, no additional soil or vadose zone investigations were conducted during Phase II.

8.4.2 Groundwater

Groundwater samples were collected from 16 monitoring wells (11GW22 through 11GW29 and 11GW66 through 11GW73) during Phase I of the RI. Groundwater from 21 Monitoring Wells (11GW22 through 11GW29, 11GW66 through 11GW73, and 11GW84 through 11GW88) was sampled during Phase II. Groundwater Monitoring Wells 11GW22 through 11GW29 were installed prior to Phase I activities; Monitoring Wells 11GW66 through 11GW73 were installed during Phase I; and Monitoring Wells 11GW84 through 11GW88 were installed during Phase II. Figure 8-1 shows the location of all monitoring wells and piezometers used for groundwater level measurements. Groundwater analytical

data for Phase I sampling is summarized on Table 8-5, and a summary of groundwater analytical data for Phase II sampling is presented on Table 8-6. Parameters with concentrations above background levels are shaded.

The highest concentration of total chromium and total lead detected in the groundwater samples were 326 μg/L and 134 μg/L, respectively, from Monitoring Well 11GW27 during Phase II. The highest concentration of TCE detected was 150 μg/L from Monitoring Well 11GW22 collected during Phase II. The highest concentration of tetrachloroethene detected was 77 μg/L from Monitoring Well 11GW28 collected during Phase II.

The analytical results for all mercury concentrations in groundwater samples collected during Phase II were rejected. The analytical results for acetone from groundwater Sample 11GW22, 11GW24, 11GW25, 11GW26, 11GW27, 11GW28, 11GW70D and 11GW72; and the analytical results for methylene chloride from groundwater Samples 11GW67, 11GW68, 11GW69, 11GW70D, 11GW71, 11GW72, and 11GW73 collected during Phase II were rejected. The concentration of acetone and methylene chloride in the sample was less than 10 times the concentration found in the associated analytical blank. Therefore, these compounds which have not been detected previously at the site are considered to be laboratory contaminants. The analytical result for chloroform for groundwater Sample 11GW25 collected during Phase II was rejected. The acetone analytical results for groundwater Samples 11GW23, 11GW85, and 11GW86; and the methylene chloride were reported as estimated values. These estimated values are based on the results of unsatisfactory laboratory equipment calibration which caused a high relative percent deviation from the initial calibration and are considered to be laboratory contaminants.

Volatile organic contamination was present in three Monitoring Wells (11GW22, 11GW24, and 11GW66) and chromium and copper contamination was present in one Monitoring Well (11GW27) at Site 11 during Phase I at concentrations above drinking water MCLs (Table 8-5). Volatile organic contamination was present in two wells and metal contamination was present at similar concentrations in Monitoring Well 11GW27 during the Verification Phase. Volatile organic compounds were present in groundwater samples collected from eleven monitoring wells and metals contamination was present in groundwater samples collected from 14 monitoring wells during Phase II at concentrations above drinking water MCLs (Table 8-6). The source of the volatile contamination appears to be the leaching wells that are associated with Site 11. The concentrations have decreased

since the Verification Phase which supports horizontal movement and dispersion of contaminants in the groundwater.

8.4.3 Surface Water and Sediments

During Phase I two surface water samples were collected from the stream that flows through the golf course to the west of Site 11. These samples were taken to document potential surface water contamination from Site 11 as well as surface water contamination originating from an off-site source. The surface water sampling locations are presented on Figure 8-1. A summary of the analytical data for the surface water samples collected during Phase I is presented on Table 8-7.

During Phase II, two surface water samples were collected from the same sampling points. No levels of compounds above background levels or drinking water MCLs were detected at either surface water sampling location. Acetone and methylene chloride were detected at low concentrations (6 μg/L and 24 μg/L, respectively) in surface water Sample 11SW1. A summary of the analytical data for the surface water samples collected during Phase II is presented on Table 8-8.

During Phase I, three sediment samples were collected from the stream to the west of Site 11 to document potential contamination from Site 11 as well as that contamination originating from an off-site source. A summary of all stream sediment analytical data for Site 11 is presented on Table 8-3.

During Phase II, three sediment samples were collected from the same sampling points. A summary of the stream sediment analytical results is presented on Table 8-4. Parameters with concentrations above background levels are shaded.

Analytical results from sampling events conducted in Phase I and Phase II indicates that levels of metals, including cadmium, chromium, copper, lead, and zinc were slightly elevated above background levels established for the facility as presented on Table 1-13. In addition, mercury was detected at 11SD1 and 11DS3 (1.9 mg/kg and 0.21 mg/kg, respectively) during Phase I. Analytical results for mercury samples were rejected during Phase II. While levels of metals were above those established as background, only the level of mercury reported in sample 11SD1 exceeded those of naturally occurring soils as shown in Table 1-12. No levels exceeded RCRA Corrective Action levels.

Analytical results from sampling events conducted in Phase I indicates that levels of semi-volatile organic compounds, including Phenanthrene, Fluoranthene, and Chrysene were slightly elevated above detection limits (Table 8-3) in the stream sediments. No semi-volatile organic compounds were detected during stream sediment sampling at the same sampling points in Phase II (Table 8-4).

Sediment Sample 11SD1, which was collected where the stream enters the facility, had higher levels of contaminants than the other two locations during both Phase I and Phase II of the RI.

The location of 11SD1 supports the assumption of contamination coming from an off-site source at this location. The presence of metal and semi-volatile contamination in the stream sediments is consistent with the presence of a parking lot and gas station to the north of the facility, from which rain water enters this stream and then flows onto the site.

8.4.4 Ecological

Approximately 300 feet of Stream 11 was electrofished during bioassay fish collection activities. The sampling area extended from the southern property line to the outfall of the pond adjacent to the facility golf course. Three American Eels were collected in this stretch of the stream, and processed for bioassay. Although Black-nosed Dace were originally targeted for bioassay, Goldfish were used as the second species due to the scarcity of dace in this portion of the stream. Two male and two female Goldfish were collected for bioassay. The fish were cut in half for processing, thereby enabling the identification of their sex.

Bioassay results for Site 11 are given in Table 16, Appendix A. The data show that chromium, copper and PCB levels are above detection limits for fish in the lower portion of Stream 11.

Copper levels for the two American Eel samples measure 1.06 and 0.99 ppm. Copper levels in the two Goldfish measured 3.5 and 3.28 ppm. Chromium concentrations in one of the Goldfish were 0.52 ppm. PCB Arochlor 1254 measured 10 ppm in one eel. PCB Arochlor 1260 measured 0.4 ppm in the other eel sample, and 1.0 and 0.6 ppm in Goldfish Samples 1 and 2, respectively.

Table 15, Appendix A, shows that at least some of the Goldfish in Stream 11 have elevated chromium levels. No thresholds exist for the United States, however, these levels are approximately one-half the legal limits for fish and fish products in Hong Kong. Copper

levels in both American Eel and Goldfish measure well within the legal limits for fish and fish products in the United Kingdom. There are no known published legal limits for copper in the United States. One of the eel samples in Stream 11 contained PCB Arochlor 1254 levels five times the United States legal limit for PCBs.

As mentioned earlier, it is not known whether there is a cause and effect relationship between the site contaminants on White Oak and elevated levels in the fish analyzed. It is suspected that the elevated levels of Arochlor 1254 are due to site factors, however, there contaminants may have accumulated in the fish while they were residing off-site. Due to the size and age of the eel, it is presumed that the animals have been resident on the site for several years, allowing site contaminants to bioaccumulate. A more rigorous bioassay would be necessary to prove a cause and effect link between site contamination and bioaccumulation in fish.

8.5 CONTAMINANT FATE AND TRANSPORT

8.5.1 Potential Routes of Migration

The potential route of migration at Site 11 is the transport of contaminants through the groundwater system from contaminated areas. Volatile organic compounds are present in the groundwater at three areas at Site 11.

8.5.2 Contaminant Migration

The contaminants of greatest concern in the groundwater at Site 11 include 1,2-dichloroethene, TCE, benzene, tetrachloroethene, chromium, and copper. The volatile organic compounds identified in the groundwater at Site 11, dichloroethene, TCE, benzene, and tetrachloroethene, have similar migration characteristics within groundwater. All are relatively mobile, and would be expected to migrate at a rate slightly slower than the groundwater flow velocity determined to be 3.82×10^{-6} cm/sec or 0.002 ft/day.

The analytical results indicate that the concentration of volatile organic compounds in Wells 11GW22 and 11GW24 have decreased slightly since the Verification Phase study in 1985. Analytical results from Well 11GW66, located hydraulically downgradient from 11GW22 (Figure 8-1), also indicates decreasing concentration levels of volatile organic compounds from Phase I to Phase II. In addition, analytical results from Wells 11GW87

and 11GW29 suggest limited migration of volatile organics compounds from Wells 11GW22 to these wells (Table 8-6). In fact, the volatile organic plume has migrated approximately 500 feet from Well 11GW22. Wells 11GW68 and 11GW73, located downgradient from Well 11GW24 (Figure 8-1), show no volatile organic contamination. Wells are located over 1,000 feet from the contaminated well and the slow rate of migration probably accounts for no downgradient volatile organic contamination at this point.

Based on the analytical results of groundwater sampling, low concentrations of volatile organic compounds are present in the groundwater throughout the site. However, based on analysis of monitoring wells located downgradient from the former leaching Well locations (11GW29, 11GW70D, 11GW68, and 11GW73) migration of the volatile organic compounds is limited by the fractured flow conditions and slow rate of migration.

High levels of chromium and copper were identified in Monitoring Well 11GW27 during Phase I. However, reduced levels more representative of background levels were reported for these compounds in the analytical results for Monitoring Well 11GW27 during Phase II. Analytical results for chromium and copper from monitoring wells downgradient of 11GW27 (11GW28 in Phase I and 11GW28, 11GW84, 11GW85, and 11GW86 in Phase II) indicate that no migration of dissolved metals has occurred from 11GW27. It is expected that the metals are attenuated by soil particles. The migration of dissolved metals in the groundwater at Site 11 would be retarded by attenuation and transformation of the metals during transport. Therefore the migration of the dissolved metals in groundwater is significantly slower than the estimated rate for volatile organic compounds at Site 11.

8.6 RISK ASSESSMENT

8.6.1 Human Health Evaluation

A summary of the risk estimates in relation to USEPA's Superfund remediation criteria is presented in Table 8-9. The non-cancer and cancer risks associated with exposure to contaminated groundwater at Site 11 may be summarized as follows.

8.6.1.1 Non-cancer Risks

Adverse non-carcinogenic health effects in the off-site residential population (adults and children) from exposure to groundwater are unlikely. The total hazard indices for the pathways for adults and children are less than the criterion of 1.0.

8.6.1.2 Cancer Risks

The total cancer risk for future on-site adult and child residents who potentially may be exposed to contaminated groundwater from Site 11, if groundwater were used in the vicinity of the site, exceeds the USEPA Superfund remediation goal. Ingestion of groundwater contributes the greatest risk.

Thus, based on cancer risk estimates and potential future use as a residential area, consideration of the need for remediation of groundwater at Site 11 is warranted.

8.6.2 Ecological Risk Assessment

In determining the potential risk to wildlife of contaminants in the media at Industrial Wastewater Disposal Area 100, it should be noted that for many compounds, the toxicity and availability of the parameters are dependant on many factors including water chemistry, soil chemistry, the form of the particular compound is in at the site, and the presence of other compounds within the media.

Concentrations of copper in food sources of the species selected for this risk assessment were twice the acceptable levels calculated in Section 8.2.5 above. The risk from exposure to copper in the contaminated media at the site is expected to be moderate.

Concentrations of Aroclor 1254 and Aroclor 1260 in food sources for the indicator species selected were well above the acceptable levels calculated. However, this compound was not selected for analysis in any of the media sampled at Site 11. The origin of the Aroclor 1254 and Aroclor 1260 in the biota is not known. Therefore, the risk that Site 11 poses to the biota in the area is unknown.

8.7 SUMMARY AND CONCLUSIONS

8.7.1 Summary

Site 11 (Industrial Waste Disposal Area 100) was used for chemical disposal in 10 leaching wells associated with laboratory buildings covering an area of approximately 16 acres. Site 11 is located along the western boundary of the facility, adjacent to the main entrance. According to the IAS, approximately 20,000 gallons of liquid wastes were disposed of at this site.

The RI at Site 11 included a hydrogeologic investigation, and contaminant characterization and risk assessment. The hydrogeologic investigation included lithologic descriptions of the subsurface, monitoring well elevation and location survey, groundwater level measurements, 13 aquifer Slug Tests (11GW22, 11GW23, 11GW24, 11GW27, 11GW28, 11GW29, 11PZ63, 11GW66, 11GW67, 11GW68, 11GW69, 11GW70D, and 11GW71) and a pumping test at Monitoring Well 11GW87. The lithology beneath Site 11 consists of a thin veneer (0 to 20 feet thick) of the Upland Sand and Gravel unit overlying the gneiss saprolite of the Wissahickon Formation. The Upland Sand and Gravel unit is thinnest in the north-central part of the site, possibly due to non-deposition or erosion, and thickest in the east and southeastern parts of Site 11. Where the Upland Sand and Gravel unit is absent, the surficial unit is the gneiss saprolite of the Wissahickon Formation. Groundwater flow at the site is to the south-southeast. The average hydraulic conductivity based on the analysis of the slug test data was 1.96×10^{-3} cm/sec and for the constant rate pumping test at Well 11GW87 was 4.62×10^{-5} cm/sec. The results of the aquifer slug test and constant rate pumping test analyses are listed on Table 1-3.

The contaminant characterization included the collection and analysis of samples from the soil, groundwater, and biota to be used for determining the risk to human health and the environment. Four Piezometers, (11PZ62, 11PZ63, 11PZ64, and 11PZ65) and 9 groundwater Monitoring Wells, 11GW66, 11GW67, 11GW68, 11GW69, 11GW70D, 11GW70S, 11GW71, 11GW72, and 11GW73 were installed during Phase I. In addition, 3 soil gas surveys were conducted during Phase I to delineate areas with soils contaminated with volatile organic compounds (Building 304, Buildings 344 and 345, Building 336, Building 328, Building 310 and Building 311). Two surface soil samples and 16 groundwater samples were collected for analysis during Phase I. Five additional groundwater Monitoring Wells, 11GW84, 11GW85, 11GW86, 11GW87, and 11GW88 were installed during Phase II. Twenty-one groundwater samples were collected during Phase II. Three monitoring wells were abandoned during Phase II; two which were installed during the Verification Phase (11GW20 and 11GW21) and one which was installed during Phase I (11GW70S).

The ecological investigation during Phase II consisted of terrestrial vegetation and mammal surveys. Site 11 consists largely of cultivated lawns. The majority of the site is developed and maintained in park conditions, vegetated with grass species and trees such as oaks, Tulip Poplar, and Red Maple. Adjacent to these cultivated areas are portions of mixed deciduous forest. The deciduous forest portions are characterized by various species

of sycamore, oak, cherry, poplar, gum, and holly. The mammalian species found at the site are those commonly associated with a forested ecosystem and domestic cats.

Results from the benthic survey indicates that water quality improves downstream based on the HBI values for the three portions of the stream sampled. Poor water quality in the upstream area may be associated with stream morphology and substrate in that area or may be due to contamination from sources off site.

8.7.1.1 Nature and Extent of Contamination

No elevated and reproducible levels of organic vapor were detected in the in the soils. The surficial soil samples collected at Site 11, due to the lack of detection of contaminants of concern, were used as background levels for the facility. The soil gas surveys indicated the presence of volatile organic compounds at low concentrations in the soils behind Buildings 2 and 5, behind Buildings 3 and 5, and in the softball field behind Building 30. No volatile organic compounds were detected in the soil gas vapor behind Buildings 2 and 5. One reading detected the presence of volatile organic compounds were detected in the soil gas vapor behind Buildings 3 and 5. The reading, 450 ppm, could not be reproduced during attempts to confirm the reading. Since this reading could not be reproduced, it was considered an anomaly. Only two readings detected the presence of organic vapors in the soils in the softball field behind Building 30, these were 0.8 and 1.5 ppm respectively. However, elevated contamination levels were detected in the groundwater.

The contaminants of greatest concern in the groundwater are the volatile organic compounds and metals. Elevated levels of volatile organic compounds, including acetone, benzene, chloroform, 1,2-Dichloroethane, 1,2-Dichloroethene, Tetrachloroethene, and TCE, and elevated levels of metals including cadmium, chromium, copper, and lead were detected in the groundwater during both Phase I and II. The volatile organic compounds detected in the groundwater at concentrations within the range or greater than the MCL's or background in the groundwater identified at Site 11 have decreased since the Verification Phase. This trend suggests slight horizontal movement and dispersion of the contaminants in the groundwater.

No levels of contamination above background or drinking water MCLs were detected in either surface water sampling location. However, Acetone and methylene chloride were detected at low concentrations (6 μg/L and 24 μg/L, respectively) in Sample 11SW1. Stream sediment samples were collected at three locations during both Phase I and II.

Analytical results from stream Sediment Sample 11SD1, which was collected where the stream enters the facility (Figure 8-1) indicate the presence of slightly elevated levels of semi-volatile organic compounds and metals in the stream sediment. The levels of contaminants decreases downstream, suggesting the contribution of solvents and metals to the stream sediments from possible off-site activities upgradient of the site.

The bioassay conducted on fish collected from the surface water at Site 11 showed that copper, mercury, and PCBs were present in the fish collected from the lower stretch of the stream. The ecological risk assessment identified chromium, copper, and PCBs (Aroclor 1254 and Aroclor 1260) in food sources for the indicator species selected were well above the acceptable levels calculated. Samples were not collected for PCB analysis from any of the media sampled at Site 11, therefore, the risk to wildlife from exposure to chromium, copper, Aroclor 1254 and Aroclor 1260 in the media is unknown at this time. It is not known whether the elevated levels of contaminants are due to sources on the NSWCWODET or from outside the facility.

The risk assessment determinations are included as Appendix G in this text. Adverse non-carcinogenic health effects in the residential population from exposure to the groundwater are unlikely. The total cancer risk for a future on-site residential population who may potentially be exposed to contaminated groundwater, if groundwater were used in the vicinity of the site, exceeds the USEPA Superfund remediation goal. Therefore, based on the cancer risk evaluation, consideration of the need for remediation of groundwater at Site 11 is warranted.

8.7.1.2 Fate and Transport

At Site 11, the primary source of contamination are volatile organic compounds and low levels of dissolved metals. The major potential routes of migration include the transport of contaminants through the soil and groundwater systems. Based on the shallow groundwater conditions and the potential mobility and concentration of the contaminants detected in the groundwater, transport of the leachate in the groundwater system has been moderate. The direction of the volatile organic compound contaminants in the groundwater is to the south-southeast towards the confluence of a perennial stream and a intermittent stream.

8.7.2 Conclusions

The hydrogeologic investigation from Phase I and Phase II provided the information necessary to determine the direction of groundwater flow, the groundwater gradient, and the hydraulic conductivity and transmissivity of the unconfined aquifer.

Metals and volatile organic compounds were identified in the shallow aquifer underlying Site 11 during both Phase I and Phase II. The groundwater contamination appears to emanate from multiple sources associated with the former leaching wells. Migration of the leachate in the groundwater is to the south.

The risk assessment identified groundwater contaminated with volatile organic compounds as a potential concern for total cancer risk for future on-site adults and children who may be exposed to the groundwater, if groundwater were used in the vicinity of Site 11. Based on the cancer risk evaluation, remediation of the groundwater at Site 11 is warranted.

8.7.2.1 Data Limitations

Soil samples collected from Site 11 during Phase I were used for facility background levels of metals within the soils.

No investigations of contaminant levels within stream sediments off-site of the facility have been made; therefore, the influence of urbanization on contaminant levels identified in the stream sediment soils on the facility can not be determined.

The analytical results for mercury in the groundwater were rejected. The extent and potential migration of mercury contamination in the groundwater, therefore, could not be confirmed.

Results of the Benthic sampling identified PCB contamination in fish tissue. No media was collected for PCB analysis at Site 11, therefore, the origin of the PCBs in the biota is unknown. The possible extent of contamination of PCB's at Site 11 is unknown at this time.

8.7.2.2 Preliminary Remedial Action Objectives

The risk assessment of contamination present at Site 11 indicates that the primary threat to human health and the environment is from the volatile organic compounds in the groundwater. The primary exposure route would be through ingestion of groundwater and a secondary exposure route would be through transport of contaminants in the soil. The remedial objective is to remove any source(s) of contaminants to prevent contaminant migration into soil or groundwater and to limit further migration of the contaminant plume in the groundwater.

9.0 BACKGROUND SITES

In an effort to provide an indication of ambient, or background quality of the surface water, stream sediment, and groundwater, background sites were chosen within the facility boundary. The locations of three background surface water and stream sediment sampling points and two background wells are illustrated on Figure 9-1.

9.1 PAINT BRANCH CREEK

9.1.1 Site Description and History

Paint Branch Creek is the largest surface water body on the NSWCWODET facility. The creek flows south through the facility, eventually emptying into the Anacostia River, south of the site. The creek flows through a mixture of land north of the site, including residential, agricultural, forested, and commercial land.

9.1.2 Previous Investigations

No sampling of the surface water or stream sediment of Paint Branch Creek was conducted prior to Phase I of the Remedial Investigation.

9.1.3 RI Investigations

9.1.3.1 Surface Water and Sediment Investigations

During Phase I, surface water and stream sediment investigations were accomplished by the collection of samples from the surface water (three samples) and sediment (three samples) of Paint Branch Creek. The stream's surface water and sediment were sampled at locations where the stream entered the facility (PBC-SW1 and PBC-SD1 on Figure 9-1), along the stream downgradient at a location approximately mid-way of the facility (PBC-SW2 and PBC-SD2 on Figure 9-1), and where the stream exits the facility at the south central part of the facility (PBC-SW3 and PBC-SD3 on Figure 9-1). The purpose of the sampling was to document the chemical quality of the surface water and stream sediment of the largest stream on the facility. A summary of the environmental sampling conducted in Paint Branch Creek during Phase I is presented on Table 9-1.

During Phase II, the same locations sampled during Phase I were resampled in order to assess current surface water and stream sediment sample quality and to provide an

assessment of conditions over time. A summary of the environmental sampling conducted in Paint Branch Creek during Phase II is presented on Table 9-2.

9.1.3.2 Ecological Investigations

During Phase II of the RI, investigations were conducted in order to assess the current ecological conditions along Paint Branch Creek. Included in the investigations were terrestrial vegetation, mammal, fish and benthic invertebrate surveys.

The vegetation survey consisted of a quantitative analysis of species types located on site. In this study, field identification was supplemented with office confirmation of the major vegetative species. Relative abundance of the species was established and vegetation community relationships were delineated.

A general mammalian survey was performed consisting of a presence/absence identification of species. Identification of tracks, scat, and burrows was also used to supplement direct observations.

A survey consisting of collection and identification of aquatic benthic organisms were collected from Paint Branch Creek and were identified. The benthic invertebrate sampling was conducted using a kick screen method at three locations along the stream (upstream, midstream, and downstream). After collection, the organisms were preserved in alcohol and formaldehyde for office identification.

A survey of the fish species present in the Paint Branch Creek was conducted. The species, maturity, and size of the fish observed was recorded. The fish survey was completed using a Smith-Root electrofisher at upstream, midstream and downstream points along the length of the stream on site.

Specific sampling materials and methods are used are presented in Section 1.6 and outlined in Appendix A.

9.1.4 Physical Characteristics of the Site

9.1.4.1 Surface Water Hydrology

The Paint Branch Creek on-site ranges from 15 to 35 feet wide and averages 6 inches to 1-foot deep. There are many undercut banks and holes in the stream which are 2 to 3 feet deep. A rocky substrate is found in the riffle-run areas of the stream and there is abundant in-stream cover for fish. The substrate contains little algal growth and consists

mainly of gravel and cobbles measuring 1 to 6 inches in diameter. A fine silt covers portions of the stream bottom.

9.1.4.2 Ecology

Paint Branch Creek flows through a mature hardwood forest on the facility. Forested areas adjacent to the stream are characterized by three species such as Southern Red Oak, White Oak, Black Oak, Tulip Poplar, Mockernut Hickory, Red Maple, Eastern Sycamore, Flowering Dogwood, and River Birch. The understory in the forest consists primarily of grasses, Poison Ivy, Virginia Creeper, Sourgum, Grap (Vitis sp.), Southern Arrowood, Ironwood, Flowering Dogwood, Spicebush, Mountain Laurel, and various ferns. The vegetative cover of areas ranged from 60 to 80 percent during site visits.

There was evidence of site utilization by White-tailed Deer, Eastern Cottontail, Raccoon, and squirrel. Eastern Chipmunk, Grey Squirrel, Fox Squirrel, Northern Water Snake, Leopard Frog, and Box Turtle were seen on-site. Birds observed include Eastern Wood Peewee, Northern Mockingbird, European Starling, American Crow, American Robin, Belted Kingfisher, and various woodpeckers.

The benthic survey in the upper portion of Paint Branch Creek (PBCR U) contained one oligochaete worm, three mayflies (Ephemerella sp.), one fishfly (Family Corydalidae), one darner (Aeshna sp.), and one snail larva (Family Planorbidae). The PBCR U Duplicate sample contained two riffle beetles (Zaitzevia sp.; Psepheninae sp.), two midges (Cricotopus sp.), eight mayflies (seven Ephemerela sp.; one Stenonema sp.), and eight caddisflies (three Cheumatopsyche sp.; four Hydropsyche sp.; and one Symphitopsyche sp.).

Benthic sampling in the middle portion of Paint Branch Creek (PBCR M) yielded one midge (Chironomus sp.), one aquatic caterpillar (Paragyractis sp.), and five caddisflies (Hydropsyche sp.). The PBCR M Duplicate sample contained one Coleopteram, one Dipsteran, eight Chironomid midges (Chironomus sp.), five danceflies (Hemerodromia sp.), six mayflies (Ephemerella sp.), and 26 caddisflies (two members of the Family Glossosomatidae; four Cheumatopsyche sp.; 17 Hydropsyche sp.; and three Symphitopsyche sp.).

Benthic sampling in the lower portion of Paint Branch Creek (PBCR L) contained two oligochaete worms, one Coleopteran, two craneflies (Tipula sp.), one darner (Aeshna sp.), and nine caddisflies (one member of the Family Hydropsychidae; one Cheumatopsyche sp.; four Hydropsyche sp.; and three Symphitopsyche sp.). PBCR L Duplicate yielded one

midge (Chironomus sp.), three dance flies (Hemerodromia sp.), two mayflies (Ephemerella sp.), one fishfly (Family Corydalidae), and seven caddisflies (one Hydropsychidae; two Cheumatopsyche sp., and four Hydropsyche sp.).

Sampling results from PBCR U and PBCR U Duplicate included 16.7 and 0 percent oligochaete worms, respectively. There were no oligochaete worms found in the middle portion of Paint Branch Creek. PBCR L and PBCR L Duplicate included 9.5 and 0 percent oligochaete worms. These data indicate that water quality within the stream is generally good.

Two important indicator organisms found in Paint Branch Creek are Ephemerella sp. and Rithrogena sp. These two genus of mayflies generally are very intolerant of pollution and require clean, well-oxygenated water for reproduction. Their presence in Paint Branch Creek indicates, in general, good water quality in the stream.

The HBI values for the stream reflect the generally high water quality of the portion of Paint Branch Creek which flows through the facility. HBI values for PBCR U and PBCR U Duplicate were calculated as 1.92 and 1.66, respectively. Values for PBCR M and PBCR M Duplicate were 2.7 and 2.28, respectively. Values for PBCR L and PBCR L Duplicate were 1.91 and 2.51, respectively. Composite HBI calculations indicate good water quality in upstream, mid-stream, and downstream portions of Paint Branch Creek.

Fish surveys for the stream yielded the highest diversity and largest populations of any surface water body on the NWSCWODET facility. A total of 100 fish from 14 species were collected from the stream. Perhaps one of the most important indicator species found in the stream was Brown Trout. Although Brown Trout do not have as stringent habitat requirements as Brook Trout, they generally require cool, clean water to survive. Optimal Brown Trout riverine habitat is characterized by: clear, cool-to-cold water; a relatively silt-free rocky substrate in riffle-run areas; a 50 to 70 percent to 30 to 50 percent pool to riffle-run ratio; well-vegetated, stable stream banks; abundant in-stream cover; and relatively stable annual water flow and temperature regime (HSI Model, 1986).

Paint Branch Creek contains good Brown Trout habitat including well-vegetated, stable banks; abundant in-stream cover, including deep pools and undercut banks; an adequate pool to riffle-run ratio; and generally clean, cool water. The stream's variable flow regime, as evidenced by scouring and trash racks within the floodplain, as well as siltation are probable limiting factors to spawning success and fry survival in this stretch of the stream. Water temperature may also be a limiting factor to survival of fish embryos and fry.

Nevertheless, the presence of adult trout in the stream indicate generally good water quality.

9.1.5 Nature and Extent of Contamination

9.1.5.1 Surface Water and Sediments

Surface Water

During Phase I three surface water samples were collected from the Paint Branch Creek at locations shown on Figure 9-1. A summary of the analytical results for surface water samples collected during Phase I is presented on Table 9-3. The analytical results indicate that the surface water of the Paint Branch Creek contains no contamination above MCL or USEPA Ambient Water Quality Standards (Table 1-11).

During Phase II, three surface water samples were collected from the same sampling points sampled during Phase I. A summary of the analytical results for surface water quality samples collected during Phase II is presented on Table 9-4.

Volatile and semi-volatile organic compounds were detected at all three Sample Locations (PBC-SW1, PBC-SW2, and PBC-SW3 from upstream to downstream) along Paint Branch Creek. Acetone was detected in all three surface water samples at relatively low levels (13, 6, and 11 μg/L, respectively), while tetrachloroethene was detected at a concentration of 7 μg/L in the sample from PBC-SW3 above the MCL of 5 μg/L and the RCRA Corrective Action level (proposed rule) of 0.7 μg/L. Bis(2-ethylhexyl)phthalate was detected at a concentration of 240 μg/L in the sample from PBC-SW3, well in excess of the RCRA Corrective Action level (proposed rule) of 3 μg/L. Analytical results for mercury was rejected for all surface water sample locations due to analytical error. 1,3,5 trinitrobenzene analytical results was also rejected due to laboratory error for Samples PBC-SW2 and PBC-SW3.

The presence of tetrachloroethene and Bis(2-ethylhexyl)phthalate at levels above MCLs or RCRA action levels in surface water samples collected during Phase II of the RI at PBC-SW3 indicates that contamination from past waste disposal activities has begun to affect the downstream surface water quality of the Paint Branch Creek as these compounds were not detected in Phase I or in the upstream or midstream sampling points during Phase II.

During Phase I three stream sediment samples were collected from the Paint Branch Creek at locations shown on Figure 9-1. A summary of the analytical results for stream sediment samples collected during Phase I is presented on Table 9-5. The analytical results

indicate that the stream sediments of Paint Branch Creek contains relatively low levels of semi-volatile organic compounds. These levels are below RCRA Corrective Action Levels (proposed rule) or general concentrations of U.S. Natural soils as presented in Table 1-12. Acetone, methylene chloride and toluene were detected at the midstream Sampling Location (PBC-SD2). However, acetone and methylene chloride were also detected in the laboratory blank. Toluene (2 μg/L) was reported below the detection limit of 5 μg/L.

During Phase II, three stream sediment samples were collected from the same sampling points sampled during Phase I. A summary of the analytical results for stream sediment quality samples collected during Phase II is presented on Table 9-6. Volatile organic compounds acetone and methylene Chloride were detected at all sampling locations. Semi-volatile organic compounds fluoranthene and pyrene were detected at the midstream Sampling Location (PBC-SD2) at levels higher that those expected for background sediments (Table 1-12). Analytical results were rejected for the semi-volatile organic compounds collected from the upstream sampling location during Phase II.

Analytical results of samples collected during Phase I and Phase II indicates contamination of volatile and semi-volatile organic compounds in the stream sediments of Paint Branch Creek. The concentration of volatile organic compounds detected in stream sediment samples collected during Phase II were highest in the upstream Sampling Location (PBC-SD1) and decreased at the midstream and downstream Locations (PBC-SD2 and PBC-SD3 respectively) suggesting the possibility of a contamination source upstream of the facility. The presence of volatile organic compounds in the laboratory blanks during Phase I precludes assessment of that data.

The concentration of semi-volatile organic compounds detected in stream sediment samples decreased at midstream and downstream locations during Phase I sampling. This trend suggests the possibility of contamination source upstream of the facility. Rejection of upstream analytical results for semi-volatile organic compounds during Phase II precludes confirmation of that trend over time. However, no semi-volatile organic compounds were detected in the downstream Sampling Location (PBC-SD3) during Phase II. This indicates that contamination of stream sediments by semi-volatile organic compounds have not migrated off-site.

9.1.5.2 Ecological

American Eel were collected from a 30-foot stretch of Paint Branch Creek, at a point approximately 400 feet upstream of the southern property line. Two individuals were taken from the stream immediately downstream from the terminus of Keuster Road and processed for bioassay. One of the individuals exhibited physical abnormalities such as skull and jaw deformities and body lesions. This individual also exhibited internal organ deformities and tumors.

Black-nosed Dace were originally targeted for bioassay, however, due to the low population of the species, a composite of Black-nosed Dace and Long-nosed Dace was prepared. An approximately 1,200-foot section of the stream was sampled, extending upstream from the terminus of Keuster Road.

Results of the bioassay for Paint Branch Creek are presented in Table 17 (Appendix A). The data show that levels of cadmium, copper and PCB's are above detection limits for fish in this stretch of the stream.

Copper levels for the dace composite and the two eel samples were 1.03, 3.94 and 3.31 ppm, respectively. Cadmium levels for the deformed eel measured 0.32 ppm. The concentration of PCB Arochlor 1260 in the deformed fish was 6.0 ppm.

Eel in Paint Branch Creek contain Arochlor 1260 levels above that of the United States legal limit for that pollutant. The cadmium levels in the deformed eel were in exceedance of the legal limits for fish and fish products in Switzerland and Australia. The United States has no thresholds for cadmium and copper.

It is not known whether the elevated levels of contaminants in fish are due to sources on the White Oak site. Although there are no waste sources directly on the stream, there are waste sources on tributaries to the stream.

Similarly, it is not known whether the skeletal and organ deformities were caused by the high cadmium and PCB body burden in the eel. It is suspected that elevated PCB levels in the eel are partially attributable to site contamination and that copper levels in the fish may be attributable to background levels of the metal in the stream. In order to prove a cause and effect relationship between site contamination and fish body burdens of heavy metals and PCBs, a much more rigorous bioassay would need to be performed.

It is probable that game fish found in Paint Branch Creek, such as Brown Trout and Red-breast Sunfish, contain levels of cadmium and PCBs similar to those found in the eel. This assumption is based on the fact that the three species of fish occupy the same

ecological niche. Elevated levels of cadmium and PCBs in game fish is significant in that these species represent a greater potential threat to human health through possible ingestion of contaminated fish caught upstream or downstream from the facility.

9.2 BACKGROUND WELLS

9.2.1 Site Description and History

Two background water quality monitoring wells were installed at the perimeter of the NSWCWODET facility to provide a baseline for the quality of groundwater in the vicinity of the facility, in areas not affected by past waste disposal activities. The locations of the two Wells (BGW16 and BGW40) are shown on Figure 9-1.

9.2.2 Previous Investigations

During the Verification Phase, BGW16 and BGW40 were installed and sampled for total metals and filtered metals, TOC, TOX, TDS, pH, conductivity, volatile and semi-volatile organic compounds, PCBs, nitroaromatics, oil and grease, cyanide, and phosphorous. In the Verification Phase report recommendations for additional sampling, focused on metals and special analysis parameters was suggested. Due to the lack of PCBs and nitroaromatics, no additional sampling in the background wells for those compounds was recommended.

9.2.3 RI Investigations

During Phase I, both background monitoring wells were sampled for total and dissolved metals, mercury and hexavalent chromium, volatile and semi-volatile organic compounds, TOC, TOX, TDS, and TSS. A summary of the field environmental sampling for the background wells conducted during Phase I of the RI is presented on Table 9-7.

During Phase II, as a result of additional information regarding groundwater contamination at the NSWCWODET facility, both background monitoring wells were sampled for total and dissolved metals and mercury, semi-volatiles, PCBs, nitroaromatics, and volatile organic compounds. A summary of the field environmental sampling for the background wells conducted during Phase II of the RI is presented on Table 9-8.

9.2.3.1 Groundwater

During Phase I groundwater samples were collected from two Background Wells (BGW16/BGW40) to document groundwater quality at background locations. A summary of the analytical results for the background wells sampled during Phase I is present in Table 9-9. No volatile organic or semi-volatile organic compounds were detected during Phase I sampling. Analytical results for total metals concentrations indicated the presence of mercury at a concentration of 1.2 μg/L, below the MCL of 2.0 μg/L (Table 1-11) in Monitoring Well BGW16. Mercury was not detected in BGW40. Hexavalent chromium was not detected in either sample. Dissolved cadmium at a concentration of 4.3 μg/L, below the MCL of 5 μg/L (Table 1-11), was detected in BGW16. Cadmium was not detected in BGW40.

During Phase II, groundwater samples were collected at both background wells to document groundwater quality and changes in concentration of contaminants over time. A summary of the analytical results for the background wells sampled during Phase II is present in Table 9-10. No volatile organic, semi-volatile organic, or PCB compounds were detected during Phase II sampling. No nitroaromatic compounds were detected in BGW 16, however, the analytical results for nitroaromatics were rejected in Sample BGW40. Analytical results of total and dissolved metals concentrations in the groundwater samples indicated a reduction in concentration since Phase I. The dissolved copper concentration in Monitoring Well BGW40 (11 μg/L) while below the detection limit was above the concentration reported during Phase I of the RI (Non Detect). Analytical results for mercury were rejected due to 0 percent recovery of the matrix spike during Phase II of the RI.

9.2.4 Nature and Extent of Contamination

9.2.4.1 Groundwater

Analytical results of the background groundwater samples collected at Monitoring Wells BGW16 and BGW40 provide an indication of the water quality at the NWSCWODET facility that is unaffected by past waste disposal practices. Groundwater at the background well locations at the facility shows no gross contamination, and can be used to determine a baseline water quality for the facility that can be compared to water quality from waste disposal areas.

TABLE 1-1
DESCRIPTION OF GEOLOGIC UNITS

PERIOD	UNIT NAME (Symbol)	DESCRIPTION
QUATERNARY	Alluvium (QAL)	Occurs along drainages. Material derived from surrounding rocks. Maximum thickness of 30 ft., average 10 ft. Quartz sand, well-sorted; micaceous, sticky, quartz and mica schist fragments and masses to several tons. USCS: SC-GC
	UNCONFORMITY	
	(Qt)	Occurs as a thin cover. Similar to QAL. USCS: GM, SC-GC, SW
	UNCONFORMITY	
	Upland Terrace Deposits (Qtu)	Caps hills in eastern part of quadrangle. Maximum thickness 30 ft. May be reworked gravels from the underlying Potomac Group. Predominantly sand, with some gravel and clay. Sand, fine to coarse, crossbedded, light-brown, contains quartz, quartzite, sandstone fragments or iron-cemented sand, and widely scattered schist pebbles. Clay, white, in thin beds and lenses. USCS: GM
TERTIARY	Upland Sand and Gravel (Tug)	Formed as alluvial fans. Maximum thickness 60 ft. Possibly equivalent to Brandywine Formation of Pliocene(?) age. Gravel, sand, silt, and clay. Gravel consists of rounded to subangular white and pink quartz; white quartzite and quartzite conglomerate; fine-grained sandstone; rare chert pebbles. Maximum size of boulders is 1.5 ft in diameater. Sand is subangular fine to medium fine quartz; contains mica flakes. Clay as beds and lenses: kaolinite 40-60%, illite 30-60%, montmorillinite 5-10%. Locally feldspar present in clay; some clay rich in organic matter. USCS:GM-GC, SW.
CRETACEOUS	UNCONFORMITY	
	Potomac Group Two components:	
	(Kpc) Clay Facies	(Upper Potomac Group, Kpc, Clay Facies) Approximately 250 ft. thick. Clay, silt, sand, and gravel: Silty and sandy clay, stiff, hard, brick red, becoming drab near surface; kaolinite, 75-90%, remainder illite. Sand as extensive thin beds less than 5 ft. thick scattered through the formation. Lenses of black lignitic clay containing wood fragments, spores, leaf impressions, some pyrite crystals and sulfur bloom; iron as limonite and siderite; lignitic lenses are no more than 7 ft. thick, and 100 ft. long, and are scattered throughout the formation. Incipient east-trending joints in clay approximately 2 ft. apart (Withington, 1964). USCS: ML-CL
	(Kps) Sand Facies	(Lower Potomac Group, Kps, Sand Facies) Maximum thickness 180 ft.; pinches out near Montgomery-Prince Georges County line. Deposited unconformably on the metamorphic rocks by a south-flowing river system. Gravel, sand, silt, and clay; Gravel contains quartz and quartzite, as much as 10 ft. thick found at top of the formation. Sand, medium-fine to coarse, generally well sorted, light-brown; locally purple. USCS: GM, SM
	UNCONFORMITY	

SOURCE: Froelich, 1974

TABLE 1-1 (Cont.)
DESCRIPTION OF GEOLOGIC UNITS

PERIOD	UNIT NAME (Symbol)	DESCRIPTION
TRIASSIC	Diabase Dikes (Trd)	A single dike approximately 10 ft. thick is in the northern part of the Beltsville quadrangle.
	UNCONFORMITY	
	Quartz Veins (Q)	Approximately 20 ft. thick. White to clear, massive to shattered.
PRECAMBRIAN AND/OR PALEOZOIC	Pegmatite Masses or Dikes (P)	Dikes as thick as 20 ft., in western part of Beltsville quadrangle. Coarse-grained quartz, feldspar, and mica. Maximum crystal size 7 in., scattered mica books as much as 4 in. in diameter.
	WISSAHICKON FORMATION Diamictite Gneiss Facies: Gneiss (Wd) and Saprolite on Gneiss (Wds)	Mica gneiss (Wd) metamorphosed from sedimentary rock. Contains sub-rounded quartz and rounded schist pebbles. Weathers to saprolite (Wds), a porous, spongy red-brown material that retains the structure of the original rock; grades upward to sticky, micceous clay. Saprolite averages 15 ft. thick below Coastal Plain sediments, but may be as much as 100 ft. thick on uplands. Clay, gray, mont-morillonite - red-brown above water table; some montmorillinite altering to kaolinite in oxidizing environment. Some saprolite and mixed layer clays. USCS: GM, SC, ML-CL, MH
	Pelitic Schist Facies: Schist (Wp) and Saprolite on Schist (Wps)	Quartz-mica schist (Wp), interbedded with metagraywacke and gneiss. Weathering features similar to those of gneiss. Saprolite may be as thick as 150 ft. on interstream uplands. USCS: ML-CL, MH, SC, GM

TABLE 1-2
SUMMARY OF WELL DATA
(Phase II - 1991)

WELL NO.	Elevations (ft MSL) TOC	TPVC	GRND	DTW from TPVC ft.	H2O TABLE ELEV ft MSL	DATE OF H2O LEVELS	WELL STICKUP TPVC (FT)	TOTAL DEPTH	SCREENED INTERVAL	GEOLOGIC UNIT	USCS OF SCREENED INT
SITE 2 - APPLE ORCHARD LANDFILL											
2GW30	298.49	298.32	296.07	6.40	291.92	08/20/91	2.25	17	2-17	Wds/Wd	Sap
2GW31	313.67	313.47	310.51	16.43	297.04	08/20/91	2.96	28	8-28	Wds	Sap
2GW32	304.71	304.56	302.58	6.64	297.92	08/20/91	1.98	20	5-20	Wds	Sap
2GW45	298.05	297.98	296.02	6.89	291.09	08/20/91	1.96	9.5	6.5-9.5	Tug	MH
2GW76	340.80	340.46	340.80	19.39	321.07	08/20/91	-0.34	38	28-38	Wds	Sap
SITE 3 - PISTOL RANGE LANDFILL											
3GW17	222.86	222.75	220.94	8.32	214.43	08/19/91	1.81	25	5-25	Kps/Wds/Wd	Sap
3GW18	221.25	221.09	217.94	8.40	212.85	08/19/91	3.15	20.5	0.5-20.5	Kps/Wds/Wd	GM/Sap
3GW19	219.83	219.73	216.50	8.39	211.34	08/19/91	3.23	23.5	5-23.5	Kps/Wds/Wd	GM/Sap
3GW47	—	213.87	211.86	8.21	205.66	08/19/91	2.01	12.5	5.5-12.5	Kps/Wds	GM
3GW77	210.28	210.15	207.24	8.29	201.86	08/19/91	2.91	8.5	3.5-8.5	Wds	Sap
3GW78S	213.68	213.23	211.63	11.12	202.11	08/19/91	1.60	23.5	8.5-23.5	Wds	Sap
3GW78D	214.45	213.63	212.23	10.75	202.88	08/19/91	1.40	72	33-72	Wd	Rock
SITE 4 - CHEMICAL BURIAL SITE											
4GW10	283.39	283.28	280.29	33.05	250.23	08/19/91	2.99	41.5	21.5-41.5	Kps	GM-SP
4GW11	279.31	279.15	276.53	28.14	251.01	08/19/91	2.62	43.5	23.5-43.5	Kps	GM-SP
4GW11A	277.38	277.15	275.66	8.55	268.60	08/19/91	1.49	8	1-8	Kps	GM-SP
4GW12	287.37	287.26	284.30	39.54	247.72	08/19/91	2.96	52	32-52	Kps	GM-SP
4GW13	297.96	297.85	294.80	51.21	246.64	08/19/91	3.05	69	49-69	Kps	GM-SP
4GW15	292.94	292.81	290.06	43.43	249.38	08/19/91	2.75	60.5	40.5-60.5	Kps	GM-SP
4GW48	—	287.05	285.06	37.57	249.48	08/19/91	1.99	46.4	26-46	Kps	GM-SP
4GW49S	—	292.40	290.84	42.62	249.78	08/19/91	1.56	42.5	37.5-42.5	Kps	GM-SP
4GW49D	—	293.20	291.36	43.46	249.74	08/19/91	1.84	61	51-61	Wds	GM-SP
4GW50	—	306.49	304.63	61.44	245.05	08/19/91	1.86	70	50-70	Kps/Wds	GM-SP
4GW51S	—	303.86	301.67	58.57	245.29	08/19/91	2.19	61	56-61	Wds	GM-SP

TABLE 1-2 (CONTINUED)
SUMMARY OF WELL DATA
(Phase II - 1991)

WELL NO.	Elevations (ft MSL) TOC	TPVC	GRND	DTW from TPVC ft.	H2O TABLE ELEV. ft. MSL	DATE OF H20 LEVELS	WELL STICKUP TPVC (FT)	TOTAL DEPTH	SCREENED INTERVAL	GEOLOGIC UNIT	USCS OF SCREENED INT
SITE 4 CONTINUED											
4GW52	--	296.55	294.91	49.12	247.43	08/19/91	1.64	63	43-63	Kps/Wds	GM-SP
4GW79	303.48	303.34	301.90	58.81	244.53	08/19/91	1.44	77	47-77	Kps	GM-SP
4GW80	298.60	298.50	296.93	53.79	244.71	08/19/91	1.57	76	56-76	Kps	GM-SP
4GW81S	302.56	302.46	299.85	58.10	244.36	08/19/91	2.61	80	60-80	Kps	GM-SP
4GW81D	302.22	301.86	300.77	57.36	244.50	08/19/91	1.09	84	54-84	Kps	GM-SP
4GW82	287.60	287.50	284.80	39.83	247.67	08/19/91	2.70	44.5	34.5-44.5	Kps	GM-SP
4PZ89	302.39	302.28	301.51	57.41	244.87	08/19/91	0.77	84	54-84	Kps	GM-SP
SITE 7 - ORDNANCE BURN AREA											
7GW8	281.56	281.48	278.02	34.51	246.97	08/19/91	3.46	55	35-55	Kps	GM-SP
7PZ42	—	291.09	288.60	48.56	242.53	08/19/91	2.49	60	45-60	Kps/Wds	GM-SP
7GW41	—	292.72	290.69	50.96	241.76	08/19/91	2.03	65.5	55.5-65.5	Kps	GM-SP
7GW43	—	288.88	287.04	46.38	242.50	08/19/91	1.84	55	40-55	Kps/Wds	GM-SP
SITE 8 - ABANDONED CHEMICAL DISPOSAL PIT											
8GW33	286.53	286.36	283.11	38.22	248.14	08/20/91	3.25	55	25-55	Wds	Sap
8GW34	279.60	279.44	277.58	32.70	246.74	08/20/91	1.86	55	25-55	Wds	Sap
8GW35	278.64	278.46	276.13	31.49	246.97	08/20/91	2.33	38.5	8.5-38.5	Wds	Sap
8GW36	279.14	278.97	276.62	30.86	248.11	08/20/91	2.35	44	14-44	Wds	Sap
8GW53	282.78	282.26	282.78	32.20	250.06	08/20/91	-0.52	37.5	27.5-37.5	Wds/Wd	Sap
SITE 9 - INDUSTRIAL WASTEWATER DISPOSAL AREA 300											
9GW1	206.58	206.47	204.09	16.62	189.85	08/20/91	2.38	34	14-34	Wds	Sap
9GW2	196.80	196.73	193.88	9.10	187.63	08/20/91	2.85	26.5	6.5-26.5	Wds	Sap
9GW3	222.09	221.94	218.85	11.34	210.60	08/20/91	3.09	25	15-25	Wds	Sap
9GW4	249.90	249.73	246.68	16.36	233.37	08/20/91	3.05	24.5	14.5-24.5	Kps	GM-SP
9GW5	296.95	296.91	293.52	55.15	241.76	08/20/91	3.39	58	43-58	Kps	GM-SP

TABLE 1-2 (CONTINUED)
SUMMARY OF WELL DATA
(Phase II - 1991)

WELL NO.	Elevations (ft MSL)			DTW from TPVC ft.	H2O TABLE ELEV ft MSL	DATE OF H20 LEVELS	WELL STICKUP TPVC (FT)	TOTAL DEPTH	SCREENED INTERVAL	GEOLOGIC UNIT	USCS OF SCREENED INT.
	TOC	TPVC	GRND								
SITE 9 CONTINUED											
9GW6	289.97	289.88	286.50	50.20	239.68	08/20/91	3.38	60	40-60	Kps	GM-SP
9GW7	298.20	297.97	294.89	55.74	242.23	08/20/91	3.08	60	40-60	Kps	GM-SP
9PZ44	275.66	275.62	273.65	39.87	235.75	08/20/91	1.97	67	34.5-40.5	Kps	SM
9PZ55	262.05	261.92	260.04	36.99	224.93	08/20/91	1.88	42.5	32.5-42.5	Kps/Wds	SP
9PZ56	—	245.82	244.21	14.02(dry)	--	08/20/91	1.61	35.8	7-12	Wds	G\Sap
9GW57S	—	201.16	199.22	12.15	189.01	08/20/91	1.94	16	9-14	Kps	SP
9GW57D	—	200.38	198.18	14.82	185.56	08/20/91	2.20	31.5	25-30	Wds	Sap
9GW58	281.85	281.90	280.02	43.54	238.36	08/20/91	1.88	51.4	34.5-49.5	Kps/Wds	GP
9GW59	—	231.47	230.06	10.79	220.68	08/20/91	1.41	24	8-18	Kps	GM
9GW74	—	200.13	198.02	13.92	186.21	08/20/91	2.11	27	10.25-25.25	Wds	SM?
9GW75	—	244.44	242.33	12.27	232.17	08/20/91	2.11	21	11-21	Kps	GM
9GW83	162.50	162.40	160.10	9.86	152.54	08/20/91	2.30	10	5-10	Wds	Sap
SITE 11 - INDUSTRIAL WASTEWATER DISPOSAL AREA 100											
11GW22	371.45	371.31	368.40	28.49	342.82	08/20/91	2.91	40	20-40	Tug/Wds	GP/Sap
11GW23	372.67	372.51	369.70	30.88	341.63	08/20/91	2.81	45	20-45	Wds	Sap
11GW24	363.62	363.39	360.83	21.08	342.31	08/20/91	2.56	30	10-30	Wds	Sap
11GW25	358.66	358.48	355.15	21.84	336.64	08/20/91	3.33	30.5	10.5-30.5	Wds	Sap
11GW26	355.48	355.32	353.57	18.76	336.56	08/20/91	1.75	30	10-30	Wds	Sap
11GW27	356.34	356.20	353.20	18.55	337.65	08/20/91	3.00	29	9-29	Wds	Sap
11GW28	349.28	349.19	346.33	18.73	330.46	08/20/91	2.86	40	20-40	Wds	Sap
11GW29	332.42	332.27	329.29	13.76	318.51	08/20/91	2.98	19	9-19	Wds	Sap
11PZ62	—	338.02	336.01	5.23	332.79	08/20/91	2.01	18	7-15	Wds/Wps	Sap
11PZ63	—	377.79	375.64	20.14	357.65	08/20/91	2.15	30	10-30	Wds/Wps	Cl/Sap
11PZ64	360.06	360.10	358.55	27.95	332.15	08/20/91	1.55	45	30-40	Wds	Sap

TABLE 1–2 (CONTINUED)
SUMMARY OF WELL DATA
(Phase II – 1991)

WELL NO.	Elevations (ft MSL) TOC	TPVC	GRND	DTW from TPVC ft.	H2O TABLE ELEV.ft.MSL	DATE OF H20 LEVELS	WELL STICKUP TPVC (FT)	TOTAL DEPTH	SCREENED INTERVAL	GEOLOGIC UNIT	USCS OF SCREENED INT
SITE 11 CONTINUED											
11PZ65	372.10	372.08	370.64	21.66	350.42	08/20/91	1.44	40.8	30–40	Wps	Sap
11GW66	--	348.43	346.38	14.60	333.83	08/20/91	2.05	25	9–24	Wds	Sap
11GW67	--	348.09	346.25	12.88	335.21	08/20/91	1.84	19	14–19	Wds	Sap
11GW68	--	348.20	346.24	18.74	329.46	08/20/91	1.96	23.3	11–21	Wds	SM\Sap
11GW69	367.20	367.41	366.54	27.56	339.85	08/20/91	0.87	31	16–31	Wds	Sap
11GW70D	--	354.13	352.02	35.60	318.53	08/20/91	2.11	60	40–60	Wds/Wd	Sap
11GW71	--	352.13	349.94	13.90	338.23	08/20/91	2.19	25.25	10.25–25.25	Wds	Sap
11GW72	--	351.46	349.21	22.25	329.21	08/20/91	2.25	31	23–28	Wds	Sap
11GW73	--	342.89	340.27	21.40	321.49	08/20/91	2.62	32	23.5–28.5	Wds	Sap
11GW84	350.88	350.79	348.04	17.92	332.87	08/20/91	2.75	29	19–29	Wds	Sap
11GW85	346.41	346.32	343.52	17.70	328.62	08/20/91	2.80	40	25–40	Wds	Sap
11GW86	365.42	365.23	362.50	32.63	332.60	08/20/91	2.73	30	20–30	Wds	Sap
11GW87	343.25	342.94	341.64	16.74	326.20	08/20/91	1.30	56	36–56	Wds	Sap
11GW88	361.91	361.53	361.91	18.59	342.94	08/20/91	–0.38	35	25–35	Wds	Sap
BACKGROUND WELLS											
BGW16	310.07	309.97	307.40	54.24	255.83	08/20/91	2.57	66	46–66	Kps	GP/GM
BGW40	396.89	396.69	393.88	21.82	375.07	08/20/91	2.81	30	10–30	Wds	Sap

NOTES: Tug – Upland Sand and Gravel
Kps, Kpe – Potomac Group (Kps – Sand facies/Kpc – Clay facies)
Wd, Wds – Wissahickon Formation (Wd – gneiss/Wds – saprolite on gneiss)
Wp, Wps – Wissahickon Formation (Wp – schist/Wps – saprolite on schist)
Sap – Saprolite
GM – Silty gravels, gravel–sand–silt mixtures
SP – Poorly graded sands and gravelly sands
GP – Poorly graded gravels (little or no fines)
SM – Silty sands
Cl – Sandy clay, inorganic clays (medium plasticity)
TOC – Top of Casing
TPVC – Top of Cap
GRND – Grade Elevation

TABLE 1-3
SUMMARY OF WELL TEST DATA

Site No.	AQUIFER SLUG TEST [a]			CONSTANT RATE PUMPING TEST			
	Well No.	Average Hydraulic Conductivity (K)[b]		Well No.	Average Transmissivity (T)[b]		Storativity (S)
		(cm/sec)	(gpd/ft²)		(cm²/sec)	(gpd/ft)	
SITE 2	2GW32[c] 2GW32 2GW45	0.00235	48.9				
SITE 3	3GW47 3GW78S	0.00128	26.6				
SITE 4	4GW10 4GW12 4GW13 4GW48 4GW50 4GW52 4GW80	0.00094	18.4	4GW81D[d]	0.06	4230	0.001
				4GW81D[e]	0.06	3900	0.002
				4GW79[e]	0.11	7700	0.003
SITE 7	7GW41 7GW43	0.00167	34.6				
SITE 8	8GW35 8GW53[g]	0.00228	47.3				
SITE 9	9GW1 9GW2 9GW7 9PZ55 9GW57D 9GW57S[g] 9GW58 9GW59 9GW74 9GW75	0.00069	14.4				
SITE 11	11GW22 11GW23 11GW24 11GW27 11GW28 11GW29 11PZ63 11GW66 11GW67 11GW68 11GW69 11GW70D 11GW71	0.00196	40.6		Average Hydraulic Conductivity (K)		
					(cm/sec)	(gpd/ft²)	
				11GW87[a, f]	0.0000462	0.98	

TABLE 1-4
ESTIMATED GROUNDWATER FLOW VELOCITY

Site No.	Based on Pumping Test Results From:	Hydraulic Conductivity* (cm/sec)	Groundwater Gradient*	Effective Porosity**	Groundwater Velocity*** (cm/sec)	Groundwater Velocity*** (gpd/sq ft)
Site 2	11GW87	4.62E-05	0.04	0.261	7.00E-06	0.15
Site 3	11GW87	4.62E-05	0.04	0.261	6.21E-06	0.13
Site 4	4GW81D *	6.78E-03	0.01	0.413	2.29E-04	4.86
	4GW79	1.30E-02	0.01	0.399	3.25E-04	6.89
Site 7	4GW81D *	6.78E-03	0.01	0.413	2.05E-04	4.35
	4GW79	1.30E-02	0.01	0.399	4.06E-04	8.62
Site 8	4GW81D *	6.78E-03	0.03	0.413	4.43E-04	9.40
	4GW79	1.30E-02	0.03	0.399	8.78E-04	18.61
Site 9	4GW81D *	6.78E-03	0.03	0.413	4.71E-04	9.98
	4GW79	1.30E-02	0.03	0.399	9.33E-04	19.77
	11GW87	7.00E-05	0.03	0.260	8.01E-06	0.17
Site 11	11GW87	4.62E-05	0.02	0.261	3.82E-06	0.08

NOTES: * Values based on Geometric Mean (GM)

** Based on field capacity - wilting point (from HELP Model, 1983)

*** Darcy velocity using the effective porosity (Bower, 1978)

$$v = (K*dH/dL)/Pe$$

Where:

v = velocity of groundwater
K = hydraulic conductivity
dH/dL = groundwater gradient
Pe = effective porosity

Notes:

a.) Analysis after Bower and Rice (1976) and Bower (1989) for slug tests.

$$K = r_c^2 \frac{\ln(R_e/r_w)}{2L_e} \quad \frac{1}{t}\ln\frac{y_0}{y_t}$$

Where:

- K = Hydraulic conductivity (cm/sec)
- r_c = Well casing radius (cm)
- R_e = Effective radial distance over which Y is dissipated
- L_e = Screen length (cm)
- y_t = Water level at time t from start of test (cm)
- y_0 = Water level at time 0 of the test (cm)
- t = Time at y_t (sec)

b.) Geometric mean.

c.) Falling head test, all other wells tested using Rising head test method.

d.) Analysis from Driscoll (1988) using Time-Drawdown Graphs.

$$T = \frac{264Q}{b} \quad S = \frac{0.3T \cdot t_0}{r^2}$$

e.) Analysis from Driscoll (1988) using Distance-Drawdown Graphs.

$$T = \frac{528Q}{b} \quad S = \frac{0.3T \cdot t}{r_0^2}$$

Where:

- T = Coefficient of transmissivity (gpd/ft)
- Q = Pumping rate (gpm)
- b = Change in drawdown between any two times whose ratio is 10 (one log cycle)
- S = Storage coefficient
- t = Time since pumping started (days)
- t_0 = Intercept of extrapolated line at zero drawdown (days)
- r = Distance from pumped well to observation well (ft)
- r_0 = Intercept of extrapolated line at zero drawdown (ft)

f.) Analysis based on rate of well recovery.

g.) Data recorded during the slug test could not be used to calculate K.

TABLE 1-5
SUMMARY OF RI INVESTIGATION TASKS

SITE	PHASE	MEDIA				
		SURFACE WATER	STREAM SEDIMENT	SOIL	GROUNDWATER	ECOLOGICAL
2	I	Collect 6 samples	Collect 10 samples	1 soil boring Soil gas survey 2 surface soil samples	Install 1 well Sample 4 wells	Not evaluated
	II	Collect 6 samples	Collect 10 samples	7 soil borings Collect 25 surface samples	Install 1 well Sample 5 wells Grain size analysis Conduct 2 slug tests	Collect 3 fish samples Collect 3 benthic samples Survey of vegetation species Survey of mammal species
3	I	Collect 4 samples	Collect 4 samples	Soil gas survey 1 soil boring Collect 2 soil samples	Install 1 well Sample 4 wells	Not evaluated
	II	Not sampled	Collect 4 samples	3 soil borings Collect 2 soil samples	Install 3 wells Sample 7 monitoring wells Conduct 3 slug tests Grain size analysis	Collect 2 fish samples Collect 2 benthic samples Survey of vegetation species Survey of mammal species
4	I	Not applicable	Not applicable	6 soil borings GPR survey Soil gas survey	Install 6 groundwater wells Sample 12 monitoring wells	Not evaluated
	II	Not applicable	Not applicable	5 soil borings Collect 2 soil samples	Install 5 wells Sample 17 monitoring wells Conduct 7 slug tests Conduct 2 pump tests Grain size analysis	Survey of vegetation species Survey of mammal species
7	I	Not applicable	Not applicable	Collect 27 soil samples 3 soil borings	Install 2 monitoring wells Sample 3 monitoring wells Install one piezometer	Not evaluated
	II	Not applicable	Not applicable	Collect 6 subsurface soil samples from two borings	Sample 3 monitoring wells Conduct 2 slug tests Grain size analysis Hydraulic conductivity	Survey of vegetation species Survey of mammal species
8	I	Not applicable	Not applicable	GPR survey Collect 2 soil samples 1 soil boring	Install 1 monitoring well Samples 5 GW wells Determine gradient and flow conditions	Not evaluated
	II	Not applicable	Not applicable	None	Sample 5 GW wells Conduct 1 Slug test Grain size analysis	Survey of vegetation species Survey of mammal species
9	I	Collect 3 samples	Collect 10 samples	Soil gas survey 9 soil borings	Install 6 monitoring wells Install 3 piezometers Sample 13 wells	Not evaluated
	II	Collect 3 samples	Collect 10 samples	1 soil boring	Install 1 monitoring well sample 14 wells Conduct 10 slug tests Grain size analysis	Survey of mammal species Survey of vegetation species Collect 3 fish samples Collect 3 benthic samples
11	I	Collect 2 samples	Collect 3 samples	Soil gas survey Collect 2 soil samples 12 soil borings 3 soil gas surveys	Install 8 monitoring wells Install 4 piezometers Sample 16 MW	Not evaluated
	II	Collect 2 samples	Collect 3 samples	5 soil borings	Abandon 3 wells (20,21,70s) Install 5 wells Sample 21 wells Conduct 13 slug tests Grain size analysis Conduct pump test	Survey of mammal species Survey of vegetation species Collect 3 fish samples Collect 3 benthic samples
Paint Branch Creek	I	Collect 3 samples	Collect 3 samples	Not applicable	Not applicable	Not evaluated
	II	Collect 3 samples	Collect 3 samples	Not applicable	Not applicable	Survey of vegetation species Survey of mammal species Collect 3 benthic samples Collect 3 fish samples
Background MW	I	Not applicable	Not applicable	Not applicable	Sample 2 wells	Not evaluated
	II	Not applicable	Not applicable	Not applicable	Samples 2 wells	Not evaluated

TABLE 1-6
GEOLOGIC INVESTIGATION SUMMARY
(Phase I - 1989)
(Phase II - 1991)

Site Number	Borehole Number	Sampling Interval (ft)	Date Drilled	Well Number	Date Installed
2	2GW45	0-2 5-6.5	9-21-89	2GW45	9-21-89
	2GW76	Continuous to 32 35-37	4-9-91	2GW76	4-9-91
3	3GW47	@5' to TD	9-18-89	3GW47	9-18-89
	3GW77	Continuous to 8.5	4-10-91	3GW77	4-10-91
	3GW78S	Continuous to 24	4-12-91	3GW78S	4-12-91
	3GW78D	None	4-10 to	3GW78D	4-12-91
4	4GW48	Continuous to 42	9-20-89	NA	—
	4GW48A	10-14 28-30 42-43 44-44.8 46-46.4	9-20-89	4GW48	9-21-89
	4GW49D	Continuous to 61	9-21 to 9-26-89	4GW49D	9-26-89
	4GW49S	None	9-26 to 9-27-89	4GW49S	9-27-89
	4GW50	@5' to 72	9-21 to 9-25-89	4GW50	9-26-89
	4GW51S	Continuous to 67	9-27 to 9-29-89	4GW51S	9-29-89
	4GW52	@5' to 63	9-26-89	4GW52	9-27-89
	4GW79	None	7-30 to 8-1-91	4GW79	8-2-91
	4GW80	Continuous to 74	4-15 to 4-16-91	4GW80	4-17-91
	4GW81D	None	NA	4GW81D	4-29-91
	4GW81S	Continuous to 42 @5' to 82	4-18-91	4GW81S	4-19-91
	4GW82	Continuous to 56 60-62 65-67	4-10-91	4GW82	4-11-91
	4PZ89	Continuous to 70 75-77 80-82	4-22-91	4PZ89	4-30-91
7	7GW41	@5' to 67.5	9-12-89	7GW41	9-18-89
	7PZ42	@5' to 62	9-27-89	7PZ42	9-28-89
	7GW43	@5' to 57	9-29 to 10-2-89	7GW43	10-3-89
	7SB28	4-6 9-11 14-16	4-19-91	NA	NA
	7SB29	4-6 9-11 14-16	4-19-91	NA	NA

TABLE 1-6 (CONTINUED)
GEOLOGIC INVESTIGATION SUMMARY
(Phase I - 1989)
(Phase II - 1991)

Site Number	Borehole Number	Sampling Interval (ft)	Date Drilled	Well Number	Date Installed
8	8GW53	@5' to 36.5	9-28-89	8GW53	9-29-89
9	9PZ44	@5' to 65.3	9-13 to 9-15-89	9PZ44	9-15-89
	9PZ55	@5' to 42	10-4-89	9PZ55	10-4-89
	9PZ56	@5' to 35	10-3-89	9PZ56	10-4-89
	9GW57S	None	10-11-89	9GW57S	10-11-89
	9GW57D	Continuous to 16 @5' to 30.5	10-10-89	9GW57D	10-11-89
	9GW58	@5' to 51.4	10-6-89	9GW58	10-9-89
	9GW59	@5' to 24	10-10-89	9GW59	10-10-89
	9GW74	Continuous to 27	10-18-89	9GW74	10-18-89
	9GW75	None	10-19-89	9GW75	10-19-89
	9GW83	Continuous to 12	4-18-91	9GW83	4-18-91
11	11PZ62	Continuous to 18	10-4 to 10-5-89	11PZ62	10-5-89
	11PZ63	@5' to 30	10-5-89	11PZ63	10-5-89
	11PZ64	@5' to 45	10-4-89	11PZ64	10-5-89
	11PZ65	@5' to 41	10-5-89	11PZ65	10-13-89
	11GW66	@5' to 25	10-11-89	11GW66	10-11-89
	11GW67	@5' to 17	10-12-89	11GW67	10-12-89
	11GW68	Continuous to 10 @5' to 23	10-12-89	11GW68	10-12-89
	11GW69	@5' to 30	10-12-89	11GW69	10-12-89
	11GW70D	Continuous to 20 @5' to 61	10-13-89	11GW70D	10-20-89
	11GW71	@5' to 25	10-11 to 10-12-89	11GW71	10-12-89
	11GW72	@5' to 30	10-13-89	11GW72	10-13-89
	11GW73	Continuous to 22 @10' to 32	10-13-89	11GW73	10-13-89
	11GW84	@5' to 20 Continuous to 28	4-24-91	11GW84	4-24-91
	11GW85	@5' to 15 Continuous to 40	4-29 to 4-30-91	11GW85	4-30-91
	11GW86	@5' to 15 Continuous to 32	4-29-91	11GW86	4-29-91
	11GW87	Continuous to 36	4-23-91	11GW87	4-30 to
	11GW88	Continuous to 28 31-33	4-18-91	11GW88	4-18-91

TABLE 1-7 (1991)
SUMMARY OF WELL DEVELOPMENT AND SAMPLING

SITE NUMBER	WELL NUMBER	DATE DEVELOPED	PHASE I - 1989		PHASE II - 1991	
			DATE PURGED	DATE SAMPLED	DATE PURGED	DATE SAMPLED
BACKGROUND WELLS	BGW16	---	10-23-89	10-23-89	4-24-91	4-24-91
	BGW40	---	10-27-89	10-27-89	4-25-91	4-25-91
2	2GW30	---	10-26-89	10-26-89	4-16-91	4-16-91
	2GW31	---	10-26-89	10-26-89	4-15-91	4-15-91
	2GW32	---	10-26-89	10-26-89	4-10-91	4-10-91
	2GW45	10-25-89	10-26-89	10-26-89	4-16-91	4-16-91
	2GW76	4-29-91	---	---	5-30-91	5-30-91
3	3GW17	---	10-24-89	10-24-89	4-22-91	4-22-91
	3GW18	---	10-24-89	10-24-89	4-22-91	4-22-91
	3GW19	---	10-24-89	10-24-89	4-22-91	4-22-91
	3GW47	10-18-89	10-24-89	10-24-89	4-23-91	4-23-91
	3GW77	4-26-91	---	---	5-30-91	5-30-91
	3GW78D	5-6-91	---	---	6-7-91	6-7-91
	3GW78S	4-26-91	---	---	5-30-91	5-30-91
4	4GW10	---	10-16-89	10-16-89	5-21-91	5-21-91
	4GW11	---	10-16-89	10-16-89	5-21-91	5-21-91
	4GW11A	---	10-23-89	10-23-89	5-29-91	5-29-91
	4GW12	---	10-16-89	10-16-89	5-23-91	5-23-91
	4GW13	---	10-16-89	10-16-89	5-28-91	5-28-91
	4GW15	---	10-16-89	10-16-89	5-29-91	5-29-91
	4GW48	10-15-89	10-18-89	10-18-89	5-30-91	5-30-91
	4GW49S	10-15-89	10-23-89	10-23-89	5-22-91	5-22-91
	4GW49D	10-12-89	10-17-89	10-17-89	5-22-91	5-22-91
	4GW50	10-12-89	10-16-89	10-16-89	5-29-91	5-29-91
	4GW51S	10-16-89	10-17-89	10-17-89	5-29-91	5-29-91
	4GW52	10-15-89	10-17-89	10-17-89	5-22-91	5-22-91
	4GW79	5-3-91	---	---	6-7-91	6-7-91
	4GW80	4-25-91	---	---	6-5-91	6-5-91
	4GW81D	4-25-91	---	---	6-6-91	6-6-91
	4GW81S	4-24-91	---	---	6-5-91	6-5-91
	4GW82	4-25-91	---	---	6-6-91	6-6-91
7	7GW8	---	10-23-89	10-23-89	4-25-91	4-25-91
	7GW41	10-11-89	10-23-89	10-23-89	4-25-91	4-25-91
	7PZ42	---	---	---	---	---
	7GW43	10-11-89	10-23-89	10-23-89	4-25-91	4-25-91

TABLE 1-7 (1991) (cont)
SUMMARY OF WELL DEVELOPMENT AND SAMPLING

SITE NUMBER	WELL NUMBER	DATE DEVELOPED	PHASE I - 1989		PHASE II - 1991	
			DATE PURGED	DATE SAMPLED	DATE PURGED	DATE SAMPLED
8	8GW33	---	10-25-89	10-25-89	4-26-91	4-26-91
	8GW34	---	10-25-89	10-25-89	4-29-91	4-29-91
	8GW35	---	10-25-89	10-25-89	4-30-91	4-30-91
	8GW36	---	10-25-89	10-25-89	4-30-91	4-30-91
	8GW53	10-23-89	10-25-89	10-25-89	4-29-91	4-29-91
9	9GW1	---	10-24-89	10-24-89	5-8-91	5-8-91
	9GW2	---	10-23-89	10-23-89	5-8-91	5-8-91
	9GW3	---	10-23-89	10-23-89	5-8-91	5-8-91
	9GW4	---	10-24-89	10-24-89	5-8-91	5-8-91
	9GW5	---	10-24-89	10-24-89	5-7-91	5-7-91
	9GW6	---	10-24-89	10-24-89	5-7-91	5-7-91
	9GW7	---	10-24-89	10-24-89	5-7-91	5-7-91
	9PZ44	---	---	---	---	---
	9PZ55	---	---	---	---	---
	9PZ56	---	---	---	---	---
	9GW57S	10-16-89	10-24-89	10-24-89	5-8-91	5-8-91
	9GW57D	10-16-89	10-24-89	10-24-89	5-8-91	5-8-91
	9GW58	10-16-89	10-24-89	10-24-89	---	well obstructed
	9GW59	10-23-89	10-24-89	10-24-89	5-7-91	5-7-91
	9GW74	10-23-89	10-24-89	10-24-89	5-7-91	5-7-91
	9GW75	10-23-89	10-24-89	10-24-89	5-7-91	5-7-91
	9GW83	5-22-91	---	---		
11	11GW22	---	10-25-89	10-25-89	5-3-91	5-3-91
	11GW23	---	10-25-89	10-25-89	5-2-91	5-2-91
	11GW24	---	10-27-89	10-27-89	5-2-91	5-2-91
	11GW25	---	10-27-89	10-27-89	5-2-91	5-2-91
	11GW26	---	10-25-89	10-25-89	5-2-91	5-2-91
	11GW27	---	10-25-89	10-25-89	5-2-91	5-2-91
	11GW28	---	10-25-89	10-25-89	5-3-91	5-3-91
	11GW29	---	10-25-89	10-25-89	5-2-91	5-2-91
	11PZ62	---	---	---	---	---
	11PZ63	---	---	---	---	---
	11PZ64	---	---	---	---	---
	11PZ65	---	---	---	---	---
	11GW66	10-24-89	10-26-89	10-26-89	5-2-91	5-2-91
	11GW67	10-26-89	10-27-89	10-27-89	5-1-91	5-1-91
	11GW68	10-25-89	10-27-89	10-27-89	4-30-91	4-30-91
	11GW69	10-20-89	10-27-89	10-27-89	5-1-91	5-1-91

TABLE 1-7 (1991) (cont)
SUMMARY OF WELL DEVELOPMENT AND SAMPLING

SITE NUMBER	WELL NUMBER	DATE DEVELOPED	PHASE I - 1989		PHASE II - 1991	
			DATE PURGED	DATE SAMPLED	DATE PURGED	DATE SAMPLED
11 (cont)	11GW70D	10-24-89	10-26-89	10-26-89	5-1-91	5-1-91
	11GW71	10-24-89	10-26-89	10-26-89	5-1-91	5-1-91
	11GW72	10-25-89	10-26-89	10-26-89	5-1-91	5-1-91
	11GW73	10-26-89	10-27-89	10-27-89	5-1-91	5-1-91
	11GW84	4-26-91	---	---	5-30-91	5-30-91
	11GW85	5-3-91	---	---	6-5-91	6-5-91
	11GW86	5-2-91	---	---	5-30-91	5-30-91
	11GW87	5-6-91	---	---	6-7-91	6-7-91
	11GW88	5-2-91	---	---	6-5-91	6-5-91

NOTES: (1) GW - Ground water monitoring well
(2) PZ - Piezometer
(3) Only newly installed wells were developed.
(4) Piezometers were not included in sampling event.

TABLE 1-8 (1991)
SUMMARY OF WATER TABLE ELEVATION DATA

WELL NO.	Elevations (ft MSL)			TOTAL DEPTH	SCREENED INTERVAL	H2O TABLE ELEV. (ft MSL)		
	TOC	TPVC	GRND			7/3/86	'90	'91
SITE 2 – APPLE ORCHARD LANDFILL								
2GW30	298.49	298.32	296.07	17.0	2.0 – 17.0	293.1	292.90	291.92
2GW31	313.67	313.47	310.51	28.0	8.0 – 28.0	300.6	299.51	297.04
2GW32	304.71	304.56	302.58	20.0	5.0 – 20.0	298.5	298.66	297.92
2GW45	298.05	297.98	296.02	9.5	6.5 – 9.5	*	293.90	291.09
2GW76	340.80	340.46	340.80	38.0	18.0 – 38.0	**	**	321.07
SITE 3 – PISTOL RANGE LANDFILL								
3GW17	222.86	222.75	220.94	25.0	5.0 – 25.0	215.3	216.61	214.43
3GW18	221.25	221.09	217.94	20.5	0.5 – 20.5	214.1	215.02	212.85
3GW19	219.83	219.73	216.50	23.5	5.0 – 23.5	212.3	212.75	211.34
3GW47	—	213.87	211.86	12.5	5.5 – 12.5	*	206.04	205.66
3GW77	210.28	210.15	207.24	8.5	3.5 – 8.5	**	**	201.86
3GW78S	213.68	213.23	211.63	23.5	8.5 – 23.5	**	**	202.11
3GW78D	214.45	213.63	212.23	72.0	32.0 – 72.0	**	**	202.88
SITE 4 – CHEMICAL BURIAL SITE								
4GW10	283.39	383.28	280.29	41.5	21.5 – 41.5	249.9	253.08	250.23
4GW11	279.31	279.15	276.53	43.5	23.5 – 43.5	249.8	253.20	251.01
4GW11A	277.38	277.15	275.66	8.0	1.0 – 8.0		PERCHED	268.60
4GW12	287.37	287.26	284.3	52.0	32.0 – 52.0	245.5	249.97	247.72
4GW13	297.96	297.85	294.80	69.0	49.0 – 69.0	244	248.72	246.64
4GW15	292.94	292.81	290.06	60.5	40.5 – 60.5	246.2	250.81	249.38
4GW48	—	287.05	285.06	46.4	26.0 – 46.0	*	253.22	249.48
4GW49S	—	292.40	290.84	42.5	37.5 – 42.5	*	250.07	249.78
4GW49D	—	293.20	291.36	61.0	51.0 – 61.0	*	251.45	249.74
4GW50	—	306.49	304.63	70.0	50.0 – 70.0	*	258.32	245.05
4GW51S	—	303.86	301.67	61.0	56.0 – 61.0	*	247.28	245.29
4GW52	—	296.55	294.91	63.0	43.0 – 63.0	*	235.72	247.43
4GW79	303.48	303.34	301.90	77.0	47.0 – 77.0	**	**	244.53
4GW80	298.60	298.50	296.93	76.0	56.0 – 76.0	**	**	244.71
4GW81S	302.56	302.46	299.85	80.0	60.0 – 80.0	**	**	244.36
4GW81D	302.22	301.86	300.77	84.0	54.0 – 84.0	**	**	244.50
4GW82	287.60	287.50	284.80	44.5	34.5 – 44.5	**	**	247.67
4PZ89	302.39	302.28	301.51	84.0	54.0 – 84.0	**	**	244.87
SITE 7 – ORDNANCE BURN AREA								
7GW8	281.56	—	278.02	55.0	35.0 – 55.0	242.5	246.48	246.97

TABLE 1-8 (1991) (cont)
SUMMARY OF WATER TABLE ELEVATION DATA

WELL NO.	Elevations (ft MSL)			TOTAL DEPTH	SCREENED INTERVAL	H2O TABLE ELEV. (ft MSL)		
	TOC	TPVC	GRND			7/3/86	'90	'91
SITE 7 CONTINUED								
7PZ42	—	291.09	288.60	60.0	45.0 - 60.0	*	243.09	242.53
7GW41	—	292.72	290.69	65.5	55.5 - 65.5	*	242.47	241.76
7GW43	—	288.88	287.04	55.0	40.0 - 55.0	*	243.05	242.50
SITE 8 - ABANDONED CHEMICAL DISPOSAL PIT								
8GW33	286.53	286.36	283.11	55.0	25.0 - 55.0	248.7	249.36	248.14
8GW34	279.60	279.44	277.58	55.0	25.0 - 55.0	247.1	223.58	246.74
8GW35	278.64	278.46	276.13	38.5	8.5 - 38.5	249.5	249.75	246.97
8GW36	279.14	278.97	276.62	44.0	14.0 - 44.0	249.6	250.04	248.11
8GW53	282.78	282.26	282.78	37.5	27.5 - 37.5	*	250.93	250.06
SITE 9 - INDUSTRIAL WASTEWATER DISPOSAL AREA 300								
9GW1	206.58	206.47	204.09	34.0	14.0 - 34.0	191.8	191.17	189.85
9GW2	196.80	196.73	193.88	26.5	6.5 - 26.5	188.3	188.42	187.63
9GW3	222.09	221.94	218.85	25.0	15.0 - 25.0	211.3	210.77	210.60
9GW4	249.90	249.73	246.68	24.5	14.5 - 24.5	233.4	235.93	233.37
9GW5	296.95	296.91	293.52	58.0	43.0 - 58.0	238.4	242.35	241.76
9GW6	289.97	289.88	286.50	60.0	40.0 - 60.0	237.3	241.17	239.68
9GW7	298.20	297.97	294.89	60.0	40.0 - 60.0	239.2	243.06	242.23
9PZ44	275.66	275.62	273.65	67.0	34.5 - 40.5	*	236.79	235.75
9PZ55	262.05	261.92	260.04	42.5	32.5 - 42.5	*	227.50	224.93
9PZ56	—	245.82	244.21	35.8	7.0 - 12.0	*	233.99	—
9GW57S	—	201.16	199.22	16.0	9.0 - 14.0	*	190.41	189.01
9GW57D	—	200.38	198.18	31.5	25.0 - 30.0	*	185.30	185.56
9GW58	281.85	281.90	280.02	51.4	34.5 - 49.5	*	239.40	238.36
9GW59	—	231.47	230.06	24.0	8.0 - 18.0	*	223.89	220.68
9GW74	—	200.13	198.02	27.0	10.25 - 25.25	*	192.38	186.21
9GW75	—	244.44	242.33	21.0	11.0 - 21.0	*	234.02	232.17
9GW83	162.50	162.40	160.10	10.0	5.0 - 10.0	**	**	152.54
SITE 11 - INDUSTRIAL WASTEWATER DISPOSAL AREA 100								
11GW22	371.45	371.31	368.40	40.0	20.0 - 40.0	343.2	346.49	342.82
11GW23	372.67	372.51	369.70	45.0	20.0 - 45.0	342	344.74	341.63
11GW24	363.62	363.39	360.83	30.0	10.0 - 30.0	340.4	341.24	342.31
11GW25	358.66	358.48	355.15	30.5	10.5 - 30.5	337.6	339.48	336.64
11GW26	355.48	355.32	353.57	30.0	10.0 - 30.0	338.6	340.45	336.56

TABLE 1-8 (1991) (cont)
SUMMARY OF WATER TABLE ELEVATION DATA

WELL NO.	Elevations (ft MSL)			TOTAL DEPTH	SCREENED INTERVAL	H2O TABLE ELEV. (ft MSL)		
	TOC	TPVC	GRND			7/3/86	'90	'91
SITE 11 CONTINUED								
11GW27	356.34	356.20	353.20	29.0	9.0 - 29.0	339.6	341.28	337.65
11GW28	349.28	349.19	346.33	40.0	20.0 - 40.0	331.7	333.25	330.46
11GW29	332.42	332.27	329.29	19.0	9.0 - 19.0	318.6	319.13	318.51
11PZ62	—	338.02	336.01	18.0	7.0 - 15.0	*	335.02	332.79
11PZ63	—	377.79	375.64	30.0	10.0 - 30.0	*	365.79	357.65
11PZ64	360.06	360.10	358.55	45.0	30.0 - 40.0	*	334.40	332.15
11PZ65	372.10	372.08	370.64	40.8	30.0 - 40.0	*	—	350.42
11GW66	—	348.43	346.38	25.0	9.0 - 24.0	*	340.01	333.83
11GW67	—	348.09	346.25	19.0	14.0 - 19.0	*	337.42	335.21
11GW68	—	348.20	346.24	23.3	11.0 - 21.0	*	333.91	329.46
11GW69	367.20	367.41	366.54	31.0	16.0 - 31.0	*	342.08	339.85
11GW70D	—	354.13	352.02	60.0	40.0 - 60.0	*	320.30	318.53
11GW71	—	352.13	349.94	25.25	10.25 - 25.25	*	340.46	338.23
11GW72	—	351.46	349.21	31.0	23.0 - 28.0	*	333.21	329.21
11GW73	—	342.89	340.27	32.0	23.5 - 28.5	*	326.89	321.49
11GW84	350.88	350.79	348.04	29.0	19.0 - 29.0	**	**	332.87
11GW85	346.41	346.32	343.52	40.0	25.0 - 40.0	**	**	328.62
11GW86	365.42	365.23	362.50	30.0	20.0 - 30.0	**	**	332.60
11GW87	343.25	342.94	341.64	56.0	36.0 - 56.0	**	**	326.20
11GW88	361.91	361.53	361.91	35.0	25.0 - 35.0	**	**	342.94
BACKGROUND WELLS								
BGW16	310.07	309.97	307.40	66.0	46.0 - 66.0	252.6	256.90	255.83
BGW40	396.89	369.69	393.88	30.0	10.0 - 30.0	376.8	378.88	375.07

NOTES: Tug - Upland Sand and Gravel
Kps, Kpe - Potomac Group (Kps - Sand facies/Kpc - Clay facies)
Wd, Wds - Wissahickon Formation (Wd - gneiss/Wds - saprolite on gneiss)
Wp, Wps - Wissahickon Formation (Wp - schist/Wps - saprolite on schist)
Sap - Saprolite
GM - Silty gravels, gravel-sand-silt mixtures
SP - Poorly graded sands and gravelly sands
GP - Poorly graded gravels (little or no fines)
SM - Silty sands
Cl - Sandy clay, inorganic clays (medium plasticity)

* - well installed during Phase I.
** - well installed during Phase II.

TABLE 1-9

ANALYTICAL METHODS AND DETECTION LIMITS (PHASE I - 1989)

Analyte	Methodology		Detection Limits	
	Water	Soil	Water	Soil
METALS:	All Metals by SW-846 Methods			
Cadmium	3010/6010	3050/6010	3.0 ug/l	0.78 mg/kg
Chromium	3010/6010	3050/6010	7.0 ug/l	0.70 mg/kg
Copper	3010/6010	3050/6010	3.0 ug/l	0.30 mg/kg
Lead	3010/6010	3050/6010	24.0 ug/l	3.60 mg/kg
Zinc	3010/6010	3050/6010	3.0 ug/l	0.50 mg/kg
MERCURY	SW-846,7470	SW-846,7471	0.2 ug/l	0.14 mg/kg
CHROMIUM VI	SW-846,7197	SW-848,7197(a)	10.0 ug/l	10.0 ug/l
TOC	MCAWW 415.2	MCAA 415.1	0.5 mg/l	100 mg/kg
TOX	MCAWW 450.1	SW-846,9076	8.0 ug/l	15 mg/kg
TSS	MCAWW 160.2	Not Required	4.0 mg/l	--
TDS	MCAWW 160.1	Not Required	20.0 mg/l	--
NITROAROMATICS:	USATHAMA Revised Method 8H for Explosives by HPLC for Water and Soil Samples			
2,4,6-Trinitrotoluene	"		10.0 ug/l	20 ug/kg
RDX	"		10.0 ug/l	20 ug/kg
HMX	"		10.0 ug/l	20 ug/kg
2,4-Dinitrotoluene	"		10.0 ug/l	20 ug/kg
2,6-Dinitrotoluene	"		10.0 ug/l	20 ug/kg
1,3,5-Trinitrobenzene	"		10.0 ug/l	20 ug/kg

TABLE 1-9
(Continued)

ANALYTICAL METHODS AND DETECTION LIMITS
(PHASE I - 1989)

Analyte	Methodology		Detection Limits	
	Water	Soil	Water	Soil
PCB'S:	EPA 608 Method for Water and Soil Samples			
Aroclor-1016	"		0.5 ug/l	70 ug/kg
Aroclor-1221	"		0.5 ug/l	70 ug/kg
Aroclor-1232	"		0.5 ug/l	70 ug/kg
Aroclor-1242	"		0.5 ug/l	70 ug/kg
Aroclor-1248	"		0.5 ug/l	70 ug/kg
Aroclor-1254	"		1.0 ug/l	70 ug/kg
Aroclor-1260	"		1.0 ug/l	70 ug/kg
VOLATILES:	CLP Package for Water and Soil Samples			
Chloromethane	"		10.0 ug/l	10 ug/kg
Bromomethane	"		10.0 ug/l	10 ug/kg
Vinyl Chloride	"		10.0 ug/l	10 ug/kg
Chloroethane	"		10.0 ug/l	10 ug/kg
Methylene Chloride	"		5.0 ug/l	5 ug/kg
Acetone	"		10.0 ug/l	10 ug/kg
Carbon Disulfide	"		5.0 ug/l	5 ug/kg
1,1-Dichloroethene	"		5.0 ug/l	5 ug/kg
1,1-Dichloroethane	"		5.0 ug/l	5 ug/kg
1,2-Dichloroethene	"		5.0 ug/l	5 ug/kg
Chlorform (THM)	"		5.0 ug/l	5 ug/kg
1,2-Dichloroethane	"		5.0 ug/l	5 ug/kg
2-Butanone (MEK)	"		10.0 ug/l	10 ug/kg
1,1,1-Trichloroethane	"		5.0 ug/l	5 ug/kg
Carbon Tetrachloride	"		5.0 ug/l	5 ug/kg
Vinyl Acetate	"		10.0 ug/l	10 ug/kg
Bromodichloromethane (THM)	"		5.0 ug/l	5 ug/kg
1,2-Dichloropropane	"		5.0 ug/l	5 ug/kg
cis-1,3-Dichloropropene	"		5.0 ug/l	5 ug/kg
Trichloroethene	"		5.0 ug/l	5 ug/kg
Dibromochloromethane (THM)	"		5.0 ug/l	5 ug/kg

TABLE 1-9
(Continued)

ANALYTICAL METHODS AND DETECTION LIMITS
(PHASE I - 1991)

Analyte	Methodology		Detection Limits	
	Water	Soil	Water	Soil
VOLATILES (CON'T):				
1,1,2-Trichlorethane	"		5.0 ug/l	5 ug/kg
Benzene	"		5.0 ug/l	5 ug/kg
trans-1,3-Dichloropropene	"		5.0 ug/l	5 ug/kg
Bromoform (THM)	"		5.0 ug/l	5 ug/kg
4-Methy1-2-pentanone	"		10.0 ug/l	10 ug/kg
2-Hexanone	"		10.0 ug/l	10 ug/kg
Tetrachloroethene	"		5.0 ug/l	5 ug/kg
Toluene	"		5.0 ug/l	5 ug/kg
1,1,2,2-Tetrachloroethane	"		5.0 ug/l	5 ug/kg
Chlorobenzene	"		5.0 ug/l	5 ug/kg
Ethyl Benzene	"		5.0 ug/l	5 ug/kg
Styrene	"		5.0 ug/l	5 ug/kg
Xylene	"		5.0 ug/l	5 ug/kg
SEMIVOLATILES:	CLP Package for Water and Soil Samples			
Phenol	"		10.0 ug/l	330 ug/kg
bis(2-Chloroethyl) ether	"		10.0 ug/l	330 ug/kg
2-Chlorophenol	"		10.0 ug/l	330 ug/kg
1,3-Dichlorobenzene	"		10.0 ug/l	330 ug/kg
1,4-Dichlorobenzene	"		10.0 ug/l	330 ug/kg
Benzyl Alchol	"		10.0 ug/l	330 ug/kg
1,2-Dichlorobenzene	"		10.0 ug/l	330 ug/kg
2-Methylphenol	"		10.0 ug/l	330 ug/kg
bis(2-Chloroisoproply) ether	"		10.0 ug/l	330 ug/kg
4-Methylphenol	"		10.0 ug/l	330 ug/kg
N-Nitroso-di-n-dipropylamine	"		10.0 ug/l	330 ug/kg

TABLE 1-9
(Continued)

ANALYTICAL METHODS AND DETECTION LIMITS
(PHASE I - 1989)

Analyte	Methodology		Detection Limits	
	Water	Soil	Water	Soil
SEMIVOLATILES (CON'T):				
Hexachloroethane	"		10.0 ug/l	330 ug/kg
Nitrobenzene	"		10.0 ug/l	330 ug/kg
Isophorone	"		10.0 ug/l	330 ug/kg
2-Nitrophenol	"		10.0 ug/l	330 ug/kg
2,4-Dimethylphenol	"		10.0 ug/l	330 ug/kg
Benzoic Acid	"		50.0 ug/l	1600 ug/kg
bis(2-Chloroethoxy) methane	"		10.0 ug/l	330 ug/kg
2,4-Dichlorophenol	"		10.0 ug/l	330 ug/kg
1,2,4-Trichlorobenzene	"		10.0 ug/l	330 ug/kg
Naphthalene	"		10.0 ug/l	330 ug/kg
4-Chloroaniline	"		10.0 ug/l	330 ug/kg
Hexachlorobutadiene	"		10.0 ug/l	330 ug/kg
4-Chloro-3-Methylphenol	"		10.0 ug/l	330 ug/kg
2-Methylnaphthalene	"		10.0 ug/l	330 ug/kg
Hexachlorocyclopentadiene	"		10.0 ug/l	330 ug/kg
2,4,6-Trichlorophenol	"		10.0 ug/l	330 ug/kg
2,4,5-Trichlorophenol	"		50.0 ug/l	1600 ug/kg
2-Chloronaphthalene	"		10.0 ug/l	330 ug/kg
2-Nitroaniline	"		50.0 ug/l	1600 ug/kg
Dimethylphthalate	"		10.0 ug/l	330 ug/kg
Acenaphthylene	"		10.0 ug/l	330 ug/kg
2,6-Dinitrotoluene	"		10.0 ug/l	330 ug/kg
3-Nitroaniline	"		50.0 ug/l	1600 ug/kg
Acenaphthene	"		10.0 ug/l	330 ug/kg
2,4-Dinitrophenol	"		50.0 ug/l	1600 ug/kg
4-Nitrophenol	"		50.0 ug/l	1600 ug/kg
Dibenzofuran	"		10.0 ug/l	330 ug/kg
2,4-Dinitrotoluene	"		10.0 ug/l	330 ug/kg

TABLE 1-9
(Continued)

ANALYTICAL METHODS AND DETECTION LIMITS
(PHASE I - 1989)

Analyte	Methodology		Detection Limits	
	Water	Soil	Water	Soil
SEMIVOLATILES (CON'T):				
Diethylphthalate	"		10.0 ug/l	330 ug/kg
4-Chlorophenyl-phenyl ether	"		10.0 ug/l	330 ug/kg
Fluorene	"		50.0 ug/l	1600 ug/kg
4-Nirtoaniline	"		50.0 ug/l	1600 ug/kg
4,6-Dinitro-2-methylphenol	"		50.0 ug/l	1600 ug/kg
N-nitrosodiphenylamine	"		10.0 ug/l	330 ug/kg
4-Bromophenyl-phenyl ether	"		10.0 ug/l	330 ug/kg
Hexachlorobenze	"		10.0 ug/l	330 ug/kg
Pentachlorophenol	"		50.0 ug/l	1600 ug/kg
Phenanthrene	"		10.0 ug/l	330 ug/kg
Anthracene	"		10.0 ug/l	330 ug/kg
Di-n-butylphthalate	"		10.0 ug/l	330 ug/kg
Fluoranthene	"		10.0 ug/l	330 ug/kg
Pyrene	"		10.0 ug/l	330 ug/kg
Butylbenzylphthalate	"		10.0 ug/l	330 ug/kg
3,3-Dichlorobenzidine	"		20.0 ug/l	660 ug/kg
Benzo(a)anthracene	"		10.0 ug/l	330 ug/kg
Chrysene	"		10.0 ug/l	330 ug/kg
bis-(2-Ethylhexyl)phthalate	"		10.0 ug/l	330 ug/kg
Di-n-octylphthalate	"		10.0 ug/l	330 ug/kg
Benzo(b)fluoranthene	"		10.0 ug/l	330 ug/kg
Benzo(k)fluoranthene	"		10.0 ug/l	330 ug/kg
Benzo(a)pyrene	"		10.0 ug/l	330 ug/kg
Indeno(1,2,3-cd)pyrene	"		10.0 ug/l	330 ug/kg
Dibenz(a,h)anthracene	"		10.0 ug/l	330 ug/kg
Benzo(g,h,i)perylene	"		10.0 ug/l	330 ug/kg

TABLE 1-10 ANALYTICAL METHODS AND DETECTION LIMITS (PHASE II - 1991)				
	Methodology		Detection Limits	
Analyte	Water	Soil	Water	Soil
METALS:	All Metals by SW-846 Methods			
Cadmium		3050/6010	4.0 ug/l	0.4 mg/kg
Chromium	3010/6010	3050/6010	6.0 ug/l	0.6 mg/kg
Copper	3010/6010	3050/6010	4.0 ug/l	0.4 mg/kg
Lead	3010/6010	3050/6010	32.0 ug/l	3.2 mg/kg
Zinc	3010/6010	3050/6010	4.0 ug/l	0.4 mg/kg
	3010/6010			
MERCURY	SW-846,7470	SW-846,7471	0.2 ug/l	0.1 mg/kg
NITROAROMATICS:	USATHAMA by HPLC Method for Water and Soil Samples			
TNT	"		0.78 ug/l	1.920 mg/kg
RDX	"		0.63 ug/l	0.977 mg/kg
HMX	"		1.30 ug/l	1.270 mg/kg
2,4-DNT	"		0.60 ug/l	0.416 mg/kg
2,6-DNT	"		0.55 ug/l	0.402 mg/kg
1,3,5-TNB	"		0.56 ug/l	2.090 mg/kg
PCB'S:				
Aroclor-1016	EPA 608	EPA 8080	0.5 ug/l	80 ug/kg
Aroclor-1221	"	"	0.5 ug/l	80 ug/kg
Aroclor-1232	"	"	0.5 ug/l	80 ug/kg
Aroclor-1242	"	"	0.5 ug/l	80 ug/kg
Aroclor-1248	"	"	0.5 ug/l	80 ug/kg

TABLE 1-10
(Continued)

ANALYTICAL METHODS AND DETECTION LIMITS
(PHASE II - 1991)

Analyte	Methodology		Detection Limits	
	Water	Soil	Water	Soil
PCB'S (CON'T)				
Aroclor-1254	"	"	1.0 ug/l	160 ug/kg
Aroclor-1260	"	"	1.0 ug/l	160 ug/kg
VOLATILES:	CLP Package for Water and Soil Samples			
Chloromethane			10.0 ug/l	10 ug/kg
Bromomethane	"		10.0 ug/l	10 ug/kg
Vinyl Chloride	"		10.0 ug/l	10 ug/kg
Chloroethane	"		10.0 ug/l	10 ug/kg
Methylene Chloride	"		5.0 ug/l	5 ug/kg
Acetone	"		10.0 ug/l	10 ug/kg
Carbon Disulfide	"		5.0 ug/l	5 ug/kg
1,1-Dichloroethene	"		5.0 ug/l	5 ug/kg
1,1-Dichloroethane	"		5.0 ug/l	5 ug/kg
1,2-Dichloroethene	"		5.0 ug/l	5 ug/kg
Chlorform (THM)	"		5.0 ug/l	5 ug/kg
1,2-Dichloroethane	"		5.0 ug/l	5 ug/kg
2-Butanone (MEK)	"		10.0 ug/l	10 ug/kg
1,1,1-Trichloroethane	"		5.0 ug/l	5 ug/kg
Carbon Tetrachloride	"		5.0 ug/l	5 ug/kg
Vinyl Acetate	"		10.0 ug/l	10 ug/kg
Bromodichloromethane (THM)	"		5.0 ug/l	5 ug/kg
1,2-Dichloropropane	"		5.0 ug/l	5 ug/kg
cis-1,3-Dichloropropene	"		5.0 ug/l	5 ug/kg
Trichloroethene	"		5.0 ug/l	5 ug/kg
Dibromochloromethane (THM)	"		5.0 ug/l	5 ug/kg
	"			

TABLE 1-10
(Continued)

ANALYTICAL METHODS AND DETECTION LIMITS
(PHASE II - 1991)

Analyte	Methodology		Detection Limits	
	Water	Soil	Water	Soil
VOLATILES (CON'T):				
1,1,2-Trichlorethane	"		5.0 ug/l	5 ug/kg
Benzene	"		5.0 ug/l	5 ug/kg
trans-1,3-Dichloropropene	"		5.0 ug/l	5 ug/kg
Bromoform (THM)	"		5.0 ug/l	5 ug/kg
4-Methy1-2-pentanone	"		10.0 ug/l	10 ug/kg
2-Hexanone	"		10.0 ug/l	10 ug/kg
Tetrachloroethene	"		5.0 ug/l	5 ug/kg
Toluene	"		5.0 ug/l	5 ug/kg
1,1,2,2-Tetrachloroethane	"		5.0 ug/l	5 ug/kg
Chlorobenzene	"		5.0 ug/l	5 ug/kg
Ethyl Benzene	"		5.0 ug/l	5 ug/kg
Styrene	"		5.0 ug/l	5 ug/kg
Xylene	"		5.0 ug/l	5 ug/kg
SEMIVOLATILES:	CLP Package for Water and Soil Samples			
Phenol			10.0 ug/l	330 ug/kg
bis(2-Chloroethyl) ether	"		10.0 ug/l	330 ug/kg
2-Chlorophenol	"		10.0 ug/l	330 ug/kg
1,3-Dichlorobenzene	"		10.0 ug/l	330 ug/kg
1,4-Dichlorobenzene	"		10.0 ug/l	330 ug/kg
Benzyl Alchol	"		10.0 ug/l	330 ug/kg
1,2-Dichlorobenzene	"		10.0 ug/l	330 ug/kg
2-Methylphenol	"		10.0 ug/l	330 ug/kg
bis(2-Chloroisoproply) ether	"		10.0 ug/l	330 ug/kg
4-Methylphenol	"		10.0 ug/l	330 ug/kg
N-Nitroso-di-n-dipropylamine	"		10.0 ug/l	330 ug/kg
	"			

TABLE 1-11
GROUND/SURFACE WATER STANDARDS

Chemical	MCL (a)	Md GW Stds (b)	USEPA AWQC (c) Consumption of Water and Organisms	USEPA AWQC (c) Consumption of Organisms Only	Maryland SWQC (d) Drinking Water	Maryland SWQC (d) Fish Consumption	RCRA CA Levels (e)	Other Criteria
Acetone	-	-	-	-	-	-	4,000	-
Benzene	5	-	1.2	71	5	400	-	-
Benzoic Acid	-	-	-	-	-	-	-	-
Bis(2-ethylhexyl)phthalate	-	-	1.8	5.9	-	-	3	-
2-Butanone (MEK)	-	-	-	-	-	-	2,000	-
Cadmium	5	10	16	170	10	-	-	-
Carbon tetrachloride	5	-	0.25	4.4	-	-	0.30	-
Chlorobenzene	100	-	680	21,000	-	-	700	-
Chloroform	100 (f)	-	5.7	470	-	-	6	-
Chromium (total)	50	50	33,000	670,000	-	3,430,000	-	-
Copper	1,300 (g)	-	1,300	1,300	-	-	-	-
1,1-Dichloroethane	-	-	-	-	-	-	-	-
1,2-Dichloroethane	5	-	0.38	99	-	-	-	-
cis-1,2-Dichloroethene	70	-	-	-	-	-	-	-
trans-1,2-Dichloroethene	100	-	700	140,000	-	-	-	-
1,2-Dichloropropane	5	-	10	1,700	-	-	-	-
2,4-Dinitrotoluene	-	-	0.11	8.1	-	-	-	-
2,6-Dinitrotoluene	-	-	-	-	-	-	-	-
Ethylbenzene	700	-	3,100	29,000	-	-	4,000	-
HMX	-	-	-	-	-	-	-	2,000 (h)
Lead	50/15 (i)	50	50	-	50	-	-	-
Mercury (inorganic)	2	2	0.14	0.15	2	0.146	-	-
Methylene Chloride	-	-	4.7	1,600	-	-	5	-
Nitrobenzene	-	-	17	1,900	-	-	20	-
RDX	-	-	-	-	-	-	-	105 (h)
Tetrachloroethene	5	-	0.80	8.85	-	-	0.70	-
1,1,2,2-Tetrachloroethane	-	-	0.17	11	-	-	2	-
Toluene	1,000	-	6,800	200,000	-	-	10,000	-
1,1,1-Trichloroethane	200	-	3,100	170,000	200	1,030,000	3,000	-
1,1,2-Trichloroethane	-	-	0.60	42	-	-	6	-
Trichloroethene	5	-	2.7	81	5	807	-	-
Trichlorofluoromethane	-	-	-	-	-	-	10,000	-
1,3,5-Trinitrobenzene	-	-	-	-	-	-	-	-
2,4,6-Trinitrotoluene	-	-	-	-	-	-	-	20 (h)
Vinyl Chloride	2	-	2	525	-	-	-	-
Xylene (total)	10,000	-	-	-	-	-	70,000	-
Zinc	5,000 (j)	-	5,000	-	-	-	-	-

Notes:

(a) MCL - Maximum Contaminant Level (40 CFR 141 and 143).

(b) Maryland Ground Water Standards (COMAR 26.04.01)

(c) USEPA Ambient Water Quality Criteria (40 CFR 131)

(d) Maryland Surface Water Quality Criteria (COMAR 26.08.02)

(e) RCRA Corrective Action Levels, Proposed Rule

(f) Chloroform is one of four trihalomethanes, MCL = 100 ug/l.

(g) MCL for copper is secondary standard.

(h) Drinking Water Equivalent Levels (DWELs) from EPA Health Advisories for nitroaromatic compounds.

(i) MCL for lead is 50 ug/l. Proposed action level is 15 ug/l (effective December 7, 1992).

(j) MCL for zinc is secondary standard.

Standards reported in micrograms per liter (μg/l).

TABLE 1–12
SOIL/SEDIMENT GUIDELINES

Chemical	RCRA CA Levels (a)	Natural U.S. Soils (b)	Other Criteria
Acenaphthene	–	–	(c)
Acenaphthylene	–	–	(c)
Acetone	8,000	–	–
Anthracene	–	–	(c)
Benzo(a)anthracene	–	–	(c)
Benzo(b)fluoranthene	–	–	(c)
Benzo(k)fluoranthene	–	–	(c)
Benzo(g,h,i)Perylene	–	–	(c)
Benzo(a)Pyrene	–	–	(c)
Bis(2–ethylhexyl)phthalate	50	–	–
2–Butanone (MEK)	4,000	–	–
Butylbenzylphthalate	50	–	–
Cadmium	40	0.01 – 2	–
Carbon Disulfide	8,000	–	–
Carbon tetrachloride	5	–	–
Chromium (total)	–	5 – 1,500	–
Chrysene	–	–	(c)
Copper	–	2 – 250	–
Dibenz(a,h)anthracene	–	–	(c)
Di–n–butylphthalate	8,000	–	–
Diethylphthalate	60,000	–	–
2,6–Dinitrotoluene	1	–	–
Ethylbenzene	8,000	–	–
Fluoranthene	–	–	(c)
Fluorene	–	–	(c)
Indeno(1,2,3–cd)Pyrene	–	–	(c)
Lead	–	2 – 300	–
Mercury (inorganic)	20	0.01 – 0.50	–
Methylene Chloride	90	–	–
2–Methylnaphthalene	–	–	(c)
Naphthalene	–	–	(c)
Nickel	2,000	2 – 750	–
Phenanthrene	–	–	(c)
Polychlorinated Biphenyls	0.09	–	0.19 – 25 (d)
Pyrene	–	–	(c)
Siloxane	–	–	(c)
Silver	200	–	–
1,1,2,2–Tetrachloroethane	40	–	–
Toluene	20,000	–	–
1,1,1–Trichloroethane	7,000	–	–
Trichloroethene	60	–	–

TABLE 1–12
(Continued)
SOIL/SEDIMENT GUIDELINES

Chemical	RCRA CA Levels (a)	Natural U.S. Soils (b)	Other Criteria
Trichlorofluoromethane	20,000	–	–
Xylene (total)	200,000	–	–
Zinc	–	1 – 900	–

Notes:
(a) RCRA Corrective Action Levels, Proposed Rule
(b) Bodek et al. Elemental composition of natural soils in the U.S.
(c) Typical background range for soils in urban areas for total PAHs = 16 to 475 mg/kg. (ATSDR, Toxicological Profile for PAHs, 1990, U.S. Public Health Service)
(d) USEPA, "A Guide on Remedial Actions at Superfund Sites with PCB Contamination", August 1990.
Levels reported in milligrams per kilogram (mg/kg).

TABLE 1–13
SOIL/SEDIMENT BACKGROUND SAMPLE RESULTS

Parameter	Sample Type		Units	Soil/Sediment Sample Number	
	Soil	Sediment		Soil	Sediment
Metals:					
Cadmium	0.81	> 0.78	mg/kg	11SL1/11SL2	PBC–SD1/2/3
Chromium	17.9	10.9	mg/kg	11SL1/11SL2	PBC–SD1/2/3
Copper	12.4	8.1	mg/kg	11SL1/11SL2	PBC–SD1/2/3
Lead	37.7	15.6	mg/kg	11SL1/11SL2	PBC–SD1/2/3
Zinc	43.7	28.2	mg/kg	11SL1/11SL2	PBC–SD1/2/3

Notes:

(1) 11SL1/11SL2 – Surficial soil samples collected at Site 11 deemed as "background".

(2) PBC–SD1/2/3 – Sediment samples collected from Paint Branch Creek deemed as "background".

(3) mg/kg – milligrams per kilogram

TABLE 2-1
SUMMARY OF FIELD ENVIRONMENTAL SAMPLING
SITE 2
(Phase I - 1989)

SAMPLE MATRIX	PARAMETERS		FIELD SAMPLES SEDIMENT	SOIL	QA/QC SAMPLES FD	ER	TB	TOTAL SAMPLES
SEDIMENTS/SOIL	VOLATILES		10	2	1	1	0	14
	SEMIVOLATILES		0	2	0	1	0	3
	PCBS		10	2	1	1	0	14
	METALS		10	2	1	1	0	14
	MERCURY		0	0	0	0	0	0
	CHROMIUM VI		10	0	1	1	0	12
	NITROAROMATICS		0	0	0	0	0	0
	TOC		10	2	1	1	0	14
	TOX		10	2	1	1	0	14
	pH		10	2	1	0	0	13
		SUB-TOTAL	70	14	7	7	0	98
			WATER GROUND	SURFACE	QA/QC SAMPLES FD	ER	TB	TOTAL SAMPLES
GROUND/SURFACE WATER	VOLATILES		4	6	1	0	2	13
	SEMIVOLATILES		4	0	0	0	0	4
	PCBS		4	0	1	0	0	5
	METALS 1		8	0	2	0	0	22
	MERCURY		8	12	0	0	0	8
	CHROMIUM VI		8	0	2	0	0	10
	NITROAROMATICS		0	0	0	0	0	0
	TOC		4	6	1	0	0	11
	TOX		4	6	1	0	0	11
	TDS		4	6	1	0	0	11
	TSS		4	6	1	0	0	11
		SUB-TOTAL	52	42	10	0	2	106
		TOTAL SAMPLES	122	56	17	7	2	204

Notes: 1. Metals (Cd, Cr, Cu, Pb, Zn), mercury, and chromium VI - Filtered (dissolved) and unfiltered (total) fractions were collected for each water sample.
FD - Field duplicate
ER - Equipment Rinsate
TB - Trip blank

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TABLE 2–2
SUMMARY OF FIELD ENVIRONMENTAL SAMPLING
SITE 2
(Phase II – 1991)

SAMPLE MATRIX	PARAMETERS		SEDIMENT SAMPLES			SOIL SAMPLES			TOTAL SAMPLES
			FIELD	QA/QC		FIELD	QA/QC		
				FD	ER		FD	ER	
SEDIMENTS/SOIL	VOLATILES		10	1	1	38	4	4	58
	SEMIVOLATILES		0	0	0	38	4	4	46
	PCBS		10	1	1	38	4	4	58
	METALS		10	1	1	38	4	4	58
	MERCURY		0	0	0	0	0	0	0
	NITROAROMATICS		0	0	0	0	0	0	0
		SUB-TOTAL	30	3	3	152	16	16	220
			GROUNDWATER SAMPLES			SURFACE WATER SAMPLES			TOTAL SAMPLES
			FIELD	QA/QC		FIELD	QA/QC		
				FD	ER		FD	ER	
GROUND/SURFACE WATER	VOLATILES		5	1	1	6	1	0	14
	SEMIVOLATILES		5	1	1	0	0	0	7
	PCBS		5	1	1	6	1	0	14
	METALS 1		10	2	1	0	0	0	13
	MERCURY		10	2	1	0	0	0	13
	NITROAROMATICS		0	0	0	0	0	0	0
		SUB-TOTAL	35	7	5	12	2	0	61
	TOTAL SAMPLES		**65**	**10**	**8**	**164**	**18**	**16**	**281**

Notes: 1. Metals (Cd, Cr, Cu, Pb, Zn), mercury, and chromium VI – Filtered (dissolved) and unfiltered (total) fractions were collected for each water sample.

FD – Field duplicate

ER – Equipment rinsate

Equipment rinsate analyzed for total metals

TABLE 2-3
SITE 2 – APPLE ORCHARD LANDFILL
STREAM SEDIMENT/SURFICIAL SOIL ANALYTICAL RESULTS
(Phase I – 1989)

Parameter	Sample Locations												Detection Limit	Units
	2SD1	2SD2	2SD3	2SD4	2SD5	2SD7	2SD9	2SD10	2SD11	2SD12	2SL1	2SL2		
TOTAL METALS:														
Cadmium	U	U	U	U	U	1.1	U	1.9	0.87	U	U	U	0.78	mg/kg
Chromium	18.8	24.2	14.8	24.3	35.0	31.7	19.3	31.1	12.3	15.2	22.9	34.4	0.70	mg/kg
Copper	17.4	24.8	24.0	19.3	26.1	32.6	19.8	33.8	26.7	19.5	33.6	26.5	0.30	mg/kg
Lead	12.6	13.1	15.0	15.5	64.9	10.1	32.6	118.0	17.6	9.9	15.0	7.8	3.60	mg/kg
Zinc	36.0	47.5	34.8	58.7	108.0	67.1	50.6	299.0	75.4	58.7	80.9	50.7	0.50	mg/kg
Chromium VI	U	U	U	U	U	U	U	U	U	U	--	--	10.0	ug/l
pH	7.65	7.30	7.31	7.01	7.72	6.70	7.50	7.32	7.13	7.16	5.81	7.88	--	su
PCBs	710	910	1,200	1,700	1,600	570	2,900	140,000	520	470	3,200	8,700	70.0	ug/kg
TOC	5,580	6,110	2,885	4,500	14,300	3,530	4,130	13,500	3,115	5,965	12,200	3,325	100	mg/kg
TOX	U	92.6	35.4	248.0	19.2	128.0	28.3	151.0	98.4	70.4	18.8	U	15.0	mg/kg
VOLATILE ORGANICS:														
Acetone	U	U	U	U	U	U	16	U	U	U	U	U	14	ug/kg
Methylene Chloride	7	U	U	U	U	8	U	U	8	8	U	U	7	ug/kg
Siloxane	U	U	U	5 J	5 J	U	U	U	U	U	U	U	5	ug/kg
Trichlorofluoromethane	U	U	17 J	17 J	7 J	U	U	U	U	U	U	U	17	ug/kg
SEMIVOLATILES:														
Diethylphthalate	--	--	--	--	--	--	--	--	--	--	U	410 J	500	ug/kg
Phenanthrene	--	--	--	--	--	--	--	--	--	--	250 J	850	500	ug/kg
Anthracene	--	--	--	--	--	--	--	--	--	--	U	220 J	500	ug/kg
Fluoranthene	--	--	--	--	--	--	--	--	--	--	U	1600	500	ug/kg
Pyrene	--	--	--	--	--	--	--	--	--	--	270 J	1100 X	500	ug/kg
Benzo(a)Anthracene	--	--	--	--	--	--	--	--	--	--	250 JX	710	500	ug/kg
Chrysene	--	--	--	--	--	--	--	--	--	--	300 J	880	500	ug/kg
bis(2-Ethylhexyl)Phthalate	--	--	--	--	--	--	--	--	--	--	U	520 J	500	ug/kg
Benzo(b)Fluoranthene	--	--	--	--	--	--	--	--	--	--	300 JX	610	500	ug/kg
Benzo(k)Fluoranthene	--	--	--	--	--	--	--	--	--	--	200 J	610	500	ug/kg
Benzo(a)Pyrene	--	--	--	--	--	--	--	--	--	--	270 JX	690	500	ug/kg
Indeno(1,2,3-cd)Pyrene	--	--	--	--	--	--	--	--	--	--	U	380 JX	500	ug/kg
Benzo(g,h,i)Perylene	--	--	--	--	--	--	--	--	--	--	U	370 JX	500	ug/kg
Hexadecanoic Acid	--	--	--	--	--	--	--	--	--	--	230 J	U	500	ug/kg

Notes:
U – Not detected.
J – Compound is present but less than the detection limit.
X – EPA CLP criteria for confirmation not met but compound is present.

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TABLE 2-4
SITE 2 – APPLE ORCHARD LANDFILL
SURFICIAL SOIL ANALYTICAL RESULTS
(PHASE II – 1991)

Parameter	Sample Locations												Detection Limits	Units
	2SL3	2SL4	2SL5	2SL6	2SL7	2SL8	2SL9	2SL10	2SL11	2SL12	2SL13	2SL14		
TOTAL METALS:														
Cadmium	U	U	U	U	U	U	U	1.4	U	U	U	1.9	5	mg/kg
Chromium	18	11	20	8.4	12	31	45	8.7	22	14	15	26	10	mg/kg
Copper	29	18	19	U	13	47	16	18	14	17	18	52	25	mg/kg
Lead	101	U	12	18	35	22	16	31	38	19	17	50	3	mg/kg
Zinc	164	24	52	5.2	27	62	134	62	40	43	28	110	10	mg/kg
PCBs (1)	2500	24	U	U	U	260	64	250	130	210	320	900	(2)	ug/kg
VOLATILE ORGANICS:													(2)	
Acetone	U	9 E	U	U	210 E	R	70 E	720	6 E	6	U	U	--	ug/kg
Methylene Chloride	98	11	R	R	160	R	33	33	67	42	43	64	--	ug/kg
Carbon Disulfide	18	U	U	U	U	U	U	U	U	U	2	U	--	ug/kg
1,2-Dichloroethane	28	U	U	U	U	U	U	U	U	U	U	U	--	ug/kg
Dichloropropane	U	U	U	U	U	32	U	U	U	U	U	U	--	ug/kg
2-Butanone	U	U	U	U	U	U	U	U	U	U	U	U	--	ug/kg
Ethylbenzene	U	U	U	U	U	U	U	U	U	U	U	U	--	ug/kg
m & p Xylenes	U	U	U	U	U	U	U	U	U	U	U	U	--	ug/kg
o-Xylenes	U	U	U	U	U	U	U	U	U	U	U	U	--	ug/kg
Toluene	U	U	U	U	U	U	U	U	U	U	U	U	--	ug/kg
1,1,2,2-Tetrachloroethane	U	U	U	U	U	U	U	U	U	U	U	U	--	ug/kg
Benzene	9	U	U	U	U	U	U	U	U	U	U	U	--	ug/kg
SEMIVOLATILES:														
Diethylphthalate	U	U	U	U	U	U	U	U	U	U	U	U	(2)	ug/kg
Phenanthrene	230	U	210	100	U	U	U	200	360	U	3700	200	--	ug/kg
Anthracene	110	U	57	220	U	U	U	U	99	U	950	41	--	ug/kg
Fluoranthene	400	U	350	200	110	78	U	320	850	65	5900	330	--	ug/kg
Pyrene	200	U	310	290	54	65	U	630	470	55	3000	380	--	ug/kg
Butylbenzylphthalate	U	U	U	U	U	U	U	U	U	34	U	U	--	ug/kg
Benzo(a)Anthracene	200	U	220	190	38	41	U	230	300	U	2800	180	--	ug/kg
Chrysene	220	U	220	230	47	44	U	300	350	U	3000	200	--	ug/kg
bis(2-Ethylhexyl)Phthalate	U	U	U	U	U	U	U	U	170	U	U	200	--	ug/kg
Di-n-octyl Phthalate	U	U	U	U	U	U	U	U	U	U	U	U	--	ug/kg
Benzo(b)Fluoranthene	330	U	210	370	62	U	U	220	320	U	2400	220	--	ug/kg
Benzo(k)Fluoranthene	66	U	190	280	34	U	U	390	350	U	2000	200	--	ug/kg
Benzo(a)Pyrene	210	U	230	540	32	40	U	300	280	U	2500	130	--	ug/kg
Indeno(1,2,3-cd)Pyrene	130	U	180	390	22	U	U	230	200	U	1300	160	--	ug/kg
Benzo(g,h,i)Perylene	150	U	230	600	22	U	U	300	200	U	1200	120	--	ug/kg
Acenaphthylene	94	U	39	390	U	U	U	U	U	U	U	U	--	ug/kg
Acenaphthene	U	U	20	U	U	U	U	U	53	U	770	U	--	ug/kg
Dibenzofuran	U	U	U	U	U	U	U	U	25	U	310	U	--	ug/kg
Dibenzo(a,h)Anthracene	U	U	49	110	U	U	U	U	60	U	560	U	--	ug/kg
Di-n-butylphthalate	U	U	U	U	U	U	U	410	U	U	U	160	--	ug/kg
Bis(2-chloroisopropyl)ether	U	U	U	U	U	U	U	700	U	U	U	300	--	ug/kg
Benzoic Acid	U	U	U	U	R	U	U	370 E	U	U	U	U	--	ug/kg
Benzyl Alcohol	U	U	U	U	U	U	U	U	U	U	U	U	--	ug/kg
Naphthalene	U	U	U	U	U	U	U	U	U	U	150	U	--	ug/kg
2-Methylnaphthalene	U	U	U	U	U	U	U	U	U	U	44	U	--	ug/kg
Fluorene	U	U	U	46	U	U	U	U	U	U	460	U	--	ug/kg
3,3-Dichlorobenzidine	U	U	U	U	U	U	U	U	U	U	U	U	--	ug/kg

NOTES: (1) The PCB compound for which values are given here is AR1260.
(2) The detection limits are based on % moisture determination.
U – Not detected.
E – Quantitation Estimated
R – Quantitation Rejected.

TABLE 2-4 (CONTINUED)
SITE 2 – APPLE ORCHARD LANDFILL
SURFICIAL SOIL ANALYTICAL RESULTS
(PHASE II – 1991)

Parameter	Sample Locations											Detection Limits	Units
	2SL15	2SL16	2SL17	2SL18	2SL19	2SL20	2SL21	2SL22	2SL23	2SL24	2SL25		
TOTAL METALS:													
Cadmium	1.3	U	U	U	U	U	U	U	U	U	U	5	mg/kg
Chromium	16	22	8.6	9.9	7.9	10	10	9.7	17	25	16	10	mg/kg
Copper	12	17	26	37	18	9.3	14	4.8	10	24	5.8	25	mg/kg
Lead	32	26	44	72	18	11	27	11	36	27	19	3	mg/kg
Zinc	48	46	49	58	31	25	40	15	53	70	20	10	mg/kg
PCBs (1)	140	U	830	1200	U	U	83	120	1000	U	U	(2)	ug/kg
VOLATILE ORGANICS:												(2)	
Acetone	470	83 E	4 E	7	86 E	U	18	U	>200	140 E	170	--	ug/kg
Methylene Chloride	180	180	66	100	30	26	41	38	39	190	73	--	ug/kg
Carbon Disulfide	7	6	U	4	U	2	U	3	U	7	U	--	ug/kg
1,2-Dichloroethane	U	U	U	U	U	U	U	U	U	U	U		
Dichloropropane	U	U	U	U	U	U	U	U	U	U	U	--	ug/kg
2-Butanone	34 E	U	U	U	U	U	U	U	37 E	U	U	--	ug/kg
Ethylbenzene	7	2	U	U	U	U	U	U	U	U	U	--	ug/kg
m & p Xylenes	13	10	U	U	U	U	U	U	U	U	U		
o-Xylenes	7	3	U	U	U	U	U	U	U	U	U	--	ug/kg
Toluene	U	2	U	U	U	U	U	U	U	U	U		
1,1,2,2-Tetrachloroethane	9 E	U	U	U	U	U	U	U	U	U	U	--	ug/kg
Benzene	U	U	U	U	U	U	U	U	U	U	U		
SEMIVOLATILES:													
Diethylphthalate	87	67	U	U	U	U	U	U	U	110	79	(2)	ug/kg
Phenanthrene	50	52	1000	170	38	U	23	U	700 E	110	U	--	ug/kg
Anthracene	U	U	250	100	38	U	23	U	130 E	U	U	--	ug/kg
Fluoranthene	79	130	2100	380	110	U	56	38	2400 E	180	U	--	ug/kg
Pyrene	79	120	1300	270	53	U	28	26	830 E	170	U	--	ug/kg
Butylbenzylphthalate	U	U	72	U	U	U	U	U	U	U	U	--	ug/kg
Benzo(a)Anthracene	U	U	650	180	32	U	19	18	600 E	78	U	--	ug/kg
Chrysene	U	U	760	230	45	U	21	23	730 E	95	U	--	ug/kg
bis(2-Ethylhexyl)Phthalate	U	U	320	240	170	U	400	210	660 E	130	120	--	ug/kg
Di-n-octyl Phthalate	U	U	31	U	U	140	U	19	U	35	U	--	ug/kg
Benzo(b)Fluoranthene	U	100	1400	320	94	U	U	U	790 E	92	U	--	ug/kg
Benzo(k)Fluoranthene	U	68	1400	160	110	U	U	U	1200 E	98	U	--	ug/kg
Benzo(a)Pyrene	U	72	690	200	36	U	14	U	450 E	83	U	--	ug/kg
Indeno(1,2,3-cd)Pyrene	U	65	190	110	13	U	U	U	400 E	70	U	--	ug/kg
Benzo(g,h,i)Perylene	U	72	220	100	U	U	U	U	370 E	81	U	--	ug/kg
Acenaphthylene	U	U	220	120	U	U	U	U	35 E	U	U	--	ug/kg
Acenaphthene	U	U	85	U	U	U	U	U	47 E	U	U	--	ug/kg
Dibenzofuran	U	U	U	U	U	U	U	U	U	U	U	--	ug/kg
Dibenzo(a,h)Anthracene	U	U	130	34	U	U	U	U	130 E	U	U	--	ug/kg
Di-n-butylphthalate	440	310	220	U	U	U	U	U	U	760	740	--	ug/kg
Bis(2-chloroisopropyl)ether	260	900	320	U	U	39	170	U	U	790	300	--	ug/kg
Benzoic Acid	U	210 E	R	R	81	U	U	U	U	270	250 E	--	ug/kg
Benzyl Alcohol	U	U	U	U	U	U	U	U	U	40	U	--	ug/kg
Naphthalene	U	U	U	U	U	U	U	U	U	U	U	--	ug/kg
2-Methylnaphthalene	U	U	U	U	U	U	U	U	U	U	U	--	ug/kg
Fluorene	U	U	U	U	U	U	U	U	65 E	U	U	--	ug/kg
3,3-Dichlorobenzidine	U	U	U	U	U	U	U	U	U	U	U	--	ug/kg

NOTES: (1) The PCB compound for which values are given here is AR1260.
(2) The detection limits are based on % moisture determination.
U – Not detected.
E – Quantitation Estimated
R – Quantitation Rejected.

TABLE 2–5
SITE 2 – APPLE ORCHARD LANDFILL
SOIL BORING ANALYTICAL RESULTS
(PHASE II – 1991)

Parameter	Sample Locations (1)															Detection Limit	Units
	2SB1A	2SB1B	2SB2A	2SB2B	2SB3A	2SB3B	2SB4A	2SB4B	2SB4C	2SB5A	2SB5B	2SB5C	2SB6A	2SB6B	2SB6C		
TOTAL METALS:																(3)	
Cadmium	U	1.1	U	8.1	U	U	3.5	1.8	1.2	U	U	U	U	U	U	5	mg/kg
Chromium	12	18	22	42	9.0	24	36	16	3.3	5.2	11	12	11	13	19	10	mg/kg
Copper	14	20	29	1530	5.2	22	89	14	U	4.1	15	13	14	15	23	25	mg/kg
Lead	14	11	12	533	3.4	7.4	424	23	21	14	6.7	11	5.6	72	18	3	mg/kg
Zinc	32	60	90	1440	7.2	1.5	242	34	15	16	35	21	23	51	30	20	mg/kg
PCBs (2)	U	U	400	4600	1400	120	8700	180	76	U	U	U	lost in extraction	U	U	(3)	ug/kg
VOLATILE ORGANICS:																(3)	
Acetone	U	9	U	U	34	40	15	210 R	160 E	170 E	99 E	160 E	170	54	23	--	ug/kg
Methylene Chloride	22	16	26	25 E	65	18	47	83 R	90	81	75	76	36	11	36	--	ug/kg
Carbon Disulfide	1	U	2	3 E	U	2	U	U	U	U	U	U	U	U	U	--	ug/kg
1,2–Dichloroethene (Total)	U	U	U	3	U	U	U	U	U	U	U	U	U	U	U	--	ug/kg
Trichloroethene	U	U	U	3 E	U	U	U	U	U	U	U	U	U	U	U	--	ug/kg
1,1,2–Trichloroethane	U	U	U	U	U	U	4	U	U	U	U	U	U	U	U	--	ug/kg
1,1,2,2–Tetrachloroethene	U	U	U	U	U	U	U	43 E	U	U	U	U	U	U	U	--	ug/kg

NOTES(1) The letter at the end of each sample location indicates the depth at which the sample was collected:
A – 1 foot below the surface.
B – 3 feet below the surface.
C – 5 feet below the surface.
(2) The PCB compound for which values are given here is AR1260.
(3) The detection limits are based on % moisture determination.
U – Not detected.
E – Quantitation Estimated.
R – Rejected.

TABLE 2-5 (CONTINUED)
SITE 2 - APPLE ORCHARD LANDFILL
SOIL BORING ANALYTICAL RESULTS
(PHASE II - 1991)

Parameter	Sample Locations (1)															Detection Limit (3)	Units
	2SB1A	2SB1B	2SB2A	2SB2B	2SB3A	2SB3B	2SB4A	2SB4B	2SB4C	2SB5A	2SB5B	2SB5C	2SB6A	2SB6B	2SB6C		
SEMIVOLATILES:																	
Diethylphthalate	U	U	U	U	U	U	U	U	U	150 E	170	150	U	U	U	--	ug/kg
Phenanthrene	180	U	230	240	U	U	5400 E	U	U	U	U	U	U	U	130 E	--	ug/kg
Anthracene	41	U	U	U	U	U	900 E	U	U	U	U	U	U	U	U	--	ug/kg
Fluoranthene	320	U	400	520	U	U	6000 E	140	46	U	U	U	U	U	180 E	--	ug/kg
Pyrene	200	U	320	680	U	U	7500 E	130	40	U	U	U	U	U	130 E	--	ug/kg
Benzo(a)Anthracene	140	U	U	320	U	U	3000 E	47	U	U	U	U	U	U	U	--	ug/kg
Chrysene	140	U	U	370	U	U	3100 E	53	U	U	U	U	U	U	U	--	ug/kg
bis(2-Ethylhexyl)Phthalate	U	U	U	250	U	U	U	U	U	95 E	210	460	U	U	U	--	ug/kg
Benzo(b)Fluoranthene	120	U	280	380	U	U	2400 E	73	U	U	U	U	U	U	U	--	ug/kg
Benzo(k)Fluoranthene	100	U	U	410	U	U	3400 E	120	U	U	U	U	U	U	U	--	ug/kg
Benzo(a)Pyrene	130	U	U	350	U	U	2500 E	36	U	U	U	U	U	U	U	--	ug/kg
Indeno(1,2,3-cd)Pyrene	70	U	U	250	U	U	1900 E	32	U	U	U	U	U	U	U	--	ug/kg
Dibenzo(a,h)anthracene	22	U	U	U	U	U	820 E	U	U	U	U	U	U	U	U	--	ug/kg
Di-n-octyl Phthalate	83	U	U	U	U	U	U	U	U	170 E	U	U	U	U	U	--	ug/kg
Benzo(g,h,i)Perylene	67	U	U	260	U	U	2000 E	U	U	U	U	U	U	U	U	--	ug/kg
N-Nitrosodiphenylamine	U	U	U	U	U	U	U	510	U	U	U	U	U	U	U	--	ug/kg
Di-n-butylphthalate	U	U	U	U	U	U	U	180	U	720 E	1700	2000	4100 E	3400 E	U	--	ug/kg
Butylbenzylphthalate	U	U	U	U	U	U	U	U	U	U	73	47	990 E	300 E	730 E	--	ug/kg
bis(2-chloroisopropyl)ether	U	U	U	U	U	U	U	U	U	280 E	U	U	U	U	U	--	ug/kg
Acenaphthene	15	U	U	U	U	U	520 E	U	U	U	U	U	U	U	U	--	ug/kg
Dibenzofuran	U	U	U	330	U	U	220 E	U	U	U	U	U	U	U	U	--	ug/kg
Fluorene	U	U	U	U	U	U	590 E	U	U	U	U	U	U	U	U	--	ug/kg
Benzoic Acid	U	U	U	U	U	U	U	180 E	260 E	330 E	370 E	360 E	U	U	U	--	ug/kg
Butyl Alcohol	U	U	U	U	U	U	U	U	U	U	45	U	U	U	U	--	ug/kg
1,2,4-Trichlorobenzene	U	U	U	U	42	U	U	U	U	U	U	U	U	U	U	--	ug/kg
Naphthalene	U	U	U	U	U	U	100 E	U	U	U	U	U	U	U	U	--	ug/kg
2-Methylnaphthalene	U	U	U	U	U	U	64 E	U	U	U	U	U	U	U	U	--	ug/kg
Nitrobenzene	U	U	U	U	U	U	U	110	U	U	U	U	U	U	U	--	ug/kg
Isophorone	U	U	U	U	U	U	U	260	U	U	U	U	U	U	U	--	ug/kg
2,6-Dinitrotoluene	U	U	U	U	U	U	U	230	U	U	U	U	U	U	U	--	ug/kg
2,4-Dinitrotoluene	U	U	U	U	U	U	U	340	U	U	U	U	U	U	U	--	ug/kg
2,4-Dinitrophenol	U	U	U	U	U	U	U	370	U	U	U	U	U	U	U	--	ug/kg

NOTES(1) The letter at the end of each sample location indicates the depth at which the sample was collected:
A - 1 foot below the surface.
B - 3 feet below the surface.
C - 5 feet below the surface.
(2) The PCB compound for which values are given here is AR1260.
(3) The detection limits are based on % moisture determination.
U - Not detected.
E - Quantitation Estimated.

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TABLE 2-6
SITE 2 – APPLE ORCHARD LANDFILL
GROUNDWATER ANALYTICAL RESULTS
(Phase I – 1989)

Parameter	Sample Locations				Detection Limit	Units
	2GW30	2GW31	2GW32	2GW45		
TOTAL METALS:						
Cadmium	U	U	U	U	3.0	ug/l
Chromium	31.6	55.0	261.0	34.7	7.0	ug/l
Copper	24.6	80.2	241.0	40.8	3.0	ug/l
Lead	U	34.2	U	U	28.0	ug/l
Mercury	U	U	62.7	U	0.20	ug/l
Zinc	83.4	173.0	1640.0	94.1	3.0	ug/l
Chromium VI	U	U	U	U	10.0	ug/l
FILTERED METALS:						
Cadmium	U	U	27.6	3.7	3.0	ug/l
Chromium	U	U	U	U	7.0	ug/l
Copper	21.6	U	208.0	U	3.0	ug/l
Lead	U	U	U	U	28.0	ug/l
Mercury	U	U	10.9	U	0.20	ug/l
Zinc	59.2	29.4	961.0	24.0	3.0	ug/l
Chromium VI	U	U	U	U	10.0	ug/l
pH	5.80	5.50	4.70	6.10	--	su
PCBs	U	U	U	U	1.0	ug/l
TOC	9,300	900	3,300	5,400	500	ug/l
TOX	48	8	35	33	8	ug/l
TDS	2,050	U	37,700	1,020	20	mg/l
TSS	719	1,930	7,690	1,650	4	mg/l
VOLATILE ORGANICS:						
Methylene Chloride	U	U	6 B	U	5	ug/l
Trichloroethene	7	U	240	U	5	ug/l
Trichlorofluoromethane	7 J	U	U	U	10	ug/l
SEMIVOLATILE ORGANICS:						
bis(2-ethylhexyl)phthalate	U	8 J	U	23	10	ug/l

Notes: U – Not detected.
J – Compound is present but below detection limit (Estimated Value).
B – Compound also found in the blank.

TABLE 2-7
SITE 2 – APPLE ORCHARD LANDFILL
GROUNDWATER ANALYTICAL RESULTS
(PHASE II – 1991)

Parameter	Sample Locations					Detection Limit	Units
	2GW30	2GW31	2GW32	2GW45	2GW76		
TOTAL METALS:							
Cadmium	6.0	74	10	7.0	39	5.0	ug/l
Chromium	31	179 R	53	77	147	10	ug/l
Copper	79	1680	102	158	141	25	ug/l
Lead	44	377	41	41	235	3	ug/l
Mercury	R	R	16 R	R	R	0.2	ug/l
Zinc	147	3400	508	349	893	20	ug/l
FILTERED METALS:							
Cadmium	U	U	6.0	U	U	5.0	ug/l
Chromium	U	U	U	U	U	10	ug/l
Copper	39	U	U	U	U	25	ug/l
Lead	U	U	17	U	9.3	3	ug/l
Mercury	R	R	P R	R	R	0.2	ug/l
Zinc	73	32	381	75	61	20	ug/l
PCBs (1)	U	U	No report	U	U	1.0	ug/l
VOLATILE ORGANICS:							
Methylene Chloride	U	U	U	U	U	5	ug/l
Trichloroethene	5	U	140	1	U	5	ug/l
cis-1,2-Dichloroethene	U	U	1	U	U	10	ug/l
1,1,2,2-Tetrachloroethane	U	U	1	U	U	5	ug/l
SEMIVOLATILE ORGANICS:							
bis(2-ethylhexyl)phthalate	U	U	U	U	R	10	ug/l

NOTES: (1) The PCB compound for which values are given here is AR1260.
U – Not detected.
E – Quantitations Estimated
R – Quantitation Rejected.
P – Present

TABLE 2–8
SITE 2 – APPLE ORCHARD LANDFILL
SURFACE WATER ANALYTICAL RESULTS
(Phase I – 1989)

Parameter	Sample Locations						Detection Limit	Units
	2SW1	2SW2B	2SW3	2SW4	2SW5	2SW6		
TOTAL METALS:								
Cadmium	U	U	U	U	U	U	5.0	ug/l
Chromium	U	U	U	U	U	U	7.0	ug/l
Copper	12.4	6.7	14.4	18.9	16.1	5.0	3.0	ug/l
Lead	U	U	U	U	U	U	28.0	ug/l
Zinc	35.4	32.5	58.9	58.6	54.6	10.4	3.0	ug/l
FILTERED METALS:								
Cadmium	U	U	U	U	U	U	5.0	ug/l
Chromium	U	U	U	U	U	U	7.0	ug/l
Copper	11.1	3.3	12.2	11.7	11.7	6.7	3.0	ug/l
Lead	U	U	U	U	U	U	28.0	ug/l
Zinc	49.5	74.8	59.3	25.0	58.7	27.8	3.0	ug/l
pH	6.84	7.10	6.89	7.41	6.76	7.06	--	su
TOC	3,000	2,300	2,600	8,100	2,800	2,200	500	ug/l
TOX	27	25	33	21	35	20	8	ug/l
TDS	671	563	721	182	588	482	20	mg/l
TSS	U	7	4	55	6	U	4	mg/l
VOLATILE ORGANICS:								
Trichloroethene	U	U	5	U	U	U	5	ug/l

Note: U – Not detected.

TABLE 2-9
SITE 2 – APPLE ORCHARD LANDFILL
SURFACE WATER ANALYTICAL RESULTS
(PHASE II – 1991)

Parameter	Sample Locations						Detection Limit	Units
	2SW1	2SW2B	2SW3	2SW4	2SW5	2SW6		
PCBs (1)	U	U	U	U	U	U	1.0	ug/l
VOLATILE ORGANICS:								
Trichloroethene	2	U	5	U	3	U	5	ug/l
Acetone	U	U	U	R	U	U	10	ug/l
Methylene Chloride	U	U	U	U	1	U	5	ug/l

NOTES: (1) The PCB compound for which values are given here is AR1260.
U – Not detected.
R – Quantitation Rejected.

TABLE 2-10
SITE 2 – APPLE ORCHARD LANDFILL
SEDIMENT ANALYTICAL RESULTS
(PHASE II – 1991)

Parameter	Sample Locations										Detection Limits	Units
	2SD1	2SD3	2SD4	2SD5	2SD6	2SD7	2SD9	2SD10	2SD11	2SD12		
TOTAL METALS:												
Cadmium	U	U	U	3.1	U	1.2	U	3.8	U	2.4	5	mg/kg
Chromium	8.8	8.7	8.5	12	13	8.3	43	26	15	15	10	mg/kg
Copper	16	13	13	42	12	23	20	52	15	43	25	mg/kg
Lead	37	40	23	22	12	12	41	119	6.1	18	3	mg/kg
Zinc	43	34	38	46	38	62	70	182	31	111	10	mg/kg
PCBs (1)	1400	1900	1700	4300	540	490	340	56,000	430	630	(2)	ug/kg
VOLATILE ORGANICS:											(2)	
Acetone	U	15	R	5	52	50	27	14	U	U	--	ug/kg
Methylene Chloride	U	5	R	170	4	4	3	11	2	5	--	ug/kg
Carbon Disulfide	U	U	U	37	U	U	U	U	U	U	--	ug/kg
1,2-Dichloroethane	U	U	U	U	U	U	U	U	U	U	--	ug/kg
Dichloropropane	U	U	U	U	U	U	U	U	U	U	--	ug/kg
2-Butanone	U	U	U	U	U	U	U	U	U	U	--	ug/kg
Ethylbenzene	U	U	U	U	U	U	U	U	U	U	--	ug/kg
m & p Xylenes	U	U	U	U	U	U	U	U	U	U	--	ug/kg
o-Xylenes	U	U	U	U	U	U	U	U	U	U	--	ug/kg
Toluene	U	U	U	U	U	U	U	U	U	U	--	ug/kg
1,1,2,2-Tetrachloroethane	U	U	U	U	U	U	U	U	U	U	--	ug/kg
Benzene	3	U	U	U	U	U	U	U	U	U	--	ug/kg
Trichloroethene	U	U	43	U	U	U	U	U	U	U	--	ug/kg

NOTES: (1) The PCB compound for which values are given here is AR1260.
(2) The detection limits are based on % moisture determination.
U – Not detected.
E – Quantitation Estimated
R – Quantitation Rejected.

TABLE 2-11
SITE 2 - APPLE ORCHARD LANDFILL
SUMMARY OF RISK ESTIMATES

CURRENT AND FUTURE LAND USE	NSWCWODET WORKERS		OFF-SITE POPULATIONS			
	Noncancer Risk	Cancer Risk	Adult: Noncancer Risk	Adult: Cancer Risk	Adolescent: Noncancer Risk	Adolescent: Cancer Risk
SOIL						
Ingestion	NE	X	NE		NE	
Dermal Contact	NE	X	NE		NE	
SEDIMENT						
Dermal Contact	NE	X	NE		NE	

Notes:
X = Exceeds USEPA criteria for Noncancer Risk (hazard index $\geq$ 1.0) or USEPA Superfund remediation goals for cancer risk (10^{-4} to 10^{-6})

NE = Not evaluated (PCB could not be quantitatively evaluated, no RFD available)

TABLE 3-1
SUMMARY OF FIELD ENVIRONMENTAL SAMPLING
SITE 3
(Phase I – 1989)

SAMPLE MATRIX	PARAMETERS		FIELD SAMPLES SEDIMENT	FIELD SAMPLES SOIL	QA/QC SAMPLES FD	QA/QC SAMPLES ER	QA/QC SAMPLES TB	TOTAL SAMPLES
SEDIMENTS/SOIL	VOLATILES		0	0	0	0	0	0
	SEMIVOLATILES		0	2	0	1	0	3
	PCBS		0	0	0	0	0	0
	METALS		4	2	1	1	0	8
	MERCURY		4	2	0	0	0	6
	CHROMIUM VI		4	0	0	0	0	4
	NITROAROMATICS		0	0	0	0	0	0
	TOC		4	0	0	1	0	5
	TOX		4	0	0	1	0	5
	pH		4	0	0	0	0	4
		SUB-TOTAL	24	6	1	4	0	35
			WATER GROUND	WATER SURFACE	QA/QC SAMPLES FD	QA/QC SAMPLES ER	QA/QC SAMPLES TB	TOTAL SAMPLES
GROUND/SURFACE WATER	VOLATILES		4	4	1	1	2	12
	SEMIVOLATILES		0	0	0	0	0	0
	PCBS		0	0	0	0	0	0
	METALS 1		8	8	2	1	0	19
	MERCURY		8	8	0	0	0	16
	CHROMIUM VI		0	0	0	0	0	0
	NITROAROMATICS		0	0	0	0	0	0
	TOC		4	4	1	1	0	10
	TOX		4	4	1	1	0	10
	TDS		4	4	1	1	0	10
	TSS		4	4	1	1	0	10
		SUB-TOTAL	36	36	7	6	2	87
		TOTAL SAMPLES	60	42	8	10	2	122

Notes: 1. Metals (Cd, Cr, Cu, Pb, Zn), mercury, and chromium VI – Filtered (dissolved) and unfiltered (total) fractions were collected for each water sample.

FD – Field duplicate

ER – Equipment Rinsate

TB – Trip blank

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TABLE 3-2
SUMMARY OF FIELD ENVIRONMENTAL SAMPLING
SITE 3
(Phase II - 1991)

SAMPLE MATRIX	PARAMETERS		SEDIMENT SAMPLES			SOIL SAMPLES			TOTAL SAMPLES
			FIELD	QA/QC		FIELD	QA/QC		
				FD	ER		FD	ER	
SEDIMENTS/SOIL	VOLATILES		0	0	0	2	0	0	2
	SEMIVOLATILES		0	0	0	2	0	0	2
	PCBS		0	0	0	0	0	0	0
	METALS		4	0	0	2	0	0	6
	MERCURY		4	0	0	2	0	0	6
	NITROAROMATICS		0	0	0	0	0	0	0
		SUB-TOTAL	8	0	0	8	0	0	16
			GROUNDWATER SAMPLES			SURFACE WATER SAMPLES			TOTAL SAMPLES
			FIELD	QA/QC		FIELD	QA/QC		
				FD	ER		FD	ER	
GROUND/SURFACE WATER	VOLATILES		7	1	0	0	0	0	8
	SEMIVOLATILES		0	0	0	0	0	0	0
	PCBS		7	1	0	0	0	0	8
	METALS 1		14	2	0	0	0	0	16
	MERCURY		13	2	0	0	0	0	15
	NITROAROMATICS		0	0	0	0	0	0	0
		SUB-TOTAL	41	6	0	0	0	0	47
	TOTAL SAMPLES		**49**	**6**	**0**	**8**	**0**	**0**	**63**

Notes: 1. Metals (Cd, Cr, Cu, Pb, Zn), mercury, and chromium VI - Filtered (dissolved) and unfiltered (total) fractions were collected for each water sample.
FD - Field duplicate
ER - Equipment Rinsate
Equipment rinsate analyzed for total metals

TABLE 3-3
SITE 3 – PISTOL RANGE LANDFILL
SEDIMENT/SURFICIAL SOIL ANALYTICAL RESULTS
(Phase I – 1989)

Parameter	Sample Locations 3SD1	3SD2	3SD3	3SD6	3SL1	3SL2	Detection Limit	Units
TOTAL METALS:								
Cadmium	U	U	U	U	60.1	5.6	0.78	mg/kg
Chromium	33.9	12.0	6.3	16.8	83.0	34.2	0.70	mg/kg
Copper	9.9	3.3	6.6	8.9	2530	241	0.30	mg/kg
Lead	5.9	U	U	4.7	1460	141	3.60	mg/kg
Zinc	23.2	14.2	8.9	14.8	7300	544	0.50	mg/kg
Mercury	0.19	0.18	0.24	0.17	12.4	1.7	0.14	mg/kg
Chromium VI	U	U	U	U	U	U	10.0	ug/l
pH	7.21	7.42	7.23	7.21	--	--	--	su
TOC	2,580	1,735	3,400	1,310	--	--	100	mg/kg
TOX	19.8	19.2	16.2	10.2	--	--	10.0	mg/kg
SEMIVOLATILES:								
Phenanthrene	--	--	--	--	7,400	2,900	2,300	ug/kg
Anthracene	--	--	--	--	1,300 J	U	2,200	ug/kg
Di-n-Butylphthalate	--	--	--	--	15,000	7,200	2,300	ug/kg
Fluoranthene	--	--	--	--	14,000	5,400	2,300	ug/kg
Pyrene	--	--	--	--	9,600	4,000	2,300	ug/kg
Benzo(a)Anthracene	--	--	--	--	5,200	2,300	2,300	ug/kg
Chrysene	--	--	--	--	5,000	2,500	2,300	ug/kg
Benzo(b)Fluoranthene	--	--	--	--	4,700	2,700	2,300	ug/kg
Benzo(k)Fluoranthene	--	--	--	--	4,200	2,000 J	2,200	ug/kg
Benzo(a)Pyrene	--	--	--	--	4,800	2,600	2,200	ug/kg
Indeno(1,2,3-cd)Pyrene	--	--	--	--	2,600	1,200	1,100	ug/kg
Dibenz(a,h)Anthracene	--	--	--	--	1,100 JX	U	2,200	ug/kg
Benzo(g,h,i)Perylene	--	--	--	--	2,600	1,200	1,100	ug/kg

Notes: U – Not detected.
J – Compound is present but less than the detection limit.
X – EPA CLP criteria for confirmation not met but compound is present.

TABLE 3-4
SITE 3 – PISTOL RANGE LANDFILL
SEDIMENT/SURFICIAL SOIL ANALYTICAL RESULTS
(PHASE II – 1991)

Parameter	Sample Locations						Detection Limit	Units
	3SD1	3SD2	3SD3	3SD6	3SL3	3SL4		
TOTAL METALS:								
Cadmium	U	U	U	U	1.1	U	5	mg/kg
Chromium	8.3	3.5	8.7	7.4	28	12	10	mg/kg
Copper	4.2	5.9	U	U	16	22	25	mg/kg
Lead	4.4	4.5	2.0	0.8	92	20	3	mg/kg
Mercury	R	R	R	R	R	R	0.2	mg/kg
Zinc	8.7	14	13	8.8	20	38	20	mg/kg
VOLATILE ORGANICS:							(1)	
Acetone	--	--	--	--	36E	80E	--	ug/kg
Methylene Chloride	--	--	--	--	58E	48E	--	ug/kg
SEMIVOLATILES:							(1)	
Phenanthrene	--	--	--	--	UE	UE	--	ug/kg
Anthracene	--	--	--	--	UE	UE	--	ug/kg
Di-n-Butylphthalate	--	--	--	--	UE	UE	--	ug/kg
Fluoranthene	--	--	--	--	UE	UE	--	ug/kg
Pyrene	--	--	--	--	UE	UE	--	ug/kg
Benzo(a)Anthracene	--	--	--	--	UE	UE	--	ug/kg
Chrysene	--	--	--	--	UE	UE	--	ug/kg
Benzo(b)Fluoranthene	--	--	--	--	UE	UE	--	ug/kg
Benzo(k)Fluoranthene	--	--	--	--	UE	UE	--	ug/kg
Benzo(a)Pyrene	--	--	--	--	UE	UE	--	ug/kg
Indeno(1,2,3-cd)Pyrene	--	--	--	--	UE	UE	--	ug/kg
Dibenz(a,h)Anthracene	--	--	--	--	UE	UE	--	ug/kg
Benzo(g,h,i)Perylene	--	--	--	--	UE	UE	--	ug/kg

NOTES: (1) Detection limits are based on % moisture determination.
U – Not detected.
R – Quantitation Rejected
E – Quantitation Estimated

TABLE 3–5
SITE 3 – PISTOL RANGE LANDFILL
GROUNDWATER ANALYTICAL RESULTS
(Phase I – 1989)

Parameter	Sample Locations 3GW17	3GW18	3GW19	3GW47	Detection Limit	Units
TOTAL METALS:						
Cadmium	U	U	U	U	5.0	ug/l
Chromium	14.8	69.9	56.9	259.0	5.0	ug/l
Copper	14.4	49.0	98.8	170.0	3.0	ug/l
Lead	U	U	53.4	91.1	28.0	ug/l
Mercury	U	0.33	0.24	U	0.20	ug/l
Zinc	34.1	137.0	122.0	275.0	3.0	ug/l
FILTERED METALS:						
Cadmium	U	U	U	U	5.0	ug/l
Chromium	U	U	5.6	U	5.0	ug/l
Copper	U	U	U	U	3.0	ug/l
Lead	U	U	U	64.3	28.0	ug/l
Mercury	U	U	U	U	0.20	ug/l
Zinc	21.3	106.0	39.0	283.0	3.0	ug/l
pH	6.20	6.10	6.30	5.80	--	su
TOC	5,790	36,400	38,200	34,200	500	ug/l
TOX	13.2	U	34.9	19.8	8	ug/l
TDS	48.0	138.0	208.0	262.0	20	mg/l
TSS	645	4,920	5,420	3,880	4	mg/l
VOLATILE ORGANICS:						
1,2–Dichloroethene (total)	U	8	38	U	5	ug/l
Trichloroethene	U	7	7	U	5	ug/l
Chlorobenzene	U	U	16	U	5	ug/l

Note: U – Not detected.

TABLE 3-6
SITE 3 – PISTOL RANGE LANDFILL
GROUNDWATER ANALYTICAL RESULTS
(PHASE II – 1991)

Parameter	Sample Locations							Detection Limit	Units
	3GW17	3GW18	3GW19	3GW47	3GW77	3GW78D	3GW78S		
TOTAL METALS:									
Cadmium	U	U	U	25	19	U	U	5.0	ug/l
Chromium	40	32	25	136	119	U	28	10	ug/l
Copper	86	25	U	543	186	U	54	25	ug/l
Lead	18	19	38	117	65	U	20	3	ug/l
Mercury	R	R	R	R	R	R	R	0.2	ug/l
Zinc	98	78	62	661	794	18	372	20	ug/l
FILTERED METALS:									
Cadmium	U	U	U	U	U	U	U	5.0	ug/l
Chromium	U	U	U	2.7	U	U	U	2.2	ug/l
Copper	33	25	26	30	U	U	U	11	ug/l
Lead	U	U	3.1	9.1	U	U	U	1.5	ug/l
Mercury	R	R	R	R	R	U	U	0.2	ug/l
Zinc	19	53	19	178	42	18	14	4.6	ug/l
PCBs (1)	U	U	U	U(2)	U	U	U	1.0	ug/l
VOLATILE ORGANICS:									
1,2-Dichloroethene (total)	U	U	120	U	U	U	U	5	ug/l
Trichloroethene	U	U	11	U	6	U	U	5	ug/l
Chlorobenzene	U	U	27	U	U	U	U	5	ug/l
Methylene Chloride	U	U	U	U	U	7	U	5	ug/l

NOTES: (1) The PCB compound for which values are given here is AR1260.

(2) Quantitated from field duplicate

U – Not detected.

TABLE 3-5
SITE 3 - PISTOL RANGE LANDFILL
SURFACE WATER ANALYTICAL RESULTS
(Phase I - 1989)

Parameter	Sample Locations				Detection Limit	Units
	3SW1	3SW2	3SW3	3SW4		
TOTAL METALS:						
Cadmium	U	U	U	U	5.0	ug/l
Chromium	U	8.8	U	U	7.0	ug/l
Copper	3.7	5.3	4.2	5.8	3.0	ug/l
Lead	31.4	U	U	U	28.0	ug/l
Zinc	14.5	28.3	19.7	26.7	3.0	ug/l
Mercury	U	U	U	0.22	0.20	ug/l
Chromium VI	U	U	U	U	10.0	ug/l
FILTERED METALS:						
Cadmium	U	U	U	U	5.0	ug/l
Chromium	U	U	U	U	7.0	ug/l
Copper	5.9	7.5	3.8	6.4	3.0	ug/l
Lead	U	U	U	U	28.0	ug/l
Zinc	42.2	26.2	30.8	19.1	3.0	ug/l
Mercury	U	U	0.41	U	0.20	ug/l
Chromium VI	U	U	U	U	10.0	ug/l
pH	7.38	7.57	7.33	7.69	--	su
TOC	4640	4620	4280	5240	500	ug/l
TOX	23.9	24.8	28.0	25.8	8	ug/l
TDS	212	165	206	177	20	mg/l
TSS	U	U	U	8	4	mg/l
VOLATILE ORGANICS:	U	U	U	U	--	ug/l

Note: U - Not detected.

TABLE 3-8
SITE 3 - PISTOL RANGE LANDFILL
SUMMARY OF RISK ESTIMATES

CURRENT AND FUTURE LAND USE	OFF-SITE POPULATIONS			
	Adult: Noncancer Risk	Adult: Cancer Risk	Children: Noncancer Risk	Children: Cancer Risk
GROUND WATER				
Ingestion		X		
Dermal Contact				
Inhalation				
Total Exposure Hazard/Risk		X		X

Notes:
X = Exceeds USEPA criteria for Noncancer Risk (hazard index $\geq$ 1.0) or USEPA Superfund remediation goals for cancer risk (10^{-4} to 10^{-6})

TABLE 4-1
SUMMARY OF FIELD ENVIRONMENTAL SAMPLING
SITE 4
(Phase I - 1989)

SAMPLE MATRIX	PARAMETERS		FIELD SAMPLES SEDIMENT	FIELD SAMPLES SOIL	QA/QC SAMPLES FD	QA/QC SAMPLES ER	QA/QC SAMPLES TB	TOTAL SAMPLES
SEDIMENTS/SOIL	VOLATILES		0	0	0	0	0	0
	SEMIVOLATILES		0	4	1	1	0	6
	PCBS		0	0	0	0	0	0
	METALS		0	6	1	1	0	8
	MERCURY		0	0	0	0	0	0
	CHROMIUM VI		0	6	1	1	0	8
	NITROAROMATICS		0	0	0	0	0	0
	TOC		0	6	1	1	0	8
	TOX		0	6	1	1	0	8
	pH		0	6	1	0	0	7
		SUB-TOTAL	0	34	6	5	0	45
			WATER GROUND	WATER SURFACE	QA/QC SAMPLES FD	QA/QC SAMPLES ER	QA/QC SAMPLES TB	TOTAL SAMPLES
GROUND/SURFACE WATER	VOLATILES		12	0	1	1	1	15
	SEMIVOLATILES		12	0	1	1	0	14
	PCBS		0	0	0	0	0	0
	METALS 1		24	0	2	1	0	27
	MERCURY		24	0	2	0	0	26
	CHROMIUM VI		24	0	2	1	0	27
	NITROAROMATICS		0	0	0	0	0	0
	TOC		12	0	1	1	0	14
	TOX		12	0	1	1	0	14
	TDS		12	0	1	1	0	14
	TSS		12	0	1	1	0	14
		SUB-TOTAL	144	0	12	8	1	165
		TOTAL SAMPLES	144	34	18	13	1	210

Notes: 1. Metals (Cd, Cr, Cu, Pb, Zn), mercury, and chromium VI - Filtered (dissolved) and unfiltered (total) fractions were collected for each water sample.
FD - Field duplicate
ER - Equipment Rinsate
TB - Trip blank

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TABLE 4–2
SUMMARY OF FIELD ENVIRONMENTAL SAMPLING
SITE 4
(Phase II – 1991)

SAMPLE MATRIX	PARAMETERS		SEDIMENT SAMPLES			SOIL SAMPLES			TOTAL SAMPLES
			FIELD	QA/QC		FIELD	QA/QC		
				FD	ER		FD	ER	
SEDIMENTS/SOIL	VOLATILES		0	0	0	2	0	0	2
	SEMIVOLATILES		0	0	0	2	0	0	2
	PCBS		0	0	0	0	0	0	0
	METALS		0	0	0	2	0	0	2
	MERCURY		0	0	0	0	0	0	0
	NITROAROMATICS		0	0	0	0	0	0	0
		SUB–TOTAL	0	0	0	6	0	0	6
			GROUNDWATER SAMPLES			SURFACE WATER SAMPLES			TOTAL SAMPLES
			FIELD	QA/QC		FIELD	QA/QC		
				FD	ER		FD	ER	
GROUND/SURFACE WATER	VOLATILES		17	1	2	0	0	0	20
	SEMIVOLATILES		17	1	2	0	0	0	20
	PCBS		17	1	2	0	0	0	20
	METALS 1		34	2	2	0	0	0	38
	MERCURY		34	2	2	0	0	0	38
	NITROAROMATICS		0	0	0	0	0	0	0
		SUB–TOTAL	119	7	10	0	0	0	136
	TOTAL SAMPLES		**119**	**7**	**10**	**6**	**0**	**0**	**142**

Notes: 1. Metals (Cd, Cr, Cu, Pb, Zn), mercury, and chromium VI – Filtered (dissolved) and unfiltered (total) fractions were collected for each water sample.

FD – Field duplicate

ER – Equipment rinsate

Equipment rinsate analyzed for total metals

TABLE 4-3
SITE 4 - CHEMICAL BURIAL SITE
SOIL BORING ANALYTICAL RESULTS
(Phase I - 1989)

Parameter	Sample Locations						Detection Limit	Units
	4SB1A (4GW52)	4SB1B (4GW52)	4SB2A (4GW48)	4SB2B (4GW48)	4SB3A (4GW51S)	4SB3B (4GW51S)		
TOTAL METALS:								
Cadmium	U	U	U	U	U	0.57	0.50	mg/kg
Chromium	16.4	8.3	12.2	4.4	6.0	4.8	0.70	mg/kg
Copper	5.0	9.4	3.2	2.2	3.4	1.5	0.30	mg/kg
Lead	5.3	U	U	U	U	U	3.60	mg/kg
Zinc	2.6	0.90	5.6	1.8	1.4	1.7	0.50	mg/kg
Chromium VI	U	U	U	U	U	U	10.0	ug/l
pH	5.66	5.53	5.28	5.19	5.54	6.20	--	su
TOC	492	U	492	672	615	691	100	mg/kg
TOX	U	U	U	U	U	U	15	mg/kg
SEMIVOLATILE ORGANICS:								
bis(2-ethylhexyl)phthalate	--	--	150 J	U	U	86 JX	350	ug/kg

Notes: A - Sample collected above the water table.
B - Sample collected in the saturated zone.
U - Not detected.
J - Compound present but below detection limit.
X - EPA CLP criteria not met for confirmation but compound is present.

TABLE 4-4
SITE 4 - CHEMICAL BURIAL SITE
SURFACE SOIL ANALYTICAL RESULTS
(PHASE II - 1991)

Parameter	Sample Locations 4SL1	Sample Locations 4SL2	Detection Limit	Units
TOTAL METALS:				
Cadmium	U	U	5	mg/kg
Chromium	1.0	8.5	10	mg/kg
Copper	22	3.5	25	mg/kg
Lead	7.3	14	3	mg/kg
Zinc	34	9.5	20	mg/kg
VOLATILE ORGANICS:			(1)	
Acetone	48 E	59 E	—	ug/kg
Methylene Chloride	180 E	350 E	—	ug/kg
Trichloroethene	U E	8 E	—	ug/kg
Carbon Disulfide	5 E	U E	—	ug/kg
1,1,1-Trichloroethane	3 E	U E	—	ug/kg
m & p Xylene	3 E	U E	—	ug/kg
SEMIVOLATILE ORGANICS:			(1)	
bis(2-ethylhexyl)phthalate	U	U	—	ug/kg
pyrene	340 E	U	—	ug/kg

NOTES: (1) Detection limits are based on % moisture determination.
U - Not detected.
E - Quantitation Estimated

TABLE 4-5
SITE 4 – CHEMICAL BURIAL SITE
GROUNDWATER ANALYTICAL RESULTS
(Phase I – 1989)

Parameter	Sample Locations												Detection Limit	Units
	4GW10	4GW11	4GW11A	4GW12	4GW13	4GW15	4GW48	4GW49S	4GW49D	4GW50	4GW51S	4GW52		
TOTAL METALS:														
Cadmium	U	7.6	12.6	U	9.5	2.2	2.1	U	U	U	U	8.4	2.0	ug/l
Chromium	93.9	202	157	90.5	100	113	375	51.4	34.4	128	6.1	396	5.0	ug/l
Copper	45.7	408	780	56.3	143	46.3	236	23.5	40.2	209	4.3	259	3.0	ug/l
Lead	U	204	102	U	35.3	31.4	91.2	43.9	U	34.7	U	77.0	28.0	ug/l
Mercury	2.6	2.7	3.1	3.0	2.8	4.4	2.1	0.77	4.1	3.3	U	2.5	0.20	ug/l
Zinc	60.2	1150	2850	31.9	39.0	60.4	277	51.0	25.6	58.5	5.5	198	3.0	ug/l
Chromium VI	U	U	U	U	U	U	U	U	U	U	U	U	10.0	ug/l
FILTERED METALS:														
Cadmium	3.6	2.8	2.6	2.8	2.7	U	U	4.3	U	2.9	U	5.6	2.0	ug/l
Chromium	U	U	U	U	U	U	U	U	U	U	U	U	5.0	ug/l
Copper	U	U	18.6	U	U	U	U	U	U	U	U	U	3.0	ug/l
Lead	U	U	U	U	U	U	U	U	U	U	U	U	28.0	ug/l
Mercury	1.4	U	U	0.88	U	U	U	U	0.27	U	U	U	0.20	ug/l
Zinc	145	37.9	949	106	60.3	62.1	87.0	23.8	87.7	86.8	31.7	56.2	3.0	ug/l
Chromium VI	U	U	U	U	U	U	U	U	U	U	U	U	10.0	ug/l
pH	5.90	6.70	6.70	4.50	5.00	5.60	7.00	5.60	5.40	5.40	6.60	5.50	--	su
TOC	19.6	51.7	19.3	17.1	42.4	13.3	62.5	13.9	43.8	25.2	14.4	59.8	0.50	mg/l
TOX	47.2	17.0	17.3	23.6	87.2	89.8	140	U	17.6	21.0	39.6	472.0	8	ug/l
TDS	360	296	330	196	130	752	508	488	285	228	312	212	20	mg/l
TSS	4,990	23,900	924.0	7,140	4,320	9,810	20,600	7,550	5,360	16,220	536	31,500	4	mg/l
VOLATILE ORGANICS:														
Benzene	U	6	U	U	U	U	U	U	U	U	7	U	5	ug/l
Chloroform	U	U	U	U	6	U	U	U	U	U	U	U	5	ug/l
1,2-Dichloroethene	U	U	U	U	7	U	U	U	U	U	U	170	5	ug/l
Methylene Chloride	4 J	4 J	U	U	U	U	23	U	U	U	U	U	5	ug/l
1,1,2,2-Tetrachloroethane	U	U	U	U	U	81	U	U	U	U	U	75	5	ug/l
Toluene	6	5 J	U	4 J	U	U	U	U	U	U	U	U	5	ug/l
Trichloroethene	U	U	U	U	160	170	590	U	U	U	U	1000	5	ug/l
SEMIVOLATILES:														
Benzoic Acid	14 J	29 J	U	U	U	U	U	U	U	U	15 JX	U	50	ug/l
bis(2-Ethylhexyl)Phthalate	U	7 J	U	U	U	U	6 JX	U	U	U	14	8 JX	10	ug/l

Notes: U – Not detected.

J – Compound is present but less than the detection limit.

X – EPA CLP criteria for confirmation not met but compound is present.

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TABLE 4-6
SITE 4 - CHEMICAL BURIAL SITE
GROUNDWATER ANALYTICAL RESULTS
(PHASE II - 1991)

Parameter	Sample Locations												Detection Limit	Units
	4GW10	4GW11	4GW11A	4GW12	4GW13	4GW15	4GW48	4GW49D	4GW49S	4GW50	4GW51	4GW52		
TOTAL METALS:														
Cadmium	U	U	25	U	U	U	U	U	U	9.0	U	8.0	5.0	ug/l
Chromium	3.9	U	93	42	11	24	9.5	6.3	U	82	8.1	46	2.2	ug/l
Copper	U	U	1150	20	58	22	U	U	24	139	19	121	11	ug/l
Lead	3.2	2.3	96	22	9.9	19	2.4	2.8	3.6	19	U	30	1.5	ug/l
Mercury	P R	R	R	P R	P R	R	R	P R	R	P R	R	R	0.2	ug/l
Zinc	U	40	5310	12	21	46	45	6.0	37	52	71	56	4.6	ug/l
FILTERED METALS:														
Cadmium	U	U	U	U	U	U	U	U	U	U	U	U	5.0	ug/l
Chromium	U	U	U	U	U	U	U	U	U	U	U	U	2.2	ug/l
Copper	U	U	U	U	U	U	U	U	U	U	U	U	11	ug/l
Lead	U	U	U	U	U	U	U	U	U	U	U	U	1.5	ug/l
Mercury	R	R	P R	P R	R	R	R	R	R	R	R	R	0.2	ug/l
Zinc	6.0	18	418	41	22	8.0	104	16	42	46	18	25	4.6	ug/l
PCBs (1)	U	U	U	U	U	U	U	U	U	U	U	U		ug/l
VOLATILE ORGANICS:														
Benzene	U	U	U	U	2	U	U	U	U	U	3	U	5	ug/l
Chloroform	U	U	U	U	1	U	9	U	U	2	U	U	5	ug/l
Methylene Chloride	R	12	R	4	R	R	U	8	4	R	R	10	5	ug/l
1,1,2,2-Tetrachloroethane	U	U	U	U	3	U	U	U	U	10 E	U	U	5	ug/l
Tetrachloroethene	U	U	U	U	U	U	U	U	U	U	U	U	5	ug/l
Toluene	U	U	U	U	U	U	U	U	U	U	U	U	5	ug/l
Trichloroethene	U	U	U	U	90	24	860	U	U	650	U	U	5	ug/l
Acetone	U	98 E	R	U	R	R	U	32 E	U	8	R	93 E	10	ug/l
1,1,1-Trichloroethane	U	U	U	U	2	2	U	U	U	5	U	U	5	ug/l
1,1,2-Trichloroethane	U	U	U	U	U	U	U	U	U	2	U	U	5	ug/l
1,2-Dichloroethene (Total)	U	U	U	U	50	U	U	U	U	54	U	U	5	ug/l
1,2-Dichloroethane	U	U	U	U	2	U	U	U	U	2	U	U	5	ug/l
Chlorobenzene	U	U	U	U	1	U	U	U	U	1	U	U	5	ug/l
Vinyl Chloride	U	U	U	U	11	U	U	U	U	U	U	U	10	ug/l
2-Butanone	U	U	U	U	U	U	U	U	U	U	40 E	U	10	ug/l
Ethylbenzene	U	U	U	U	U	U	U	U	U	U	U	U	5	ug/l
m & p xylenes	U	U	U	U	U	U	U	U	U	U	U	U	5	ug/l
o-xylene	U	U	U	U	U	U	U	U	U	U	U	U	5	ug/l
SEMIVOLATILES:														
Benzoic Acid	U	R	R	R	U	R	U	U	R	U	R	U	50	ug/l
bis(2-Ethylhexyl)Phthalate	U	R	R	R	U	R	U	U	R	U	R	U	10	ug/l

NOTES: (1) The PCB compound for which values are given here is AR1260.
U - Not detected.
E - Quantitation Estimated
R - Quantitation Rejected.
P - Present

TABLE 4-6 (CONTINUED)
SITE 4 - CHEMICAL BURIAL SITE
GROUNDWATER ANALYTICAL RESULTS
(PHASE II - 1991)

Parameter	Sample Locations					Detection Limit	Units
	4PZ79(2)	4GW80	4GW81D	4GW81S	4GW82		
TOTAL METALS:							
Cadmium	U	U	U	U	7.0	5.0	ug/l
Chromium	U	26	2.3	270	45	2.2	ug/l
Copper	U	137	19	290	172	11	ug/l
Lead	U	12	U	32	34	1.5	ug/l
Mercury	P R	P R	P R	P R	U	0.2	ug/l
Zinc	32	79	14	167	666	4.6	ug/l
FILTERED METALS:							
Cadmium	U	U	U	U	U	5.0	ug/l
Chromium	U	U	U	U	U	2.2	ug/l
Copper	U	U	U	U	U	11	ug/l
Lead	U	U	U	U	U	1.5	ug/l
Mercury	R	R	R	R	U	0.2	ug/l
Zinc	74	26	42	44	45	4.6	ug/l
PCBs (1)	U	U	U	U	U	1.0	ug/l
VOLATILE ORGANICS:							
Benzene	U	U	U	U	U	5	ug/l
Chloroform	U	U	U	U	U	5	ug/l
Methylene Chloride	25	5 E	25	8 E	5	5	ug/l
1,1,2,2-Tetrachloroethane	3	U	3	10	U	5	ug/l
Tetrachloroethene	U	U	U	4	5	5	ug/l
Toluene	U	U	U	10	U	5	ug/l
Trichloroethene	39	34	2	4	U	5	ug/l
Acetone	7	12 E	13	5 E	12	10	ug/l
1,1,1-Trichloroethane	U	U	U	U	U	5	ug/l
1,1,2-Trichloroethane	U	U	U	U	U	5	ug/l
Vinyl Chloride	U	U	U	U	U	10	ug/l
1,2-Dichloroethane	U	U	U	U	U	5	ug/l
Chlorobenzene	U	U	U	U	U	5	ug/l
1,2,-Dichloroethene (Total)	U	U	U	U	U	5	ug/l
2-Butanone	U	U	U	U	U	10	ug/l
Ethylbenzene	U	U	U	U	2	5	ug/l
m & p xylenes	U	U	U	U	9	5	ug/l
o-xylene	U	U	U	U	4	5	ug/l
SEMIVOLATILES:							
Benzoic Acid	R	R	R	R	R	50	ug/l
bis(2-Ethylhexyl)Phthalate	R	R	R	R	R	10	ug/l

NOTES: (1) The PCB compound for which values are given here is AR1260.
(2) Well damaged
U - Not detected.
E - Quantitation Estimated.
P - Present

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TABLE 4-7
SUMMARY OF RISK ESTIMATES
SITE 4 - CHEMICAL BURIAL SITE

CURRENT AND FUTURE LAND USE	OFF-SITE POPULATIONS			
	Adult: Noncancer Risk	Adult: Cancer Risk	Children: Noncancer Risk	Children: Cancer Risk
GROUND WATER				
Ingestion		X		X
Dermal Contact		X		X
Inhalation		X		X
Total Exposure Hazard/Risk		X		X

Notes:
X = Exceeds USEPA criteria for Noncancer Risk (hazard index $\geq$ 1.0) or USEPA Superfund remediation goals for cancer risk (10^{-4} to 10^{-6})

TABLE 5-1
SUMMARY OF FIELD ENVIRONMENTAL SAMPLING
SITE 7
(Phase I - 1989)

SAMPLE MATRIX	PARAMETERS		FIELD SAMPLES SEDIMENT	SOIL	QA/QC SAMPLES FD	ER	TB	TOTAL SAMPLES
SEDIMENTS/SOIL	VOLATILES		0	0	0	0	0	0
	SEMIVOLATILES		0	0	0	0	0	0
	PCBS		0	0	0	0	0	0
	METALS		0	0	0	0	0	0
	MERCURY		0	0	0	0	0	0
	CHROMIUM VI		0	0	0	0	0	0
	NITROAROMATICS		0	49	6	2	0	57
	TOC		0	0	0	0	0	0
	TOX		0	0	0	0	0	0
	pH		0	49	6	0	0	55
		SUB-TOTAL	0	98	12	2	0	112
			WATER GROUND	SURFACE	QA/QC SAMPLES FD	ER	TB	TOTAL SAMPLES
GROUND/SURFACE WATER	VOLATILES		0	0	0	0	0	0
	SEMIVOLATILES		0	0	0	0	0	0
	PCBS		0	0	0	0	0	0
	METALS 1		6	0	0	0	0	6
	MERCURY		6	0	0	0	0	6
	CHROMIUM VI		0	0	0	0	0	0
	NITROAROMATICS		3	0	0	0	0	3
	TOC		3	0	0	0	0	3
	TOX		3	0	0	0	0	3
	TDS		3	0	0	0	0	3
	TSS		3	0	0	0	0	3
		SUB-TOTAL	27	0	0	0	0	27
		TOTAL SAMPLES	27	98	12	2	0	139

Notes: 1. Metals (Cd, Cr, Cu, Pb, Zn), mercury, and chromium VI - Filtered (dissolved) and unfiltered (total) fractions were collected for each water sample.
FD - Field duplicate
ER - Equipment Rinsate
TB - Trip blank

F:\U\STEPHENS\WHITEOAK\TABLES\TABLE5-1.WK1 6-8-92

TABLE 5-2
SUMMARY OF FIELD ENVIRONMENTAL SAMPLING
SITE 7
(Phase II – 1991)

SAMPLE MATRIX	PARAMETERS		SEDIMENT SAMPLES			SOIL SAMPLES			TOTAL SAMPLES
			FIELD	QA/QC		FIELD	QA/QC		
				FD	ER		FD	ER	
SEDIMENTS/SOIL	VOLATILES		0	0	0	0	0	0	0
	SEMIVOLATILES		0	0	0	0	0	0	0
	PCBS		0	0	0	0	0	0	0
	METALS		0	0	0	0	0	0	0
	MERCURY		0	0	0	0	0	0	0
	NITROAROMATICS		6	1	1	0	0	0	8
		SUB-TOTAL	6	1	1	0	0	0	8
			GROUNDWATER SAMPLES			SURFACE WATER SAMPLES			TOTAL SAMPLES
			FIELD	QA/QC		FIELD	QA/QC		
				FD	ER		FD	ER	
GROUND/SURFACE WATER	VOLATILES		3	1	2	0	0	0	6
	SEMIVOLATILES		0	0	0	0	0	0	0
	PCBS		0	0	0	0	0	0	0
	METALS 1		6	2	2	0	0	0	10
	MERCURY		7	2	2	0	0	0	11
	NITROAROMATICS		5	1	0	0	0	0	6
		SUB-TOTAL	21	6	6	0	0	0	33
	TOTAL SAMPLES		27	7	7	0	0	0	41

Notes: 1. Metals (Cd, Cr, Cu, Pb, Zn), mercury, and chromium VI – Filtered (dissolved) and unfiltered (total) fractions were collected for each water sample.

FD – Field duplicate

ER – Equipment rinsate

Equipment rinsate analyzed for total metals

TABLE 5-3
SITE 7 - ORDNANCE BURN AREA
SOIL BORING ANALYTICAL RESULTS - NITROAROMATICS
(Phase I - 1989)

LOCATION	DETECTION LIMIT (ug/kg)	COMPOUNDS					
		HMX (ug/kg)	RDX (ug/kg)	1,3,5-TNB (ug/kg)	2,4,6-TNT (ug/kg)	2,6-DNT (ug/kg)	2,4-DNT (ug/kg)
7SL03A	20	30,000	8,300	U	U	U	U
7SL03B	19	360	1,100	U	U	U	U
7SL06A	20	1,500	270	U	2,100	U	U
7SL06B	20	710	U	U	910	U	U
7SL11A	20	3,000	U	U	U	U	U
7SL11B	20	520	280	U	450	U	U
7SL12A	20	74,000	1,300	U	230	U	U
7SL12B	20	51,000	470	U	450	U	U
7SL13A	20	6,000	1,000	U	210	U	U
7SL13B	19	5,800	850	U	380	U	U
7SL15A	20	1,300	740	U	330	U	U
7SL15B	20	980	380	U	410	U	U
7SL16A	19	51,000	1,300	U	120	U	U
7SL16B	190	17,000	930	U	130	U	U
7SL17A	20	13,000	220	U	U	U	U
7SL17B	20	16,000	760	U	230	U	U
7SL18A	20	19,000	3,500	U	15,000	U	U
7SL18B	19	16,000	5,100	U	34,000	U	U
7SL19A	19	160,000	430	U	U	U	U
7SL20A	19	3,100	U	U	380	U	U
7SL20B	20	4,900	260	U	490	U	U
7SL21A	19	46,000	700	U	600	U	U
7SL22A	20	8,400	U	U	U	U	U
7SL23A	20	820	U	U	U	U	U
7SL23B	19	370	U	U	U	U	U
7SL23C	20	250	U	U	U	U	U

Notes: U - Not detected.
A - Sample taken at depth of 0 to 1 foot.
B - Sample taken at depth of 4 to 5 feet.
C - Sample taken at depth of 3 feet.

TABLE 5-4
SITE 7 – ORDNANCE BURN AREA
SOIL BORING ANALYTICAL RESULTS– NITROAROMATICS
(PHASE II - 1991)

Compound	Sample Location						Detection Limit	Units
	7SB28A	7SB28B	7SB28C	7SB29A	7SB29B	7SB29C		
HMX	U	0.400	150.0	U	U	U	0.470	ug/g
RDX	0.350	1.100	U	U	U	U	0.180	ug/g
1,3,5-TNB	U	U	U	U	U	U	0.270	ug/g
2,4,6-TNT	1.30	U	U	U	U	U	0.660	ug/g
2,6-DNT	U	U	U	U	U	U	0.360	ug/g
2,4-DNT	U	U	U	U	U	U	0.530	ug/g
1,3-DNB	U	U	U	U	U	U	0.200	ug/g
Nitrobenzene	U	U	U	U	U	U	0.570	ug/g
Tetryl	U	U	U	U	U	U	4.00	ug/g

NOTES: A – Sample taken at depth of 5 feet.
B – Sample taken at depth of 10 feet.
C – Sample taken at depth of 15 feet.
U – Not detected.

TABLE 5-5
SITE 7 – ORDNANCE BURN AREA
GROUNDWATER ANALYTICAL RESULTS
(Phase I – 1989)

Parameter	Sample Locations 7GW8	7GW41	7GW43	Detection Limit	Units
TOTAL METALS:					
Cadmium	U	6.1	9.5	5.0	ug/l
Chromium	218.0	315.0	426.0	7.0	ug/l
Copper	190.0	753.0	513.0	3.0	ug/l
Lead	43.5	71.9	55.2	28.0	ug/l
Mercury	2.1	2.6	1.4	0.20	ug/l
Zinc	68.2	250.0	145.0	3.0	ug/l
FILTERED METALS:					
Cadmium	U	6.2	U	5.0	ug/l
Chromium	U	U	U	7.0	ug/l
Copper	12.7	14.7	21.5	3.0	ug/l
Lead	U	U	U	28.0	ug/l
Mercury	U	U	U	0.20	ug/l
Zinc	11.7	60.2	24.2	3.0	ug/l
pH	4.3	5.1	5.8	--	su
TOC	12.1	56.1	39.7	0.50	mg/l
TOX	13.0	32.3	128.0	8	ug/l
TDS	U	U	244.0	20	mg/l
TSS	22,800	19,300	11,400	4	mg/l
NITROAROMATICS:					
HMX	190.0	U	U	10.0	ug/l
RDX	700.0	U	U	10.0	ug/l
1,3,5-trinitrobenzene	U	U	U	10.0	ug/l
2,4,6-trinitrotoluene	U	U	U	10.0	ug/l
2,6-dinitrotoluene	U	U	U	10.0	ug/l
2,4-dinitrotoluene	U	U	U	10.0	ug/l

Note: U – Not detected.

TABLE 5-6
SITE 7 - ORDNANCE BURN AREA
GROUNDWATER ANALYTICAL RESULTS
(PHASE II - 1991)

Parameter	Sample Locations			Detection Limit	Units
	7GW8	7GW41	7GW43		
TOTAL METALS:					
Cadmium	U	U	U	5.0	ug/l
Chromium	U	12	5.2	10	ug/l
Copper	23	121	34	25	ug/l
Lead	U	3.8	3.8	3	ug/l
Mercury	R	R	R	0.2	ug/l
Zinc	312	34	10	20	ug/l
FILTERED METALS:					
Cadmium	U	U	U	5.0	ug/l
Chromium	U	U	U	10	ug/l
Copper	20	45	15	25	ug/l
Lead	3.8	U	U	3	ug/l
Mercury	R	R	R	0.2	ug/l
Zinc	15	5350	44	20	ug/l
VOLATILE ORGANICS:					
Methylene Chloride	U	U	U	5	ug/l
cis-1,2-Dichloroethene	U	6	U	5	ug/l
Trichloroethene	U	33	U	5	ug/l
1,1,2,2-Tetrachloroethane	U	6	U	5	ug/l
Acetone	U	U	17E	10	ug/l
NITROAROMATICS:					
HMX	470.0	U	U	4.200	ug/l
RDX	2300	U	U	1.600	ug/l
1,3,5-Trinitrobenzene	31.10	U	1.10	0.200	ug/l
2,4,6-Trinitrotoluene	1900	U	U	0.940	ug/l
2,6-Dinitrotoluene	3.20	U	U	0.500	ug/l
2,4-Dinitrotoluene	3.10	U	U	0.500	ug/l
1,3-Dinitrobenzene	10.30	U	U	2.600	ug/l
Nitrobenzene	U	U	U	1.500	ug/l
Tetryl	U	13.30	U	3.700	ug/l

NOTES: U - Not detected.
R - Quantitation Rejected
E - Quantitation Estimated

TABLE 5-7
SUMMARY OF RISK ESTIMATES
SITE 7 - ORDNANCE BURN AREA

CURRENT AND FUTURE LAND USE	NSWCWODET WORKERS		OFF-SITE POPULATIONS			
	Noncancer Risk	Cancer Risk	Adult: Noncancer Risk	Adult: Cancer Risk	Adolescent: Noncancer Risk	Adolescent: Cancer Risk
SOIL						
Ingestion		X	NA	NA	NA	NA
Dermal Contact		X	NA	NA	NA	NA
GROUND WATER						
Ingestion	NA	NA	X	X	X	X
Dermal Contact	NA	NA	X	X	X	X

Notes:
X = Exceeds USEPA criteria for Noncancer Risk (hazard index $\geq$ 1.0) or USEPA Superfund remediation goals for cancer risk (10^{-4} to 10^{-6})

NA = Not applicable

TABLE 6–1
SUMMARY OF FIELD ENVIRONMENTAL SAMPLING
SITE 8
(Phase I – 1989)

SAMPLE MATRIX	PARAMETERS		FIELD SAMPLES SEDIMENT	FIELD SAMPLES SOIL	QA/QC SAMPLES FD	QA/QC SAMPLES ER	QA/QC SAMPLES TB	TOTAL SAMPLES
SEDIMENTS/SOIL	VOLATILES		0	0	0	0	0	0
	SEMIVOLATILES		0	2	0	0	0	2
	PCBS		0	0	0	0	0	0
	METALS		0	2	0	0	0	2
	MERCURY		0	2	0	0	0	2
	CHROMIUM VI		0	0	0	0	0	0
	NITROAROMATICS		0	0	0	0	0	0
	TOC		0	0	0	0	0	0
	TOX		0	0	0	0	0	0
	pH		0	0	0	0	0	0
		SUB-TOTAL	0	6	0	0	0	6
			WATER GROUND	WATER SURFACE	QA/QC SAMPLES FD	QA/QC SAMPLES ER	QA/QC SAMPLES TB	TOTAL SAMPLES
GROUND/SURFACE WATER	VOLATILES		5	0	1	0	1	7
	SEMIVOLATILES		5	0	1	0	0	6
	PCBS		0	0	0	0	0	0
	METALS 1		10	0	2	0	0	12
	MERCURY		10	0	2	0	0	12
	CHROMIUM VI		0	0	0	0	0	0
	NITROAROMATICS		0	0	0	0	0	0
	TOC		5	0	1	0	0	0
	TOX		5	0	1	0	0	6
	TDS		5	0	1	0	0	6
	TSS		5	0	1	0	0	6
		SUB-TOTAL	50	0	10	0	1	61
		TOTAL SAMPLES	50	6	10	0	1	67

Notes: 1. Metals (Cd, Cr, Cu, Pb, Zn), mercury, and chromium VI – Filtered (dissolved) and unfiltered (total) fractions were collected for each water sample.
FD – Field duplicate
ER – Equipment Rinsate
TB – Trip blank

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TABLE 6–2
SUMMARY OF FIELD ENVIRONMENTAL SAMPLING
SITE 8
(Phase II – 1991)

SAMPLE MATRIX	PARAMETERS		SEDIMENT SAMPLES			SOIL SAMPLES			TOTAL SAMPLES
			FIELD	QA/QC		FIELD	QA/QC		
				FD	ER		FD	ER	
SEDIMENTS/SOIL	VOLATILES		0	0	0	0	0	0	0
	SEMIVOLATILES		0	0	0	0	0	0	0
	PCBS		0	0	0	0	0	0	0
	METALS		0	0	0	0	0	0	0
	MERCURY		0	0	0	0	0	0	0
	NITROAROMATICS		0	0	0	0	0	0	0
		SUB–TOTAL	0	0	0	0	0	0	0
			GROUNDWATER SAMPLES			SURFACE WATER SAMPLES			TOTAL SAMPLES
			FIELD	QA/QC		FIELD	QA/QC		
				FD	ER		FD	ER	
GROUND/SURFACE WATER	VOLATILES		5	1	3	0	0	0	9
	SEMIVOLATILES		5	1	3	0	0	0	9
	PCBS		5	1	3	0	0	0	9
	METALS 1		10	2	3	0	0	0	15
	MERCURY		10	2	3	0	0	0	15
	NITROAROMATICS		0	0	0	0	0	0	0
		SUB–TOTAL	35	7	15	0	0	0	57
	TOTAL SAMPLES		**35**	**7**	**15**	**0**	**0**	**0**	**57**

Notes: 1. Metals (Cd, Cr, Cu, Pb, Zn), mercury, and chromium VI – Filtered (dissolved) and unfiltered (total) fractions were collected for each water sample.

FD – Field duplicate

ER – Equipment Rinsate

Equipment rinsate analyzed for total metals

TABLE 6-3
SITE 8 - ABANDONED CHEMICAL DISPOSAL PIT
SURFICIAL SOIL ANALYTICAL RESULTS
(Phase I - 1989)

Parameter	Sample Locations		Detection Limit	Units
	8SL1	8SL2		
METALS:				
Cadmium	U	U	0.78	mg/kg
Chromium	14.6	58.5	0.70	mg/kg
Copper	7.7	12.4	0.30	mg/kg
Lead	30.0	57.2	3.60	mg/kg
Mercury	U	U	0.15	mg/kg
Zinc	28.1	47.7	0.50	mg/kg
SEMIVOLATILE ORGANICS:				
Benzoic Acid	U	280 JX	2,500	ug/kg

Notes: U - Not detected.
J - Compound is present but below the detection limit.
X - EPA CLP criteria not met for confirmation but compound is present.

TABLE 6-4
SITE 8 - ABANDONED CHEMICAL DISPOSAL PIT
GROUNDWATER ANALYTICAL RESULTS
(Phase I - 1989)

Parameter	Sample Locations 8GW33	8GW34	8GW35	8GW36	8GW53	Detection Limit	Units
TOTAL METALS:							
Cadmium	U	U	U	U	U	5.0	ug/l
Chromium	395.0	162.0	381.0	344.0	462.0	7.0	ug/l
Copper	505.0	167.0	357.0	269.0	452.0	3.0	ug/l
Lead	106.0	57.3	102.0	101.0	123.0	28.0	ug/l
Mercury	4.5	0.51	U	U	U	0.20	ug/l
Zinc	1,280.0	385.0	910.0	876.0	1,350.0	3.0	ug/l
FILTERED METALS:							
Cadmium	U	2.7	U	U	U	5.0	ug/l
Chromium	U	U	U	U	U	7.0	ug/l
Copper	U	U	U	U	U	3.0	ug/l
Lead	U	U	U	U	U	28.0	ug/l
Mercury	U	U	U	U	U	0.20	ug/l
Zinc	16.8	24.3	18.2	18.1	37.6	3.0	ug/l
pH	8.30	4.80	5.10	4.80	6.00	--	su
TOC	1,700	600	1,100	1,100	500	500	ug/l
TOX	8	18	11	U	--	8	ug/l
TDS	U	U	U	22	U	20	mg/l
TSS	14,800	3,920	9,410	9,000	11,100	4	mg/l
VOLATILE ORGANICS:							
Chloroform	U	U	10	U	U	5	ug/l
1,1,2-Trichloroethane	U	U	U	7	U	5	ug/l
SEMIVOLATILE ORGANICS:							
bis(2-ethylhexyl)phthalate	19	U	13	7 J	15	10	ug/l

Notes: U - Not detected.
J - Compound is present but below the detection limit.

TABLE 6-5
SITE 8 - ABANDONED CHEMICAL DISPOSAL PIT
GROUNDWATER ANALYTICAL RESULTS
(PHASE II - 1991)

Parameter	Sample Locations					Detection Limit	Units
	8GW33	8GW34	8GW35	8GW36	8GW53		
TOTAL METALS:							
Cadmium	U	U	U	5.0	U	5.0	ug/l
Chromium	63	U	U	2.9	U	10	ug/l
Copper	131	51	15	53	36	25	ug/l
Lead	29	6.9	5.2	8.2	2.5	3	ug/l
Mercury	R	R	R	R	R	0.2	ug/l
Zinc	159	17	42	165	27	20	ug/l
FILTERED METALS:							
Cadmium	U	U	U	U	U	5.0	ug/l
Chromium	U	U	U	U	U	10	ug/l
Copper	45	U	11	20	U	25	ug/l
Lead	7.3	U	U	U	U	3	ug/l
Mercury	R	R	R	R	R	0.2	ug/l
Zinc	31	138	39	60	51	20	ug/l
PCBs (1)	U	U	U	U	U	1.0	ug/l
VOLATILE ORGANICS:							
Chloroform	U	U	8	U	U	5	ug/l
1,1,2-Trichloroethane	U	U	U	4	U	5	ug/l
Methylene Chloride	10	13	U	U	U	5	ug/l
Acetone	R	R	U	U	U	10	ug/l
SEMIVOLATILES:							
bis(2-ethylhexyl)phthalate	R	R	R	R	R	10	ug/l

NOTES: (1) The PCB compound for which values are given here is AR1260.
U - Not detected.
R - Quantitation Rejected

TABLE 6-6
SITE 8 - ABANDONED CHEMICAL DISPOSAL PIT
SUMMARY OF RISK ESTIMATES

CURRENT AND FUTURE LAND USE	OFF-SITE POPULATIONS			
	Adult: Noncancer Risk	Adult: Cancer Risk	Children: Noncancer Risk	Children: Cancer Risk
GROUNDWATER				
Ingestion		X		X
Dermal Contact				
Inhalation				X
Total Exposure Hazard/Risk		X		X

Notes:
X = Exceeds USEPA criteria for Noncancer Risk (hazard index $\geq$ 1.0) or USEPA Superfund remediation goals for cancer risk (10^{-4} to 10^{-6})

TABLE 7-1
SUMMARY OF FIELD ENVIRONMENTAL SAMPLING
SITE 9
(Phase I - 1989)

SAMPLE MATRIX	PARAMETERS		FIELD SAMPLES SEDIMENT	SOIL	QA/QC SAMPLES FD	ER	TB	TOTAL SAMPLES
SEDIMENTS/SOIL	VOLATILES		0	0	0	1	0	1
	SEMIVOLATILES		1	2	1	1	0	5
	PCBS		0	0	0	0	0	0
	METALS		10	2	1	1	0	14
	MERCURY		0	0	0	0	0	0
	CHROMIUM VI		0	0	0	0	0	0
	NITROAROMATICS		10	0	0	0	0	0
	TOC		10	0	1	0	0	12
	TOX		10	0	1	1	0	12
	pH		10	0	1	1	0	11
		SUB-TOTAL	41	4	5	5	0	55
			WATER GROUND	SURFACE	QA/QC SAMPLES FD	ER	TB	TOTAL SAMPLES
GROUND/SURFACE WATER	VOLATILES		13	3	2	1	1	20
	SEMIVOLATILES		1	0	1	1	0	3
	PCBS		0	0	0	0	0	0
	METALS 1		26	6	4	1	0	37
	MERCURY		0	0	0	0	0	0
	CHROMIUM VI		0	0	0	0	0	0
	NITROAROMATICS		13	0	1	1	0	15
	TOC		13	3	2	1	0	19
	TOX		13	3	2	1	0	19
	TDS		13	3	2	1	0	19
	TSS		13	3	2	1	0	19
		SUB-TOTAL	105	21	16	8	1	151
		TOTAL SAMPLES	146	25	21	13	1	206

Notes: 1. Metals (Cd, Cr, Cu, Pb, Zn), mercury, and chromium VI - Filtered (dissolved) and unfiltered (total) fractions were collected for each water sample.
FD - Field duplicate
ER - Equipment Rinsate
TB - Trip blank

F:\U\STEPHENS\WHITEOAK\TABLES\TABLE7-1.WK1 6-8-92

TABLE 7–2
SUMMARY OF FIELD ENVIRONMENTAL SAMPLING
SITE 9
(Phase II – 1991)

SAMPLE MATRIX	PARAMETERS		SEDIMENT SAMPLES			SOIL SAMPLES			TOTAL SAMPLES
			FIELD	QA/QC		FIELD	QA/QC		
				FD	ER		FD	ER	
SEDIMENTS/SOIL	VOLATILES		10	1	0	0	0	0	11
	SEMIVOLATILES		0	0	0	0	0	0	0
	PCBS		0	0	0	0	0	0	0
	METALS		10	1	0	0	0	0	11
	MERCURY		0	0	0	0	0	0	0
	NITROAROMATICS		10	1	0	0	0	0	11
		SUB–TOTAL	30	3	0	0	0	0	33
			GROUNDWATER SAMPLES			SURFACE WATER SAMPLES			TOTAL SAMPLES
			FIELD	QA/QC		FIELD	QA/QC		
				FD	ER		FD	ER	
GROUND/SURFACE WATER	VOLATILES		13	1	1	3	0	0	18
	SEMIVOLATILES		1	1	1	0	0	0	3
	PCBS		13	1	1	0	0	0	15
	METALS 1		26	2	1	6	0	0	35
	MERCURY		27	2	1	1	0	0	31
	NITROAROMATICS		12	1	1	3	0	0	17
		SUB–TOTAL	92	8	6	13	0	0	119
	TOTAL SAMPLES		122	11	6	13	0	0	152

Notes: 1. Metals (Cd, Cr, Cu, Pb, Zn), mercury, and chromium VI – Filtered (dissolved) and unfiltered (total) fractions were collected for each water sample.

FD – Field duplicate

ER – Equipment Rinsate

Equipment rinsate analyzed for total metals

TABLE 7-3
SITE 9 – INDUSTRIAL WASTEWATER DISPOSAL AREA 300
SEDIMENT/SURFICIAL SOIL ANALYTICAL RESULTS
(Phase I – 1989)

Parameter	Sample Locations												Detection Limit	Units
	9SD2	9SD3	9SD7	9SD9	9SD10	9SD11	9SD13	9SD16	9SD17	9SD18	9SL1	9SL2		
TOTAL METALS:														
Cadmium	0.83	1.3	U	U	U	U	U	U	U	0.82	U	U	0.78	mg/kg
Chromium	14.6	12.0	16.8	16.8	10.6	15.3	10.6	14.6	31.1	5.0	14.3	10.8	0.70	mg/kg
Copper	9.3	68.9	5.6	42.7	9.8	16.7	9.0	9.0	18.4	4.0	273.0	9.3	0.30	mg/kg
Lead	54.2	40.3	15.9	37.3	19.9	71.8	18.8	10.9	10.9	U	65.0	24.0	3.60	mg/kg
Zinc	38.1	118.0	85.2	43.7	31.6	44.8	20.3	26.9	37.4	17.7	298.0	46.5	0.50	mg/kg
pH	4.83	6.40	8.16	6.54	7.51	4.93	6.62	7.41	7.52	7.26	--	--	--	su
TOC	29,100	28,700	5,760	20,600	5,400	22,000	9,030	5,420	5,870	2,660	--	--	100	mg/kg
TOX	33.8	18.8	11.8	24.8	U	34.3	12.6	11.2	32.8	U	--	--	10	mg/kg
SEMIVOLATILE ORGANICS:														
Benzoic Acid	--	--	--	--	--	--	--	--	--	U	310 JX	U	2,400	ug/kg
Phenanthrene	--	--	--	--	--	--	--	--	--	U	400 J	U	490	ug/kg
Fluoranthene	--	--	--	--	--	--	--	--	--	U	650	U	490	ug/kg
Pyrene	--	--	--	--	--	--	--	--	--	U	520	U	490	ug/kg
Benzo(a)anthracene	--	--	--	--	--	--	--	--	--	U	320 J	U	490	ug/kg
Chrysene	--	--	--	--	--	--	--	--	--	U	400 J	U	490	ug/kg
Benzo(b)fluoranthene	--	--	--	--	--	--	--	--	--	U	370 J	U	490	ug/kg
Benzo(k)fluoranthene	--	--	--	--	--	--	--	--	--	U	250 J	U	490	ug/kg
Benzo(a)pyrene	--	--	--	--	--	--	--	--	--	U	320 J	U	490	ug/kg
Hexadecanoic Acid	--	--	--	--	--	--	--	--	--	U	1,600 J	1,700 J	2,400	ug/kg
Octodecanoic Acid	--	--	--	--	--	--	--	--	--	U	U	380 J	490	ug/kg

Notes: U – Not detected.
J – Compound is present but less than the detection limit.
X – EPA CLP criteria for confirmation not met but compound is present.

TABLE 7-4

SITE 9 – INDUSTRIAL WASTEWATER DISPOSAL AREA 300

SEDIMENT/SURFICIAL SOIL ANALYTICAL RESULTS

(PHASE II - 1991)

Parameter	Sample Locations										Detection Limit	Units
	9SD2	9SD3	9SD7	9SD9	9SD10	9SD11	9SD13	9SD16	9SD17	9SD18		
TOTAL METALS:												
Cadmium	U	U	U	U	U	U	U	U	U	U	5	mg/kg
Chromium	13	9.8	21	13	19	15	14	5.9	7.4	U	10	mg/kg
Copper	11	13	3.8	4.7	4.2	8.2	8.7	9.5	3.6	4.6	25	mg/kg
Lead	58	26	10	8.2	5.3	30	14	5.4	1.1	0.68	3	mg/kg
Zinc	41	74	24	6.8	28	26	14	72	16	4.6	20	mg/kg
VOLATILE ORGANICS:												
Methylene Chloride	95 E	32	23	13	R	R	R	37	7	5	5	ug/kg
Acetone	39 E	>200	>200	U	810	R	R	39 E	59 E	16 E	10	ug/kg
Carbon Disulfide	10 E	3	U	U	U	4	U	3	3	U	5	ug/kg
2-Butanone	U	9 E	U	U	U	34 E	U	U	U	U	10	ug/kg
1,1,1-Trichloroethane	9 E	U	U	U	U	U	U	U	U	U	5	ug/kg
NITROAROMATICS:												
1,3,5 Trinitrobenzene	U	U	U	U	U	0.94	U	U	U	U	0.2	ug/kg
2,4,6 Trinitrotoluene	U	U	U	U	U	1.20	U	U	U	U	0.94	ug/kg
HMX	U	U	U	U	U	2.70	U	U	U	U	4.2	ug/kg
RDX	U	U	U	U	U	1.80	U	U	U	U	1.6	ug/kg
Tetryl	U	U	U	U	U	15.00	U	U	U	U	3.7	ug/kg

NOTES: U - Not detected.
R - Quantitation Rejected
E - Quantitation Estimated.

TABLE 7–5
SITE 9 – INDUSTRIAL WASTEWATER DISPOSAL AREA 300
GROUNDWATER ANALYTICAL RESULTS
(Phase I – 1989)

Parameter	Sample Locations													Detection Limit	Units
	9GW1	9GW2	9GW3	9GW4	9GW5	9GW6	9GW7	9GW57S	9GW57D	9GW58	9GW59	9GW74	9GW75		
TOTAL METALS:															
Cadmium	U	U	4.4	U	U	U	U	5.2	U	U	U	U	U	2.0	ug/l
Chromium	30.8	152.0	98.2	9.9	106.0	159.0	130.0	224.0	U	61.2	29.0	222.0	90.1	5.0	ug/l
Copper	42.9	175.0	151.0	7.9	129.0	223.0	138.0	173.0	9.4	56.8	44.4	223.0	60.3	3.0	ug/l
Lead	U	66.2	32.4	U	U	48.2	U	130.0	U	U	U	108.0	U	28.0	ug/l
Mercury	U	1.1	U	U	5.2	3.2	3.7	0.48	U	3.2	0.24	U	0.43	0.20	ug/l
Zinc	59.7	531.0	132.0	11.8	78.2	51.0	121.0	241.0	22.8	18.4	22.7	652.0	27.0	3.0	ug/l
FILTERED METALS:															
Cadmium	U	4.3	5.1	U	U	U	U	U	U	U	U	U	U	2.0	ug/l
Chromium	U	U	U	U	U	U	U	U	U	U	U	U	U	5.0	ug/l
Copper	U	28.3	18.2	U	U	U	U	U	U	U	U	U	U	3.0	ug/l
Lead	U	U	U	U	U	U	U	U	U	U	U	U	U	28.0	ug/l
Mercury	U	U	U	U	U	U	U	U	U	0.24	U	U	U	0.20	ug/l
Zinc	33.3	220.0	72.3	14.5	17.9	37.8	16.3	34.1	21.9	22.6	32.4	45.1	23.9	3.0	ug/l
pH	5.10	5.50	4.90	5.70	4.60	4.30	4.70	5.30	5.40	5.60	5.50	5.10	5.40	--	su
TOC	15.7	7.7	14.0	5.29	10.3	16.5	32.7	45.2	4.7	37.7	38.5	11.1	17.5	0.50	mg/l
TOX	35.5	24.9	16.8	15.2	14.4	343.0	U	19.1	89.6	12.8	18.0	15.5	20.8	8	ug/l
TDS	48	50	124	28	U	U	U	40	55	U	38	104	76	20	mg/l
TSS	674	3,980	5,070	309	13,900	9,280	19,400	5,730	144	9,640	4,040	5,410	7,890	4	mg/l
NITROAROMATICS:															
HMX	U	U	14	U	U	U	U	25	U	U	U	U	U	10	ug/l
RDX	150	U	U	U	U	U	U	U	U	U	U	U	U	10	ug/l
2,6–dinitrotoluene	U	U	U	U	U	U	U	U	U	24	U	U	U	10	ug/l
VOLATILES:															
Chloroform	6	7	U	7	18	20	8	U	4 J	3 J	2 J	6	U	5	ug/l
1,2–Dichloroethene	4 J	U	U	U	U	U	U	3 J	19	U	U	U	U	5	ug/l
Tetrachloroethene	U	8	U	U	U	U	U	U	U	U	U	U	U	5	ug/l
Toluene	4 J	U	U	2 J	U	U	U	U	U	U	U	U	U	5	ug/l
Trichloroethene	67	17	29	U	U	U	U	31	100	U	U	U	U	5	ug/l
Trichlorofluoromethane	8 J	5 J	U	U	U	U	U	20 J	57 J	U	U	U	U	--	ug/l
3–Methylpentane	U	U	U	U	U	U	U	U	U	U	U	U	7 J	--	ug/l
SEMIVOLATILES:	U	--	--	--	--	--	--	--	--	--	--	--	--	--	ug/l

Notes: U – Not detected.
J – Compound is present but less than the detection limit.
X – EPA CLP criteria for confirmation not met but compound is present.

TABLE 7–6
SITE 9 – INDUSTRIAL WASTEWATER DISPOSAL AREA 300
GROUNDWATER ANALYTICAL RESULTS
(PHASE II – 1991)

Parameter	Sample Locations													Detection Limit	Units
	9GW1	9GW2	9GW3	9GW4	9GW5	9GW6	9GW7	9GW57D	9GW57S	9GW59	9GW74	9GW75	9GW83		
TOTAL METALS:															
Cadmium	U	U	U	U	U	U	U	U	U	U	U	U	U	5.0	ug/l
Chromium	3.3	U	11	U	8.9	3.4	2.5	U	4.7	U	U	U	3.7	10	ug/l
Copper	57	27	31	U	U	U	27	U	16	13	20	U	U	25	ug/l
Lead	9.1	13	9.3	3.6	6.9	7.6	4.7	U	11	U	5.1	U	11	3	ug/l
Mercury	R	R	R	R	R	R	R	R	R	R	R	R	R	0.2	ug/l
Zinc	30	91	70	12	16	12	40	6.0	7.0	13	76	13	70	20	ug/l
FILTERED METALS:															
Cadmium	U	U	U	U	U	U	U	U	U	U	U	U	U	5.0	ug/l
Chromium	U	U	U	U	3.9	U	U	U	U	U	U	U	U	10	ug/l
Copper	U	U	U	U	15	17	13	U	U	19	U	U	U	25	ug/l
Lead	U	U	U	U	U	U	U	4.6	5.0	U	U	U	2.1	3	ug/l
Mercury	R	R	R	R	R	R	R	R	R	R	R	R	R	0.2	ug/l
Zinc	25	11	35	6.0	10	10	16	8.0	7.0	44	21	16	38	20	ug/l
PCBs (1)	U	U	U	U	U	U	U	U	U	U	U	U	U	1.0	ug/l
NITROAROMATICS:															
HMX	10.60	U	U	U	U	U	U	1.60 E	2.00 E	U	U	U	3.10 E	4.2	ug/l
RDX	214.0	U	U	12.50	U	U	U	12.30	12.10	U	U	U	11.00	1.6	ug/l
Nitrobenzene	U	U	U	3.3	U	U	U	U	U	U	U	U	U	1.5	ug/l
2,6–Dinitrotoluene	U	U	U	U	U	U	U	U	U	U	U	U	U	0.5	ug/l
1,3,5 Trinitrobenzene	U	R	R	R	R	R	R	U	U	R	R	U	R	0.2	ug/l
VOLATILE ORGANICS:															
Chloroform	6	3 E	2 E	7	6	3 E	7	4 E	3 E	3 E	U	2 E	U	5	ug/l
Carbon Tetrachloride	U	2 E	U	U	2 E	U	U	U	U	U	U	U	U	5	ug/l
1,2–Dichloroethene	2 E	U	U	U	U	U	U	20	11	U	U	U	U	5	ug/l
Tetrachloroethene	U	7	U	U	U	U	U	U	U	U	U	U	U	5	ug/l
Toluene	U	U	U	U	U	U	U	U	U	U	U	U	U	5	ug/l
Trichloroethene	49	16	5	U	14	7	U	160	83	U	2 E	U	U	5	ug/l
1,1,2,2–Tetrachloroethane	U	U	U	U	2 E	U	U	U	U	U	U	U	U	5	ug/l
Methylene Chloride	12	R	R	R	R	R	R	R	R	R	R	R	5 E	5	ug/l
Acetone	U	R	R	R	U	U	U	R	R	U	R	R	7 E	10	ug/l
1,2–Dichloroethane	U	U	U	3 E	U	2 E	U	U	U	U	U	U	U	5	ug/l

NOTES: (1) The PCB compound for which values are given here is AR1260.
U – Not detected.
R – Quantitation Rejected.
E – Quantitation Estimated

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TABLE 7-7
SITE 9 – INDUSTRIAL WASTEWATER DISPOSAL AREA 300, SURFACE WATER ANALYTICAL RESULTS
(Phase I - 1989)

Parameter	Sample Locations 9SW1	9SW2	9SW3	Detection Limit	Units
TOTAL METALS:					
Cadmium	7.3	6.6	U	5.0	ug/l
Chromium	U	U	U	7.0	ug/l
Copper	4.8	5.8	5.3	3.0	ug/l
Lead	U	U	28.1	28.0	ug/l
Zinc	13.6	17.8	20.7	3.0	ug/l
FILTERED METALS:					
Cadmium	U	U	U	5.0	ug/l
Chromium	U	U	U	7.0	ug/l
Copper	U	4.2	U	3.0	ug/l
Lead	U	U	U	28.0	ug/l
Zinc	10.5	13.8	9.3	3.0	ug/l
pH	7.30	7.40	7.30	--	su
TOC	3,900	5,500	5,200	500	ug/l
TOX	35	18	17	8	ug/l
TDS	88	68	66	20	mg/l
TSS	43	43	37	4	mg/l
VOLATILE ORGANICS:					
Acetone	34 B	4 JB	U	5	ug/l

Notes: U - Not detected.
B - Compound also detected in blank sample.
J - Compound is present but less than the detection limit.

TABLE 7-8
SITE 9 - INDUSTRIAL WASTEWATER DISPOSAL AREA 300
SURFACE WATER ANALYTICAL RESULTS
(PHASE II - 1991)

Parameter	Sample Locations			Detection Limit	Units
	9SW1	9SW2	9SW3		
TOTAL METALS:					
Cadmium	U	U	U	5	ug/l
Chromium	U	U	U	10	ug/l
Copper	U	U	U	25	ug/l
Lead	4.5	U	Not Reported	3	ug/l
Zinc	12	U	U	20	ug/l
FILTERED METALS:					
Cadmium	U	U	U	5	ug/l
Chromium	U	U	U	10	ug/l
Copper	U	12	U	25	ug/l
Lead	U	U	U	3	ug/l
Zinc	U	7.0	14	20	ug/l
VOLATILE ORGANICS:					
Acetone	U	14 E	31 E	10	ug/l
Methylene Chloride	5	U	6	5	ug/l
NITROAROMATICS:					
1,3,5 Trinitrobenzene	Not Reported	R	U	0.2	ug/l

NOTES: U - Not detected.
E - Quantitation Estimated.
R - Quantitation Rejected

TABLE 7-9
SITE 9 - INDUSTRIAL WASTEWATER DISPOSAL AREA 300
SUMMARY OF RISK ESTIMATES

CURRENT AND FUTURE LAND USE	OFF-SITE POPULATIONS			
	Adult: Noncancer Risk	Adult: Cancer Risk	Children: Noncancer Risk	Children: Cancer Risk
GROUND WATER				
Ingestion	X	X	X	X
Dermal Contact		X		X
Inhalation		X		X
Total Exposure Hazard/Risk	X	X	X	X

Notes:
X = Exceeds USEPA criteria for Noncancer Risk (hazard index $\geq$ 1.0) or USEPA Superfund remediation goals for cancer risk (10^{-4} to 10^{-6})

TABLE 8-1
SUMMARY OF FIELD ENVIRONMENTAL SAMPLING
SITE 11
(Phase I - 1989)

SAMPLE MATRIX	PARAMETERS		FIELD SAMPLES SEDIMENT	SOIL	QA/QC SAMPLES FD	ER	TB	TOTAL SAMPLES
SEDIMENTS/SOIL	VOLATILES		0	0	0	0	0	0
	SEMIVOLATILES		3	2	0	0	0	5
	PCBS		0	0	0	0	0	0
	METALS		3	2	0	0	0	5
	MERCURY		3	0	0	0	0	3
	CHROMIUM VI		0	0	0	0	0	0
	NITROAROMATICS		0	0	0	0	0	0
	TOC		3	0	0	0	0	3
	TOX		3	0	0	0	0	3
	pH		3	0	0	0	0	3
		SUB-TOTAL	18	4	0	0	0	22
			WATER GROUND	SURFACE	QA/QC SAMPLES FD	ER	TB	TOTAL SAMPLES
GROUND/SURFACE WATER	VOLATILES		14	2	0	1	2	19
	SEMIVOLATILES		0	0	0	0	0	0
	PCBS		0	0	0	0	0	0
	METALS 1		32	4	2	1	0	39
	MERCURY		32	0	0	0	0	32
	CHROMIUM VI		0	0	0	0	0	0
	NITROAROMATICS		0	0	0	0	0	0
	TOC		13	2	1	1	0	17
	TOX		14	2	1	1	0	18
	TDS		16	2	1	1	0	20
	TSS		16	2	1	1	0	20
		SUB-TOTAL	137	14	6	6	2	165
		TOTAL SAMPLES	155	18	6	6	2	187

Notes: 1. Metals (Cd, Cr, Cu, Pb, Zn), mercury, and chromium VI - Filtered (dissolved) and unfiltered (total) fractions were collected for each water sample.
FD - Field duplicate
ER - Equipment Rinsate
TB - Trip blank

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TABLE 8–2
SUMMARY OF FIELD ENVIRONMENTAL SAMPLING
SITE 11
(Phase II – 1991)

SAMPLE MATRIX	PARAMETERS		SEDIMENT SAMPLES			SOIL SAMPLES			TOTAL SAMPLES
			FIELD	QA/QC		FIELD	QA/QC		
				FD	ER		FD	ER	
SEDIMENTS/SOIL	VOLATILES		0	0	0	0	0	0	0
	SEMIVOLATILES		0	0	0	0	0	0	0
	PCBS		0	0	0	0	0	0	0
	METALS		3	0	0	0	0	0	3
	MERCURY		0	0	0	0	0	0	0
	NITROAROMATICS		0	0	0	0	0	0	0
		SUB-TOTAL	3	0	0	0	0	0	3
			GROUNDWATER SAMPLES			SURFACE WATER SAMPLES			TOTAL SAMPLES
			FIELD	QA/QC		FIELD	QA/QC		
				FD	ER		FD	ER	
GROUND/SURFACE WATER	VOLATILES		21	1	0	2	0	0	24
	SEMIVOLATILES		0	0	0	0	0	0	0
	PCBS		0	0	0	0	0	0	0
	METALS 1		42	2	0	4	0	0	48
	MERCURY		42	2	0	0	0	0	44
	NITROAROMATICS		0	0	0	0	0	0	0
		SUB-TOTAL	105	5	0	6	0	0	116
	TOTAL SAMPLES		108	5	0	6	0	0	119

Notes: 1. Metals (Cd, Cr, Cu, Pb, Zn), mercury, and chromium VI – Filtered (dissolved) and unfiltered (total) fractions were collected for each water sample.

FD – Field duplicate

ER – Equipment Rinsate

Equipment rinsate analyzed for total metals

TABLE 8-3
SITE 11 – INDUSTRIAL WASTEWATER DISPOSAL AREA 100
SEDIMENT/SURFICIAL SOIL ANALYTICAL RESULTS
(Phase I – 1989)

Parameter	Sample Locations					Detection Limit	Units
	11SD1	11SD2	11SD3	11SL1	11SL2		
TOTAL METALS:							
Cadmium	4.3	U	U	0.85	U	0.78	mg/kg
Chromium	133.0	12.8	14.1	18.0	17.7	0.70	mg/kg
Copper	135.0	12.4	8.5	16.0	8.8	0.30	mg/kg
Lead	139.0	40.5	9.2	46.4	28.9	3.60	mg/kg
Mercury	1.9	U	0.21	--	--	0.14	mg/kg
Zinc	789.0	62.3	26.6	59.2	28.1	0.20	mg/kg
pH	7.31	6.23	7.21	--	--	--	su
TOC	64,600	5,880	4,885	--	--	100	mg/kg
TOX	266	20.2	18.3	--	--	15.0	mg/kg
SEMIVOLATILES:	(Note 1)						
Phenanthrene	U	670	U	U	U	450	ug/kg
Anthracene	U	U	U	U	U	450	ug/kg
Di-n-Butylphthalate	U	U	U	U	U	450	ug/kg
Fluoranthene	30,000 J	780	U	440 J	U	450	ug/kg
Pyrene	22,000 JX	670 X	U	340 JX	U	450	ug/kg
Benzo(a)Anthracene	U	410 J	U	U	U	450	ug/kg
Chrysene	31,000 J	540	U	280 JX	U	450	ug/kg
bis(2-ethylhexyl)phthalate	23,000 J	190 JX	U	150 JX	U	450	ug/kg
Benzo(b)Fluoranthene	32,000 JX	400 JX	U	240 JX	U	450	ug/kg
Benzo(k)Fluoranthene	24,000 JX	400 JX	U	230 JX	U	450	ug/kg
Benzo(a)Pyrene	22,000 JX	420 JX	U	250 JX	U	450	ug/kg
Indeno(1,2,3-cd)Pyrene	20,000 JX	U	U	U	U	450	ug/kg
Dibenz(a,h)Anthracene	U	U	U	U	U	450	ug/kg
Benzo(g,h,i)Perylene	U	360 JX	U	U	U	450	ug/kg

Notes: (1) The detection limit for this sample was 100 times greater than the limit listed on this sheet.
U – Not detected.
J – Compound is present but less than the detection limit.
X – EPA CLP criteria for confirmation not met but compound is present.

TABLE 8–4
SITE 11 – INDUSTRIAL WASTEWATER DISPOSAL AREA 100
SEDIMENT/SURFICIAL SOIL ANALYTICAL RESULTS
(PHASE II – 1991)

Parameter	Sample Locations			Detection Limit	Units
	11SD1	11SD2	11SD3		
TOTAL METALS:					
Cadmium	2.6	U	U	5.0	mg/kg
Chromium	24	7.1	13	10	mg/kg
Copper	66	5.2	5.8	25	mg/kg
Lead	48	8.2	24	3	mg/kg
Zinc	696	40	50	20	mg/kg

NOTES: U – Not detected.

TABLE 8-5
SITE 11 - INDUSTRIAL WASTEWATER DISPOSAL AREA 100
GROUNDWATER ANALYTICAL RESULTS
(Phase I - 1989)

Parameter	Sample Locations								Detection Limit	Units
	11GW22	11GW23	11GW24	11GW25	11GW26	11GW27	11GW28	11GW29		
TOTAL METALS:										
Cadmium	U	U	U	U	U	3.8	U	U	2.0	ug/l
Chromium	176.0	153.0	109.0	574.0	62.8	2,100.0	111.0	236.0	5.0	ug/l
Copper	250.0	226.0	108.0	516.0	80.8	4,880.0	144.0	226.0	3.0	ug/l
Lead	66.2	128.0	U	305.0	41.4	151.0	27.1	86.6	28.0	ug/l
Mercury	0.61	U	U	U	0.98	0.46	0.42	0.28	0.20	ug/l
Zinc	630.0	668.0	283.0	1,420.0	250.0	791.0	343.0	496	3.0	ug/l
FILTERED METALS:										
Cadmium	U	4.4	U	U	U	U	U	U	2.0	ug/l
Chromium	U	U	U	U	U	1,460.0	U	U	5.0	ug/l
Copper	U	U	U	U	U	4,150.0	U	U	3.0	ug/l
Lead	U	U	U	U	U	U	U	U	28.0	ug/l
Mercury	0.70	U	U	U	U	U	U	U	0.20	ug/l
Zinc	18.1	8.5	52.0	36.4	11.9	95.4	18.1	19.5	3.0	ug/l
pH	5.20	5.40	4.36	4.55	6.20	4.50	4.80	6.30	—	su
TOC	1.6	1.2	1.8	—	2.1	—	1.5	10.8	0.50	mg/l
TOX	480	—	59	11	14	17	47	—	8	ug/l
TDS	U	U	132	136	138	U	U	172	20	mg/l
TSS	4,040	5,490	5,160	9,610	1,520	5,270	3,120	3,960	4	mg/l
VOLATILE ORGANICS:										
Acetone	U	U	7 BJ	U	U	U	—	—	10	ug/l
Benzene	U	U	6	U	U	U	—	—	5	ug/l
Chloroform	23	U	58	4 J	U	U	—	—	5	ug/l
1,1-Dichloroethane	6 X	U	U	U	U	U	—	—	5	ug/l
1,2-Dichloroethane	6 X	U	10	U	U	U	—	—	5	ug/l
1,2-Dichloroethene	1000 D	U	U	U	U	U	—	—	5	ug/l
1,2-Dichloro-1,1,2-Tri-chloroethane	64 J	U	U	U	U	U	—	—	—	ug/l
Tetrachloroethene	10	U	U	U	U	U	—	—	5	ug/l
Tetrahydrofuran	U	U	12 J	U	19	U	—	—	—	ug/l
Trichloroethene	110 D	U	U	U	U	U	—	—	5	ug/l
Trichlorofluoromethane	U	13 J	U	U	U	U	—	—	—	ug/l

Notes: U - Not detected.
J - Compound is present but less than the detection limit.
X - EPA CLP criteria for confirmation not met but compound is present.
D - Concentration was calculated from a dilution.
B - Compound is present in blank.

TABLE 8-5 (CONTINUED)
SITE 11 - INDUSTRIAL WASTEWATER DISPOSAL AREA 100
GROUNDWATER ANALYTICAL RESULTS
(Phase I - 1989)

Parameter	Sample Locations								Detection Limit	Units
	11GW66	11GW67	11GW68	11GW69	11GW70D	11GW71	11GW72	11GW73		
TOTAL METALS:										
Cadmium	U	6.1	U	U	U	U	U	U	2.0	ug/l
Chromium	440.0	93.5	1,260.0	343.0	53.4	46.0	105.0	60.2	5.0	ug/l
Copper	456.0	149.0	3,460.0	355.0	56.9	40.8	124.0	82.1	3.0	ug/l
Lead	31.5	106.0	569.0	212.0	44.1	U	29.4	U	28.0	ug/l
Mercury	U	U	0.38	U	0.43	U	U	U	0.20	ug/l
Zinc	780.0	179.0	2,900.0	728.0	283.0	117.0	89.2	51.2	3.0	ug/l
FILTERED METALS:										
Cadmium	U	U	U	U	U	U	U	U	2.0	ug/l
Chromium	U	U	U	U	U	U	U	U	5.0	ug/l
Copper	U	U	U	U	U	U	U	U	3.0	ug/l
Lead	U	U	U	U	U	U	U	U	28.0	ug/l
Mercury	U	U	U	U	U	U	U	U	0.20	ug/l
Zinc	61.1	33.5	19.2	40.4	35.9	72.3	17.2	37.8	3.0	ug/l
pH	8.20	6.25	5.61	4.87	6.69	6.56	11.24	5.49	—	su
TOC	2.1	—	7.1	2.6	1.5	1.1	0.70	U	0.50	mg/l
TOX	11	29	10	U	U	U	11	9	8	ug/l
TDS	U	112	106	198	210	U	72	86	20	mg/l
TSS	5,980	3,540	30,500	9,520	6,380	1,720	5,980	3,120	4	mg/l
VOLATILE ORGANICS:										
Acetone	13	U	U	U	U	12	U	16 B	10	ug/l
Benzene	U	U	U	U	U	U	U	U	5	ug/l
Chloroform	U	4 J	U	U	U	U	U	4 J	5	ug/l
1,1-Dichloroethane	U	U	U	U	U	U	U	U	5	ug/l
1,2-Dichloroethane	U	U	U	U	U	U	U	U	5	ug/l
1,2-Dichloroethene	8	U	U	U	U	U	U	U	5	ug/l
1,2-Dichloro-1,1,2-Tri-chloroethane	U	U	U	U	U	U	U	U	—	ug/l
Tetrachloroethene	U	U	U	U	U	U	U	U	5	ug/l
Tetrahydrofuran	U	U	U	U	U	U	U	U	—	ug/l
Trichloroethene	6	U	U	U	U	U	U	U	5	ug/l
Trichlorofluoromethane	U	U	U	U	U	U	U	U	—	ug/l

Notes: U - Not detected.
J - Compound is present but less than the detection limit.
X - EPA CLP criteria for confirmation not met but compound is present.
D - Concentration was calculated from a dilution.
B - Compound is present in blank.

TABLE 8-6
SITE 11 - INDUSTRIAL WASTEWATER DISPOSAL AREA 100
GROUNDWATER ANALYTICAL RESULTS
(PHASE II - 1991)

Parameter	Sample Locations														Detection Limit	Units
	11GW22	11GW23	11GW24	11GW25	11GW26	11GW27	11GW28	11GW29	11GW66	11GW67	11GW68	11GW69	11GW70D	11GW71		
TOTAL METALS:																
Cadmium	17	11	U	14	10	U	8.0	13	18	U	U	U	U	U	5.0	ug/l
Chromium	65	24	14	146	72	326	104	81	264	U	5.6	U	3.7	20	10	ug/l
Copper	315	179	37	326	207	1160	184	208	485	U	28	23	18	42	25	ug/l
Lead	73	42	5.9	73	132	134	61	45	122	U	12	2.9	19	5.5	3	ug/l
Mercury	R	R	R	R	R	R	R	R	R	R	R	R	R	R	0.2	ug/l
Zinc	774	530	53	859	622	230	520	587	1030	17	19	49	109	69	20	ug/l
FILTERED METALS:																
Cadmium	U	U	U	U	U	U	U	U	U	U	U	U	U	U	5.0	ug/l
Chromium	U	3.9	U	3.2	U	492	U	U	U	U	U	6.1	U	U	10	ug/l
Copper	22	U	U	22	15	634	18	19	15	U	U	U	U	22	25	ug/l
Lead	U	U	U	U	U	U	U	U	U	U	1.8	NA	U	U	3	ug/l
Mercury	R	R	R	R	R	R	R	R	R	R	R	R	R	R	0.2	ug/l
Zinc	32	43	23	31	20	84	U	92	38	34	16	66	42	23	20	ug/l
VOLATILE ORGANICS:																
Acetone	R	24 E	R	R	R	R	R	U	U	U	U	U	R	U	10	ug/l
Chloroform	21	U	29	R	U	U	U	U	U	U	U	U	U	U	5	ug/l
1,1-Dichloroethene	U	U	U	U	U	U	U	U	U	U	U	U	U	U	5	ug/l
1,1-Dichloroethane	5	U	2	U	U	U	U	U	U	U	U	U	U	U	5	ug/l
1,2-Dichloroethane	6	U	5	U	U	U	U	U	U	U	U	U	U	U	5	ug/l
cis-1,2-Dichloroethene	U	U	U	U	U	U	2	U	2	U	U	U	U	U	5	ug/l
Tetrachloroethene	9	U	U	U	U	U	77	U	U	U	U	U	U	U	5	ug/l
Trichloroethene	150	U	U	U	U	U	9	U	5	U	U	U	U	U	5	ug/l
Methylene Chloride	U	7	3	U	3	5	4	2	4	R	R	R	R	R	5	ug/l
1,1,1-Trichloroethane	U	U	1	U	U	U	U	U	U	U	U	U	U	U	5	ug/l
Carbon Tetrachloride	U	U	1	U	U	U	U	U	U	U	U	U	U	U	5	ug/l
Benzene	U	U	2	U	U	U	U	U	U	U	U	U	U	U	5	ug/l

NOTES: U - Not detected.
E - Quantitation Estimated
R - Quantitation Rejected
NA - Not analyzed (Digested alloquot lost by laboratory)

TABLE 8-6 (CONTINUED)
SITE 11 - INDUSTRIAL WASTEWATER DISPOSAL AREA 100
GROUNDWATER ANALYTICAL RESULTS
(PHASE II - 1991)

Parameter	Sample Locations							Detection Limit	Units
	11GW72	11GW73	11GW84	11GW85	11GW86	11GW87	11GW88		
TOTAL METALS:									
Cadmium	U	U	U	U	U	U	U	5.0	ug/l
Chromium	U	U	3.2 B	18	5.0	U	14	10	ug/l
Copper	33	U	U	142	15	U	49	25	ug/l
Lead	U	U	6.0	163	U	U	35	3	ug/l
Mercury	R	R	R	R	R	R	R	0.2	ug/l
Zinc	338	U	27	270	66	40	133	20	ug/l
FILTERED METALS:									
Cadmium	U	U	U	U	U	U	U	5.0	ug/l
Chromium	U	U	U	U	U	U	U	10	ug/l
Copper	U	U	U	U	U	U	U	25	ug/l
Lead	U	U	U	1.5	1.9	U	U	3	ug/l
Mercury	R	R	R	R	R	R	R	0.2	ug/l
Zinc	8.0	21	16 B	34	29	47	33	20	ug/l
VOLATILE ORGANICS:									
Acetone	R	U	U	6 E	6 E	10	U	10	ug/l
Chloroform	U	U	U	U	U	U	U	5	ug/l
1,1-Dichloroethene	U	U	U	U	U	U	U	5	ug/l
1,1-Dichloroethane	U	U	U	U	U	U	U	5	ug/l
1,2-Dichloroethane	U	U	U	U	U	U	U	5	ug/l
cis-1,2-Dichlroethene	U	U	U	U	U	U	U	5	ug/l
Tetrachloroethene	U	U	U	U	U	U	U	5	ug/l
Trichloroethene	U	U	U	U	U	2	U	5	ug/l
Methylene Chloride	R	R	U	7 E	U	20	6 E	5	ug/l
1,1,1-Trichloroethane	U	U	U	U	U	U	U	5	ug/l
Carbon Tetrachloride	U	U	U	U	U	U	U	5	ug/l
Benzene	U	U	U	U	U	U	U	5	ug/l
1,2-Dichloroethene (Total)	U	U	U	U	U	2	U	5	ug/l

NOTES: U - Not detected.
E - Quantitation Estimated
R - Quantitation Rejected
B - Present in blank

TABLE 8-7
SITE 11 - INDUSTRIAL WASTEWATER DISPOSAL AREA 100
SURFACE WATER ANALYTICAL RESULTS
(Phase I - 1989)

Parameter	Sample Locations		Detection Limit	Units
	11SW1	11SW2		
TOTAL METALS:				
Cadmium	U	U	5.0	ug/l
Chromium	U	U	7.0	ug/l
Copper	9.6	4.8	3.0	ug/l
Lead	U	U	28.0	ug/l
Zinc	280.0	25.1	3.0	ug/l
FILTERED METALS:				
Cadmium	U	U	5.0	ug/l
Chromium	U	U	7.0	ug/l
Copper	8.0	11.7	3.0	ug/l
Lead	U	42.8	28.0	ug/l
Zinc	236.0	36.0	3.0	ug/l
pH	7.10	6.90	--	su
TOC	5,400	4,600	500	ug/l
TOX	18	18	8	ug/l
TDS	106	56	20	mg/l
TSS	U	18	4	mg/l
VOLATILE ORGANICS:	U	U	--	ug/l

Note: U - Not detected.

TABLE 8-8
SITE 11 – INDUSTRIAL WASTEWATER DISPOSAL AREA 100
SURFACE WATER ANALYTICAL RESULTS
(PHASE II - 1991)

Parameter	Sample Locations		Detection Limit	Units
	11SW1	11SW2		
TOTAL METALS:				
Cadmium	U	U	5.0	ug/l
Chromium	U	U	10	ug/l
Copper	U	U	25	ug/l
Lead	U	2.5	3	ug/l
Zinc	92	22	20	ug/l
FILTERED METALS:				
Cadmium	U	U	5.0	ug/l
Chromium	U	U	10	ug/l
Copper	U	U	25	ug/l
Lead	U	U	3	ug/l
Zinc	41	19	20	ug/l
VOLATILE ORGANICS:				
Methylene Chloride	6	1	5	ug/l
Acetone	24 E	U	10	ug/l

NOTES: U - Not detected.
E - Quantitation Estimated

TABLE 8-9
SUMMARY OF RISK ESTIMATES
SITE 11 - INDUSTRIAL WASTEWATER DISPOSAL AREA 100

CURRENT AND FUTURE LAND USE	OFF-SITE POPULATIONS			
	Adult: Noncancer Risk	Adult: Cancer Risk	Children: Noncancer Risk	Children: Cancer Risk
GROUND WATER				
Ingestion		X		X
Dermal Contact				
Inhalation		X		X
Total Exposure Hazard/Risk		X		X

Notes:
X = Exceeds USEPA criteria for Noncancer Risk (hazard index $\geq$ 1.0) or USEPA Superfund remediation goals for cancer risk (10^{-4} to 10^{-6})

TABLE 9-1
SUMMARY OF FIELD ENVIRONMENTAL SAMPLING
PAINT BRANCH CREEK
(Phase I - 1989)

SAMPLE MATRIX	PARAMETERS		FIELD SAMPLES SEDIMENT	SOIL	QA/QC SAMPLES FD	ER	TB	TOTAL SAMPLES
SEDIMENTS/SOIL	VOLATILES		3	0	1	0	0	4
	SEMIVOLATILES		3	0	1	0	0	4
	PCBS		3	0	1	0	0	4
	METALS		3	0	1	0	0	4
	MERCURY		3	0	1	0	0	4
	CHROMIUM VI		0	0	0	0	0	0
	NITROAROMATICS		3	0	0	0	0	3
	TOC		3	0	1	0	0	4
	TOX		3	0	1	0	0	4
	pH		3	0	1	0	0	4
		SUB-TOTAL	27	0	8	0	0	35
			WATER GROUND	SURFACE	QA/QC SAMPLES FD	ER	TB	TOTAL SAMPLES
GROUND/SURFACE WATER	VOLATILES		0	3	1	0	0	4
	SEMIVOLATILES		0	0	0	0	0	0
	PCBS		0	0	0	0	0	0
	METALS 1		0	6	2	0	0	8
	MERCURY		0	0	0	0	0	0
	CHROMIUM VI		0	0	0	0	0	0
	NITROAROMATICS		0	0	0	0	0	0
	TOC		0	3	1	0	0	4
	TOX		0	3	1	0	0	4
	TDS		0	3	1	0	0	4
	TSS		0	3	1	0	0	4
		SUB-TOTAL	0	21	7	0	0	28
		TOTAL SAMPLES	27	21	15	0	0	63

Notes: 1. Metals (Cd, Cr, Cu, Pb, Zn), mercury, and chromium VI - Filtered (dissolved) and unfiltered (total) fractions were collected for each water sample.
FD - Field duplicate
ER - Equipment Rinsate
TB - Trip blank

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TABLE 9–2
SUMMARY OF FIELD ENVIRONMENTAL SAMPLING
PAINT BRANCH CREEK
(Phase II – 1991)

SAMPLE MATRIX	PARAMETERS		SEDIMENT SAMPLES			SL & SB SOIL SAMPLES			TOTAL SAMPLES
			FIELD	QA/QC		FIELD	QA/QC		
				FD	ER		FD	ER	
SEDIMENTS/SOIL	VOLATILES		3	1	0	0	0	0	4
	SEMIVOLATILES		3	1	0	0	0	0	4
	PCBS		3	1	0	0	0	0	4
	METALS		3	1	0	0	0	0	4
	MERCURY		3	1	0	0	0	0	4
	NITROAROMATICS		3	1	0	0	0	0	4
		SUB-TOTAL	18	6	0	0	0	0	24
			GROUNDWATER SAMPLES			SURFACE WATER SAMPLES			TOTAL SAMPLES
			FIELD	QA/QC		FIELD	QA/QC		
				FD	ER		FD	ER	
GROUND/SURFACE WATER	VOLATILES		0	0	0	3	1	1	5
	SEMIVOLATILES		0	0	0	3	1	1	5
	PCBS		0	0	0	3	1	1	5
	METALS 1		0	0	0	6	2	1	9
	MERCURY		0	0	0	6	2	1	9
	NITROAROMATICS		0	0	0	3	1	1	5
		SUB-TOTAL	0	0	0	24	8	6	38
	TOTAL SAMPLES		18	6	0	24	8	6	62

Notes: 1. Metals (Cd, Cr, Cu, Pb, Zn), mercury, and chromium VI – Filtered (dissolved) and unfiltered (total) fractions were collected for each water sample.

FD – Field duplicate

ER – Equipment Rinsate

Equipment rinsate analyzed for total metals

TABLE 9-3
PAINT BRANCH CREEK
SURFACE WATER ANALYTICAL RESULTS
(Phase I - 1989)

Parameter	Sample Locations			Detection Limit	Units
	PBC-SW1	PBC-SW2	PBC-SW3		
TOTAL METALS:					
Cadmium	U	U	U	5.0	ug/l
Chromium	U	U	U	7.0	ug/l
Copper	7.4	U	7.4	3.0	ug/l
Lead	U	U	U	28.0	ug/l
Zinc	25.5	8.5	35.6	3.0	ug/l
FILTERED METALS:					
Cadmium	U	U	U	5.0	ug/l
Chromium	U	U	U	7.0	ug/l
Copper	U	U	U	3.0	ug/l
Lead	U	U	U	28.0	ug/l
Zinc	9.2	8.2	25.9	3.0	ug/l
pH	6.90	7.00	7.00	--	su
TOC	2,100	1,800	2,000	500	ug/l
TOX	8	11	13	8	ug/l
TDS	48	56	88	20	mg/l
TSS	7	7	6	4	mg/l
VOLATILE ORGANICS:	U	U	U	--	ug/l

Note: U - Not detected.

TABLE 9-4
PAINT BRANCH CREEK
SURFACE WATER ANALYTICAL RESULTS
(PHASE II - 1991)

Parameter	Sample Locations			Detection Limit	Units
	PBC-SW1	PBC-SW2	PBC-SW3		
TOTAL METALS:					
Cadmium	U	U	U	5	ug/l
Chromiun	U	U	U	10	ug/l
Copper	U	U	U	25	ug/l
Lead	U	U	U	3	ug/l
Mercury	R	R	R	0.2	ug/l
Zinc	U	U	12	4.6	ug/l
FILTERED METALS:					
Cadmium	U	U	U	5	ug/l
Chromium	U	U	U	10	ug/l
Copper	U	12	U	25	ug/l
Lead	U	U	U	3	ug/l
Mercury	R	R	R	0.2	ug/l
Zinc	U	15	U	4.6	ug/l
VOLATILE ORGANICS:					
Acetone	13 E	6 E	11 E	10	ug/l
Tetrachloroethene	U	U	7	5	
SEMIVOLATILES:					
Fluorene	U	U	U	10	ug/l
Bis(2-Ethylhexyl)phthalate	U	U	240	10	ug/l
NITROAROMATICS:					
1,3,5 Trinitrobenzene	U	R	R	0.200	ug/l
PCBs (1)	U	U	U	1	ug/l

NOTES: (1) The PCB compound for which values are given is AR1260
U - Not detected.
R - Quantitation Rejected
E- Quantitation Estimated

TABLE 9-5
PAINT BRANCH CREEK
STREAM SEDIMENT ANALYTICAL RESULTS
(Phase I - 1989)

Parameter	Sample Locations			Detection Limit	Units
	PBC-SD1	PBC-SD2	PBC-SD3		
TOTAL METALS:					
Cadmium	U	U	U	0.78	mg/kg
Chromium	11.3	9.4	12.1	0.70	mg/kg
Copper	10.2	7.7	6.3	0.30	mg/kg
Lead	24.0	10.8	12.1	3.60	mg/kg
Mercury	0.40	U	0.23	0.14	mg/kg
Zinc	30.8	26.9	26.8	0.20	mg/kg
PCBs	U	U	U	70	ug/kg
TOC	4,960	3,440	3,470	100	mg/kg
TOX	18.1	U	U	15.0	mg/kg
NITROAROMATICS	U	U	U	19	ug/kg
VOLATILE ORGANICS:					
Acetone	U	99 B	U	10	ug/kg
Methylene Chloride	U	12 B	U	10	ug/kg
Toluene	U	2 J	U	5	ug/kg
SEMIVOLATILES:					
Phenanthrene	570 J	U	U	610	ug/kg
Fluoranthene	890	170 JX	220 JX	610	ug/kg
Pyrene	570 J	230 J	U	610	ug/kg
Benzo(a)Anthracene	400 J	U	U	450	ug/kg
Chrysene	560 J	U	U	450	ug/kg
Benzo(b)Fluoranthene	360 J	U	U	450	ug/kg
Benzo(k)Fluoranthene	470 J	U	U	450	ug/kg
Benzo(a)Pyrene	420 J	U	U	450	ug/kg
Indeno(1,2,3-cd)Pyrene	310 J	U	U	450	ug/kg
Benzo(g,h,i)Perylene	340 JX	U	U	450	ug/kg

Notes: U - Not detected.
J - Compound is present but less than the detection limit.
X - EPA CLP criteria for confirmation not met but compound is present.
B - Compound was also found in the blank sample.

TABLE 9-6
PAINT BRANCH CREEK
SEDIMENT ANALYTICAL RESULTS
(PHASE II - 1991)

Parameter	Sample Locations			Detection Limit	Units
	PBC-SD1	PBC-SD2	PBC-SD3		
TOTAL METALS:					
Cadmium	U	U	U	5	mg/kg
Chromium	11	14	19	10	mg/kg
Copper	6.4 B	3.5 B	U	25	mg/kg
Lead	9.8	5.8	2.7 B	3	mg/kg
Mercury	R	R	R	0.2	mg/kg
Zinc	26	20	8.5 B	20	mg/kg
VOLATILE ORGANICS:				(2)	
Acetone	93	57	12	--	ug/kg
Methylene Chloride	49	33	16	--	ug/kg
SEMIVOLATILES:				(2)	
Phenanthrene	R	U	U	--	
Fluoranthene	R	1100	U	--	ug/kg
Pyrene	R	1600	U	--	
NITROAROMATICS:	U	U	U	(2)	ug/g
PCBs (1)	U	U	U	(2)	ug/kg

NOTES:(1) The PCB compound for which values are given is AR1260
(2) The detection limits are based on % moisture determination
U - Not detected.
B- Value Below Detection Limit
R - Quantitation Rejected

TABLE 9-7
SUMMARY OF FIELD ENVIRONMENTAL SAMPLING
BACKGROUND WELLS
(Phase I – 1989)

SAMPLE MATRIX	PARAMETERS		FIELD SAMPLES SEDIMENT	SOIL	QA/QC SAMPLES FD	ER	TB	TOTAL SAMPLES
SEDIMENTS/SOIL	VOLATILES		0	0	0	0	0	0
	SEMIVOLATILES		0	0	0	0	0	0
	PCBS		0	0	0	0	0	0
	METALS		0	0	0	0	0	0
	MERCURY		0	0	0	0	0	0
	CHROMIUM VI		0	0	0	0	0	0
	NITROAROMATICS		0	0	0	0	0	0
	TOC		0	0	0	0	0	0
	TOX		0	0	0	0	0	0
	pH		0	0	0	0	0	0
		SUB-TOTAL	0	0	0	0	0	0
			WATER GROUND	SURFACE	QA/QC SAMPLES FD	ER	TB	TOTAL SAMPLES
GROUND/SURFACE WATER	VOLATILES		2	0	0	0	0	2
	SEMIVOLATILES		2	0	0	0	0	2
	PCBS		0	0	0	0	0	0
	METALS 1		4	0	0	0	0	4
	MERCURY		4	0	0	0	0	4
	CHROMIUM VI		4	0	0	0	0	4
	NITROAROMATICS		0	0	0	0	0	0
	TOC		2	0	0	0	0	2
	TOX		2	0	0	0	0	2
	TDS		2	0	0	0	0	2
	TSS		2	0	0	0	0	2
		SUB-TOTAL	24	0	0	0	0	24
		TOTAL SAMPLES	24	0	0	0	0	24

Notes: 1. Metals (Cd, Cr, Cu, Pb, Zn), mercury, and chromium VI – Filtered (dissolved) and unfiltered (total) fractions were collected for each water sample.

FD – Field duplicate

ER – Equipment Rinsate

TB – Trip blank

F:\users\stephens\whiteoak\tables\table9-8.wk1 6-8-92

TABLE 9–8
SUMMARY OF FIELD ENVIRONMENTAL SAMPLING
BACKGROUND WELLS
(Phase II – 1991)

SAMPLE MATRIX	PARAMETERS		FIELD	QA/QC		SAMPLES
				FD	ER	
GROUND/SURFACE WATER	VOLATILES		2	1	1	4
	SEMIVOLATILES		2	1	1	4
	PCBS		2	1	1	4
	METALS 1		4	2	1	7
	MERCURY		4	2	1	7
	NITROAROMATICS		2	1	1	4
		TOTAL	16	8	6	30

Notes: 1. Metals (Cd, Cr, Cu, Pb, Zn), mercury, and chromium VI – Filtered (dissolved) and unfiltered (total) fractions were collected for each water sample.
FD – Field duplicate
ER – Equipment Rinsate
Equipment rinsate analyzed for total metals

TABLE 9-9
BACKGROUND WELLS
GROUNDWATER ANALYTICAL RESULTS
(Phase I - 1989)

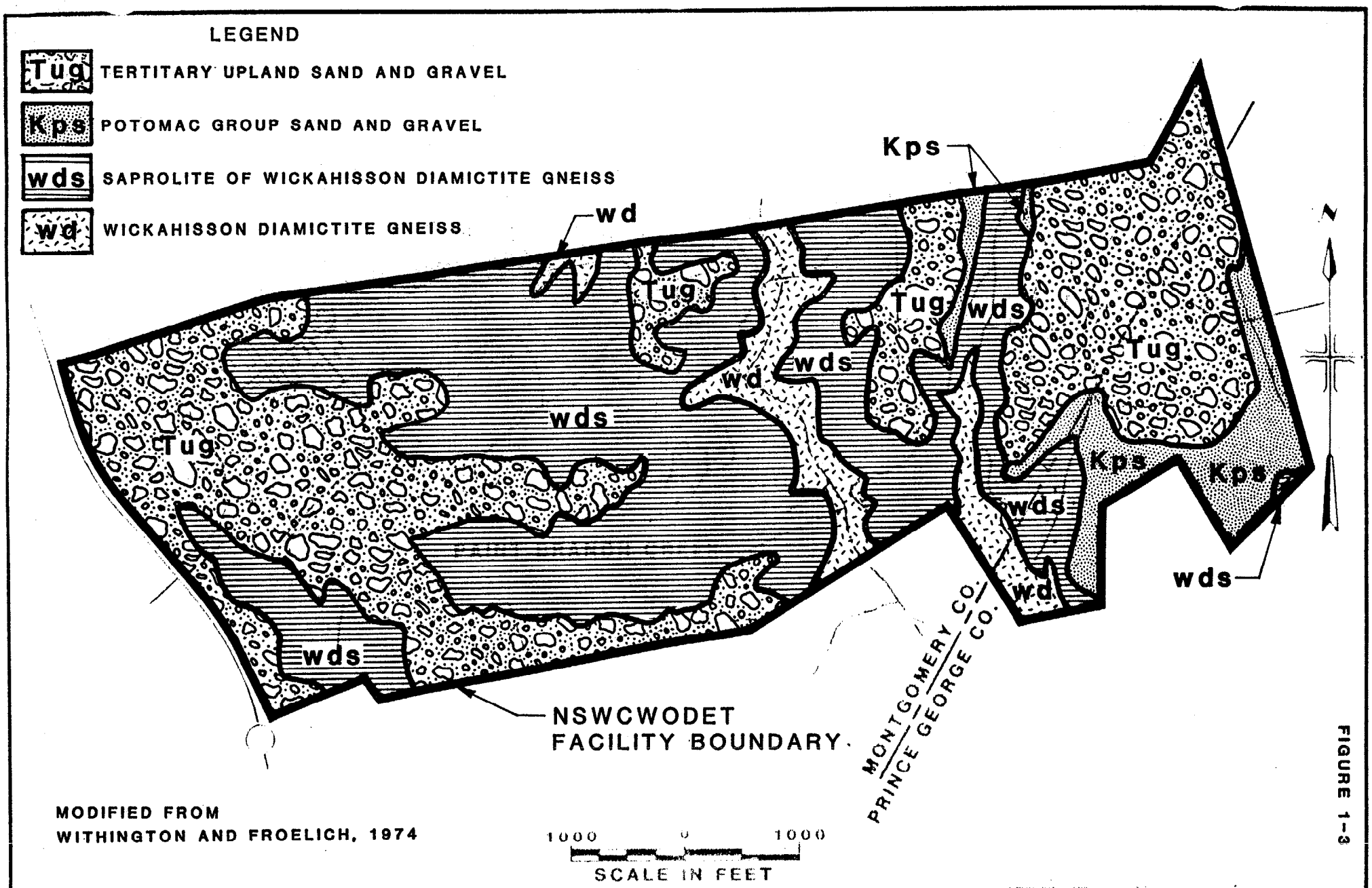
Parameter	Sample Locations		Detection Limit	Units
	BGW16	BGW40		
TOTAL METALS:				
Cadmium	7.6	U	3.0	ug/l
Chromium	213.0	97.2	7.0	ug/l
Copper	135.0	50.5	3.0	ug/l
Lead	51.9	50.7	28.0	ug/l
Mercury	1.2	U	0.20	ug/l
Zinc	101.0	244.0	3.0	ug/l
Chromium VI	U	U	10.0	ug/l
FILTERED METALS:				
Cadmium	4.3	U	3.0	ug/l
Chromium	U	U	7.0	ug/l
Copper	U	U	3.0	ug/l
Lead	U	U	28.0	ug/l
Mercury	U	U	0.20	ug/l
Zinc	34.4	36.2	3.0	ug/l
Chromium VI	U	U	10.0	ug/l
pH	4.70	4.60	--	su
TOC	12,500	1,100	500	ug/l
TOX	U	11	8	ug/l
TDS	116	150	20	mg/l
TSS	5,150	2,920	4	mg/l
VOLATILE ORGANICS:	U	U	--	ug/l
SEMIVOLATILE ORGANICS:	U	U	--	ug/l

Note: U - Not detected.

TABLE 9-10
BACKGROUND WELLS
GROUNDWATER ANALYTICAL RESULTS
(PHASE II - 1991)

Parameter	Sample Locations		Detection Limit	Units
	BGW16	BGW40		
TOTAL METALS:				
Cadmium	U	U	5	ug/l
Chromium	109	U	10	ug/l
Copper	190	35	25	ug/l
Lead	47	3.4	3	ug/l
Mercury	R	R	0.2	ug/l
Zinc	101	26	20	ug/l
FILTERED METALS:				
Cadmium	U	U	5	ug/l
Chromium	U	U	10	ug/l
Copper	U	11	25	ug/l
Lead	U	U	3	ug/l
Mercury	R	R	0.2	ug/l
Zinc	13	17	20	ug/l
PCBs (1)	U	U	1.0	ug/l
NITROAROMATICS:				
RDX	U	R	1.6	ug/l
VOLATILE ORGANICS:	U	U	5	ug/l
SEMIVOLATILE ORGANICS:	U	U	10	ug/l

NOTES: (1) The PCB compound for which values are given is AR1260
U Not detected above method detection limit
R - Quantitation Rejected



MODIFIED FROM
WITHINGTON AND FROELICH, 1974

FIGURE 1-3

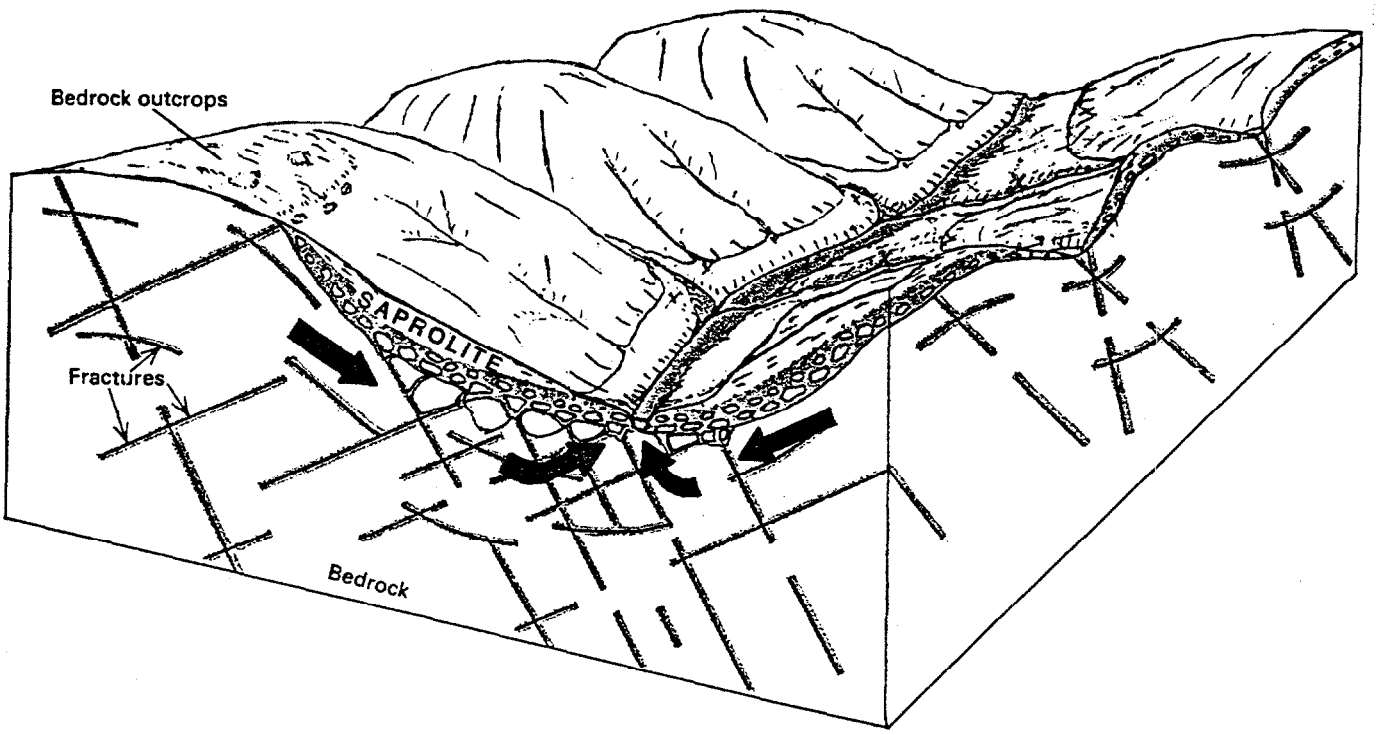
MALCOLM PIRNIE

WHITE OAK, MARYLAND
NSWCWODET RI/FS
SURFICIAL GEOLOGY MAP

MALCOLM PIRNIE, INC.

OCTOBER
1992

FIGURE 1-4



GROUND WATER FLOWS FROM UPLAND RECHARGE ZONES TO LOWLAND DISCHARGE ZONES.

SOURCE: HEATH, 1984

NOT TO SCALE

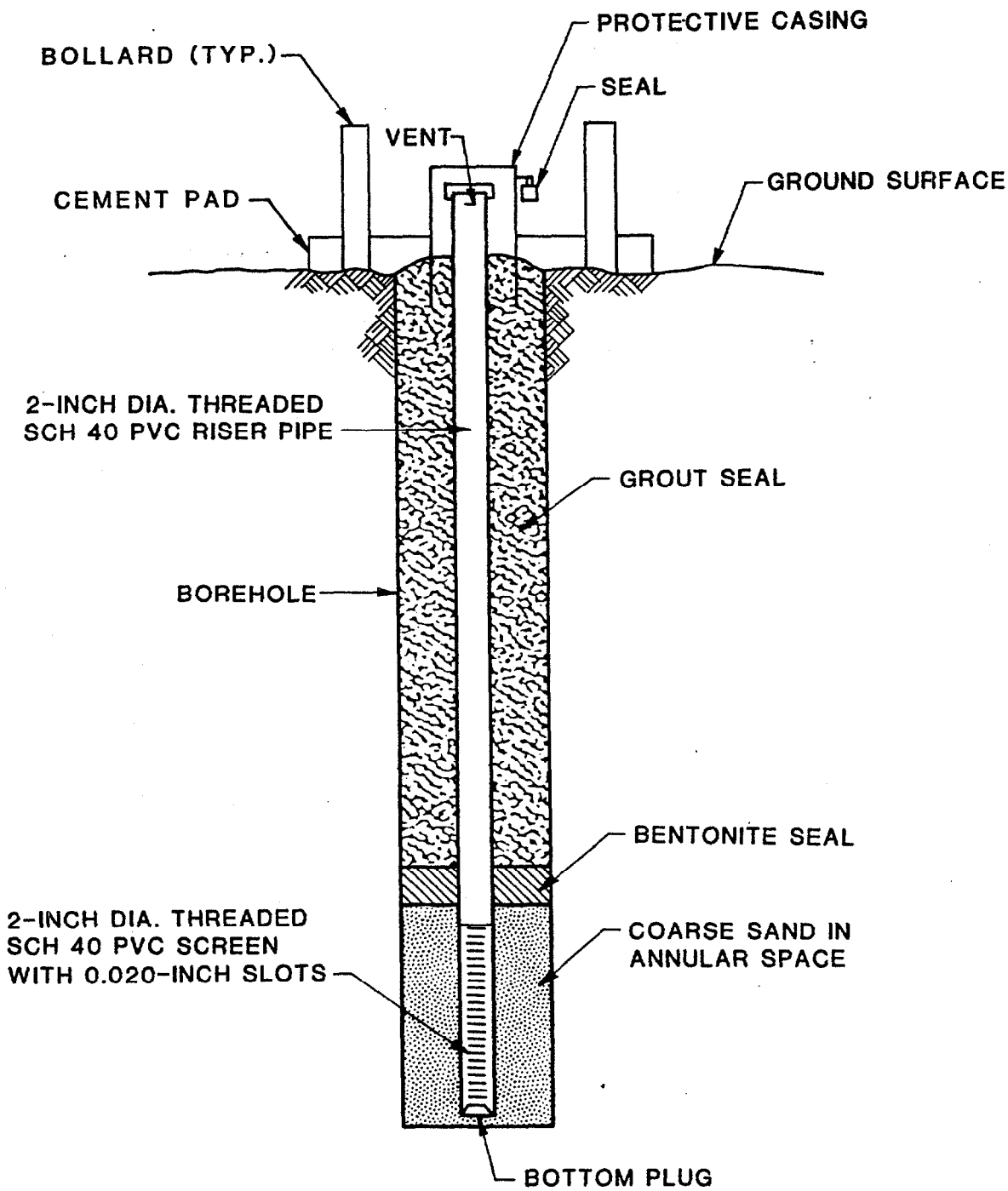
MALCOLM PIRNIE

WHITE OAK, MARYLAND
NSWCWODET RI/FS
PIEDMONT AND BLUE RIDGE
HYDROGEOLOGIC MODEL

MALCOLM PIRNIE, INC.

OCTOBER 1992

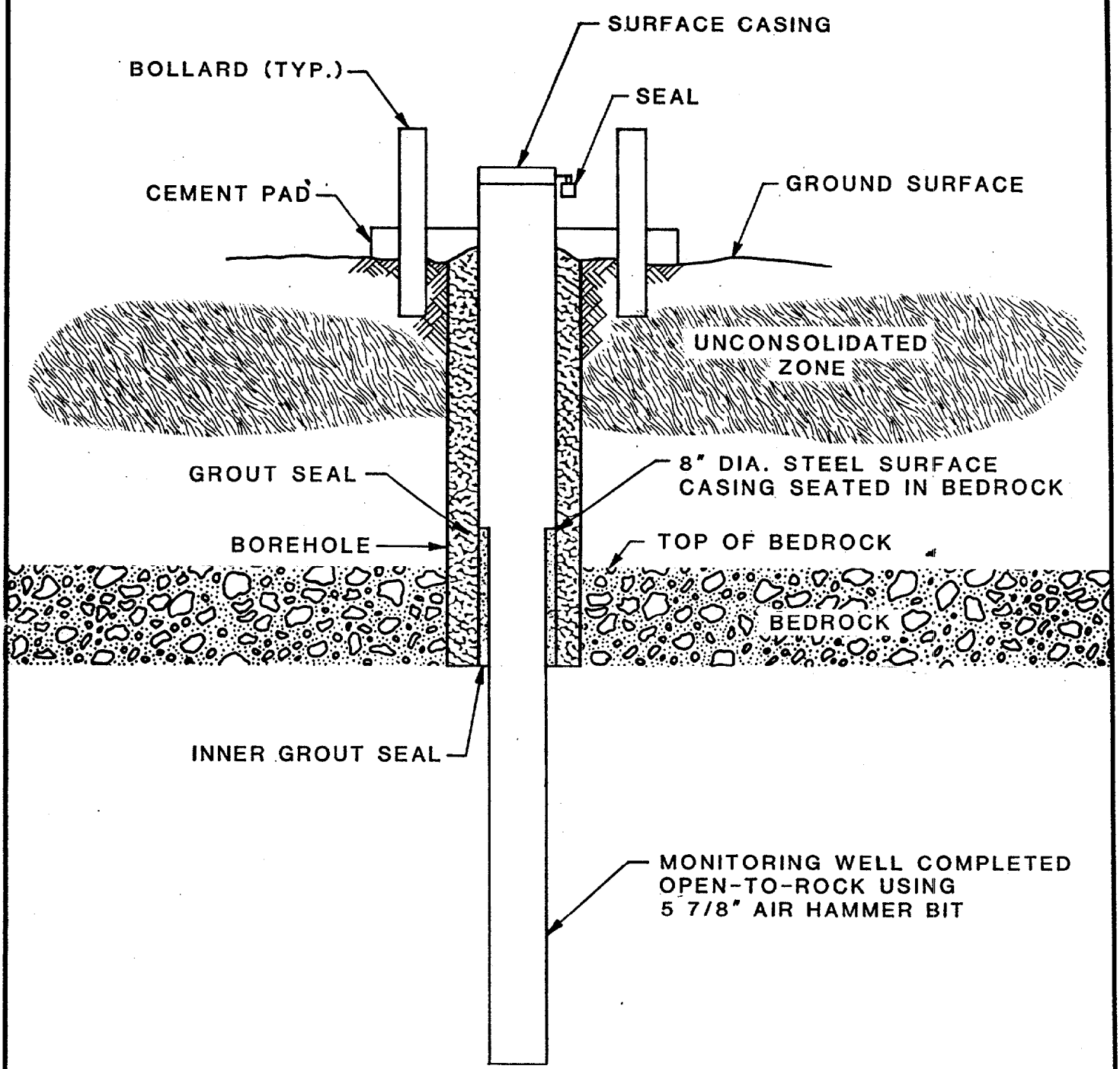
FIGURE 1-5



NOT TO SCALE

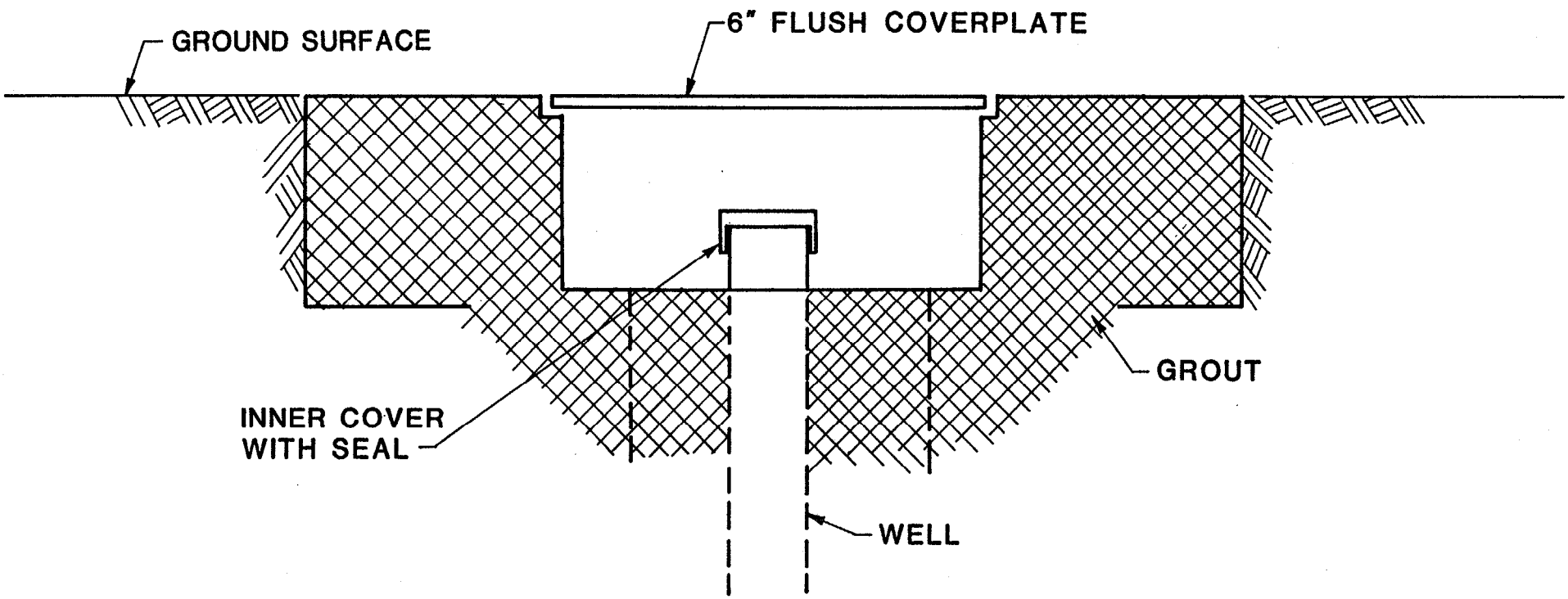
MALCOLM PIRNIE	WHITE OAK, MARYLAND NSWCWODET RI/FS MONITORING WELL CONSTRUCTION DIAGRAM	MALCOLM PIRNIE, INC. OCTOBER 1992

FIGURE 1-6



NOT TO SCALE

MALCOLM PIRNIE	OAK, MARYLAND NSWCWODET RI/FS BEDROCK MONITORING WELL CONSTRUCTION DIAGRAM	MALCOLM PIRNIE, INC. OCTOBER 1992



NOT TO SCALE

FIGURE 1-7

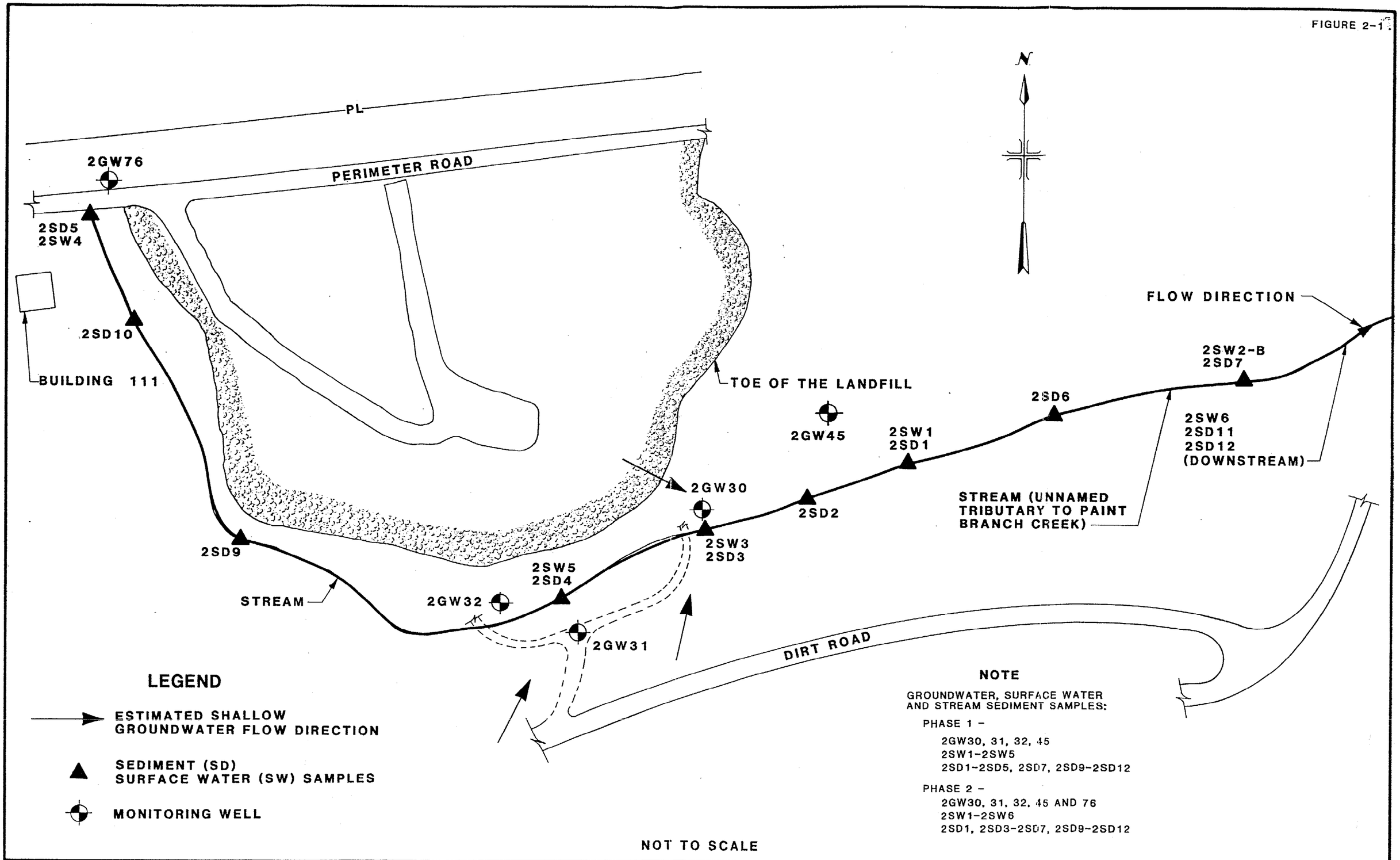
MALCOLM PIRNIE

WHITE OAK, MARYLAND
NSWCWODET RI/FS
LOCKING WELL COVER WITH FLUSH PROTECTIVE COVERPLATE

MALCOLM PIRNIE, INC.

OCTOBER
1992

FIGURE 2-1



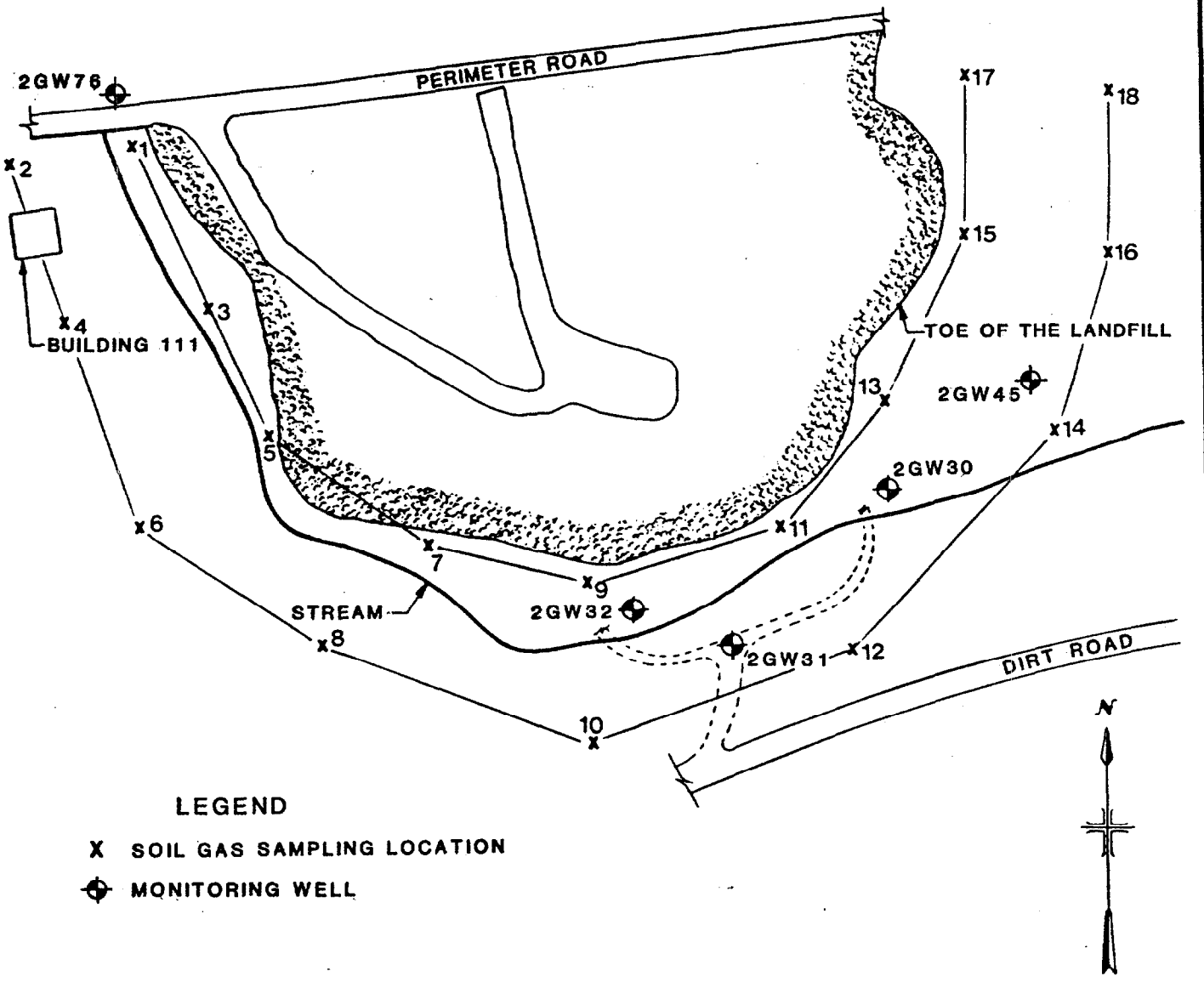
MALCOLM PIRNIE

WHITE OAK, MARYLAND
NSWCWODET RI/FS
SITE 2 - GROUNDWATER, SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS

MALCOLM PIRNIE, INC.

OCTOBER 1992

FIGURE 2-2



Sampling Point #	HNu Reading	Sampling Point #	HNu Reading	Sampling Point #	HNu Reading	Sampling Point #	HNu Reading
1	0	6	0	11	0	16	0
2	2	7	0	12	0	17	1
3	0	8	0	13	0	18	2
4	3	9	0	14	0		
5	0	10	0	15	0		

Note: HNu reading in parts per million (ppm).

NOT TO SCALE

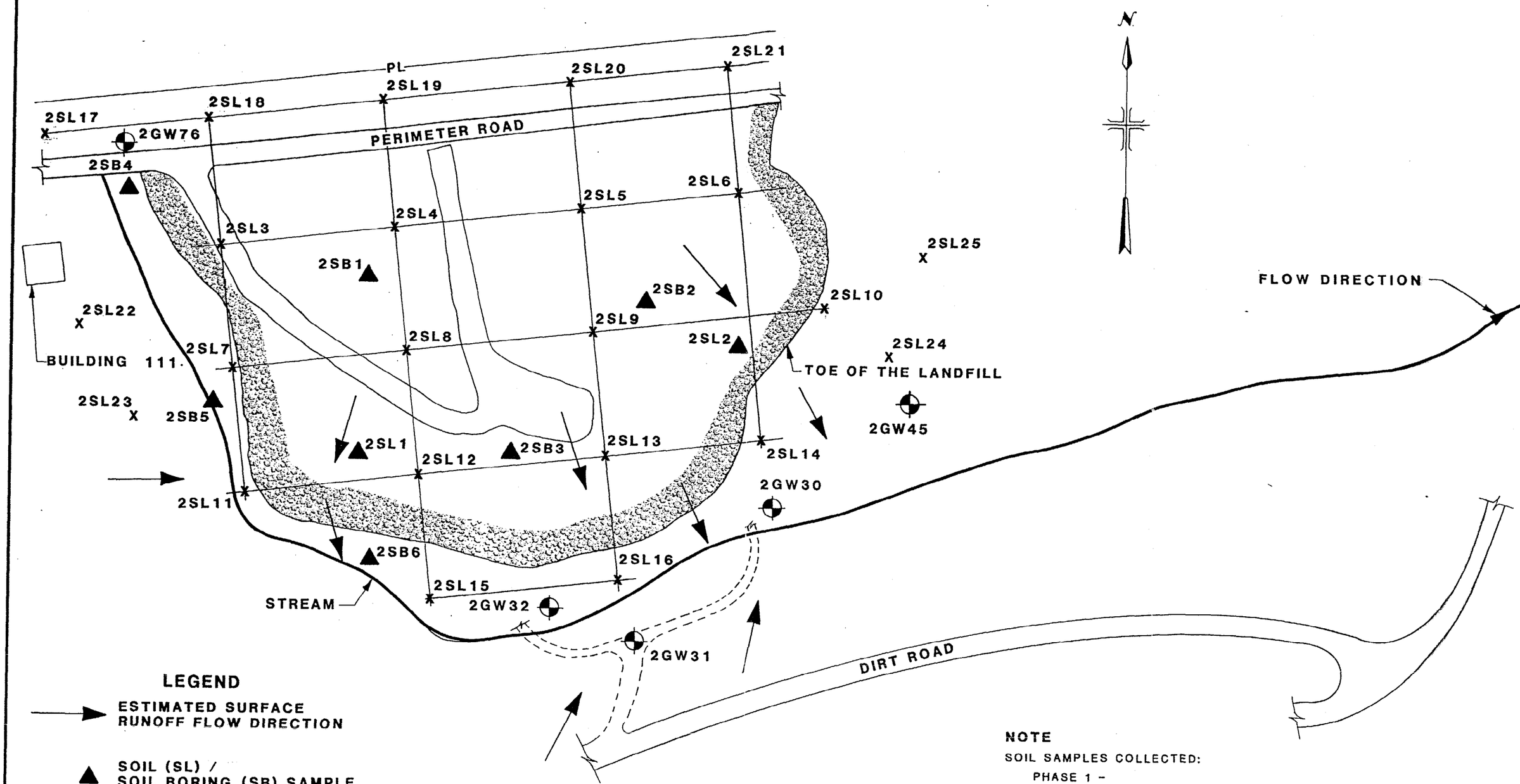
MALCOLM PIRNIE

WHITE OAK, MARYLAND
NSWCWODET RI/FS
SITE 2 - SOIL GAS SURVEY

MALCOLM PIRNIE, INC.

OCTOBER 1992

FIGURE 2-3



LEGEND

ESTIMATED SURFACE RUNOFF FLOW DIRECTION

SOIL (SL) / SOIL BORING (SB) SAMPLE

MONITORING WELL

NOTE

SOIL SAMPLES COLLECTED:

PHASE 1 -
2SL1, 2SL2

PHASE 2 -
2SL3 TO 2SL25
2SB1 TO 2SB6

NOT TO SCALE

MALCOLM PIRNIE

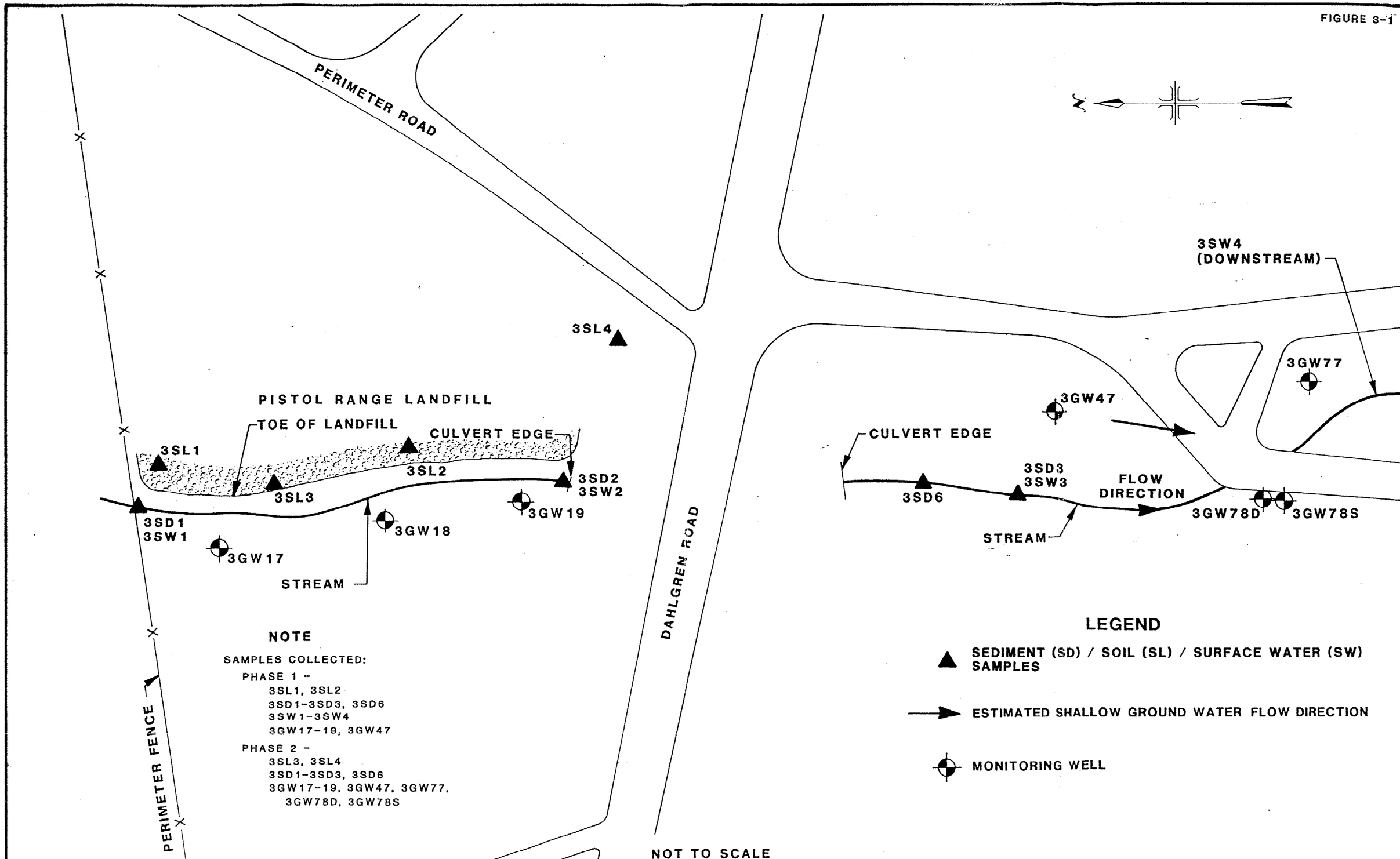
WHITE OAK, MARYLAND
NSWCWODET RI/FS
SITE 2 - SOIL SAMPLING LOCATIONS

MALCOLM PIRNIE, INC.

OCTOBER 1992

00180B22

FIGURE 3-1



MALCOLM PIRNIE

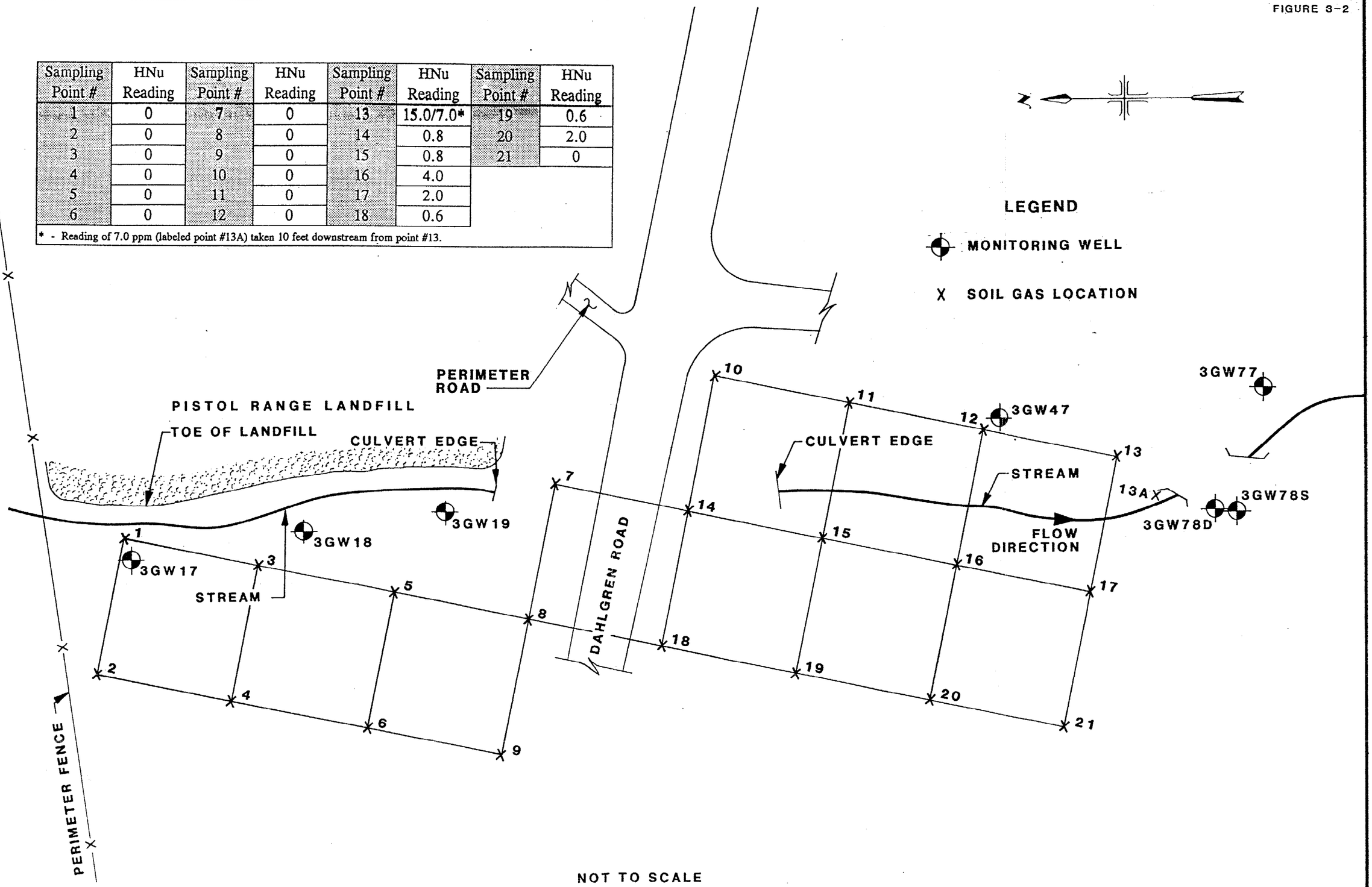
WHITE OAK, MARYLAND
NSWCWODET RI/FS
SITE 3 - GROUNDWATER, SURFACE WATER, SOIL AND SEDIMENT SAMPLING LOCATIONS

MALCOLM PIRNIE, INC.
OCTOBER 1992

FIGURE 3-2

Sampling Point #	HNu Reading	Sampling Point #	HNu Reading	Sampling Point #	HNu Reading	Sampling Point #	HNu Reading
1	0	7	0	13	15.0/7.0*	19	0.6
2	0	8	0	14	0.8	20	2.0
3	0	9	0	15	0.8	21	0
4	0	10	0	16	4.0		
5	0	11	0	17	2.0		
6	0	12	0	18	0.6		

* - Reading of 7.0 ppm (labeled point #13A) taken 10 feet downstream from point #13.



NOT TO SCALE

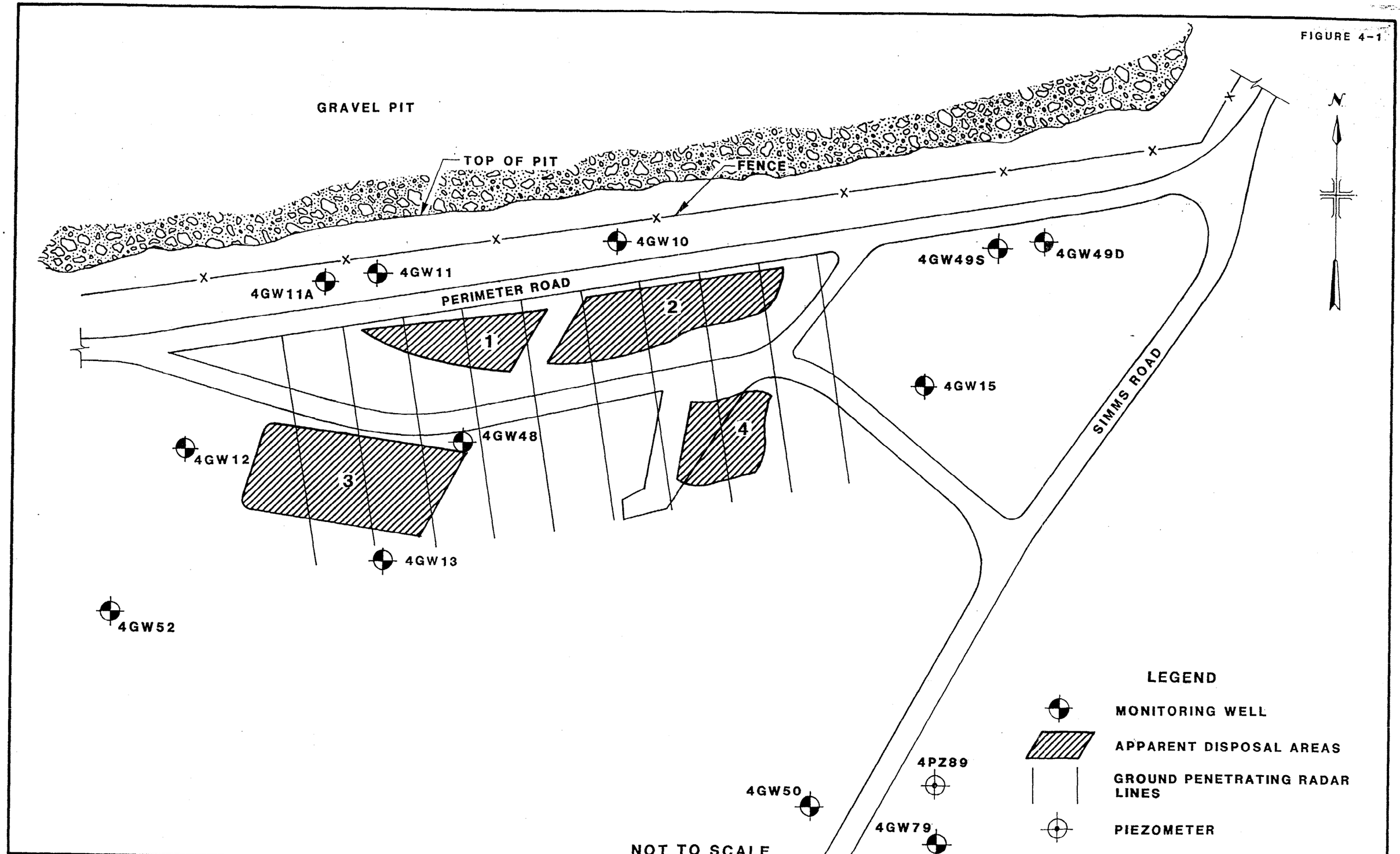
MALCOLM PIRNIE

WHITE OAK, MARYLAND
NSWCWODET RI/FS
SITE 3 - SOIL GAS SURVEY

MALCOLM PIRNIE, INC.

OCTOBER 1992

FIGURE 4-1



NOT TO SCALE

MALCOLM PIRNIE

WHITE OAK, MARYLAND

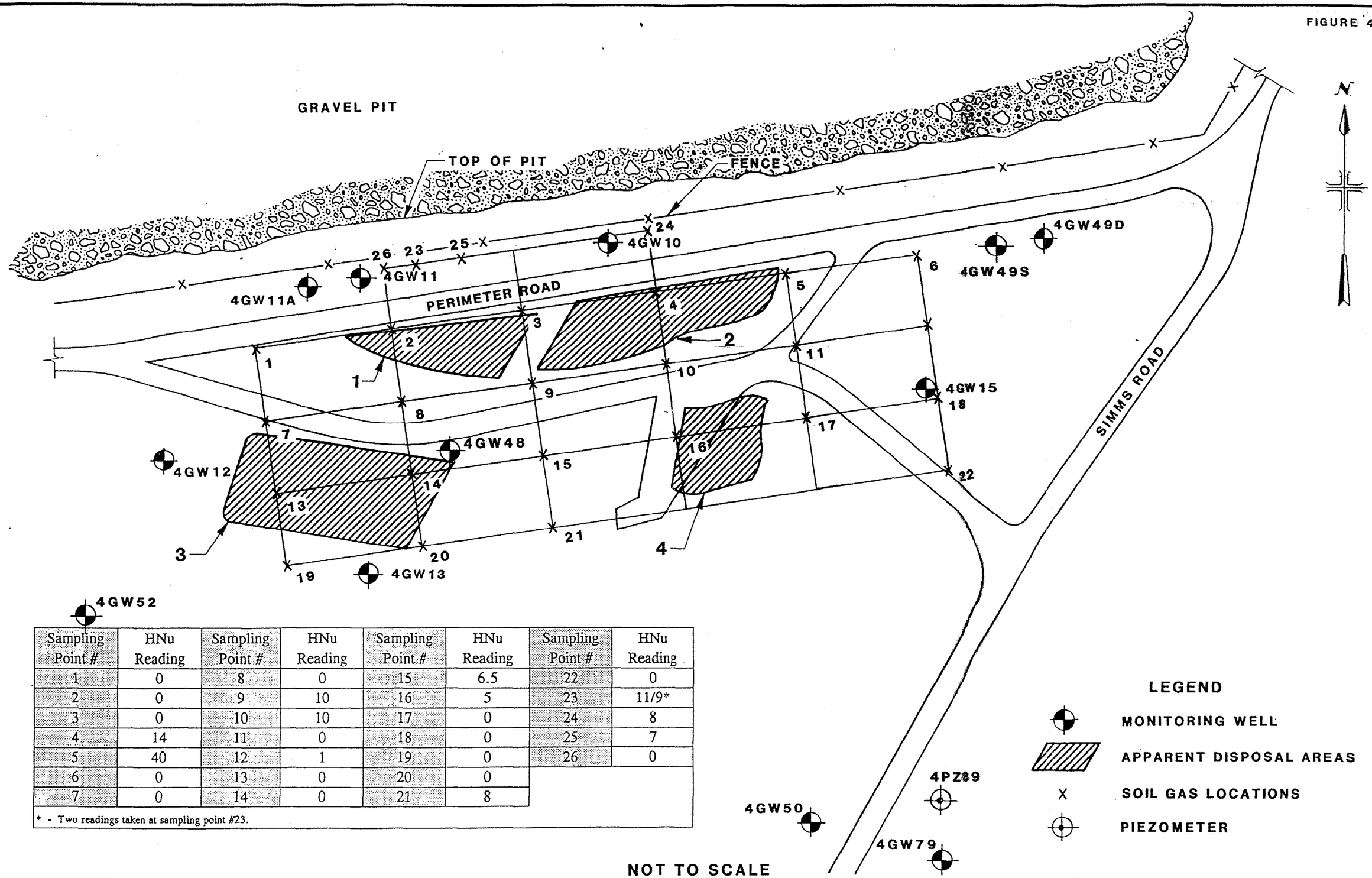
NSWCWODET RI/FS

SITE 4 - GROUND PENETRATING RADAR SURVEY

MALCOLM PIRNIE, INC.

OCTOBER 1992

FIGURE 4-2



Sampling Point #	HNu Reading	Sampling Point #	HNu Reading	Sampling Point #	HNu Reading	Sampling Point #	HNu Reading
1	0	8	0	15	6.5	22	0
2	0	9	10	16	5	23	11/9*
3	0	10	10	17	0	24	8
4	14	11	0	18	0	25	7
5	40	12	1	19	0	26	0
6	0	13	0	20	0		
7	0	14	0	21	8		

* - Two readings taken at sampling point #23.

NOT TO SCALE

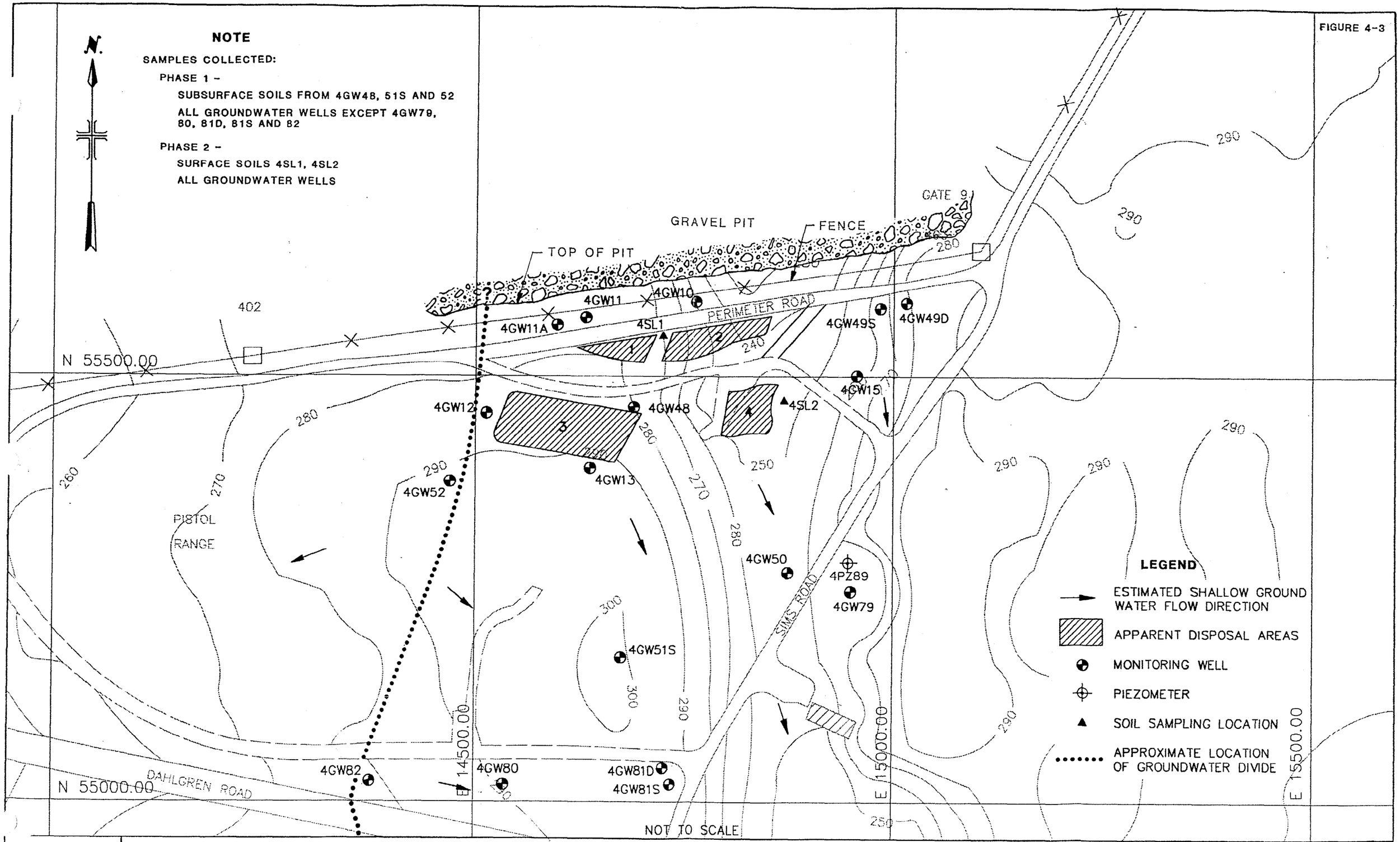
MALCOLM PIRNIE

WHITE OAK, MARYLAND
NSWCWODET RI/FS
SITE 4 - SOIL GAS SURVEY

MALCOLM PIRNIE, INC.

OCTOBER 1992

FIGURE 4-3



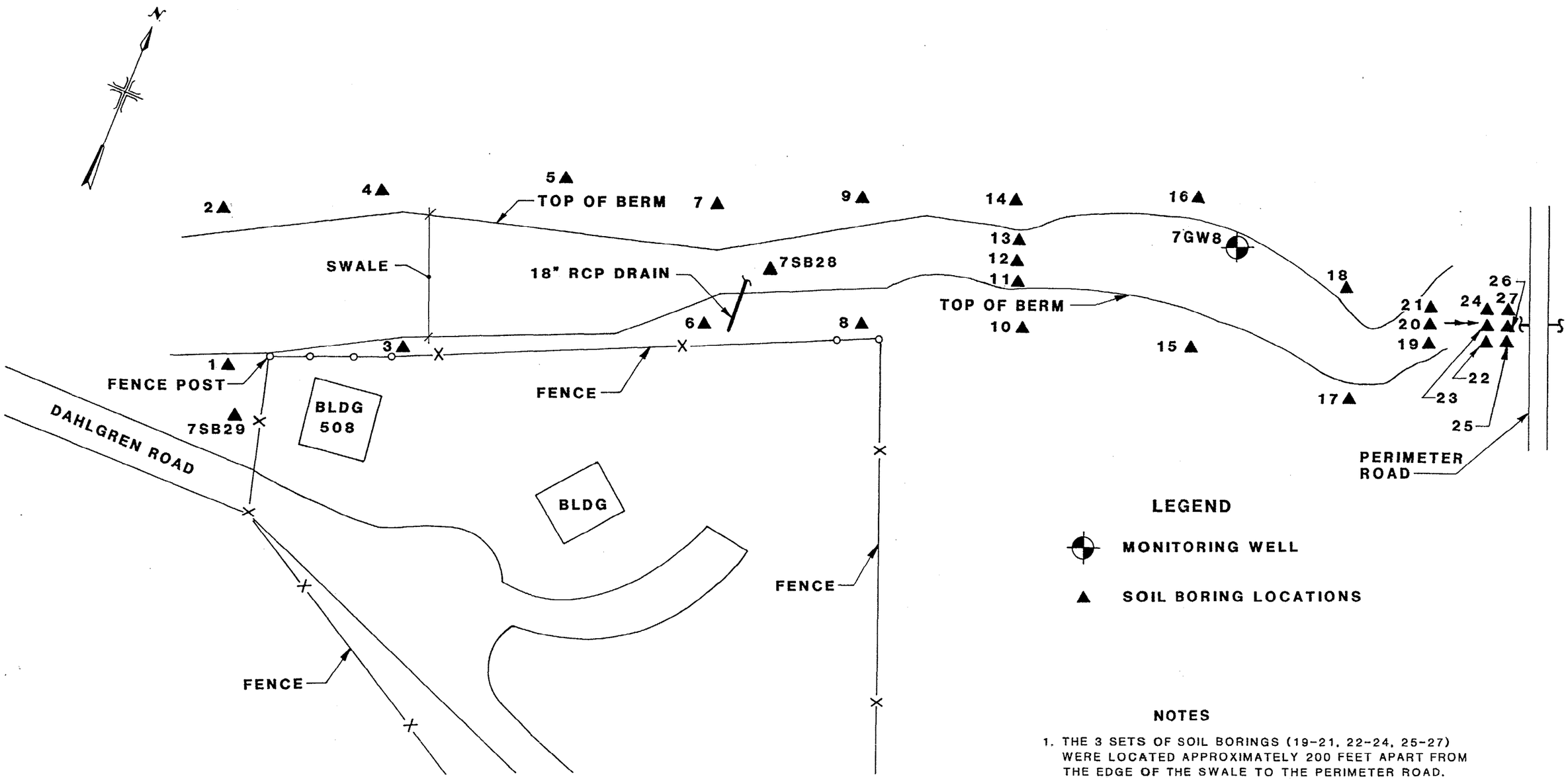
MALCOLM PIRNIE

WHITE OAK, MARYLAND
NSWCWODET RI/FS
SITE 4 - GROUNDWATER AND SOIL SAMPLING LOCATIONS

MALCOLM PIRNIE, INC.

OCTOBER 1992

FIGURE 5-1



NOTES

1. THE 3 SETS OF SOIL BORINGS (19-21, 22-24, 25-27) WERE LOCATED APPROXIMATELY 200 FEET APART FROM THE EDGE OF THE SWALE TO THE PERIMETER ROAD.

2. SAMPLES COLLECTED: PHASE 1 - 1-27
PHASE 2 - 7SB28, 7SB29

NOT TO SCALE

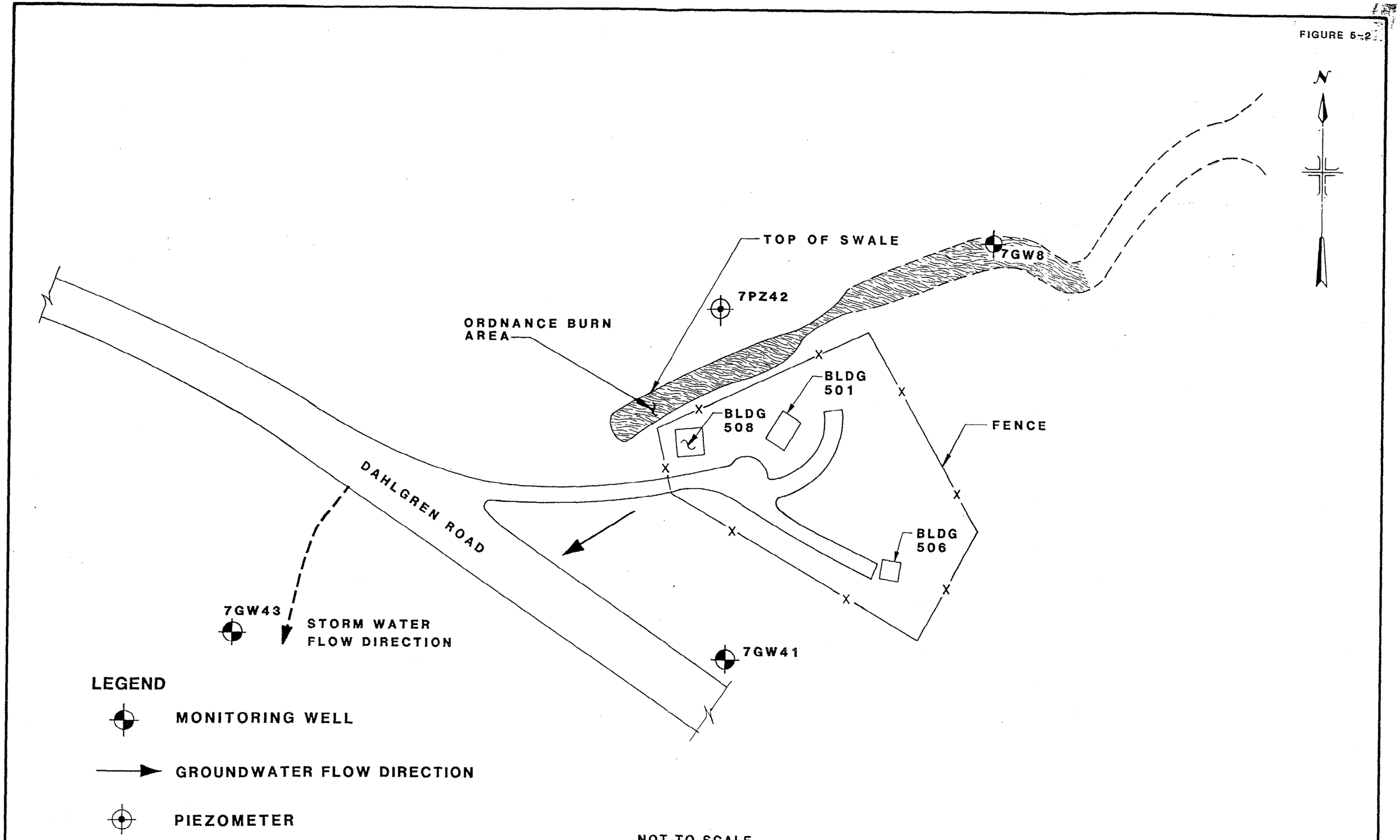
MALCOLM PIRNIE

WHITE OAK, MARYLAND
NSWCWODET RI/FS
SITE 7 - SOIL BORING SAMPLING LOCATIONS

MALCOLM PIRNIE, INC.

OCTOBER 1992

FIGURE 5-2



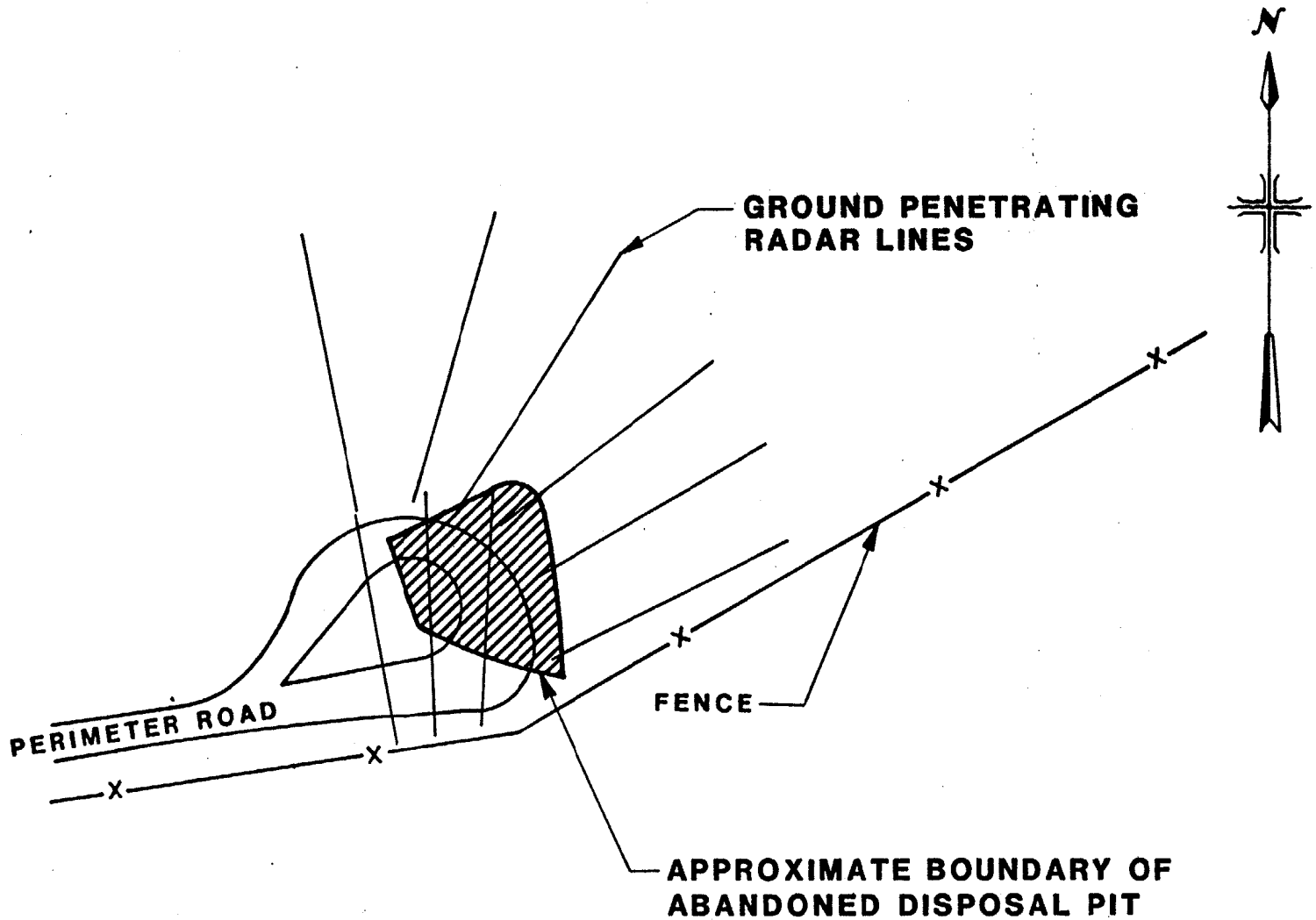
NOT TO SCALE

MALCOLM PIRNIE

WHITE OAK, MARYLAND
NSWCWODET RI/FS
SITE 7 - GROUNDWATER SAMPLING LOCATIONS

MALCOLM PIRNIE, INC.

OCTOBER 1992



LEGEND

GROUND PENETRATING RADAR LINES

NOT TO SCALE

FIGURE 6-1

MALCOLM PIRNIE

WHITE OAK, MARYLAND
NSWCWODET RI/FS
SITE 8 - GROUND PENETRATING RADAR SURVEY

MALCOLM PIRNIE, INC.

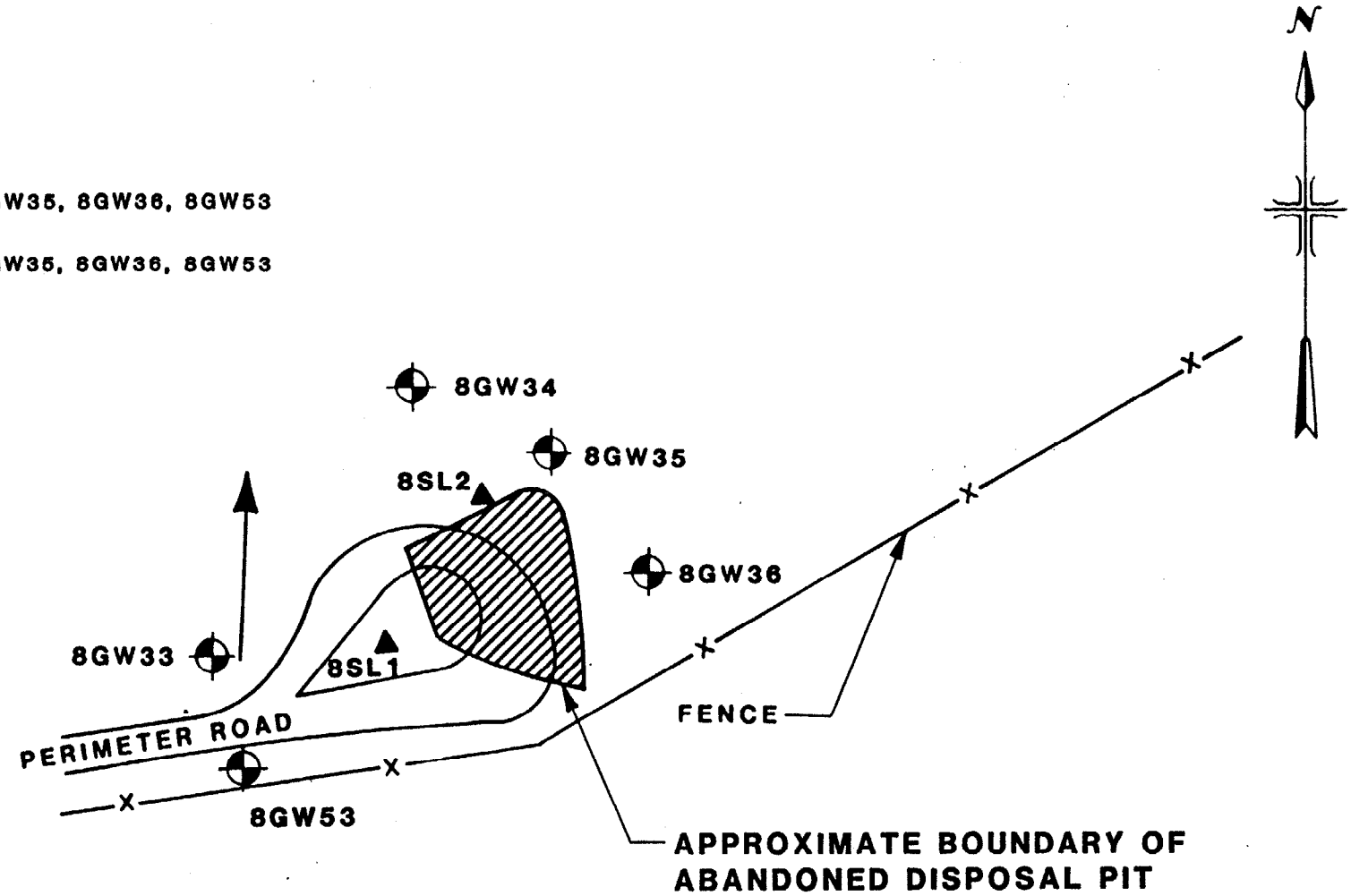
OCTOBER 1992

NOTE

SAMPLES COLLECTED:

PHASE 1 -
8SL1, 8SL2
8GW33, 8GW34, 8GW35, 8GW36, 8GW53

PHASE 2 -
8GW33, 8GW34, 8GW35, 8GW36, 8GW53



LEGEND

MONITORING WELL

GROUND WATER FLOW DIRECTION

SOIL (SL) SAMPLES

NOT TO SCALE

FIGURE 6-2

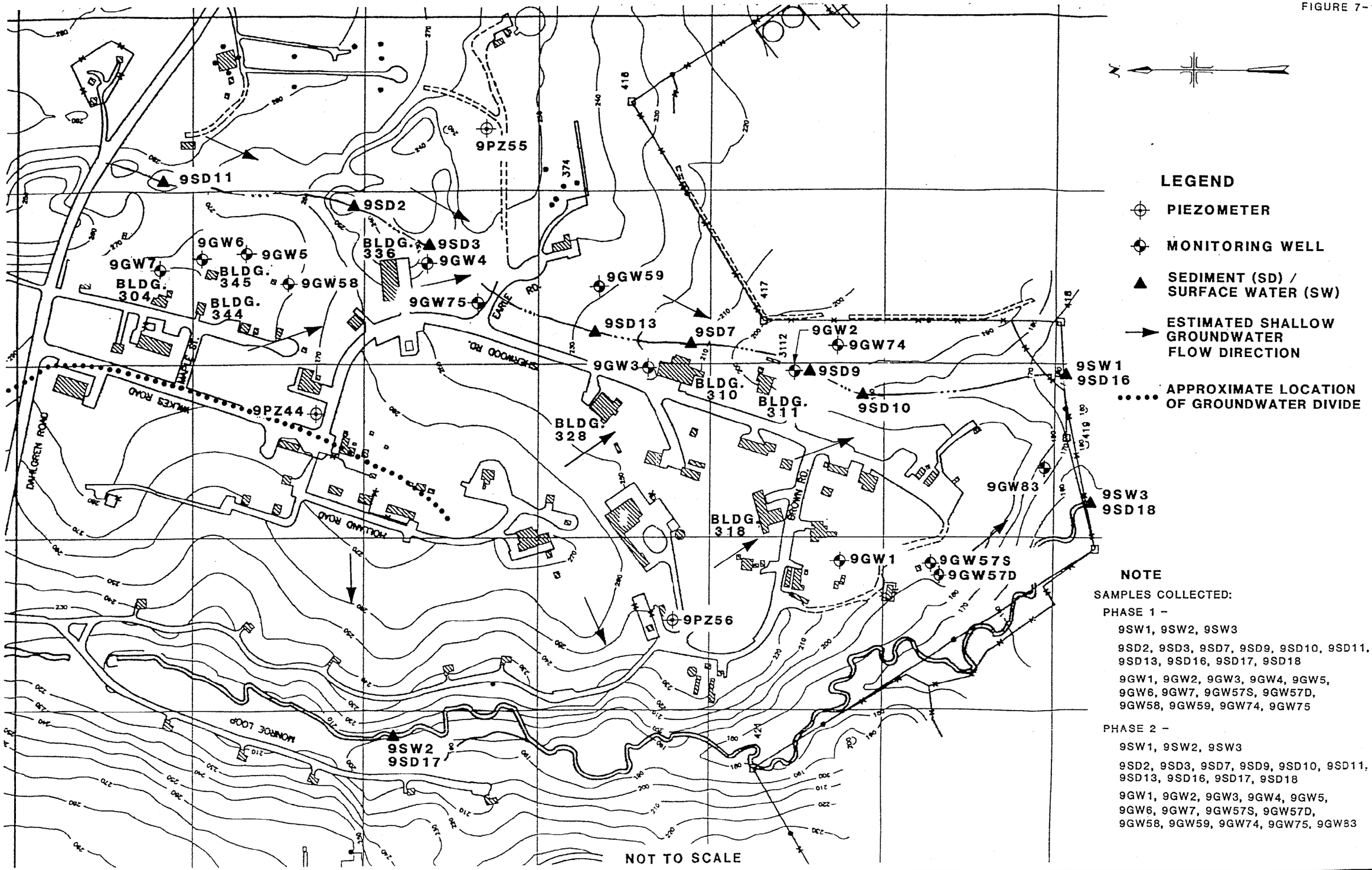
MALCOLM PIRNIE

WHITE OAK, MARYLAND
NSWCWODET RI/FS
SITE 8 - GROUNDWATER AND SOIL SAMPLING LOCATIONS

MALCOLM PIRNIE, INC.

OCTOBER 1992

FIGURE 7-1



MALCOLM PIRNIE

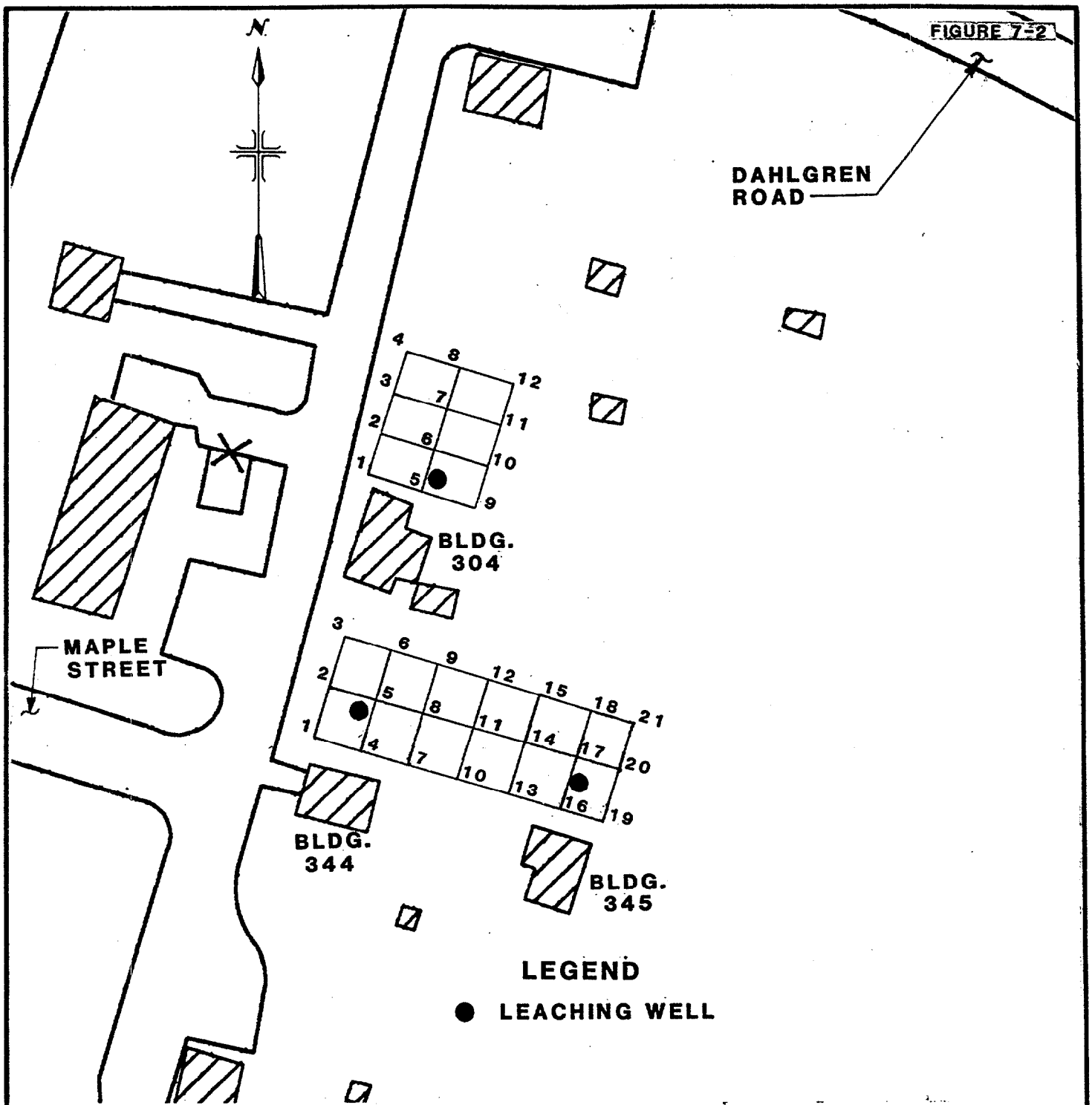
WHITE OAK, MARYLAND
NSWCWODET RI/FS
SITE 9 - GROUNDWATER, SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS

MALCOLM PIRNIE, INC.

OCTOBER 1992

00118027

FIGURE 7-2



Area Behind Bldgs 344 and 345

Sampling Point #	HNu Reading	Sampling Point #	HNu Reading	Sampling Point #	HNu Reading
1	0	8	0	15	0
2	0	9	0	16	0
3	0	10	0	17	0
4	0	11	0	18	0
5	0	12	0	19	0
6	0	13	0	20	0
7	0	14	0	21	0

Area Behind Bldg 304

Sampling Point #	HNu Reading	Sampling Point #	HNu Reading
1	0	7	0
2	0	8	0
3	0	9	0
4	0	10	0
5	0	11	0
6	0	12	0

NOT TO SCALE

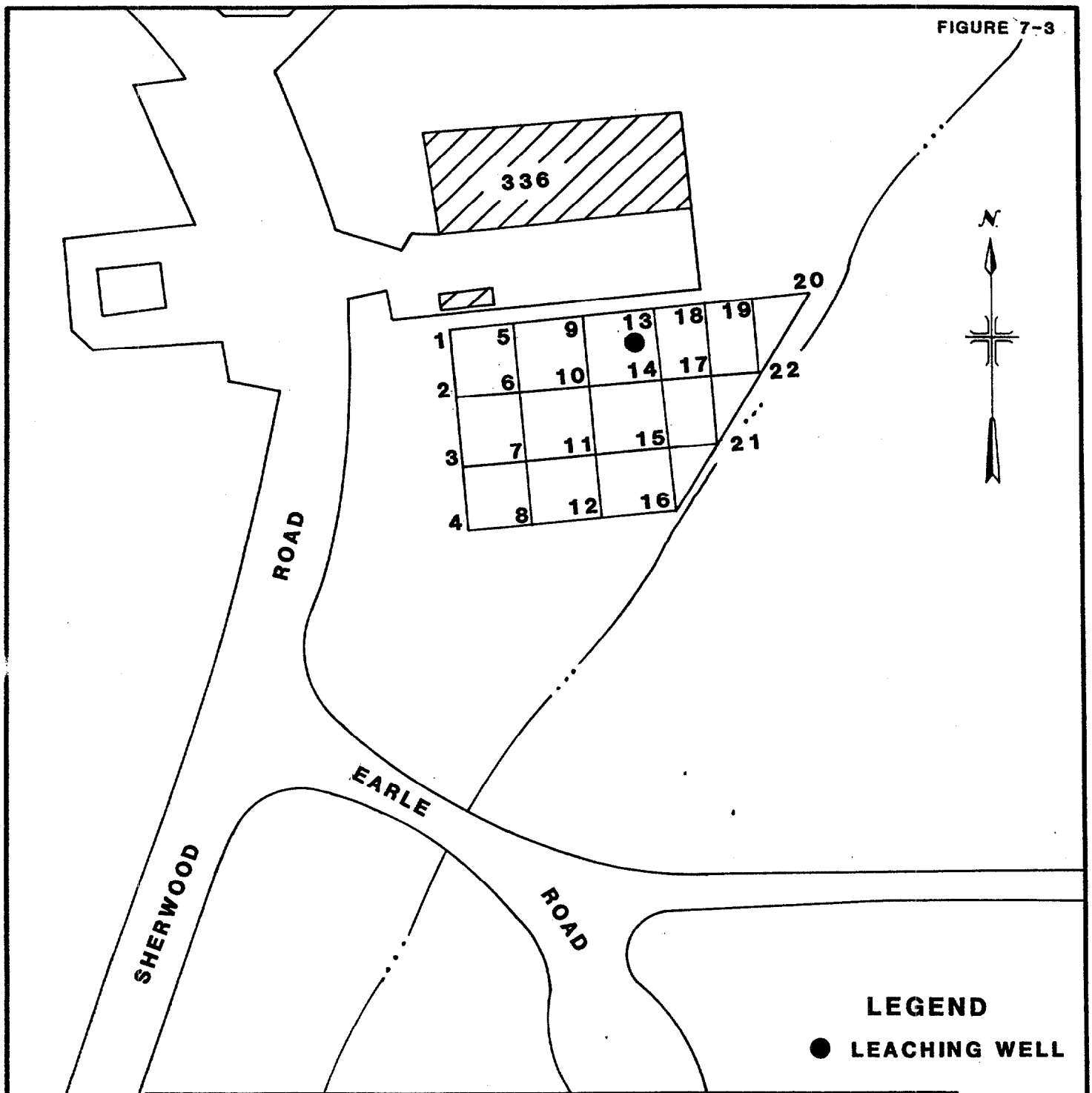
MALCOLM PIRNIE

WHITE OAK, MARYLAND
NSWCWODET RI/FS
SITE 9 (BLDGS. 304, 344, 345)
- SOIL GAS SURVEY

MALCOLM PIRNIE, INC.

OCTOBER 1992

FIGURE 7-3



Sampling Point #	HNu Reading	Sampling Point #	HNu Reading	Sampling Point #	HNu Reading	Sampling Point #	HNu Reading
1	0	7	0	13	4.8	19	1.4
2	0	8	0	14	0	20	1.2
3	0	9	0	15	2	21	1.6
4	0	10	0	16	2.8	22	1.6
5	0	11	0	17	3.2		
6	0	12	0	18	2.6		

NOT TO SCALE

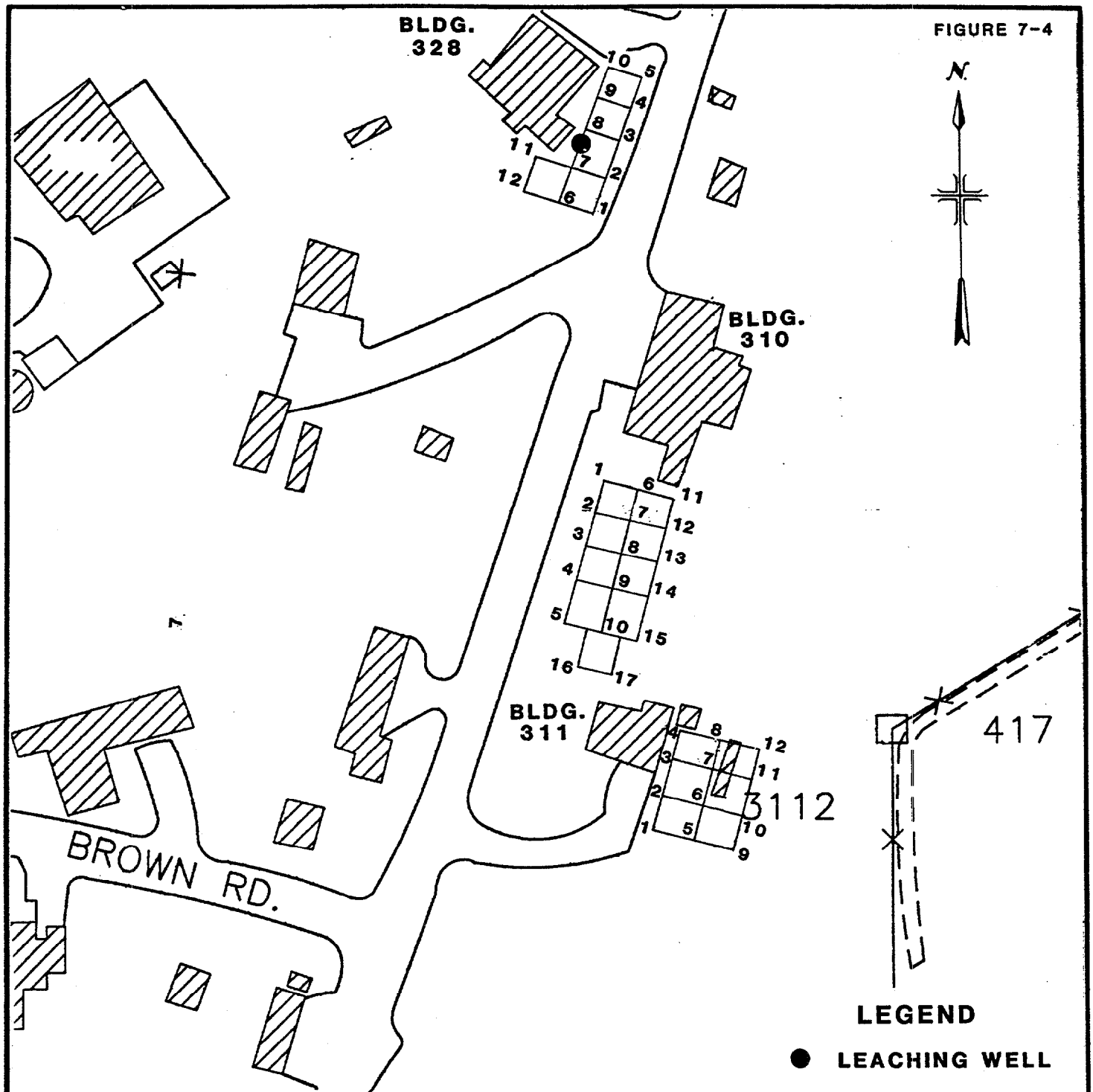
MALCOLM PIRNIE

WHITE OAK, MARYLAND
NSWCWODET RI/FS
SITE 9 (BLDG. 336)
- SOIL GAS SURVEY

MALCOLM PIRNIE, INC.

OCTOBER 1992

FIGURE 7-4



Area Behind Bldg 310

Sampling Point #	HNu Reading	Sampling Point #	HNu Reading
1	0.8	10	0
2	0	11	0
3	0.4	12	0
4	0	13	0
5	0.2	14	0.2
6	0.4	15	0
7	0	16	0.4
8	0	17	0
9	0.8		

Area Behind Bldg 311

Sampling Point #	HNu Reading	Sampling Point #	HNu Reading
1	0	7	1.6
2	0	8	3
3	0	9	0
4	0	10	5.5
5	0	11	4.9
6	0.2	12	1

Area Behind Bldg 328

Sampling Point #	HNu Reading	Sampling Point #	HNu Reading
1	0	7	0
2	0	8	5
3	0	9	0.6
4	0	10	0
5	0.3	11	0
6	0	12	0

NOT TO SCALE

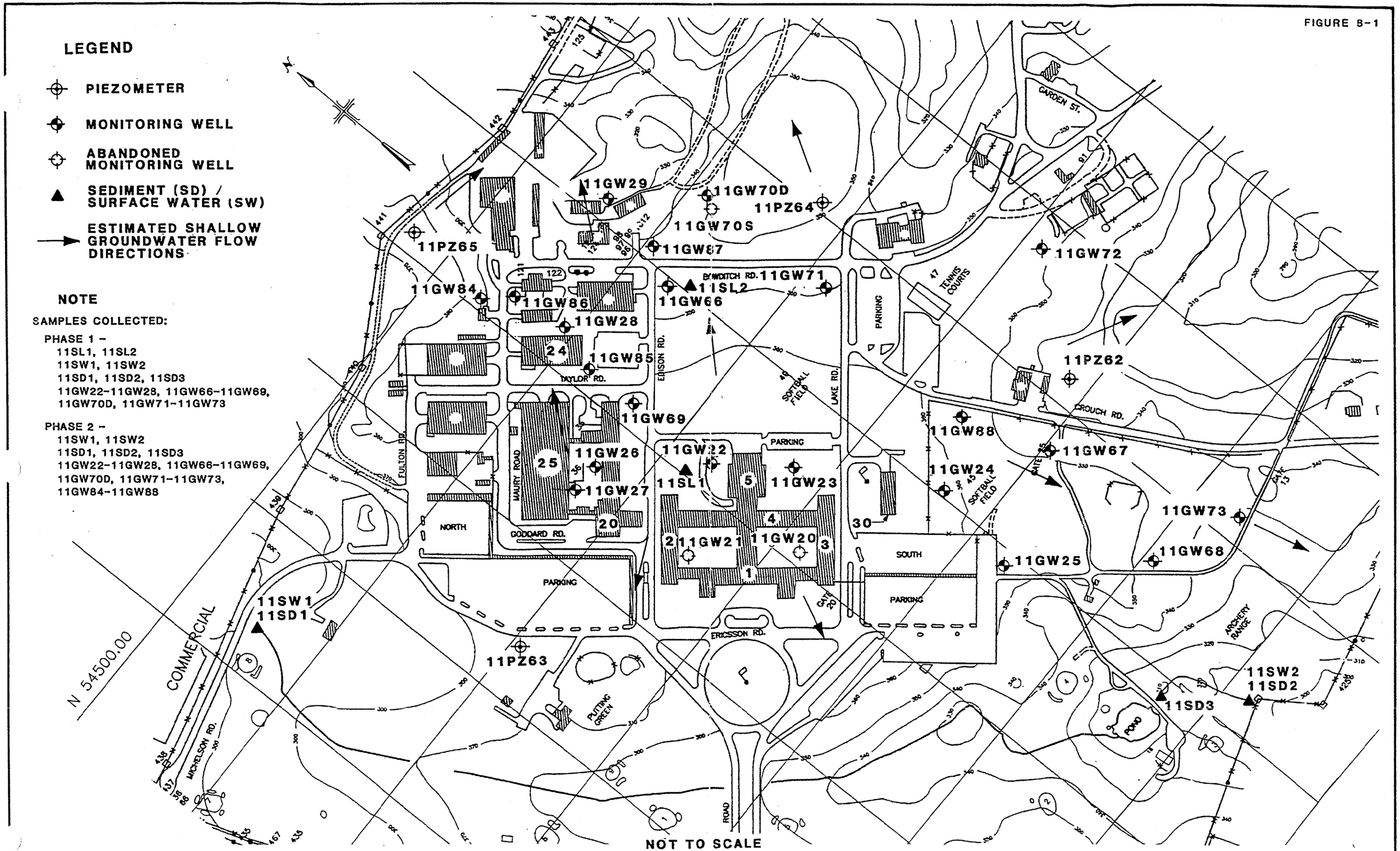
MALCOLM PIRNIE

WHITE OAK, MARYLAND
NSWCWODET RI/FS
SITE 9 - (BLDGS. 328, 310, 311)
- SOIL GAS SURVEY

MALCOLM PIRNIE, INC.

OCTOBER 1992

FIGURE B-1



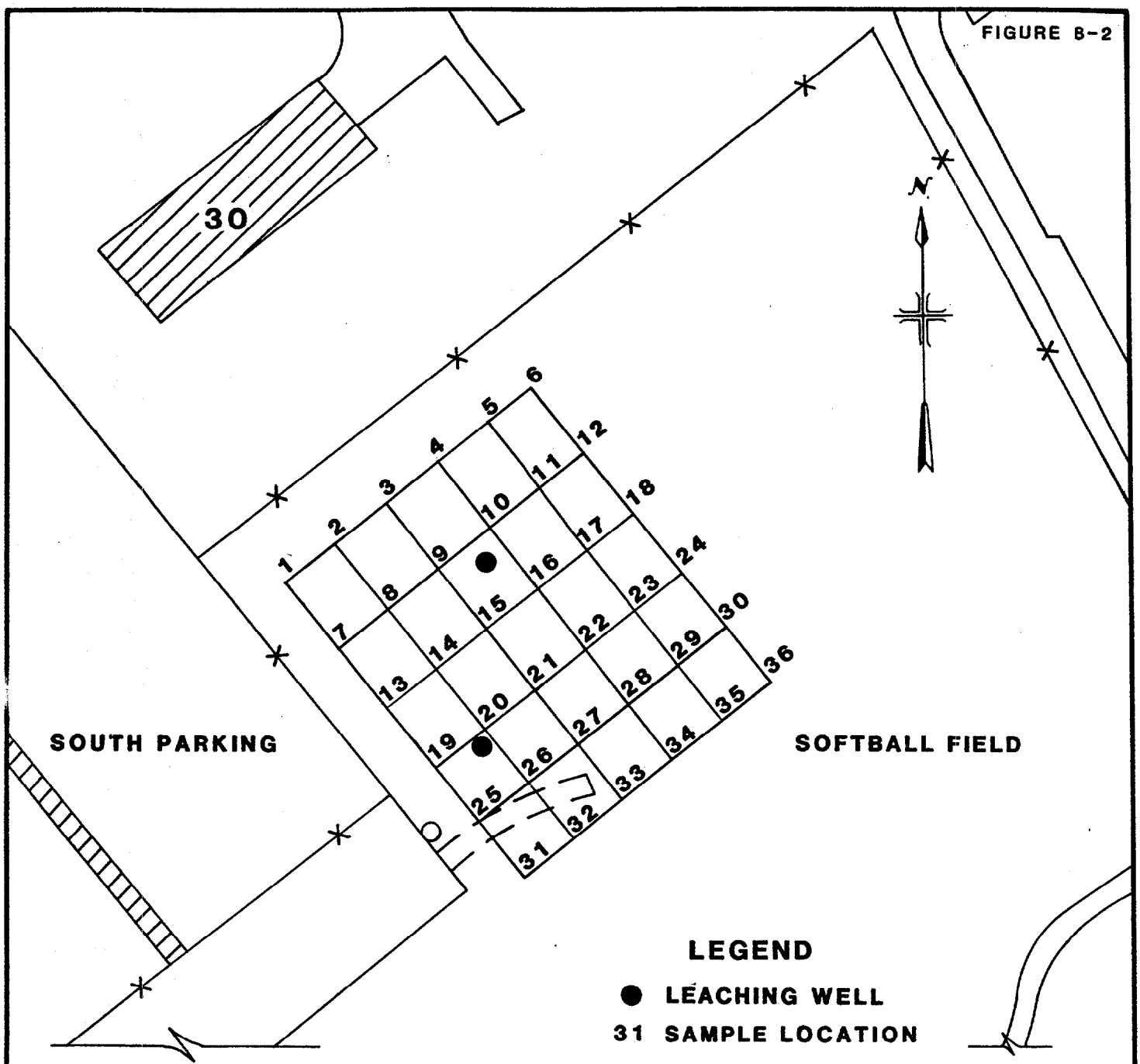
MALCOLM PIRNIE

WHITE OAK, MARYLAND
NSWCWODET RI/FS
SITE 11 - GROUNDWATER, SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS

MALCOLM PIRNIE, INC.

OCTOBER 1992

FIGURE B-2



Area Behind Bldg 30 (Softball Field)

Sampling Point #	HNu Reading	Sampling Point #	HNu Reading	Sampling Point #	HNu Reading	Sampling Point #	HNu Reading
1	1	10	0	19	0	28	0
2	1	11	0	20	0	29	0
3	0	12	0	21	0	30	0
4	0	13	0.8	22	0	31	0
5	0	14	1.5	23	0	32	0
6	0	15	0	24	0	33	0
7	0	16	0	25	0	34	0
8	0	17	0	26	0	35	0
9	0	18	0	27	0	36	0

NOT TO SCALE

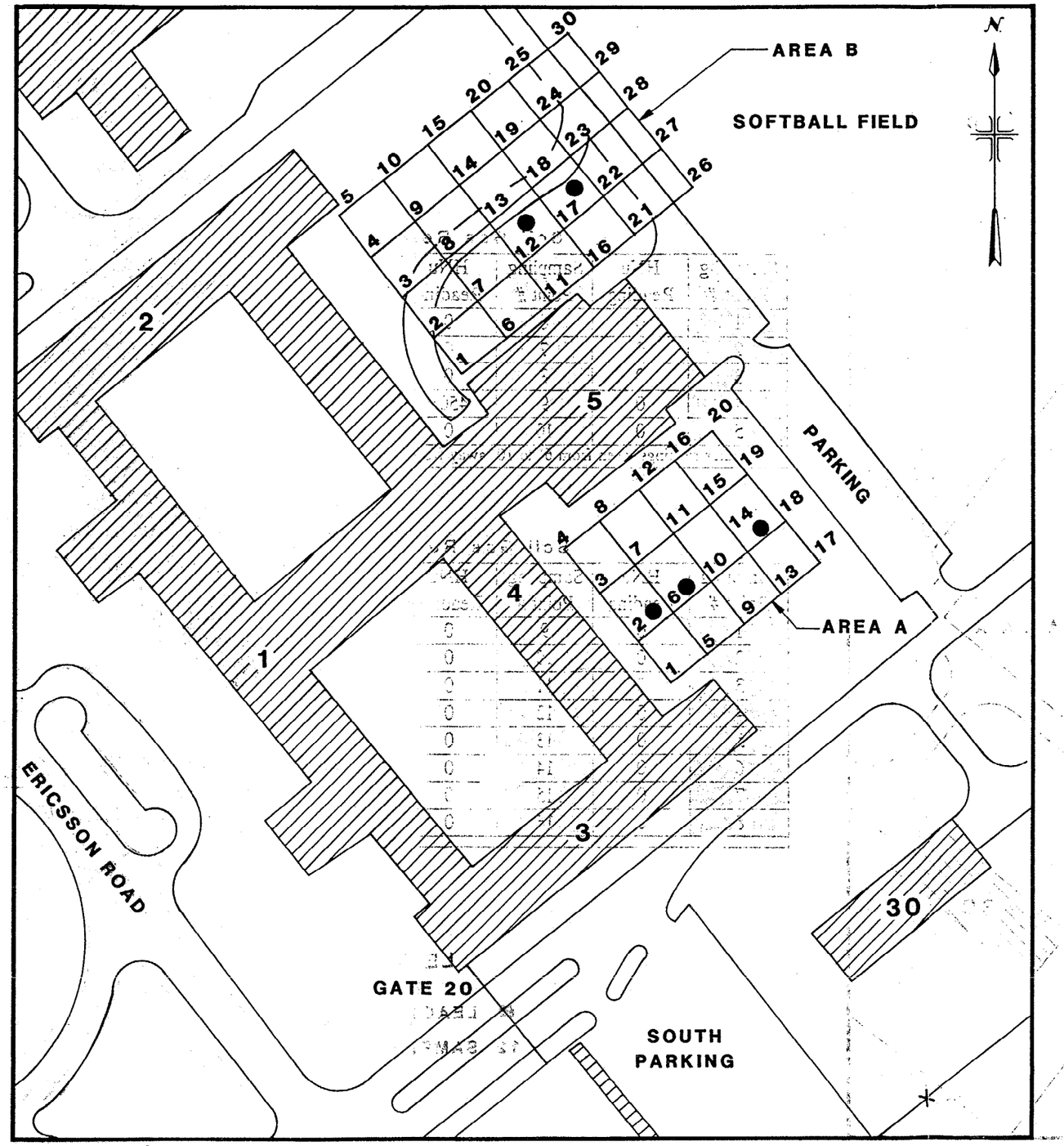
MALCOLM PIRNIE

WHITE OAK, MARYLAND
NSWCWODET RI/FS
SITE 11 (BEHIND BLDG. 30)
- SOIL GAS SURVEY

MALCOLM PIRNIE, INC.

OCTOBER 1992

FIGURE 8-3



Soil Gas Results - Area A

Sampling Point #	HNu Reading	Sampling Point #	HNu Reading	Sampling Point #	HNu Reading	Sampling Point #	HNu Reading
1	0	6	0	11	0	16	0
2	0	7	0	12	0	17	0
3	0	8	0	13	0	18	0
4	0	9	450*	14	0	19	0
5	0	10	0	15	0	20	0

* - Other readings taken from 6" to 10' away from point #9 revealed no volatiles detected.

Soil Gas Results - Area B

Sampling Point #	HNu Reading	Sampling Point #	HNu Reading	Sampling Point #	HNu Reading	Sampling Point #	HNu Reading
1	0	9	0	17	0	25	0
2	0	10	0	18	0	26	0
3	0	11	0	19	0	27	0
4	0	12	0	20	0	28	0
5	0	13	0	21	0	29	0
6	0	14	0	22	0	30	0
7	0	15	0	23	0		
8	0	16	0	24	0		

LEGEND

● LEACHING WELL

12 SAMPLE LOCATION

NOT TO SCALE

MALCOLM PIRNIE

WHITE OAK, MARYLAND
NSWC WOD ET RI/FS
SITE 11 (BEHIND BLDGS. 2/5 AND 3/5) - SOIL GAS SURVEY

MALCOLM PIRNIE, INC.

OCTOBER 1992